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NORDIC MOBILE TELEPHONE

Technical Specification for the Mobile Telephone Exchange

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Mobile telephone exchange

NORDIC MOBILE TELEPHONE GROUP

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Technical specification for the

Mobile Telephone Exchanges

(MTX)

Edition 4

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This document supersedes all previous NMT Doc.2 and NMT Doc.900-2 specifications, addenda and SIS addenda related to the specification for the NMT Mobile Telephone Exchanges.

The document is structured in such a way that it shall be easy to update. When in the future a paragraph will be updated and released, the relevant page will be issued together with a revised "List of content" which will give the actual status for the specification.
The specification can be obtained from "Telia Mobitel AB, S-851 87 Sundsvall, Sweden"
Fax +46 60 52 53 46, either by subscription or by separate order.

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1 INTRODUCTION

1.1 GENERAL

This technical specification presented as NMT Doc.900-2/ NMT Doc.2 describes the requirements set to the mobile telephone exchanges (MTX:es) for the Nordic mobile telephone system (NMT) . The specification is applicable for exchanges belonging to the second version of the NMT system (NMT- 900). It is also applicable for new and revised exchanges for the first version of the NMT system (NMT-450) as well as for the combined exchanges serving both versions, except for the parts which concern the signalling procedures in NMT 450. The specification is applicable to the MTX and its interfaces with the ordinary telephone network, the basestations and mobile stations. A general description of the whole NMT system is given in the NMT Doc.1 and NMT Doc.900-1. The MTX shall fulfil also the requirements for digital exchanges stated by CCITT and CEPT.

When referring to NMT Documents (NMT Doc.x or NMT Doc.900-x), this shall indicate the NMT Document including the latest revision of all relevant addenda to this document.

1.2 ABBREVIATIONS

The following abbreviations are used:

A - subscriber	Calling subscriber
ADP	Automatic data processing
AR	Authentication Register
B - subscriber	Called subscriber
BS	Base station
BKEY	Key used for encryption of the B-number
BSA	Base station area
CC	Calling channel
CS	Control and service unit
CU	Control unit
FFSK	Fast frequency shift keying
MFC	Multi frequency code signalling
MFP	Multi frequency pulsed signalling
MFT	Push-button multi frequency signalling
MS	Mobile station

MTX	Mobile telephone exchange
MTXH	Home mobile telephone exchange
MTXV	Visited mobile telephone exchange
MUP	Mobile user part
NMT	Nordic mobile telephone system
PMS	Mobile station with priority
R2	CCITT Recommendation R2
RAND	Random challenge
RF	Radio frequency
SAK	Secret Authentication Key
SCIP	Switching call in progress
SF	Fixed subscriber
SLU	Switching logic unit
SM	Mobile subscriber
SR	Signal strengthreceiver
SRES	Signed response
SU	Supervisory unit
TA	Traffic area
TAH	Home traffic area
TAV	Visited traffic area
TC	Traffic channel
TMS	Mobile test station
TUP	Telephone user part
VF	Voice frequency
ϕ signal	Supervisory signal

1.3 SOME MAIN FEATURES

The MTX is from the switching point of view a 4-wire transit exchange connected to the national trunk network in respective country, but it operates as well as a local exchange for the mobile subscribers. This MTX has been specified to meet the features necessitated by the mobile telephone system in accordance with the joint agreement made between the Nordic countries.

These features are mainly:

1.3.1 Execution of calls to mobile subscribers

In order to reach a mobile subscriber anywhere in the Nordic countries, the following routing principle will be used:

Calls to MS are directed to the particular MTX, in which the MS is registered (MTXH), and then, if necessary, forwarded to the MTXV corresponding to the subscribers actual location, see para 3.6.

The MTX, however, shall be made in such a way that a possible future change in the routing principle where calls are directed to the nearest MTX which makes inquiry to MTXH and then forwards to the relevant MTX, can be introduced.

The routing principle is based on a location registration procedure (updating) initiated by the MS with an interchange of information between MTXV and MTXH.

When an MS is visiting an MTXV, the MTXV shall have possibilities to store his identity in a special memory, in connection with the updating process. This (roamer) memory shall be checked by the MTXV whenever a visiting MS initiates a call.

Within the MTXH, the movements from one TA to another shall be noticed in the ordinary subscriber memory.

1.3.2 Switching call in progress and determination of MS output power level

The intention is to follow the movements of the mobiles and if necessary reswitch the connection before and/or during the conversation and determine the MS output power level. Therefore:

- The transmission quality on the radio path is monitored continuously by using a supervisory signal.

- In order to determine the best available base station and the MS output power level, the MTX shall make use of signal strength data obtained from special monitoring receivers at the base stations and of a logic unit for comparison. See also chapter18.

1.3.3 Signalling

- 1200 Bauds binary signalling with error correcting code for communication with the MS and the BS.
- National trunk line signalling on junctions between the MTX and the parent trunk exchange.
- MFC R2 signalling between MTX:s after established connection through the telephone network.
- Common channel signalling between MTXs. The specification is given in Annex 3 (MUP, HUP and SCCP) to NMT Doc.900-2/ NMT Doc. 2.

1.3.4 Subscriber facilities

The MTX should as far as practicable provide the same facilities for mobile subscribers as will be provided for subscribers in the fixed telephone network. Hence the MTX should, in addition to its switching function include subscriber facilities in such a flexible manner that the future implementation of facilities can be realized in accordance with the development of the fixed telephone network.

2 CAPACITY

2.1 GENERAL

The specifications given in this document apply to MTX of three approximate sizes a, b and c.

The MTX shall be constructed in modules in order to make enlargements possible in determined steps. Below are stated figures of relevance for each of the three sizes of MTX:s. These sizes are tentative, and other sizes and limits that may be proved more suitable from an economical and techical point of view will also be considered.

The MTX must be structured in such a way, that further extension of the common control equipment in order to meet 40% increases in call intensity (see para 13.2.1) is possible.

Normally the MTX is connected both to base stations and to the fixed telephone network. However in some cases the MTX can be used as a pure home location register (HLR) without any base stations. In this case the MTX has no visiting subscribers.

2.2 NUMBER OF SUBSCRIBERS

The subscribers using an MTX are divided into home subscribers and visiting subscribers registrated in another MTX. For simplification it is assumed that the number of home subscribers for the moment using any other MTX and the number of roamers using this particular MTX are approximatively equal.

Number of home subscribers are e.g. as follows

Max. extension	Initial capacity (suggested)	Extension steps (suggested)
MTX-size a: 50000	10000	5000
MTX-size b: 20000	5000	1000
MTX-size c: 5 000	1000	500

2.3 CONNECTIONS

The connections in the MTX are divided in mobile telephone channels towards the base stations and trunk lines connected to exchanges in the telephone network.

The channels are two ways circuits. The trunk lines are normally one way circuits and shall be dimensioned for 1% congestion, but it shall be possible to connect two way trunk lines.

Furthermore the MTX shall be implemented with connections to announcing machines, e.g. for use of different types of services and facilities (see chapter 5).

2.4 BASE STATIONS

Within one TA the number of BS may vary from 1-128 and the total number of BS:s controlled by one MTX shall be at least 1024 (512 for size c).

2.5 TRAFFIC AREAS

The number of TA controlled from one MTX may vary from 1-16.

2.6 TELEPHONE NETWORK CONNECTIONS

Number of routes connected to the switch must at least be 200 incoming and 200 outgoing. The maximum number of lines per route is 1000.

The maximum number of lines (inc and outg) towards telephone netwotk must be at least 5000.

2.7 TRAFFIC CAPACITY

The MTX shall be able to handle two types of traffic, partly the traffic carrying conversation and partly the traffic not directly carrying conversation, such as updating calls from mobile stations and other MTX:s or switching call in progress.

The figures for the traffic carrying conversation are as stated:

Total offered traffic per subscriber (in Erlang):	0.025
traffic distribution: 2/3 mobile originated, 1/3 mobile terminated	
Average effective call duration (in seconds):	100
blocking rate (in %) on radio channels, max.	5
traffic between two mobile stations (percentage of traffic between mobile and base)	5
transit traffic from the network to another MTX and to the telephone network due to transfer of calls (percentage of traffic to the MTX from subscribers in the network):	20

The figures for the traffic not carrying conversation are assumed as stated:

Number of channel shifts per conversation:	0.30
increased intensity of calls from mobile due to updating roamers (percentage of conversation calls from mobile):	35
updating calls from another MTX (percentage of conversation calls from mobile):	20
Number of signal strength measurements per BS and second, max.	14

The last two figures are corresponding with an increased traffic load less than one percent of the conversation traffic, expressed in Erlang.
Considering unsuccessful calls one must assume an increased intensity of calls, based on the following statement

unsuccessful calls mobile to fixed subscriber (percentage of attempts): 10

unsuccessful calls fixed to mobile subscriber (percentage of attempts): 50

Concerning internal blocking rate, switching time and processor capacity, see the chapters 10 and 13.

It shall be possible to connect at least 50 subscribers to same announcement at the same time.

The maximum processing time for all incoming information from the mobile station or the base station 1200 Bauds modem shall be 100 milliseconds under full traffic load. By processing time is meant the time elapsed from the incoming frame is decoded in the modem to the moment when the outgoing information is available in the MTX for encoding in the modem. (See also the signalling schemes in NMT Doc.1. and NMT Doc. 900-1.)

2.8 STORAGE CAPACITY

The MTX must have storage capacity for storing 1-19 triples per subscriber. The actual number to be stored is decided by the Administration.

3 TRAFFIC AND ROUTING

3.1 GENERAL

The MTX will be located in the network as a terminal station, directly connected to trunk exchanges. The MTX will be connected to the trunk exchange by means of trunk circuits, using the same signalling system as the trunk exchange.

The MTX shall serve as a terminal exchange in the network and will be an intermediary link in the traffic between mobile subscribers and regular telephone subscribers as well as between mobile subscribers.

The MTX shall connect calls in transit to another MTX, and exchange of data shall be possible between two MTX:s. It is also assumed that the MTX shall be able to establish connections to operators in the regular network. When common channel signalling is introduced routing to the nearest MTX shall be considered.

3.2 TYPES OF TRAFFIC

The MTX will be used to distribute calls in the following types of traffic:

SM-MTX-SM
SM-MTX-SF
SM-MTX-MTX-SM
SM-MTX-MTX-MTX-SM
SF-MTX-SM
SF-MTX-MTX-SM

For the connections SM-MTX and MTX-SM, a radio channel via a base station is used.

For the connections SF-MTX, MTX-SF and MTX-MTX, the regular telephone network is used. In the case MTX-MTX, dedicated connections are also foreseen.

3.3 SPECIAL CONNECTIONS

The MTX shall be capable of transmitting data over the telephone network to other MTX:s and exchanges in the fixed network for purposes of

- updating roaming information;
- updating black-listed subscriber registers;
- inquiries concerning subscribers in their home MTX;
- category information.
- routing information

For the transmission of this information, MFC-signalling (based on R2) or common channel signalling (MUP and HUP) are to be used. In MFC case, the MTX shall also have the possiblity of repeated attempts with a programmable repetition rate, if the previous one was not successful. An alarm print out shall be given, indicating the subscriber number, when the updating signalling has failed. Forwarding of calls from one MTX to another shall however be handled, according to the principle of an ordinary loss system, i.e. if the attempt is unsuccessful, the call will be lost.

This type of traffic between MTX:s can also be transferred on dedicated telephone circuit.

3.4 TRAFFIC AREA DIVISION

Each country will be divided into a number of traffic areas. A TA is a geographical area where calls to a subscriber are transmitted via all base stations within a period adjustable by a global parameter.

An MTX may control one or more TA:s.

3.5 ROUTING

Calls to mobile subscribers are to be routed through the telephone network on the basis of a service access code and the first two digits of the subscriber number. Such calls are always to be routed first to the MTX where the subscriber is registered (MTXH). MTXH shall have a subscriber register indicating in which traffic area controlled by this MTX the subscriber may be reached, or, if this is not the case, in which MTX he may be reached.

3.6 FURTHER ROUTING

If the MTXH, to which an incoming call is directed, has the information that the called subscriber is in an area controlled by another MTX, the call shall be forwarded or rerouted to the MTXV. This routing applies also to the case where the calling MS and the roaming MS are connected to the same MTX.

For special services (see chapter 5) the MTXH shall have the possibility to transfer calls to other subscribers, operators or announcing machines.

3.7 CHANNEL ALLOCATION

3.7.1 Channel allocation in NMT 900

The MTX has five types of channels towards the BS and MS with the following functions:

- calling channel, CC
- access channel, AC
- traffic channel, TC
- test channel
- dedicated data channel, DC

Dedicated data channel and test channel, if used, are specified by means of command. Calling channel, traffic channel and acces channel if used are automatically determined by the MTX according to the data specified for the BS.

It shall be possible to have more than one dedicated data channel to each BS.

The hardware in the MTX is equal for all channels, but different channel functions are obtained by signalling procedures. The channel allocation for each BS is stored in a BS file and channel file in the MTX. Re-allocations shall be possible via I/O-device, and also take place automatically according to the traffic situation if so commanded.

On BS:s with many channels, normally one calling channel and one dedicated data channel are allocated. On BS where one calling channel would not have enough capacity two calling channels may be used and also more than one dedicated data channel. Remaining channels are allocated as traffic channels of which some are marked free for call attempts from MS.

When a base station without acces channel has few channels occupied by traffic, at least one traffic channel shall be free for calls from mobile units.

If a base station without acces channel has several channels occupied, several free traffic channels are provided. By command, it should be possible to establish the relationship between the number of occupied and the number of free traffic channels for each base station individually.

In order to minimize the scanning time over 2000 channels within the 900 MHz-band the frequency band is divided into subbands. One of these bands is the "base-band". The BS's may have channels both within and outside this "base-band". Each BS shall have it's CC and some TC:s within the " base-band", and MTX normally also allocates and freemarks TC:s within this band. By command it shall be possible to send information on the CC about what subband to use for calls MS-MTX. At the same time the MTX shall allocate and freemark TC:s within this subband. As soon as possible after answer all traffic shall be switched over to channels outside the "base" where the MTX allocates free TC:s.

Generally calls from MS with data-category shall not be switched during data transmission. If no suitable TC outside the base band gets available the call is cleared. Calls MTX-BS shall not be set up if no suitable TC gets available outside the base-band within preset waiting time. However it shall also be possible to allow the call to continue in the base-band after the waiting time in both cases above.

If acces channel is used, the MTX will allocate the MS TC:s outside the base-band. This makes it unnecessary to switch established calls to a new channel.

A BS equipped with one or several acces channels shall have no freemarked TC:s at all, when there are no other TC:s available it shall be possible to use an acces channel as traffic channel.

On BS:s with few channels, it shall be possible to combine traffic channel and calling channel functions in order to optimize the utilization of the channels. It shall be possible to use the combination when the last ordinary traffic channel on a BS is occupied. If sq is to be done is specified by means of command for each BS. This is accomplished by a special channel mark.

Test channels are allocated only by command for maintenance and test purposes.

A call to an MS shall be transmitted on the calling channel for the actual MS group on all the base stations in the corresponding TA. If TA is not registered in the MTX for the called MS, the call shall be transmitted in all TA:s controlled by the actual exchange. The calls shall be executed one by one at each BS. Therefore a call buffer must be arranged for each BS. The call shall not be taken out of the buffer before one of the following conditions occurs:

- The call has been acknowledged on this or another BS
- The call has been transmitted twice at this BS
- The call has stayed in the buffer for 8 seconds without having the possibility to transmit the first call at all
- The call has stayed in the buffer for 10 seconds without having the possibility to transmit the second call.

A call shall be repeated after approximate 1,5 second, but not earlier than after 9 frames.

At congestion in call sending MTX to MS, a first call to one MS has higher priority than a second call to another MS.

If a call is taken out of the buffer due to time out, an printout alarm shall be given in the MTX.

If there after acknowledgement from MS is no TC available, the MTX shall queu the call in a queue for this BS. Only BS with more than 10 TC's (adjustable) shall have a queue. This queue has a lower priority than the queue for switching call in progress mentioned in chapter 18. The queue time shall be adjustable between 0 and 15 seconds. The MTX informs the MS about the queueing by sending a fictitious channel order (2f). The maximum number of calls in queue shall be adjustable according to the number of incoming lines from the fixed network. When a TC gets available on the actual BS the MTX reserves this channel, takes the first call out of the queue and makes one call attempt. In case of no acknowledgement from the MS the call is lost and next call is taken from the queue. In case of acknowledgement the MS is allocated to the reserved TC. If the MS gives acknowledgement from another BS, channel order is given to a TC on the new BS, if no TC is available the call is lost. When the queue is empty no more reservation is made for TC.

If the CC receiver on a BS is blocked by incoming radiosignal the MTX receives an alarm. Then the MTX shall replace the second ordinary call attempt on this BS by channel scanning order and awaits answer on any TC for 10 seconds. It shall be possible to activate/deactivate this function by command.

In the call set-up process, following conflict situation may occur, especially on BS:s with only one TC available:

Assume that a call to an MS has proceeded to the stage where the acknowledgement signal has been received. The MTX is, after selection of the TC (the only one), going to transmit the corresponding channel allocation signal. If MTX simultaneously receives seizure signal on this TC from another MS, the MTX shall then execute one of these colliding calls and reject the other. This decision is left to the administration policy, and corresponding command shall be given to the MTX.

In an emergency situation, it shall be possible to reserve, at a base station, a number of channels for use for calls from priority subscribers, so that these channels are not marked free for calls from the ordinary mobile units.

It should be possible via I/O units to mark in advance for the individual base station, how many channels may not be marked free for calls from ordinary mobile stations in an emergency situation (see para 19).

It should be possible to effect this restriction in channel allocation at one or several base stations by means of a simple command via an I/O unit.

3.7.2 Channel allocation in NMT 450

The MTX has four types of channels towards the BS and MS with the following functions:

- calling channel, CC
- traffic channel, TC
- test channel
- data channel, DC

Data channel and test channel, if used, are specified by means of command. Calling channel and traffic channel are automatically determined by the MTX according to data specified for the BS.

If a BS is specified to have a data channel, it is also specified which channel to be used for that purpose. The MTX may not use any other channel as data channel than the one specified for the BS concerned. This is because the hardware in the BS is not equal for the DC and the other channels respectively.

The hardware in the MTX is equal for all channels, but different channel functions are obtained by signalling procedures. The channel allocation for each BS is stored in a BS file and channel file in the MTX. Re-allocations shall be possible via I/O-device, and also take place automatically according to the traffic situation if so commanded.

On BS:s with many channels, normally one calling channel and one data channel are allocated.

Remaining channels are allocated as traffic channels of which some are marked free for call attempts from MS.

On BS:s with few channels, it shall be possible to combine traffic channel and calling channel functions in order to optimize the utilization of channels.

It shall be possible to use the combination when the last ordinary traffic channel on a BS is occupied. If so is to be done is specified by means of command for each BS. This is accomplished by a special channel mark.

Test channels are allocated only by command for maintenance and test purposes.

A call directed to an MS shall be transmitted on the calling channel of all the base stations in the corresponding TA. The actual point of time when the call is transmitted is depending on the traffic situation in each BS.

Simultaneously to one TA, addressed attempts shall be executed one by one. Therefor a buffer must be arranged. Maximum queuing time shall be 10 seconds. MTX awaits answer from MS for one second. depending on the traffic situation on the CC, unsuccessful calls shall be repeated (once) if that can be done after approximate 1.5 second but not earlier than after 9 frames.

In the call set-up process, following conflict situation may occur, especially on BS:s with only one TC available:

Assume that a call to an MS has proceeded to the stage where the acknowledgement signal has been received, the MTX is, after selection of the TC (the only one), going to transmit the corresponding channel allocation signal and simultaneously MTX receives seizure signal on this TC from another MS. The MTX shall then execute one of these colliding calls and reject the other. This decision is left to the administration policy, and corresponding command shall be given to the MTX.

When a base station has few channels occupied by traffic, an attempt is made always to keep one traffic channel free for calls from mobile units.

If a base station has several channels occupied, several free channels are provided, and if the base station has many occupied channels, a further number are marked free.

The number of free traffic channels at a base station at a given point in time thus corresponds to the number of occupied channels within the scope of the base station's total number of channels.

Through an I/O-unit, it should be possible to establish, at one channel intervals, the relationship between the number of occupied and the number of free traffic channels for each base station individually.

In an emergency situation, it shall be possible to reserve, at a base station, a number of channels for use for calls from priority subscribers, so that these channels are not marked free for calls from the usual mobile units.

It should be possible vis I/O-units to mark in advance for the individual base station, how many channels may not be marked free for calls from ordinary mobile stations in an emergency situation.

It should be possible to effect this restriction in channel allocation at one or several base stations by means of a simple command via an I/O-unit."

3.8 ROUTING TOWARDS THE TELEPHONE NETWORK

A routing case shall imply one first choice route and up to seven alternative routes. However, it must always be possible to use the last alternative for transfer to a new routing case. In that way the number of alternative routes is limited primarly by the capacity of the switching network.

4 CHARGING EQUIPMENT

4.1 GENERAL

The charging data concerning telephone traffic as well as so called updating traffic (see para 5.2.1.2) by mobile subscribers shall be stored in MTX in such a form (on e.g. magnetic tape or disc.) that the charging rate and the billing can be executed in an ordinary ADP device. It shall also be possible to transmit charging data via data circuits direct from MTX to an ADP-center for further processing.

Since the system also includes mobile coin box telephones, the MTX shall be able to meet this requirement in accordance with para 4.6.

4.2 DEBITING DATA

The data concerning the two above mentioned traffic forms, conversation traffic and updating traffic, shall be organized in blocks (formats) with the same uniform structure for each call. The main requirement are as in 4.2.1 and 4.2.2 below.

4.2.1 Conversation traffic data

Following data shall at least be stored (with a suitable label):

- The A-number = originating traffic area, category, nationality and identity (password $K_1K_2K_3$ included in NMT-900 and NMT-450 i)

- The B-number = the number chosen by the subscriber (max.23 digits). The equipment has to be programmed so that the prefix and up to the four last digits can be left out as commanded.

a) $+I_1I_2(I_3)N_1....N_{10}$
b) $N_1.....N_{10}$

-The duration of the call in whole seconds, minutes and hours, counted from the answer signal to the release of the connection.

- Record type
- Date and time for the answer year, month, day, minute and second.
- Call status
- Tariff and/or tariffclass
- Incoming- and outgoing route
- Cause for output
- Charged party

- Rerouting indicator
- Record number (for partial output)
- MFT-converter
- Priority call indicator
- Code for outgoing MTX
- Type of mobile subscriber
- Indication of correctly dialled procedure
- Originating exchanges

4.2.2 Updating traffic data between MTX:s

With updating traffic is here understood the roaming updating signalling between MTX:s. A TT-record shall be produced, in MTXV or MTXH, or in both MTXV and MTXH for each signalling sequence between MTX:s where the digit U=1 or U=4 (see para 9.4.3.3).

Following data shall be stored (with a suitable label):

- The A-number as before (the category information is given by the MTXH).
- Date and time, year, month, day, minute, second.
- Activation and deactivation of facilities.
- Originating exchange.

4.3 OTHER REQUIREMENTS

The equipment shall easily make it possible to store data continuously on two medias simultaneously. The both medias shall have a standby reserve to be used immediately when ordinary storing possibilities are not available. The data shall be stored in a buffer until all information from each call is noticed after which the information must be transferred to the storing device or to data link with magnetic tape as spare.

If the buffer is not available in a seizure situation, the MTX shall delay "the request of identity control" signal until the memory is free. The time supervision shall limit the delay time to a value set up by operating command (max.20ms).

Generally in the beginning of each call, the functioning and availability of the charging equipment shall be checked. If there are no storing possibilities, the MTX shall give alarm and react in a way defined by the administration for instance congestion, limited conversation time, blocking of lines with faulty buffers, call permitted without charging or call barring for outgoing international call etc.

If the charging equipment causes congestion, these losses shall be regarded as conventional register-congestions.

Special attention should be paid to the reliability of the equipment. The clock stability shall be better than 10-4.

The number of debiting data blocks on a media (e.g. magnetic tape or disc.) shall be stored in all situations.

4.4 INTERNATIONAL ACCOUNTING

The charging function shall give enough information for the international accounting between countries involved.

4.5 NATIONAL ACCOUNTING

The charging data shall give enough information for national accounting.

4.6 CHARGING EQUIPMENT FOR MOBILE COIN BOXES

Since the number of mobile coin boxes is foreseen to be very modest, their influence on the MTX complexity has been minimized and the corresponding charging equipment simplified.

The collecting equipment is concentrated to the coin-MS to which the actual tariff will be transferred in the beginning of each call. For visiting mobile subscribers from other nordic countries it must be possible to give them same charging information as in their own country. The corresponding signalling is given in the signalling specification (chapter 9).

The dialled number must be analysed by the MTX, which separates at least 3 different cases:

-	Emergency calls (para 5.5.3)	free of charge
-	National calls	one tariff or more
-	International calls	several tariffs

- in DK, SF and N, the MTX determines the tariff by analysing the countrycode I1 I2 I3 chosen.
- in S the MTX can eather use the tariff information used in the fixed network from e.g. the international exchange or gateway exchange or charging data built up in the own exchange to fit the mobile coin box system.

4.7 CHARGING FOR SPECIAL SERVICES

The booking of special subscriber services (see para 5.5...5.7) shall be registered in conformity with normal calls, i.e. only valid procedures shall be registered. It shall therefore be possible to put down all the symbols in a 16 button set as well as the switching in and out of special equipments, e.g. MFT converters (but not any real data message).

4.8 CHARGING IN CONNECTION WITH CALL TRANSFER.

It shall be possible to charge a transferred call so that the A-subscriber pays from A -> B-subscriber, and the B-subscriber pays from B -> C-subscriber.

4.9 CHARGING IN CONNECTION WITH ROAMING

It shall be possible to charge a roaming subscriber for incoming forwarded calls so that the A-subscriber pays from A to MTXH and roaming subscriber pays from MTXH to MTXV and to B-subscriber. It shall be possible to generate TT-datarecords in MTXH.

4.10 CHARGING BY PULSES AND TOLL TICKETING

In an MTXH it shall be possible to have subscribers charged by tollticketing and other subscribers charged by pulses.

A roaming subscriber outside MTXH is always charged by tollticketing for outgoing and incoming forwarded calls. See para 4.9

5 MOBILE SUBSCRIBER SERVICES

5.1 GENERAL

In principle the services offered at any time to regular telephone subscribers shall be available also to mobile telephone subscribers and it shall be possible to give 100% of the subscribers any or all facilities.

The MTX shall provide for the following services:

- the basic mobile telephone service, including roaming and switching call in progress;
- the services provided for now in the telephone network, including push button dialling, emergency call, information services and international subscriber dialling;
- supplementary services as specified in para 5.4-5.7.

In addition it shall as far as practicable be possible to add further services to the MTX as they are introduced in the regular telephone network.

It is recognized that some services may be introduced as ancillary equipment in the mobile station without imposing any requirements on the MTX (e.g. telephone answering machine and automatic number sender).

The services which shall be provided by the MTX and which put special functional requirements on the MTX are specified in the following paragraphs.

5.2 BASIC MOBILE TELEPHONE SERVICES

The setting-up and disconnection of ordinary calls with mobile subscribers is described in the NMT Doc.1. and NMT Doc. 900-1 as well as detailed signalling schemes and flow diagrams.

The special facilities "roaming" and "switching call in progress", which are included in the basic mobile telephone services are specified in paragraphs 5.2.1 and 5.2.2.

5.2.1 Roaming

5.2.1.1 General

Roaming shall be an integrated service in the automatic mobile telephone system available normally to all subscribers. However the roaming possibility of the subscribers having the category, local subscriber, and subscribers with added security features, may be restricted.

Every mobile subscriber belongs to an MTX area identified by his area telephone number. This area is the subscriber's home area which is controlled by the home MTX (MTXH).

Calls to a mobile subscriber will be routed to the mobile subscriber's home MTX (MTXH) or the nearest MTX or other SPC-exchange when common channel signalling is used. If the mobile subscriber is in a traffic area controlled by another MTX (MTXV), the call shall be forwarded or rerouted to the MTXV.

The subscriber register in the MTXH shall contain data indicating actual traffic area under MTXH or if the subscriber is under another MTX, the actual MTXV.

The subscriber register indicating the location of the subscriber shall be updated through updating calls from the mobile station.

For local subscribers the roaming shall be restricted according to the stored data. The data consists of the list of TA-numbers (Y1 and Y2) where the local MS may not be used). Calls to the local mobile subscribers shall not be rerouted from MTXH to MTXV. MTXV shall have two possibilities

1. Call barring according to the category data received from the MTXH

   - No restriction until the category information is received

2. The service is not allowed according to the numbering plan (number series of other MTX's "local subscribers" are not opened).

5.2.1.2 Updating of roaming data

Every MS has a routine of checking the TA indication of the calling channel. If the MS notices a "new" TA indication, an updating call shall automatically be initiated from the MS to the MTX.

Through the updating process the MS will report itself to a new TA and thus provide updating of the subscriber register in the MTXH.

If the MS reports itself to a new TA controlled by the same MTX as before, updating is made locally in the MTX. When the MS enters a new MTX, the updating information shall be transmitted to the MTXH. Transmission of updating information to an MTX may be delayed up to 5 minutes in order to allow transmission of several updatings to this MTX in one lot. This delay shall be adjustable from 0 to 5 minutes.

If the MTXV receives no answer from the MTXH in the updating process, the updating information is repeated every 5th minute (the time shall be adjustable) until the updating call is completed, but max. 3 times whereafter the MS is cleared in the roaming register.

5.2.1.3 Roaming register in the MTXV

Every MTX shall have a roaming register containing information about visiting subscribers. This roaming register shall have capacity for data about the subscriber's services so that the MTXV may offer him the same services as the MTXH.

The roaming register shall have a fixed number of entries for visiting subscribers.

The capacity of the roaming register shall be approximatively 20% of the total number of subscribers controlled by the MTX. It shall be possible to extend the capacity of the roaming register in blocks of 500 subscribers or less.

When the roaming register is filled to 70% of its capacity, a printout shall be made.

In order to give a roaming subscriber the same services as in the MTXH, and to prevent fraud, the subscriber category indication shall always be transferred to the roaming register in the MTXV during the updating process.

If the roaming register is full, and new visiting subscribers are reported, previously registered subscribers shall be cancelled in the register. Subscribers with a category indicating "no service restrictions" shall be cancelled first.

The subscriber category in the register is updated through an updating call from the MTXV to the MTXH via the telephone network on switched or dedicated lines the first time an MS initiates an updating call in an MTX area.

If an MTXV receives an ordinary call from a mobile subscriber who is not fully registered in the roaming register, the call shall be handled and an updating call shall be transmitted to the MTXH simultaneuosly. If the updating call from the MTXV to the MTXH should not be successful, the subscriber shall be allowed to proceed with his call.

If an MTXV receives an ordinary call from an MS with added security features who is not fully updated in the roaming register, the call shall not be handled, but an updating call shall be transmitted to MTXH immediately.

The MTXV disconnects this call if the service is not allowed according to the subscriber category indication.

A call to an MS forwarded to an MTXV where the subscriber is not registered in the roaming register, shall be transmitted on all TA:s controlled by the MTXV. When acknowledgement is received from the mobile subscriber, it is entered into the roaming register.

If changes are made in the subscriber category, the MTXH initiates an updating call to the MTXV containing new data for the roaming register in the MTXV. The initiating of this re-updating call can be delayed up to 5 minutes. The MTXH shall also cancel roaming information in an earlier visited MTX.

5.2.1.4 Local subscribers

It shall be possible to restrict the roaming of the mobile subscribers in certain areas specified in the MTX. These so called "local subscribers" are not allowed to get service in the specified traffic areas (identified with Y1 and Y2) and MTX-areas (identified with MTX identity). Alternatively the restrictions may be indicated as allowed area identities.

The MTXH shall not forward calls to local subscribers staying in forbidden areas. If a local subscriber makes an updating call on a forbidden MTXV, a signal indicating the service restriction shall be sent from MTXH (see para 9.4.3.1, table 5. signal R-2).

5.2.1.4.1 General

When the final function for local subscribers is introduced, it will be possible to offer lower rentals and lower call charges compared to ordinary subscriptions. On the other hand, local subscribers will only be able to make or receive calls when within certain restricted areas, local areas, with the possible exception of emergency calls, which always may be made anywhere within the coverage area of the Nordic NMT system.

A natural region for a local subscriber may be a city area with suburbs. It may be a county, or all areas outside the big cities of a country (rural area subscribers).

For the Administrations it may be of vital importance to be able to offer local subscriptions with complete coverage of a natural region (Traffic area(s)). This shall apply also in the case where the boundaries between the coverage area of several MTXs cut across the natural region.

Below is a more detailed description of how the final function for local subscribers may be introduced in NMT-450 and NMT-900, when the MUP and HUP functions (Annex 3) will be in operation, using CCITT No.7 signalling between the MTXs of the Nordic countries.

5.2.1.4.2 Description of the function

5.2.1.4.2.1 General description

Subscription areas verification orders checking of mobile station geographical positions against subscription areas for the following events :

- page response
- originating access
- handover, including inter-exchange handover
- call back

For subscribers who are not assigned a subscription area, no verification is carried out.

5.2.1.4.2.2 Structure of subscription areas

Subscription areas can be defined anywhere in the network area. They may include parts of several cooperating exchanges. They are identified by categories.

Subscription areas are formed by one or more traffic areas. A traffic area may be assigned to one or several subscription areas.

Different categories can be assigned to the same subscription area on an per exchange basis. Translation are used to convert a subscription area category in one exchange to the equivalent category designation in another exchange.

5.2.1.4.2.3 Subscription area verification

5.2.1.4.2.3.1 Registration

Subscription area verification is made for registration accesses.

5.2.1.4.2.3.2 Page response

When a mobile station responds to a page, it is checked whether the subscriber is outside his subscription area. If so, the call is rerouted according to exchange data, e.g.to an announcement machine.

5.2.1.4.2.3.3 Originating access

When a mobile station attempts to initiate a call, it is checked whether the subscriber is outside his subscription area. If so, the call shall be routed according to exchange data, e.g. to an announcement machine. It shall be possible to allow emergency calls and operator handled calls.

5.2.1.4.2.3.4 Handover

No subscription area verification applies at handover.This allowes a subscriber who has received or initiated a call when within his subscription area, to continue the call.

It shall be possible to implement the verification at handover according to an exchange parameter so that if the subscriber has a subscription area category, it is verified that the cells or outer cells approved for a possible handover belong to his subscription area. The cells within the traffic area(s) that are excluded from his subscription area are not considered further for handover.

5.2.1.4.2.3.5 Call back

Call back is used during a three party connection to remind about a parked connection. Page responses received at call back when the mobile station has moved outside his subscription area, are either dropped or accepted according to an exchange parameter.

5.2.1.4.3 Administration procedures

5.2.1.4.3.1 Administration of subscription areas

Subscription areas are defined as collections of traffic areas. Commands for definition, deletion and printout of subscription areas shall be provided.

5.2.1.4.3.2 Administration of subscription area category translations

Inter exchange translations for subscription area categories are needed in order to identify specific subscription areas at signalling between cooperating exchanges. Definition or change and printout of subscription area category translations shall be done by commands.

5.2.1.4.3.3 Activation of subscription area verification

Commands shall be provided for activation and deactivation of subscription area verification. A command to printout the status of subscription area verification must be included.

5.2.1.4.4 Capabilities

Up to 128 subscription area categories shall be defined in an exchange. The number includes a basic category for unlimited access to service in the whole network area. The basic category shall be given by default to all new subscribers.

An exchange parameter shall decide whether subscription area verification applies to page response at call back.

An exchange parameter shall determine whether subscription area verification applies at handover.

5.2.2 Switching call in progress

The switching call in progress service means that, when the transmission quality falls below a certain limit, calls are changed from one radio path to another with better transmission quality, if available. This service will be given to all subscribers in an MTX area, except data subscribers (see further chapter 18). It shall also be possible to switch a call to better BS controlled by another MTX.

5.3 HANDLING OF UNSUCCESSFUL CALLS TO MOBILE SUBSCRIBERS

Unsuccessful calls to mobile subscribers shall be handled differently in the MTX depending on whether or not the signalling system in the adjacent exchange in the telephone network includes special backward signals, e.g. R2-MFC B-signals.

Different actions can be taken according to the actual subscriber's facilities.

5.3.1 Mobile subscriber busy

Calls to busy mobile subscribers shall in the MTXH be handled in the following ways:

a) When busy signal (R2, B-3) is provided on incoming trunk, this signal is sent.

b) When busy signal is not provided, busy tone is sent to calling subscriber.

c) Call transfer on busy. (see para 5.5.2).

MTXV sends always signal B-3 to the MTXH.

5.3.2 No acknowledgement from mobile station

When the mobile station is not switched on or is out of radio coverage or roaming information is not updated, no acknowledgement is received when the mobile station is called, the MTXH shall in this situation have the possibility to:

a) connect the calling subscriber to an announcing machine at theMTXH;

b) set up a connection to an announcing machine in the telephone network;

c) set up a connection to a "who-has-called" operator (see para 5.5.2.3).

d) set up a connection to another subscriber (see para 5.5.2).

When the MTXV receives no acknowledgement on a call the corresponding B-signal is sent to the MTXH (MFC).

5.3.3 No answer from mobile subscriber (acknowledgement received)

Calls to mobile subscriber, who has not answered before time-out, shall be handled in the following ways in the MTX:

a) When answer is not received from the mobile subscriber within 10-60 seconds (adjustable) after end-of selection, the MTX releases the traffic channel and sends congestion/busy signal.

b) A connection is set up to a "who-has-called" operator in the MTXH, if this service is applicable (see para 5.5.2.3).

c) A connection is set up to another subscriber, (see para 5.5.2).

5.3.4 Vacant mobile subscriber number

Calls to vacant mobile subscriber numbers shall be handled in the following ways in the MTXH:

a) When a signal indicating vacant number (R2, B-5) is provided on incoming trunk, this signal is sent.

b) When no vacant subscriber signal is provided, the calling subscriber is connected to an announcing machine and or special information tone at the MTXH or a connection is set up to an announcing machine in the telephone network.

5.3.5 Changed mobile subscriber number

Calls to mobile subscribers, who have changed number, shall be handled in two alternative ways, similar to calls to vacant numbers (para 5.3.4). In this case a R2 signal B-2: "Subscriber transferred" is used instead of B-5.

The "Transfer-of-call" service (para 5.5.2.1) may also be applied when a number is changed.

5.3.6 Congestion in MTX

a) When congestion signal (R2, B-4) is provided in the MTX, this signal is sent.

b) When congestion signal is not provided, congestion tone is sent to calling subscriber.

c) Set up a connection to an announcing machine in MTX.

d) Call transfer on congestion on BS. (see para 5.2.2 and 5.5.2.4)

5.4 SERVICES REQUIRING SPECIAL MOBILE STATIONS

The services "Subscriber with priority" and "Mobile coinbox" require special mobile stations and special signalling procedures between the MS and the MTX by which the MTX recognizes the special MS category involved.

5.4.1 Subscriber with priority

The purpose of the priority call facility is to provide the possibilities for mobile subscribers, with priority category, of getting a traffic channel, ahead of ordinary mobile subscribers, during periods when all the traffic channels of the base station are occupied. Priority does not imply the disconnection of another call in progress on the base station (see chapter 19). The MTX shall recognize calls from the priority MS with a special seizure signal.

This service the administration can assign to special subscribers.

5.4.2 Mobile coin box telephone

The coin box facility shall not complicate the MTX function more than necessary, and therefore the coin box MS shall be with an appreciable amount of intelligence.

Special services (see para 5.5.1-5.5.2) and manual calls (booking via operator) from a coin box MS shall be possible to block in the MTX.

The MTX function associated with a coin box call differs nevertheless in some degree from the ordinary MTX operation, except for calls to the coin box MS.

Based on the dialled telephone number (or procedure) sent by the mobile coin-box station, the MTX decides the charging rate for the actual call. The tariff information Q_1Q_1 is sent from the MTX to the mobile coin-box when charging is to start (frame 5b,"Answer to coinbox")

If a Register Recall procedure is activated during the call, a revised Q_1Q_2 value shall be transmitted from the MTX using frame 5b. This revised value is calculated by adding the charging rates for each of the connections established by the subscriber. If the subscriber terminates one of the connections, the charging rate shall be adjusted accordingly, and a revised Q_1Q_2 value sent from the MTX, using frame 5b.
See NMT Doc.1. and NMT Doc.900-1.

5.4.3 Mobile stations with added security functions.

5.4.3.1 General

The MS is given a unique secret key (SAK). This key is installed both in the MS and in the AR. The SAK is used in revised signalling schemes that guarantees the infeasability to masquerade an MS in case of originating calls. It shall furthermore be infeasible to take over a call setup from the original MS and send a chosen B-number after authentication has been performed correctly by the original MS.

MTXH will for each subscriber store 1-19 triplets consisting of SRES, RAND and BKEY. This information will originally be fetched from the AR to which the MTX is connected. The triplets will normally only be used once. If the number of remaining triplets for a subscriber falls below a preset limit, the MTX will initiate transfer of more triplets from the AR for this subscriber.

In case of roaming, MTXH shall on demand from MTXV transmit one or more triplets of RAND,SRES and BKEY valid for a specific MS belonging to MTXH.

5.4.3.2 Action in the MTX

When an MS makes a call under MTXH, the MTXH will use the RAND part of a triplet and transmit this to the MS. The SRES received from the MS will then be compared with the SRES stored. Decision is then to be taken, whether to continue the call set-up or to deny service.

When an MS makes a call under MTXV, the MTXV will use stored triplets of RAND, SRES and BKEY to challenge the MS and to complete the call set-up. These triplets will be fetched from MTXH during roaming updating or later. If no triplets are available in MTXV when a call is made, the call will be disconnected and fetching of triplets from MTXH will be initiated.
When the RAND-part of a triplet is transmitted to the MS the MTX shall mark the triplet as being used. If no SRES is received back from the MS, at the next call set-up the MTX shall transmitt an unused triplet. The triplet that was marked as "used" will only be reused if there are no unused triplet avilable in the MTX.

If the MS is not fully updated in the roaming register of the MTXV, ref. para 5.2.1.3.

5.5 SPECIAL SERVICES PROVIDED BY MTX FUNCTIONS

The services "Call barring" and "Absent subscriber service" involve subscriber's control operations using the push-buttons in the mobile station. These control operations shall be acknowledged by appropriate recorded announcements from the MTX. If the subscriber makes a fault in the procedure for an operation, a recorded announcement shall tell him so. Subscribers' control operations are only accepted from the mobile subscriber number, which is concerned by the operation.

Booking of services under MTXV should be performed as follows:

- MTXV receives information from the subscriber;
- a separate announcing message for subscriber procedure under MTXV will be sent;
- MTXV immediately transfers the information to MTXH for control and registration;
- acceptance is sent to MTXV, thereafter the booking is completed and the subscriber can use the service.

It shall be possible to give different announcement for activation and deactivation.

5.5.1 Call barring

This service shall give the MS owner possibilities to choose one of the following different limitations of the calling capability:
(see technical specification for signalling system no.7, ANNEX 1 TO MOBILE USER PART, ADDITIONAL INFORMATION)

0	No service restriction
1	Barring of all outgoing calls (except emergency calls and customer care VPLMN)
2	Barring of all national and international calls except calls directed to HPLMN
3	Barring of all international calls outside Europe/Outer Area and premium rate numbers
4	Barring of premium rate numbers and all international calls outside Nordic countries/Inner Area (neighbouring countries + HPLMN)
5	Barring of premium rate numbers and all international calls except directed to HPLMN
6	Barring of premium rate numbers
7	Barring of entertainment premium rate numbers
8-10	Reserved for future international use, currently interpreted as 0001 (1)
11-15	Reserved for national use, currently interpreted as 0001 (1)

This service is ordered from the administration and executed via I/O-devices. The subscriber may then activate and cancel the chosen limitation by carrying out the control procedures described below:

The service control procedures must include a security code, "key word", in order to make possible for the MTX to verify that the service user is entitled to carry out the procedure concerned. Such a key word is agreed with the subscriber and stored in the MTXH in advance.

Call barring for outgoing calls is activated by the following procedure:

*33 (*KW)#

and cancelled by

#33*KW#

KW denotes key word and is optional in the activation procedure.

A special form of call barring is "black-listing" (no traffic allowed except emergency calls), which is executed via I/O-devices as an administrative action only.

5.5.2 Call transfer services

This call transfer service shall give the mobile subscriber the possibility to order the MTX to reroute his incoming calls to:

1) another subscriber number (SF or SM);

2) an announcing machine in the MTXH;

3) an announcing machine in the telephone network;

4) an operator in the telephone network.

When a mobile subscriber orders call transfer service from the administration, the following shall be programmed into the MTXH via I/O-devices:

- an appropriate category indication for the subscriber number ordering the service, each service has it's own category.

- the number in the telephone network or number/outlet in the MTXH, to which transfer shall take place.

Call transfer service already programmed in to the MTXH shall have the possibility to be activated and inactivated automatically by control procedures using the push-buttons in the mobile station.

In case of transfer of calls to another subscriber number, it shall be possible also to order and cancel the service automatically by a push-button control procedure from the MS.

It shall be possible to have more than one call transfer service activated. The services shall be treated according to a fixed priority list. Outgoing calls from the mobile subscriber shall not be affected by the call transfer service.

5.5.2.1 Transfer of calls to another subscriber number

The following information is sent by the mobile subscriber when using pushbuttons for ordering and cancelling transfer of calls to another subscriber number:

Ordering: *XX* telephone number [1] #

Cancelling: #XX#

[1] Telephone number max. 18 digits to which transfer shall take place.

Upon reception of this information, the MTXH shall programme itself accordingly.

Transfer of calls to another subscriber number or a list of subscriber numbers may also be ordered from the administration. In this case, the MTXH shall be programmed via I/O-devices. When the subscriber wishes to utilize the service, he will send the following information:

Activation: *XX#

Inactivation: #XX#

5.5.2.2 Transfer of calls to an announcing machine

This service will be ordered from the administration and the MTXH shall be programmed accordingly via I/O-devices. The mobile subscriber shall be able to activate and inactivate the service by sending the following information:

Activation: *XX#

Inactivation: #XX#

It shall also be possible to connect different types of announcements using following procedure.

Activation: *XX*NN#;NN ≤ 99

Inactivation: #XX#

When the service is activated, incoming calls shall be transferred to an announcing machine in the MTXH or in the telephone network. Different numbers (or outlets in the MTXH) are used for different recorded messages.

5.5.2.3 Transfer of calls to an operator in the telephone network

This service is ordered, programmed, activated and inactivated in the same way as transfer of calls to an announcing machine (see para 5.5.2.2). The service code is in this case XX.

The operator notes the calling subscriber's number, if he wishes to be called back by the called mobile subscriber.

The mobile subscriber will have to call an ordinary operator access number in the telephone network to get the information recorded for him.

5.5.2.4 Handling of call transfer services

Five variants in the handling of this service are foreseen with different categories:

a) immediate transfer indication is given in the MS that any immediate call transfer is activated;
When this or other facilities which prevent paging of the MS are activated, a special signal shall be given to the MS, indicating that no incoming calls are possible

b) transfer after time-out upon no answer from MS;

c) transfer when no call acknowledgement is received from MS;

d) transfer on busy MS;

e) transfer on congestion in BS (MS has acknowledged the call, no TC available).

The five facilities shall have different service codes.

Immediate transfer of calls to an operator in the telephone network shall in the MTXH be handled so that it's possible to give the calling subscriber an announcement about the transfer but no indication in the called MS.

Transfer after time-out upon no answer from MS shall in the MTXH be handled as follows:

- 20 sec. after end-of-selection, a recorded message is given to the calling subscriber. If the called subscriber does not answer the call will be transferred within 10 sec.

- 30 sec. after end-of-selection, the calling of the mobile subscriber is ceased, or the connection to an MTXV is cleared, and the call is transferred.

In this case, the call received indicator in the mobile station remains activated, showing that a call was received when the station was unattended.

The specified times above (10, 20 and 30 sec) shall be easy to change.

Transfer when no call acknowledgement is received from MS takes place when the MTX ceases waiting for a call acknowledgement. Also in this case it shall be possible to give an announcement to the calling subsriber. In case of roaming, the MTXV shall send an MFC signal to the MTXH, indicating "no acknowledgement". In this variant, there is no indication in the mobile station showing that a call has been transferred.

Transfer on busy MS shall be handled in the similar way as immediate call transfer.

Transfer on congestion in BS takes place when the called MS acknowledges the call in a BS having no free traffic channels at the moment. It shall be possible to give an announcement to the calling subscriber depending on the transfer type (to an operator or to another subscriber). If this transfer type is activated, the call must not be queued as specified in paragraph 3.7.

5.5.3 Emergency calls and information services

The following numbers are used for emergency calls

A common european emergency number. (This number is or will be inplemented in a near future.)	112

Excep the common european emergency number otheer emergency numbers specified by operators can be used by mobile subsribers when they are in the respective country.

Emergency calls shall in the MTX be translated to access numbers to appropriate alarm centers in the telephone network. This translation will be based on the number of the base station receiving the emergency call.

The same procedure shall be possible for certain information services which gives the alarm centers possibility to identify used BS or area of BS:s.

5.5.4 Trunk-offering facilities in MTX

Trunk-offering facilities are required in MTX:s in Denmark, Finland and Sweden, but not in Norway.

In each country, the service is restricted to operators and mobile subscribers of the country concerned and to MTX:s in the same country. This means that no trunk-offering signalling is required between different national networks and between MTX:s in different countries.

Trunk-offering signalling to and between MTX:s as well as procedures for trunk-offering are adapted to practices in the national network concerned.

The trunk-offering facility in MTX:s is provided by the three following sub-functions:

1) Transfer of operator and trunk-offering category indications to MTXH and MTXV.

2) Transfer of trunk-offering signals to MTXH and MTXV.

3) Actions in MTX when receiving trunk-offering signals.

5.5.4.1 Transfer of operator and trunk-offering category indications to MTXH and MTXV

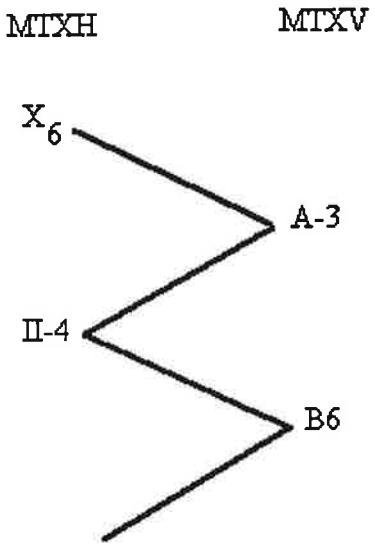
Operator category indication is transferred to MTXH according to national specifications.

In Denmark, operator calls with trunk-offering facility are indicated by MFC-signal II-15.

In Finland, for operator calls, the subscriber number is preceeded by register signal 13 (MFP) or II-5 (MFC R2).

In Sweden, operator calls may be distinguished from subscriber calls by different circuit groups from the transit exchange, i.e. no operator category signal is provided.

For operator calls with trunk-offering facility to subscribers roaming in the home country, a special trunk-offering category is transferred from MTXH to MTXV by the following MFC signalling sequence (see para 9.4.3.2).



The meaning of signal II-4 is "Trunk-offering category". Note that, upon receiving trunk-offering category II-4, MTXV shall always send signal B6 followed by ringing tone or busy tone, as appropriate. However, if the call is not acknowledged by the mobile station, signal B 10 is sent (cf para 5.3.2). Upon reception of signal B6, MTXH throughconnects speech path and the connection between MTXH and MTXV remains set-up for transfer of possible trunk-offering signals, also when the called MS is busy.

In Denmark a speech protected MFC receiver is connected in parallel to the speech path

- in MTXH upon reception of signal II-15, when MS is not roaming;
- in MTXV upon reception of signal II-4, when MS is roaming.

For operator calls to subscribers roaming in a foreign country, only ordinary operator category indication II-5 and ordinary MFC signalling, e.g. signal B3 for busy subscriber, is used.

In Denmark, calls with category II-15 to subscribers roaming in a foreign country, are rejected in MTXH.

5.5.4.2 Transfer of trunk-offering signals to MTXH and MTXV

Trunk-offering signals are sent to MTXH and MTXV according to national specifications.

In Denmark, a special in-band supervisory MFsignal is sent from the operator and received in MTXH or MTXV. Ceasing of this supervisory signal constitutes the trunk-offering signal.

In Finland and Sweden, the trunk-offering signal is a line signal in the national line signalling system. If the wanted MS is roaming in the home country, this line signal shall in MTXH be repeated to MTXV.

5.5.4.3 Actions in MTX when receiving trunk-offering signals

Actions in MTX when receiving trunk-offering signals are principally different in Denmark compared to Finland and Sweden.

The actions required in Danish MTX:s in connection with trunk offering are shown in the flowchart in CS note no.74 dated 26th of september 1985.

In Finland and Sweden, the following actions are required in the MTX (MTXH or MTXV) where the MS is actually reached:

a) The reception of a first trunk-offering signal shall put the connection under the exclusive control of clearing from the operator and prevent another operator from breaking in on the connection. This shall take place irrespective whether the MS line is free or busy.

b) The receptions of a trunk-offering signal in the case the MS is busy, shall cause break-in, i.e. the operator is connected as a third party to the established connection between the wanted MS and his correspondent.

c) If a wanted busy MS is already connected to an operator or roaming in another country, the busy tone shall continue to be sent.

d) During break-in of an operator, a warning tone shall be given to the subscribers.

e) If a further trunk-offering signal is received during breakin of an operator, the operator shall take over the connection, i.e. the connection from the operator is connected to the wanted MS and his earlier correspondent is disconnected and given busy tone.

f) The reception of a trunk-offering signal when the MS has sent a clearing signal shall initiate re-ringing. Upon re-ringing, ring- tripping etc. shall take place as for an ordinary call.

In Finland, actions a, b, c, d and f are required.
In Sweden, all actions a-f are required.
In Denmark, no warning tone shall be given to subscribers during break-in of an operator. In Finland and Sweden, warning tone shall be given during break-in. The Finnish warning tone = trunk-offering tone, is specified in para 9.6.2. The Swedish warning tone is specified in national specification Uf176 106, para 3.4.7.3.

5.5.5 Subscribers categories in the MTX

It shall be possible to distinguish different kinds of mobile categories e.g.

Ordinary MS
Priority MS
Hand held MS
Coin box MS

Datatransmission service
Official subscriber
Local subscribers (no roaming or restricted roaming facility)
Hand held MS with priority
Hand held coin box MS
MS with added security features (NMT-900 and NMT-450 i).
MS with batterysaving function. (NMT-900 and NMT-450 i)

5.6 DATA TRANSMISSION FROM MOBILE STATION

Two forms of data transmission from a mobile station shall be possible:

1) via a separate data modem;
2) via the push-button set in the mobile station.

To avoid hand-over during data transmission the data category shall be implemented fixed or activated/deactivated with a subscriber procedure or via I/O-device. If the MS has an R-button it shall be possible to activate the category during conversation. This function shall be utilized by means of a special Ø-signal order to the base station.

5.6.1 Separate data modem

Data modem may be chosen by the subscriber among those approved by the administration.

5.6.2 Push-button data transmission

In the MS, the ordinary 12 bush-button set, possibly complemented with 4 extra buttons A-D, may be used for simple data transmission utilizing the ordinary 1200 Bauds signalling with the MTX.

To translate this signalling to multi-frequency tones (MFT), the SM shall by activating a separate button on the MS, connect a special converter for this purpose in the MTX (see para 10.8).

5.7 FLEXIBILITY FOR FURTHER SERVICES AND FACILITIES

In addition to the services specified in paragraphs 5.1-5.6, it shall, as far as practicable, be possible to add further services to the MTX.

Following facilities will be introduced in the fixed network:

- Alarm call service
- Hot line
- Malicious call trace
- Three party service
- Interception of calls
- Don't disturb
- Call waiting
- Call transfer on busy
- Completion of calls to busy subscriber
- Automatic interception
- Remote control

- Conference call
- Deactivation of all activated facilities
- Automatic queue
- Completion of no answer
- Transfer of call from terminating subscriber
- Regularly alarm call service
- Immediate price
- Barring for incoming calls

The interest about introducing of these facilities can be different in the Nordic countries, but it shall be possible to introduce these facilities at reasonable cost.

It must be possible to have a register recall signal from the mobile station in order to permit subscriber controlled operations to take place in speech condition to realize some of the facilities above.

For future service, reference is made to CEPT rec.T/SF 4 and "Handbook on telephone services and facilities, offered to the subscribers in modern telephone systems", issue 3, CEPT1981.

Moreover, the services specified in paragraphs 5.1-5.6 may be improved. The following items are just given as examples:

- More elaborate announcing machines with variable recorded announcements may be introduced. They will require that the called mobile subscriber number is transferred to them. This transfer may take place with MFC R2 (or common channel) signalling in the same way as between the MTX:s.

- More elaborate operator positions with display may be introduced. This would require the same signalling as a variable announcing machine.

- The mobile station is supplemented with a display showing the number which he should call back. This would require the transmission of numerical information from the MTX to MS.

6 NUMBERING PLAN AND DIGIT ANALYSIS

6.1 NUMBERING PLAN FOR FIXED SUBSCRIBERS

- National numbering

A national telephone network is divided into numbering areas, within a numbering area any subscriber is reached by dialling his unique subscriber number, which may have 4-8 digits. To reach a subscriber, the mobile subscriber dials the trunk prefix P (Norway, Sweden, the Netherlands, Switzerland: 0, Finland, Island: 9), followed by the area code for the address area and finally the subscriber number. Denmark and Faroe Islands are not using trunk prefix or area code.

The two last parts, the area code + the subscriber number constitute the national number, while the trunk prefix is not included. An area code may have 1-3 digits and the national number up to 10 digits.

- International numbering

To reach a subscriber in another country, the international prefix of the outgoing country P P_1 P_2 (Sweden, Faroe Islands: 009, Finland: 990, Norway: 095, Switzerland, Denmark: 00, Island: 90, the Netherlands: 09) is dialled first, then the country code of the address country and finally the national number. Other international prefix may occur in other countries.
In the future a common international prefix 00 will be used.

Country code + national number constitute the international number. A country code I_1 (I_2 (I_3)) may have 1-3 digits, the international number up to 12 digits.

- Special numbers

Special numbers are used to reach special telephone services. These numbers are allocated nationally and may have 2-5 digits. Special numbers may be dialled in the same way as subscriber numbers nationally as well as internationally. For special subscriber services, it shall be possible to use also other signals than the digit signals 0-9 (pushbutton dialling).

6.2 NUMBERING PLAN FOR MOBILE SUBSCRIBERS

Mobile subscribers are within each national numbering plan treated as if belonging to a special numbering area with a two-digit area code M_1 M_2 (in the Netherlands M_1 M_2 M_3).

Mobile subscribers in a country are allocated individual numbers from a six-digit subscsriber number series $X_1X_2X_3X_4X_5X_6$. In the MTX, a mobile country code, Z, is added in front of the national mobile subscriber number, so each subscriber within the Nordic mobile telephone system has a unique subscriber number $ZX_1X_2X_3X_4X_5X_6$. The mobile country code Z is not dialled by subscribers. As an example: Z is in Denmark 5, Finland 8, Norway 7, Sweden 6, (Z=9 is shared by Finland, Norway and Sweden), Iceland 4, Faroe Islands 5, Switzerland 1 and the Netherlands 2.
The use of value Z, X_1, X_2 is decided by the EMO-M-NMT group.

For security reasons a three digit password $K_1K_2K_3$ is added automatically in NMT-900 and NMT-450 i to the end of subscriber number $X_1X_2X_3X_4X_5X_6$ by the logic in the MS. This password is not known by the mobile subscriber and it is not dialled by a calling subscriber. It is used only on the radiopath when the MS identifies itself to the MTX and in updating messages between MTX exchanges. The password is checked in the MTX (NMT-900 only) where the same password is stored together with the actual subscriber data.

K1K2K3=9XX are reserved for MS:s with added security features until the Mobile User Part (MUP) is implemented after which special cathegories will be used instead.

Examples of dialling:

- national call to a mobile subscriber

  P M_1 M_2 (M_3) X_1 X_2 X_3 X_4 X_5 X_6

- international call to a mobile subscriber

  P P_1 P_2 I_1 I_2 (I_3) M_1 M_2 (M_3) X_1 X_2 X_3 X_4 X_5 X_6

The same dialling procedure is also used for calls between mobile subscribers.

For emergency calls from mobile subscribers, see para 5.5.3.

Within the mobile telephone system, mobile subscribers are identified by the number Z X_1 X_2 X_3 X_4 X_5 X_6 $K_1K_2K_3$ where Z and $K_1K_2K_3$ is as already specified and $X_1X_2X_3X_4X_5X_6$ is the six-digit mobile subscriber number. This numbering shall be used in all signalling between (see use of K-values):

MTX - MTX
MTX - MS

6.3 NUMBERING PLAN FOR MTX:S

X_1 or X_1X_2 or X_1,X_2,X_3 in the mobile subscribers number identify the MTX where the subscriber is registered. Several combinations may be related to a given MTX.

For setting-up a call from one MTX to another MTX, corresponding digits X_1',X_2',X_3' or X_1',X_2' or X_1' of the address MTX numberseries are used in combination with the service access code to route the call through the telephone network.

Internationally the Nordic MTX:s are identified by three digits Z'X_1',X_2' where Z' denotes the country and X_1',X_2' the MTX.

6.4 NUMBERING PLAN FOR RADIO CHANNELS, BASE STATIONS AND TA:S

A special numbering plan based mainly on frequency coordination aspects is used for radio channels and base stations. This numbering plan is used in the signalling between MTX and MS and between MTX and BS.

In this numbering plan, each radio channel is identified by a number $Y_1Y_2B_1B_2B_3N_1N_2N_3$ where Y_1Y_2 indicates a traffic area and $B_1B_2B_3$ indicates a base station and $N_1N_2N_3$ indicates a radio channel number in that area. Note that Y_1Y_2 belong to an integrated numbering plan for all Nordic countries and are different from $X'_1X'_2$ in para 6.3.

6.5 DIGIT STORAGE CAPACITY

The storage capacity for ordinary national and international calls shall be 23 digits.

6.6 DIGIT ANALYSIS FOR CHARGING

Analysis for charging is required for calls from mobile coin box telephones as well as ordinary mobile subscribers. It shall be possible to distinguish the following numbers:

- Emergency calls: 112 and other emergency numbers specified by the operators
- Special service access codes: up to 5 digits
- Special subscriber services up to 5 digits
- National calls: P + area code up to 3 digits (if applicable)
- International calls: $PP_1P_2I_1$ ($I_2(I_3)$) + area code up to 3 digits

A further digit analyse shall be possible in the same way as for ordinary telephone exchanges including analyse of the incoming routes.

6.7 DIGIT ANALYSIS FOR ROUTING

For calls from mobile stations, analysis of the dialled number will show whether the call can be handled within the MTX itself or if it shall be routed to the telephone network. The analyzing capability to define outgoing route shall be at least the same as for charging analysis.

6.8 DIGIT ANALYSIS FOR DETERMINING OF NUMBER LENGTH

Calls to mobile subscribers.

Analysis of the mobile service access code will indicate the number length.

Calls to fixed subscribers.

Where no address-complete signal is provided (Sweden) up to P+four digits shall be analyzed to determine the number of digits after which the MTX shall connect through the speech path.

The same analysis is used to detect calls to vacant number series.

6.9 DIGIT ANALYSIS FOR SUBSCRIBER PASSWORD

When the MTX receives from MS the password $K_1K_2K_3$ (NMT-900 and NMT-450 i) it is analyzed and if it is not correct the call is disconnected and registered. If the number of incorrect codes for a subscriber under a specified time exceeds a preset value, the subscriber is barred and an alarm shall be generated within the MTX. In MTX the procedure is the same as used for checking of service categories (see para 5.2.1.3). The roaming updating messages shall include the password $K_1K_2K_3$ (NMT-900 and NMT-450 i).

6.10 MODIFICATION OF DIALLED NUMBER

It must be possible to make a B-number modification depending on the B-number analysis and the incoming route. The modification must be done according to the modification information (digits to be added and/or to be removed) and starts from the first digit in the B-number. After modification the analysis is restarted from the first digit.

6.11 DIGIT ANALYSIS FOR MS:S WITH ADDED SECURITY FEATURES

When the MTX receives a faulty SRES, the call shall be disconnected as soon as possible.

If the number of incorrect SRES:s for a subscriber under a specified period of time exceeds a preset value, the subscriber is barred and an alarm shall be generated in the MTX. The time period and the number of attempts shall be given by command in the MTX on a per subscriber basis.

7A TRANSMISSION REQUIREMENTS

General requirements

7A.1 DEFINITIONS

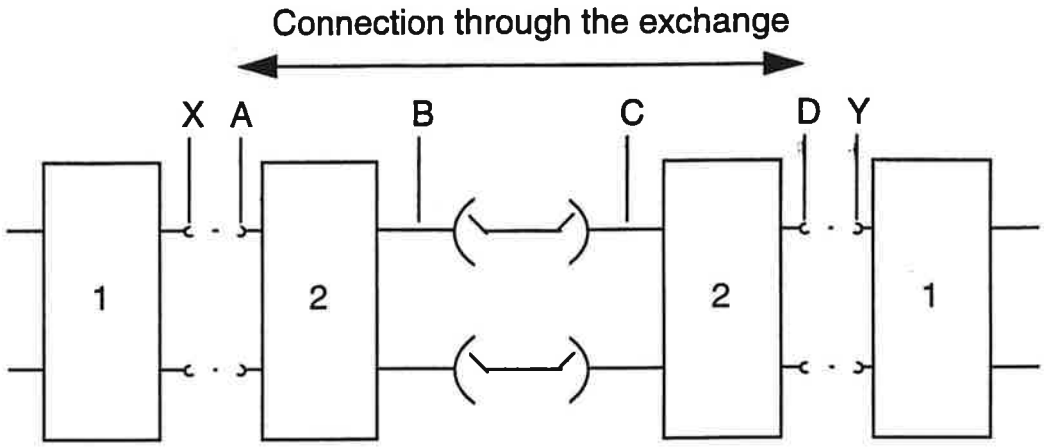


Fig. 7A.1

1: Channel translation equipment

2: Incoming and outgoing circuit

By connection through the MTX is to be understood the pair of wires corresponding to one direction of transmission and connecting the input point of one circuit incoming in the exchange and the output point of a different circuit outgoing from the exchange. The transmission requirements are normally defined by reference to the points A and D shown in figure 7A.1.

Between points A and D there may be equipment such as 1200 Bauds modems. This equipment will be specified separately. If such equipment is used, it is allowed to add to the attenuation distortion as given in para.7B.3.4 up to 0.1 dB within the speech band. Other parameters shall not be affected by the modem.

In all incoming and outgoing circuits it must be possible to supervise pilot alarms coming from the fixed network.

7A.2 NOMINAL RELATIVE LEVEL

The actual value of the nominal relative level related to the input and output points of the MTX shall meet the national specifications and the recommendations of CCITT.

7A.3 NET SWITCHING LOSS

The mean value of the net switching loss (which is defined as Actual loss - nominal loss in accordance with CCITT) shall not exceed 0.5dB.

If attenuation pads are introduced in the exchange providing the nominal loss, their value should be chosen so that the actual loss equals the nominal loss.

The standard deviation of loss measured at 800 Hz of all possible paths within the MTX shall be as small as possible and never exceed 0.2 dB.

7A.4 RETURN LOSS

The return loss measured against 600 ohms on any connection through the MTX over the frequency bands indicated below shall not be less than the values stated:

300-600Hz:15dB
600-3400Hz:20dB.

7A.5 CROSSTALK

Crosstalk shall be measured at a frequency of 1100 Hz in accordance with CCITT Rec. G.134. The signal to crosstalk ratio measured at points A and D between any two connections through the exchange (see Figure 7A.1) shall be 70 dB or better.

The signal to crosstalk ratio between the two "connections" which constitute the GO and RETURN channels of a four-wire path established through the exchange shall be 60 dB or better.

7A.6 NOISE

a) Weighted noise

The busy-hour mean psophometric noise power level on any connection through the exchange shall not exceed -67 dBm0p (200 pW0p)

b) Unweighted noise

The busy-hour mean unweighted noise power level on any connection through the exchange shall not exceed -40 dBm0 (105 pW0).

Unweighted noise shall be measured in accordance with CCITT with a device with a uniform response curve throughout the band 30Hz-20kHz.

c) Impulse noise

This measurement shall be carried out using the instrument described in the CCITT Recommendation H.13, with a measurement filter as specified in section b.

The number of disturbance marks obtained during the busy hour shall, on the average, amount to a maximum of 5 per five minutes at an instrument threshold of -35 dBm0.

7A.7 VOLTAGE INDUCED IN THE SPEECH CIRCUIT

The equipment in the exchange shall be able to withstand without damage the voltages as stated below.

A CCITT K17 generator, see fig.7A.2, is used for surge voltage test.

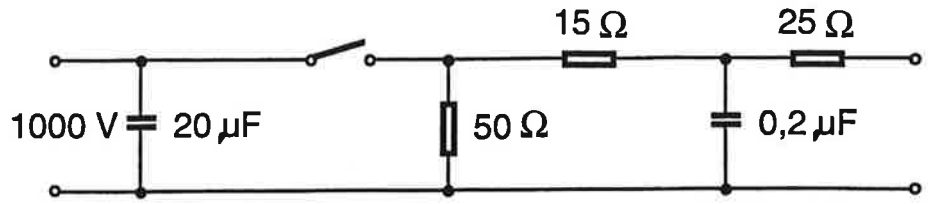


Fig. 7A.2

a) impulse tests

The tests are carried out with 10 pulses, pulse polarity reversed at consecutive pulses and with a time interval of one minut between pulses. The test voltage shall be applied between pair of wires which constitute the GO or the RETURN channel of a four-wire path and between each of the wires and earth.

b) a.c. voltage tests
voltage frequency 50Hz
amplitude: 300 Veff, short circuit current 0,5 A
duration: 300 ms

The voltage is applied between wires and earth and between the pair of wires which constitute the GO and RETURN channel.

In each of the above test it is assumed the equipment has no primary protection connected. In exposed environment the equipment is supposed to need an external protection against overvoltages.

7A.8 IMPEDANCE UNBALANCE

The impedance unbalance to earth shall not be worse than:

300 - 600Hz:	46dB
600-3400Hz:	50dB.

The degree of unbalance to earth is to be measured as shown on figure 7A.3 and 7A.4 in accordance with CCITT Rec.Q.45.

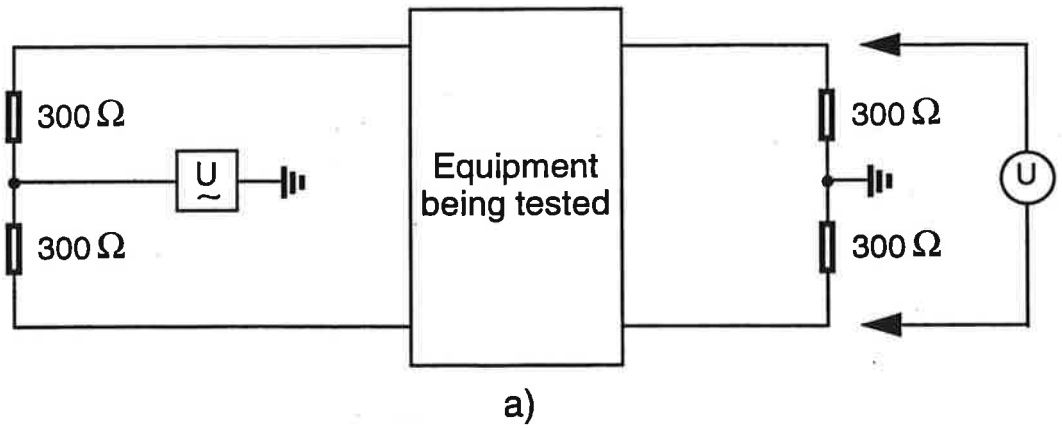


Fig. 7A.3

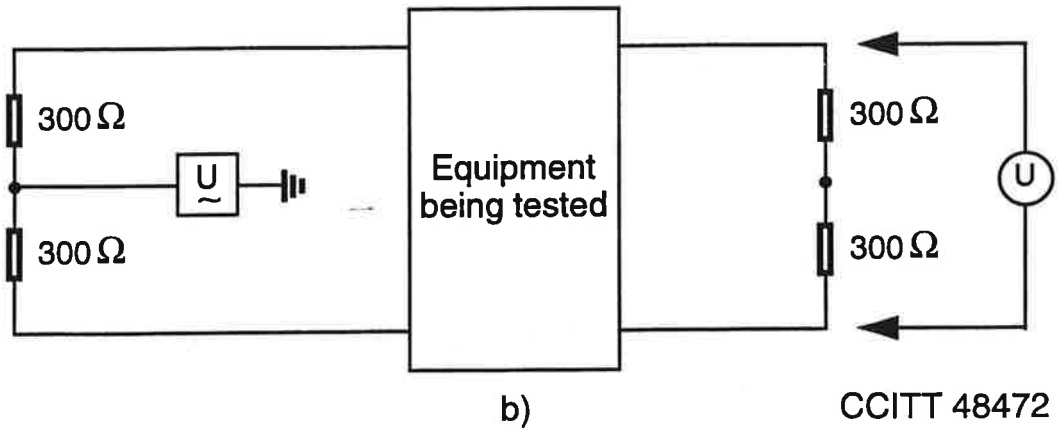
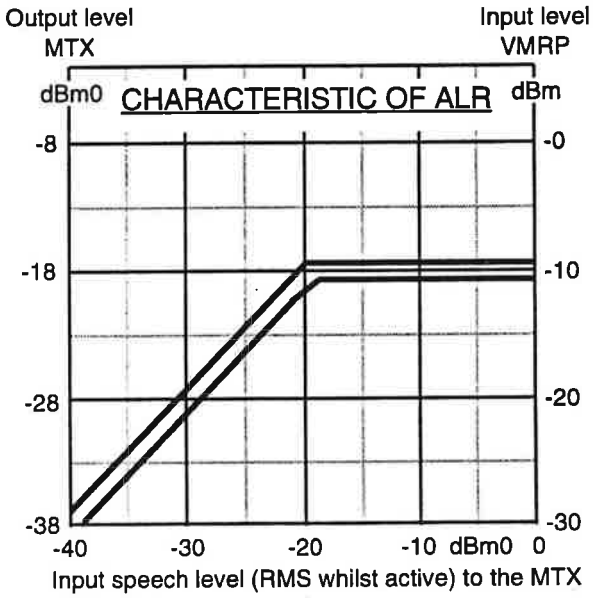


Fig. 7A.4

7A.9 AUTOMATIC LEVEL REGULATION

Taking into account the differing speech levels that may occur on the speech circuits in the telephone network, the MTX shall be equipped with devices for automatic level regulation in the transmission direction towards the base stations. These devices shall be connected in such a way that they do not operate on the signalling between the MTX and the base stations or between the telephone network and the MTX.

The level regulation range is shown in the diagram below.



The change of gain from zero signal to signal condition (attack time) shall be adjustable (e.g. by means of strapping) in the range 5 to 40 ms, while the change of gain from the signal on condition to lowersignal-level condition (decay time) shall be adjustable in the range 0.2 to 10 seconds. It shall be possible to inhibit the attenuation level regulation either by command or by a separate switch.

7B TRANSMISSION REQUIREMENTS FOR A DIGITAL MTX

7B.1 GENERAL

The transmission requirements in this chapter refer to an MTX using PCM techniques in the transmission paths. Only those characteristics are dealt with which differ from the corresponding characteristics in an MTX using analog techniques. Thus, the requirements in chapter 7A apply to the extent that they are not contradicted by the requirements in this chapter. Only the speech transmission switching network is dealt with which means that e.g. modems have to be specified separately. The modem is allowed to add to the attenuation distortion as given in para 7B.3.4 up to 0.1 dB within the speech band. Other parameters shall not be affected by the modem.

The interfaces towards the telephone network as well as towards the base stations shall be in accordance with the requirements in para 7B.2-2 (analog interface) and in accordance with the requirements in para 7B.4 (digital interface).

Digital transmission systems are expected to be used to a large extent in the future. In the case where the speech channel interfaces are wholly or partly of the analog type, it must therefore be possible to convert them to digital interfaces according to para 7B.4 for connection with digital transmission systems, preferably by removal of the line equipment for the analog channels. The interface towards the analog systems will then be located at the remote end of the digital transmission system. As for the signalling interfaces, se para 7B.5.3.

7B.2 ENCODING

The encoding law used shall be the A-law as specified in CCITT Rec.G.711. The sampling rate, load capacity and the code are also specified in that Recommendation. The number of quantized values is 256.

Note: The inversion of bits 2, 4, 6 and 8 covered by the encoding law is applicable only to voice channel time slots.

7B.3 PERFORMANCE CHARACTERISTICS AT AUDIO FREQUENCIES

The following requirements apply for connection through the MTX between analog input and output ports. The performance limits quoted shall be met in all such analog environment cases making due allowance for any inaccuracy in the testing techniques. In cases where a channel is passed on digitally at one side of the MTX, the MTX will have to cooperate with PCM channel banks which themselves fulfil the requirements of paragraphs 7B.2 and 7B.3.

7B.3.1 General

Measurements shall be made with the input and output ports of the channels terminated in their nominal impedance.

7B.3.2 Long-term stability

When a sine wave signal at a level of 0 dBm0 is applied to any audiofrequency input, the level measured at the corresponding audio frequency out put shall not vary by more than +1 dB during any one year under the permitted variations in power supply voltage and temperature.

7B.3.3 Relationship between the encoding law and the audio level

The relationship between the encoding law and the audio level is defined as follows:

A sine-wave signal of 1 kHz at a nominal level of 0 dBm0 should be present at any voice frequency output when the periodic sequence of character signals of the table below is applied to the decoder input.

The resulting theoretical load capacity (Tmax) is +3.14 dBm0 for the A-law.

Bit no.	1	2	3	4	5	6	7	8
	0	0	1	1	0	1	0	0
	0	0	1	0	0	0	0	1
	0	0	1	1	0	1	0	0
	1	0	1	1	0	1	0	0
	1	0	1	0	0	0	0	1
	1	0	1	0	0	0	0	1
	1	0	1	1	0	1	0	0

The channel unit shall be capable of readjusting the relative levels in steps of 0.5 dB within the following levels:

IN	-12.5 dBr to +3.5 dBr
OUT	-8.0 dBr to +5.5 dBr

7B.3.4 Loss-frequency distortion

The variations with frequency of the loss of any channel shall lie within the limits shown in the template of figure 7B.1

The reference frequency is 800 Hz.

The input power level shall be 0 dBm0.

The attenuation distortion in the transmit or the receive portion of any channel shall not exceed 50% of the tolerance given in the template of figure 7B.1.

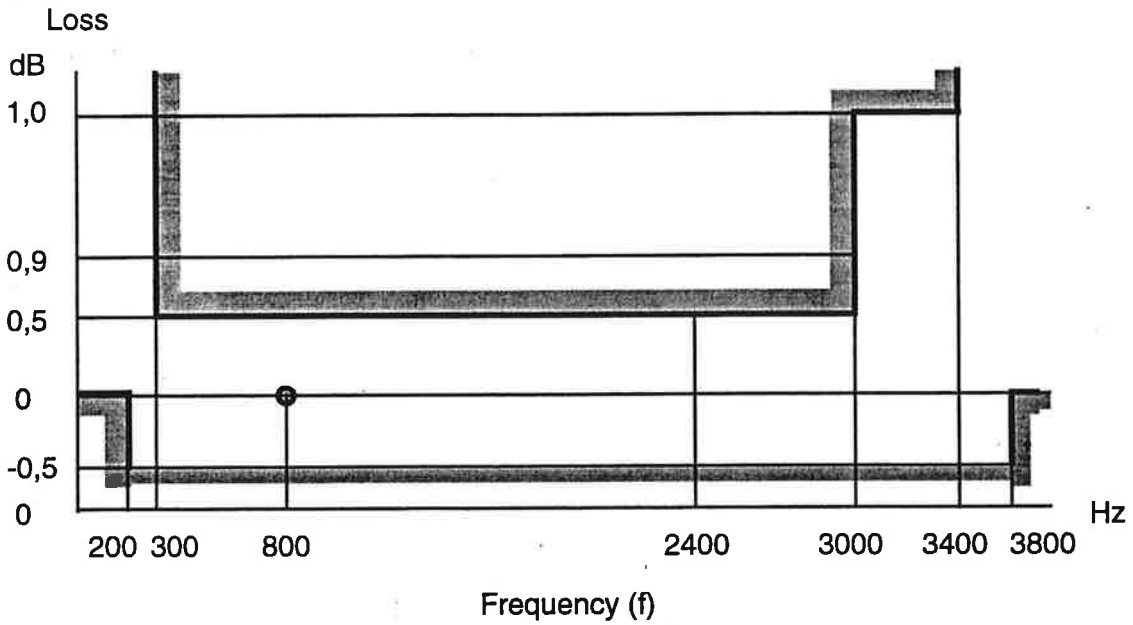


Fig. 7B.1 Loss-frequency distortion

7B.3.5 Impedance of audio-frequency ports

7B.3.5.1 Nominal impedance

The nominal impedance at the audio input and output ports shall be 600 ohms, balanced.

7B.3.6 Interchannel crosstalk

The crosstalk between individual channels of a multiplex shall be such that with a sine wave signal in the frequency range 700 - 1100 Hz (excluding sub-multiples of 8 kHz) and a level of 0 dBm0 applied to an input port, the crosstalk level received in any other channel shall not exceed -65 dBm0.

When a white noise signal in accordance with CCITT Rec. G.227, at a level of 0 dBm0, is applied to the input of up to four channels, the level of the crosstalk received in any other channel shall not exceed -60 dBm0p. Uncor related noise shall be used when more than one input channel is energized.

7B.3.7 Idle channel noise

a) Weighted noise

With the input ports of the channel terminated in the nominal impedance, the idle channel noise shall not exceed -65 dBm0p.

b) Single frequency noise

The level of any single frequency (in particular the sampling frequency and its multiples), measured selectively, shall not exceed -50 dBm0.

c) Receiving equipment noise

Noise contributed by the receiving equipment alone shall be less than -75 dBm0p when its input is driven by a PCM signal corresponding to the decoder value number 1.

d) Noise with disabled decoder

Apart from the noise contribution from the decoder, the noise at any input or output ports shall not exceed the following limits:

- weighted noise: -73dBm0

- single frequency noise: -60dBm0.

7B.3.8 Envelope delay distortion with frequency

The envelope delay distortion shall lie within the limits shown in the template of figure 7B.2.

The minimum value of the group propagation delay is taken as a reference. The input power level shall be 0 dBm0.

The envelope delay distortion in the transmit or the receive portion of any channel shall not exceed 50% of the tolerance given in the template of figure7B.2.

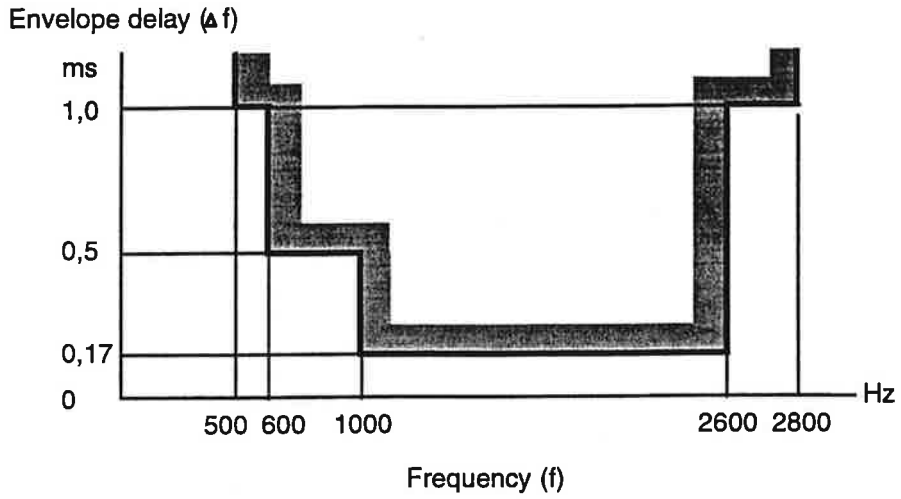


Fig.7B.2 Envelope delay distortion with frequency

7B3.9 Discrimination against out-of-band input signals

With any sine wave signal in the range 4.6-72 kHz applied to the audiofrequency input port of the channel at a suitable level, the level of any image frequency produced at the output port of the channel shall, as a minimum requirement, be at least 30 dB below the level of the test signal.

The attenuation of incoming signals in the frequency range 3.6-3.9 kHz shall follow the requirement according to CCITT Rec. G.234.

The attenuation of incoming signals in the frequency range below voice frequencies shall be greater than 20 dB for frequencies below 50 Hz and greater than 10 dB in the frequency range 50-100 Hz.

7B.3.10 Spurious out-of-band signals at the channel output

With any sine wave signal in the range 300-3400 Hz at a level of 0 dBm0 applied to the input port of a channel, the level of spurious out-of-band image signals measured selectively at the output shall be lower than -30 dBm0.

The attenuation of outgoing signals in the frequency range 3.6-3.9 kHz shall follow the requirement according to CCITT Rec.G.234.

7B.3.11 Intermodulation

Two sine wave signals of different frequencies f1 and f2 not harmonically related, in the range 300-3400 Hz and of equal levels in the range -4 to -21dBm0, applied simultaneously to the input port of a channel shall not produce any 2f1 - f2 intermodulation product having a level greater than -35 dB relative to the level of one of the two input signal.

A signal having a level of -9 dBm0 at any frequency in the range 300-3400Hz and a signal of 50 Hz at a level of -23 dBm0 applied simultaneously to the input port shall not produce any intermodulation product of a level exceeding -49 dBm0.

7B3.12 Total distortion, including quantizing distortion

Two alternative methods.

Method 1:

With a suitable noise signal applied to the input port of a channel ratio of signal to total distortion power measured at the output port shall lie above the limits shown in figure 7B.3.

Note 1 These limits are based on a noise signal having a gaussian distribution of amplitudes and the derivation of the limits is given in Annex 1 to CCITT Rec.G.712.

Note 2 Appropriate corrections must be made depending on the characteristics of the test apparatus in order that the results of measurements may be related correctly to the specificed limits (see Rec.O.131).

Method 2:

With a sine wave signal in the frequency range 700-1100 Hz (excluding sub-multiples of 8 kHz), applied to the input port of a channel, the ratio of signal to total distortion power shall be above the limits shown in figure 7B.4.

7B.3.13 Spurious in-band signals at the channel output port

With a sine wave signal in the frequency range 700-1100 Hz (excluding sub-multiples of 8 kHz) and a level of 0 dBm0, applied to the input port of a channel, the output level at any frequency other than the frequency of the applied signal, measured selectively in the frequency band 300-3400 Hz, shall be less than -40 dBm0.

7B.3.14 Variation of gain with input level

Two alternative methods are described. However, the requirements shall be based on method 1.

Method 1:

With a suitable noise signal applied to the input port of any channel at a level between -60 dBm0 and -10 dBm0, the gain variation of that channel, relative to the gain at an input level of -10 dBm0, shall lie within the limits of the template of figure 7B.5a.

Furthermore, with a sine wave signal in the frequency range 700-1100 Hz (excluding sub-multiples of 8 kHz) applied to the input port of any channel at a level between -10 dBm0 and +3 dBm0, the gain variation of that channel relative to the gain at an input level of -10 dBm0, shall lie within the limits of the template of figure 7B.5b.

Method 2:

With a sine wave signal in the frequency range 700-1100 Hz (excluding sub-multiples of 8 kHz) applied to the input port of any channel at a level between -55 dBm0 and +3 dBm0, the gain variation of that channel relative to the gain at an input level of -10 dBm0, shall lie within the limits of the template of figure 7B.5c.

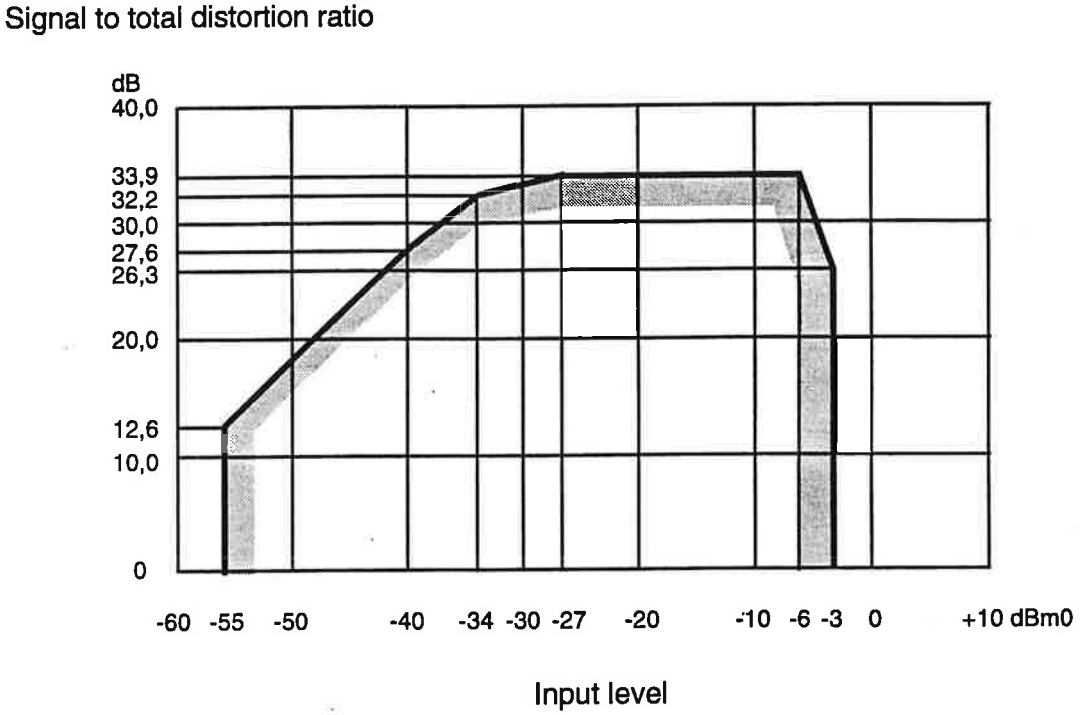


Figure 7B.3 Signal/total distortion ratio as a function of input level (Method 1)

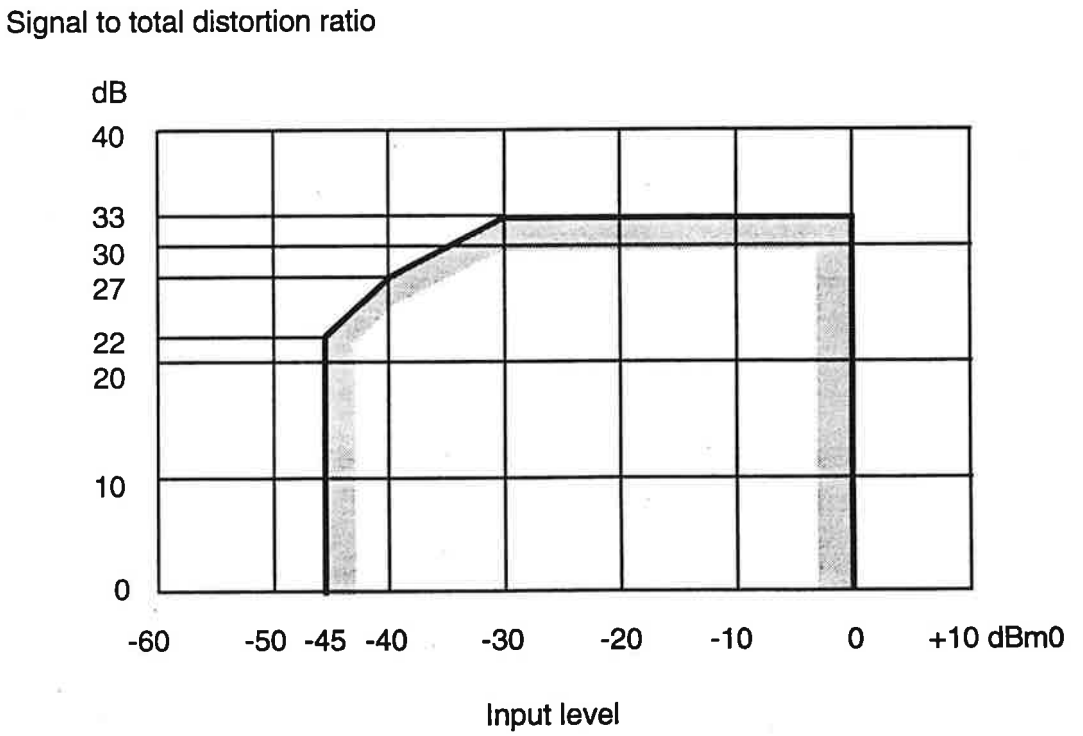
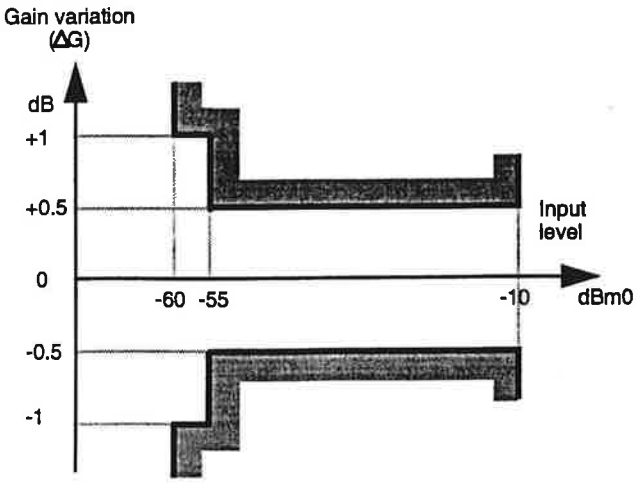
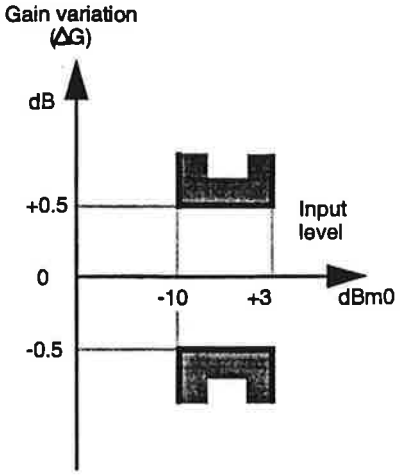


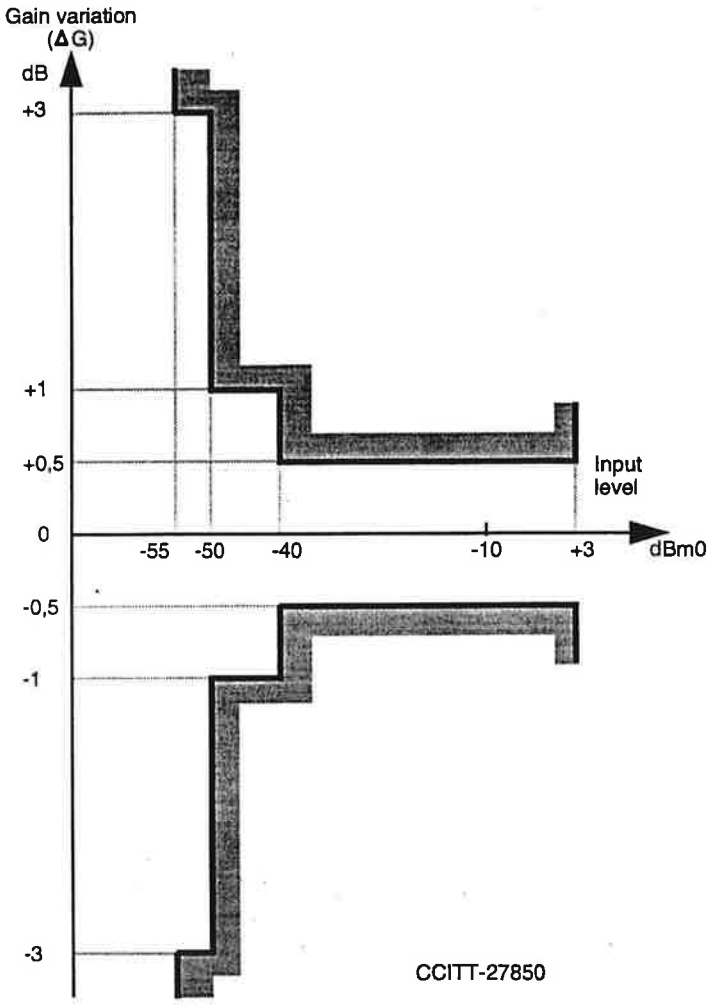
Figure 7B.4 Signal/total distortion ratio as a function of input level (Method 2)



a) Method 1: White noise test signal



b) Method 1: Sinusoidal test signal



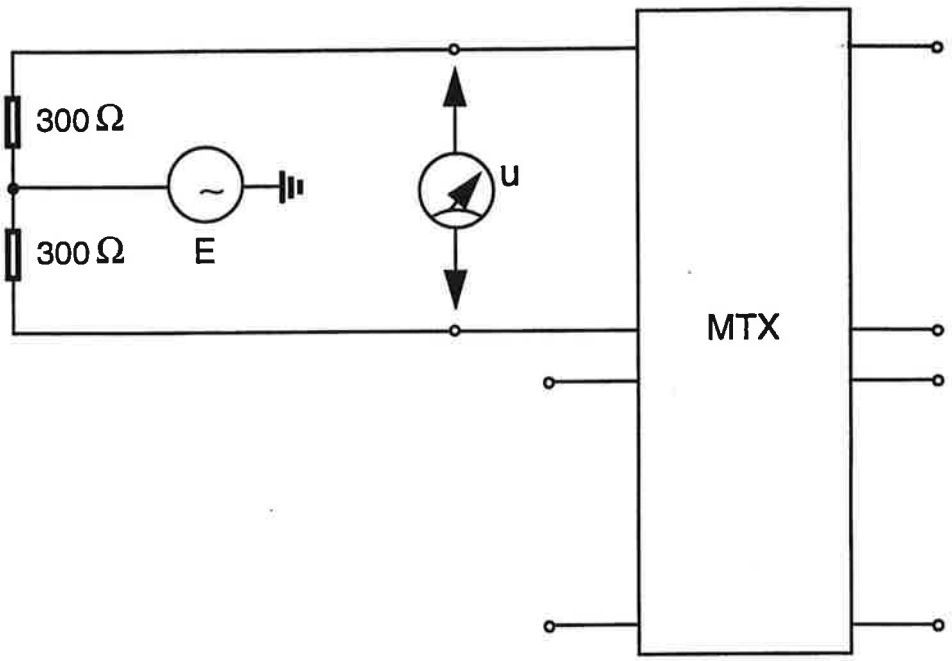
c) Method 2: Sinusoidal test signal

Fig. 7B.5 Variation of gain (G) with input level

7B.3.15 Impedance unbalance to earth

The impedance unbalance to earth, measured in accordance with the figure below, shall not be worse than:

46 dB for the frequencies 15-600 Hz
50 dB " " 600-3400 Hz.



Impedance unbalance = 20 log $\frac{E}{\mu}$ dB

Figure 7B.6

7B.4 DIGITAL PERFORMANCE CHARACTERISTICS

7B.4.1 Clock rate tolerance

The clock rate tolerance shall be ±50 parts per million (ppm).

7B.4.2 Synchronization

The MTX shall derive its clock signal from an internal source. A well defined interface shall exist between the internal source and the clock distribution circuits.

It shall be possible to synchronize the internal source from an external source or from an incoming digital line signal. A break in the synchronization must not lead to any loss of calls still having their transmission circuits available.

7B.4.3 Digital transmission delay

The delay of the digital part of a path input and output ports of the MTX shall not exceed 0.5 ms.

7B.4.4 Bit sequence independence

The 64 kbit/s path through the MTX shall be bit sequence independent, i.e. no restrictions may be imposed on the binary pattern.

7B.4.5 Error rate

The design error rate according to the CCITT definition shall be 1 in 109 or better.

7B.5 REQUIREMENTS CONCERNING THE CONNECTION OF DIGITAL EXCHANGES OR DIGITAL LINE SYSTEMS AT 2048 KBIT/S TO MTX

The MTX must be capable of being connected digitally to PCM transmission systems, specified according to CCITT recommendation, as well as to digital exchanges in the public telephone network, which are designed with CCITT recommendations for PCM systems in mind. Hence, the MTX must be able to receive, interpret and transmit signals and alarm indications as specified for the various national networks.

It should be noted that a digital transmission facility under certain failure conditions can produce an Alarm Indication Signal, forcing all bite conveyed to the state "one".

7B.5.1 Interface to the line terminating unit (2048 kbit/s)

a) General characteristics

bit rate: 2048kbit/s ± 50 ppm

code: HDB 3

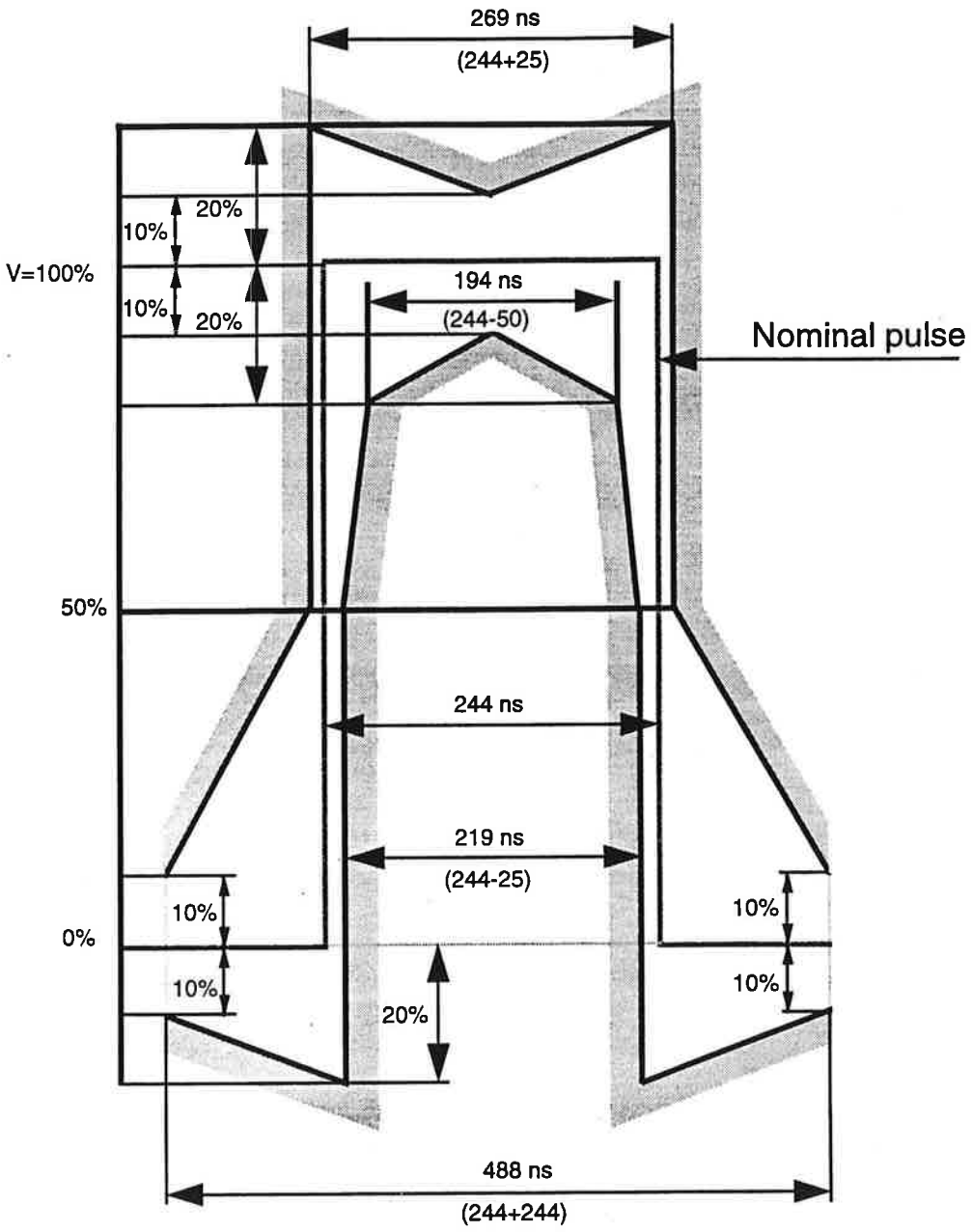
b) Specifications at the output ports:

Pulse shape (nominally rectangular)	All "marks" of a valid signal must conform with the mask (fig.7B.7), irrespective of the sign.The value V corresponds to the nominal peak value
Pair(s) in each direction	One coaxial pair (note) or symmetric cable
Test load impedance	75 ohm resistive (coaxial) or 120 ohm symmetric cable
Nominal peak voltage of a "mark" (pulse)	2.37 V
Peak voltage of a "space" (no pulse)	0 ± 0.237
Nominal pulse width	244 ns
Maximum ratio of the amplitudes of positive and negative pulses at the midpoint of a pulse width	0.95 to 1.05
Maximum ratio of the widths of positive and negative pulses at the nominal half amplitude.	0.95 to 1.05

c) Specifications at the input ports

The digital signal presented at the input port shall be assumed to be as defined above but modified by the characteristic of the interconnecting pairs. The attenuation of these pairs shall be assumed to follow a f law and the loss at a frequency of 1024 kHz shall be in the range 0 to 6 dB. This attenuation shall take into account any losses incurred by the presence of a digital distribution frame between the equipments.

Note: The outer conductor of the coaxial pair shall be connected to the earth at the output port and provision shall be made for connecting the outer conductor of the coaxial pair to earth if required, at the input port.



Note - V corresponds to the nominal peak value.

Figure 7B.7 Mask of the pulse at the 2048 kbit/s interface

7B.5.2 Frame structure

Number of bits per channel time slot:

Eight, numbered from 1 to 8.

Number of channel time slots per frame:

Thirtytwo, numbered from 0 to 31. The number of bit per frame is 256, and the frame repetition rate is 8000 Hz.

7B.5.2.1 Channel time slot assignment

Channel time slots 1 to 15 and 17 to 31 are assigned to 30 telephone channels numbered from 1 to 30.

The allocation of the bits of channel time slot 0 is given in Table1 below.

TABLE 1

Allocation of bits in channel time slot O

	Bit number							
	1	2	3	4	5	6	7	8
Time slot 0 containing the frame alignment signal	1	0	0	1	1	0	1	1
	Frame alignment signal							
Time slot 0 containing the frame alignment signal. Reserved for national use (the last three bits).	1	1				1	1	1
			Alarm indications (To be specified)					

Channel time slot 16 is assigned to signalling.

7B.5.2.2 Frame alignment signal

As shown in Table 1 above the frame alignment signal occupies positions 2 to 8 in channel time slot 0 of every other frame.

The frame alignment signal is:

0 0 1 1 0 1 1.

In order to avoid simulation of the frame alignment signal by bits 2 to 8 of channel time slot 0 not containing the frame alignment signal, bit 2 in those channel time slots is fixed at "1".

7B.5.2.3 Loss and recovery of frame alignment

Frame alignment shall be assumed to have been lost when three of four consecutive frame alignment signals have been received with an error.

Frame alignment shall be assumed to have been recovered when the following sequence is detected:

- for the first time, the presence of the correct frame alignment signal;
- the absence of the frame alignment signal in the following frame detected by verifying that bit 2 channel time slot 0 is a "1";
- for the second time, the presence of the correct frame alignment signal in the next frame.

Note: To avoid the possibility of a state in which no frame alignment can be achieved due to the presence of an initiative frame alignment signal the following procedure shall be used.

When a valid frame alignment signal is detected in frame n, a check shall be made to ensure that a frame alignment signal does not exist in frame n + 1, and also that a frame alignment signal exists in frame n + 2. Failure to meet one or both of these requirments shall cause a new search to be initiated in frame n + 2.

7B.5.3 Signalling

Channel time slot 16 shall be used for channel associated signalling.

7B.5.3.1 Multiframe structure

A multiframe comprises 16 consecutive frames and these are numbered from 0 to 15.

The multiframe alignment signal is 0000 and occupies digit time slot 1 to 4 of channel time slot 16 in frame 0.

7B.5.3.2 Allocation of channel time slot 16

Channel time slot 16 provides a 64 kbit/s digital path which is subdivided into lower rate paths using the multiframe alignment signal as a reference.

Details of the bit allocation are given in the table below.

This bit allocation provides four 500 bit/s signalling channels designated a, b, c, d, for each telephone channel.

The coding of these bits will be specified later by the administration.

Channel time slot 16 of frame 0	Channel time slot 16 of frame 1		Channel time slot 16 of frame 2		Channel time slot 16 of frame 15	
0000 xyxx	abcd channel 1	abcd channel 16	abcd channel 2	abcd channel 17	abcd channel 15	abcd channel 30

x = spare bit to be made "1"
y = bit used to indicate loss of multiframe alignment

7B.5.3.3 Loss and recovery of multiframe alignment

Multiframe alignment shall be assumed to have been lost when two consecutive multiframe alignment signals have been recieved with an error.

Multiframe alignment shall be assumed to have been recovered as soon as the first correct multiframe signal is detected.

Note: To avoid a condition of spurious multiframe alignment, the following procedure may be used, in addition to the above:

- Multiframe alignment shall be assumed to have been lost when, for a period of one or two multiframes, all the bits in TS16 are in the state "0".

- Multiframe alignment shall be assumed to have been recovered when at least one bit in the state "1" is present in the time slot 16 preceding the multiframe alignment signal first detected.

7B.5.4 Common channel signalling

For common channel signalling normally time slot 16 is used althoug in principle any time slot 1-31 could be used. In the case that time slot 16 is not needed for common channel signalling purposes, it can be used as time slot 1-15 and 16-31 to provide speech connections.

8 OPERATION AND MAINTENANCE

8.0 GENERAL

These specifications contain the requirements for the operational and maintenenace functions that are considered to be necessary in order to carry out the maintenance work at a low cost level. As wages rise progressively, the manual maintenance must be reduced in order to fulfil this goal. It is therefore necessary to automatize the operation and maintenance supervision to the greatest possible extent and to introduce maintenance aids that automatically localize and limit any faults in the system.

The requirements regarding operation and maintenance aids are naturally to a great extent dependent on the technical design chosen for the mobile telephone exchange. It may therefore be necessary to make corrections to the requirement specification at a later stage and furhter detailed work is expected to be necessary when a decision is made to purchase a new automatic mobile telephone exchange. Even from user point, corrections can later be necessary. The Nordic mobile telephone system (NMT) can, from the point of view of operation and maintenance, be divided into four main items: the mobile telephone exchange, circutis, base station and mobile station. It is very likely that the various main items of the system will be operated by staff from different categories. Moreover, the mobile station will be the responsibility of the administraion. In order to be able to send out staff of the correct category in case of faults, the system must contain built-in aids that enable the fault to be localized to the correct main part with a high degree of probability, as early as when the fault is reported.

It must be assumed that mobile telephone subscribers, to a greater extent than other subscribers, have their telephones in order to be able to call for aid in the emergency situation, and hence it is particular important that the equipement reliability is high. The main principles for the operation and maintenance systems should therefore be that the MTX shall automatically be supervised and shall detect and limit faults in its own system.

Fault clearing should as far as possible be carried out by replacing the faulty unit (printed board assembly etc.). The faulty unit is then sent to a central unit for repair.

The MTX shall be of such a simple and logical design that technicians of the administrations concerned who have had a certian basic training in the fields semiconductor technology, digital technology and computer technology and have undergone a system course, are able to carry out maintenance and repair work on the system independently.

8.1 SYSTEM DATA ADMINISTRATION

8.1.1 Changes in system data

When carrying out extension of the capacity of the MTX maintanance or work, it must be possible to make changes to subscriber data and common system data, from I/O-devices, without interrupting operation.

The changes shall be carried out by means of commands, and the system must check that these are complete and correct and also check the authorization before the commands are executed. If faults are discovered, fault messages shall be generated.

In principle only administation's staff shall be able to change system data and block and deblock functions, while the subscriber shall be able to change data within the framework of the functions supplied. It is desirable to have facilities that enable the subscriber's possibilities of making changes to be limited in certain cases.

The extent of the subscriber's possiblities could be to change the data for certain facilities.

In addition it shall be possible in a simple way by command for the administration's staff to

- change the information regarding the channels, circuits and devices available for a certain traffic case or exchange configuration;
- open and close facilities;
- block and deblock subscribers, channels, circuits and devices;
- remotely control the opening and closing of services or subscribers from, for example, an operational centre;
- change the information regarding the actual position of a certain subscriber registered in MTXH or MTXV (appropriate u-message shall if necessary automatically be sent);
- remove visiting subscribers from the roaming register, one by one or all belonging to a certain cooperating MTX.

8.1.2 Print-out of data

It shall be possible, by means of commands, to request the printout of subscriber data and common system data from I/O-devices during operation.

It shall be possible to include the following information in the printouts

- all the relevant data for a certain subscriber; (e.g. category, location, status)
- a list of all subscribers with a certain service;
- a list of all blocked devices, channels and circuits;
- a list of roaming subscribers, all or those belonging to a certain cooperating MTX or those being passive for a specified time.

The print-outs are to be well edited in text en clair.

8.1.3 Loading

By loading is meant reading software from an external memory. Loading shall be carried out when the software in the system is damaged or faulty. Loading shall also be carried out in connection with installation. It must be possible to load software both automatically and manually.

The loading time must be less than 3 minutes for a fully extended MTX, including the time required to set up the system for loading.

8.1.4 Reloading information

The exchange shall automatically feed out programs and data on a disk or similar storage medium, so that up-to-date reloading information always is available for immediate input in case of reloading the exchange.

It is required, that the exchange automatically controls the reloading information, so this under all circumstances can be used for reloading of the exchange.

It must be possible to initiate an output by means of command. New output shall take place automatically after every major change and after a number of minor changes. For the purpose of testing and changes in the system it shall be possible to function of inactivate (and activate) the function of automatically generated output of reloading information. Generating reloading information must not disturb traffichandling functions in the exchange. By command it shall be possible to set the time for automatically generated output of reloading information.

8.1.5 Recording of changes

Changes made between two outputs of reloading information shall be recorded on a separate medium.

When reloading, the system shall normally be reloaded with the latest issue of the reloading information together with the recorded changes.

The list of changes shall contain all system changes carried out since the last output of reloading information arranged in chronological order.

8.2 NETWORK SUPERVISION AND NETWORK CONTROL

These activities means continuous measuring of certain traffic data and interventions in the normal traffic handling that are based on the measurement results, in order to make possible the optimum utilization of the network when overloading occur.

8.2.1 Supervision of control systems and common switching equipment

When overload occurs on control systems and common switching equipment, (buffers, signal strength measurement buffers, call buffers and queues), it shall be possible to determine the cause of the overload, irrespective of the size of the overload, and take action so that maximum traffic handling can be maintained.

The control system shall be supervised by means of measurements on the parameter during a selected period of time. The measurements shall give unambiguosly the load on the parameter and/or the number of calls in its buffer. Measures for protecting the control system shall be initiated or cancelled automatically when preset limits are passed. It must be possible to initiate or cancel measures, change limit values and supervision times etc. manually. It shall be possible to get adequate alarms and printouts about overload.

The measures taken in case of overload of the control system, shall consist of various forms of limitation of the call intensity to the MTX. The limiting shall be aranged in such a way that calls, that have already seized switching equipment elsewhere in the telephone network, will be handled first.

The supervision of common switching equipment shall be carried out in accordance with following demands:

- measurement of call congestion (continuous measuring);
- traffic measurements during short periods of time (interval measuring);
- measurement of the queue length (continuous measuring).

When preset (it must be possible for the administration to change the limits) limits are exceeded, the same type of measures shall be carried out as in the case of overloading of the control system.

8.3 STATISTICS

The statistics function comprises:

- measurement of traffic flow
- traffic observation

8.3.1 Measurement of traffic flow

Traffic flow measurements are used for medium and long term planning of the network and for the checking of the established service goals as regards the traffic carrying capacity of the network. Traffic measurement function should be implemented according to principles defined by CCITT recommendation E.502 (traffic measurement model). At least following measurements are required.

- measurement of traffic flow on routes (junction groups)
- measurement of traffic flow to different traffic areas
- measurement of traffic flow to destination areas (numbering areas)
- measurement of immediate call transfer
- measurement of traffic flow on auxiliary equipment
- measurement of call transfer upon no reply
- measurement of congestion
- measurement of call attempts
- measurement of updating calls
- measurement of number of switching call in progress

- measurement of priority calls
- measurement of number of signal strength measurement orders
- measurement of average holding time
- measurement of utilization degree of the different services and facilities
- measurement of time congestion on junction groups
- measurement of queue lengths
- measurement of waiting times on auxiliary equipment
- measurement of waiting times in call buffers
- measurement of waiting times in signal strength measurement buffers

Measurements of traffic flow should be carried out so that it is possible to measure simultaneously traffic flow and congestion on all measurement objects even during the busy hour. A measurement object can consist of an internal or external route, numbering area, a group of supervisory, signalling or control devices etc. Measurement of the number of blocked devices (separated by the cause) in each measurement object shall be carried out simultaneously with the traffic measurements. When measuring traffic flow on base station lines it should be possible to measure separately different traffic types e.g. normal calls, updating calls, signal strength measurements. The intensity of traffic flow is measured by taking samples from the stats of junctions etc. Time interval between samples taken shall be choosen so that results are reliable.

Measurement of call attempts and congestion should be carried out so that it is possible to measure simultaneously the number of seizures, effective call attempts and unsuccesful call attempts (differentiated by cause e.g. congestion) on all incoming/outgoing junctions etc. It should be possible to measure separately different kinds of call attempts, e.g. incoming calls, outgoing calls, priority calls, roaming updating calls, signal strength measurements. Measurements of switching call should be carried out so that it is possible to see distribution of switching call between base stations and the result of switching attempts.

Measurment of time congestion on incoming and outgoing junction groups should be carried out so that it is possible to measure simultaneously time congestion on incoming and outgoing junction groups etc. Time congestion is measured by taking samples from the state of junctions. Time interval between samples taken shall be chosen so that the results are reliable.

Measurement of waiting times on auxilary equipment should be carried out so that it shall be possible to measure simultaneously the waiting times on common equipment. Also average queue length and the number of queueing calls should be measured.

Measurment of average holding time shall be carried out so that it is possible to get average holding time of junction groups, register control devices and so on.

Sealed devices shall not be included in normal measuring of average holding time and blocking time. But it shall be possible to measure the seal-time for different types of devices.

The measurement results in different measurement types shall contain at least following information.

- identification of the measurement object, day and time for the start of the measurement, the duration of the measurement and scanning interval
- measurement results
- number of connected devices
- number of blocked devices

A measuring program for a group of measurement objects is to comprise up to one year with the possibility to choosing days within each week. It must be possible to make measurements during each day, either continuously or during up to three separate periods of time, normally consisting of a whole-number multiple of 15 minutes. It shall be possible to order a measuring program a week before the measurements are to start. It shall also be possible to order several measuring programs at the same time.

Measurement programs shall be delivered unprocessed, on tape or other suitable storage medium and when so desired processed on an alphanumerical device. The output format as well as the detailed specification for measurement of traffic flow shall be given by the administration later.

The accuracy of measurements shall be 2 % or better in 95 % of the cases above.

8.3.2 Traffic observation

Traffic observation is used primarily for active control of the established goals for the grade of service on the network. Traffic observation shall be indication of where and why the established goals are not fulfilled. It shall be possible to observe all or part (n'th call) of traffic with a given origin and/or destination or on a given incoming and/or outgoing route.

Observation of traffic shall be done by observing subscriber generated traffic (live traffic). All significant events of every call in observation will be registered and put on tapes or other suitable storage media call by call bases (recording of unprocessed data) or on counter common to a lot of calls (recording of statistics). Both methods shall be possible. In case of call by call recording the recording result shall contain at least following:

- identification of the measurement object, day and time of the start of the measurements, the duration of the measurement and the value of n
- identification of mobile subscriber
- dialled digits

- identification of the routes, circuits, services and common devices used
- the results of the swithcing, including the cause of an unsuccessful call
- the events and times in the switching process in such a form that all essential holding and waiting times for each checked connection can be obtained after processing.

In case of call recording to common counters about the same information shall be the result but the information is stored to counters, each of which means a specific event in call handling.

The same requirements apply for the measuring programs as for the traffic measurements (see para. 8.3.1).

Output of data shall be made on tapes or other suitable storage media that are used exclusively for this purpose and in case of common counters also to alphanumeric device when so desired.

The output format will be specified later by the administration.

It must also be possible to use the recording of traffic observation for supervising an individual subscriber. The facility is to be used for fault localization when it has not been possible to find a fault in spite of repeated fault reports from the subscriber. In such a case, in addition to the data specified above, the recorded data shall comprise all signalling between the MS and the MTX. It must be possible to supervise a subscriber manually, by means of a listening-in device and automatically, in which case all data are to be recorded or stored. It must be possible to request a printout per supervised subscriber.

8.4 CALL METERING FUNCTION

By call metering function is meant here the possibility of checking and recording the charging information for mobile telephone subscribers.

8.4.1 Check of the chargin buffer store

The buffer store is used for storing call metering information during a call.

In order to be able to check that the buffer store is in order, it shall be possible to read and take out information automatically. Reading and checking can be done periodically or by means of commands. It shall be possible to read both individual and all call metering cells in the store by means of commands. In case of a fault, the buffer store shall be blocked automatically and an alarm is given.

8.4.2 Check of the printout of charging data

When a printout is made from the buffer store, the information shall be parity checked in accordance with the read-after-write principle. If printout is carried out simultaneously with two ouput media connected in parallel, a check must be made that the same information is given in both. If there is an error, a new attempt at printout shall be made. After three such attempts the information shall be printed with special marking. Printouts with error marking are to be noted in the fault records (see para 8.7.2).

8.4.3 Standby store for charging data

A standby store for charging data shall be available and shall be connected automatically when the regular storage facilities are lost.

An alarm shall be given in sufficiently good time to enable reloading to be carried out before the standby capacity is used up.

8.4.4. Supervision of the charging

An alarm shall be given, together with the reasons for the alarm, if charging information is not obtained as a result of overload of the buffer stores or a fault in any part in the system.

If fault situations cause disconnection of established calls (for example in the case of a major restart), the calls shall be charged for the time up to the fault. In the case of a minor restart charging is to continue if this can be done without the risk of faulty charging.

8.4.5 Processing of stored charging data

The magazine shall be protected against unintentional reuse or erasing.

It must be possible to copy the chariging information in full output magazines. It shall also be possible to transmit charging information via data circuits direct from MTX to central operational centres for further processing. Charging information shall be stored on media that are insensitive to power breaks.

8.4.6 Blocking of charging

It must be possible to prevent charging in the case of test connections,

8.5 SUPERVISORY FUNCTIONS

By supervisory functions is meant automatic supervision of the MTX with its lines, basestations and with built-in fault limiting measures.

8.5.1 Supervision of disturbances

The object of the disturbance supervision facility is to check the degree of service of the system. All disturbances and faults in the exchange shall be recorded on counters (in memory cells). All major function blocks, device groups etc. shall be provided with a utilization counter and a disturbance counter. Supervision shall be carried out in accordance with the quota principle.

If the utilization counter for a group of devices passes its limit value before the disturbance counter does, a new supervision period starts. If instead the disturbance counter passes its preset limit first, lamp alarm and an alarm printout are to be obtained.

8.5.2 Check of the switching path

A check of the switching path means a check that a connection is made to the correct address through the switching network of the MTX. The switching path for an unsuccessful connection shall be indicated and recorded in according with paras 8.7.1 and 8.7.2. Disconnection shall then be carried out.

In non-digital exchanges switching networks and devices are to be supervised with respect to:

- leaking between the branches and to earth on a path set up through the exchange;
- an extraneous voltage on the branches in a path set up through the exchange. The fault may consist of an electrical contact between two links and can only be indicated when both the links are in use;
- discontinuity in a path set up through the exchange.

In digital exchanges and certain other types of TDM exchanges, corresponding supervision shall be carried out as regards discontinuity in the path set up through the exchange and also as regards the risk of crosstalk between time slots.

8.5.3 Control of unauthorized parallel connection

A control is to be made that unauthorized parallel connection as a result of faulty test information does not occur. All connections that are set up shall be controlled. The traffic functions included in the connection where parallel connection is detected shall be indicated and recorded in accordance with paras 8.7.1 and 8.7.2. The connection shall then be cleared immediately so that there is no risk of any unauthorized listening-in. If parallel connection occurs on a connection that is not yet completely set up, but on which a speech connection has been established, the connection shall be cleared.

8.5.4 Check of devices

Traffic functions shall be checked in order to ensure that orders given are executed and that the devices are in the correct state. If fault conditions are detected, the function shall be indicated and recorded in accordance with paras 8.7.1 and 8.7.2. However, devices in the call condition shall not be disconnected.

8.5.5 Check of circuits

Every circuit connected to the MTX shall be supervised. When any circuit is faulty, it shall be blocked automatically and a fault recording in accordance with paras 8.7.1 and 8.7.2 shall be obtained. An alarm shall only be given when the traffic handling capability has decreased below what is acceptable.

The supervision shall be continuous or by means of a check of each connection. When a calling channel has been blocked because of a fault, a free traffic channel shall automatically be selected as the new calling channel. Test calls shall be carried out automatically on faulty lines. If the cause of the fault ceases, deblocking shall take place.

8.5.6 Faults that cause time release

Faults that cause time release, for example because a program is not completed within a certain time, shall give fault recordings in accordance with para 8.7.2.

8.5.7 Restart function

By restart is meant here measures that must be carried out after a software or hardware fault, in order to resume traffic handling to the normal extent. The requirements regarding time, degree of disturbance and frequency are given in the chapter of reliability. As a general rule, it can be stated that no manual action or reloading shall be required in the system in connection with a restart. The system shall comprise at least two levels for restarts (major and minor restart). The system is to select the appropriate restart level automatically, in accordance with a predetermined strategy. It must be possible to analyze the cause of a restart after it has been carried out.

8.5.8 Signal check

In the MTX facilities shall be provided for testing all devices which are sending VF signals. The test shall be carried out both automatically, at a preset interval determined by the administration, and at arbitrary times, by means of separate commands.

In the case of automatic testing each device concerned shall be tested, where as with command-controlled testing it shall be possible to test either all or only a certain device.

The testing shall comprise the length of signals sent from the signal transmitting devices, pauses, levels and, in the case of multi-frequency signals, a check that the signal content is correct.

When the test values exceed certain preset values or signals are missing, disturbance indications and fault recordings shall be obtained in accordance with para 8.5.1 and 8.7.2. If standby equipment is available for providing the signals that are faulty or missing, it shall be connected automatically. The fuse system or unit must not have such properties that a fault in some part of the system affects all signal distribution in other parts of the MTX.

8.5.9 Voltage supervision

The voltage levels in the exchange shall be supervised as follows:

- Supervision of operating voltages (excess voltages and undervoltages). Alarm shall be given at such an early stage that measures can be taken before operating disturbances occur in the MTX.

  Low voltage values shall be checked at two levels. The first level shall give a B (non-urgent) alarm (see para 8.8.5), which shall be given relatively early in order to make it possible to detect, for example, a fault in one of the mains phases feeding the rectifier. Level two shall give an A (urgent) alarm (see para 8.8.5) and this shall be given when the operating voltage is so low that measures must be undertaken quickly.

- Other secondary voltages. An alarm is to be given on loss of voltage.

8.5.10 Supervision of fuses

All fuses in the system shall be supervised. If a fuse blows, an alarm shall be given immediately and the associated alarm information shall contain direct information regarding the position of the ruptured fuse.

The blocked devices shall be deblocked automatically after the fuse has been replaced, and the alarm transmission shall be inhibited.

8.5.11 Transmission check

By transmission check is meant here simplified transmission measurements. The measurements shall comprise noise and attenuation measurements (at 800 Hz). It must be possible to carry out measurements both manually, by means of a command, and automatically (program controlled), with a preset interval. The measured values shall be checked against adjustable reference values. When measuring manually by means of a command, it shall be possible to select an arbitrary base station and/or channel.

It must be possible to carry out the measurement at two levels, so that a distinction can be made between transmission faults in the base station and those in the connection between the MTX and the BS in question.

8.5.12 BS-self test

It shall be possible to command selftest of an BS. The signalling procedures are documented in NMT Doc. 900-1. In NMT-900, each base station channel control unit, and optional also the supervisory unit on the dedicated data channel, is capable of performing a self test of the functional performance of the radio channel, see NMT Doc.900-4 para 8.10.

The BS self test is initiated by command or in the automatic routine test in MTX, described in para 8.5.11

MTX sends frame 22 (V_1=4), on the chosen channel which is acknowledged by frame 27 (V_1=5) from BS, see NMT Doc 900-1 para 4.3.3
If the self test is completed successfully, the frame 27 (V_1=6) is sent from the BS. If the self test fails the frame 28 (V_1=10,V_2=15,V_3=2) is sent. It must be noted that the self test can last up to 6 s. before the result is given from the BS.

If the self test is initiated by command, the MTX shall give a printout indicating that :

- acknowledge frame 27 (V_1=5) has not been received.
- frame 27 (V_1=6) "Self test completed" has been received.
- frame 28 has been received.

NOTE: The above mentioned selftest function is also included in the new generation of basestations for NMT-450 delivered from 88/89.

8.6 BLOCKING FUNCTIONS

8.6.1 Manual blocking

It must be possible to block any traffic-carrying device, from the I/O-device.

8.6.2 Automatic blocking

When a fault is detected, the MTX shall automatically block the faulty units.

Some examples of faults that shall result in automatic blocking are:

- A device has been indicated as faulty (see para 8.7.1);
- A circuit has been indicated as faulty (see para 8.5.5);
- The voltage supply for a device has failed;
- A printed board assembly has been removed.

It must be possible to remove the blocking by means of a deblocking command. If the fault remains, the device shall be blocked again automatically when the faulty function is repeated.

8.6.3 Indication of blocked devices

When automatic or manual blocking is performed, a distinct alarm shall be given. Different alarm classes shall be used, depending on the importance of the device for the operating functions of the system.

When a basestation or another route is blocked an alarm shall be given.

In addition it shall be possible to read the number of blocked devices from the I/O-device, either as a total or per group of devices. The printout shall indicate whether the device is blocked manually or automatically.

8.6.4 Supervision of blocking

The blocking supervision function shall supervise that the number of manually or automatically blocked devices does not exceed predetermined limit values. Each group of device shall have separate supervision of blocking.

It shall be easy to change the extent of the blocking supervision when rearranging devices, for example in connection with extensions. An alarm shall be obtained when the limit value is exceeded. It must be easy to change limit value and alarm class.

Radiochannels which are isolated due to fault in the clearing sequence enters a special state and are not included in the blocking supervision.

8.7 FAULT LIMITING AND FAULT LOCALIZATION

8.7.1 Automatically fault limiting

When a fault occurs, automatic measures shall be undertaken with a view to prevent traffic disturbances as far as possible.

When a fault is detected, all devices and switches concerned shall automatically be blocked and recorded as faulty (see para 8.7.2). Each blocked device or switch shall than be individually tested automatically by the system. The functions that are proved to be free of faults shall be deblocked.

By means of automatic fault-localization 95 % of the cases, the fault shall be localized to 1-2 printed board assemblies. The requirments shall be met for each functional unit in the exchange and shall be verified in connection with the repair times.

8.7.2 Fault recording

Fault recording shall be carried out when the system detects a fault. The data shall be sufficiently comprehensive to enable faulty procedures to be reconstructed. When the automatic fault limiting in accordance with para 8.7.1 to indicate the fault is carried out, a prinout shall be obtained. The printout shall contain the time, complete fault data and the unit indicated. There must be at least 32 fault recording possibilities. Data shall be stored in accordance with the principle of first in - first out. It must be possible to obtain a printout from the fault register by means of command. It must also be possible to order a printout of all disturbances that occur in a certain group of devices.

8.7.3 Event recording localization

The MTX shall continously record the different events in the exchange e.g. for the purpose of fault analysis. In case of break down, the total content of the programme and data memory shall be stored.

8.7.4 Check of the fault clearing

It shall be possible to order, by means of a command, a check that comprises all functions in a repaired or exchanged unit.

8.7.5 Tracing a connection

It must be possible to trace a connection from the I/O-device. The answer shall be in the form of a printout of the switching path.

It shall be possible to use MS-number own and visiting as input for tracing.

8.7.6 Control of a test connection

With the aid of the I/O-device, it shall be possible to set up a connection via the switching path which, each time a connection is set up, it is desired to test towards an arbitrary subscriber. It shall only be necessary to indicate the part of the connection that is of interest from the point of view of fault finding. It must be possible to choose the other parts of the system at random.

8.7.7 Monitoring on devices

In exchanges the maintenance staff must be enabled to do monitoring on traffic-carrying devices idle, blocked or busy with possibility for listening in or contact from the I/O-device.

8.7.8 Manual control of the processor

It must be possible to stop the processor from the I/O-device and step it manually at the desired point in the program. It shall be possible to stop the processor only by means of a double function. When the I/O-device is disconnected, the processor is to be restarted automatically.

8.7.9 Test subscriber

A special mobile test station (TMS) is used as a test subscriber for the following purposes:

- Fault tracing, in the case of a fault report, to equipment owned by the administration or by the customer.
- Transmission checks when measuring on level 1 (see para 8.5.11).
- Function checks after the completion of maintenance work.

Calls to the TMS will be connected to a test tone, to check the speech quality, and to valuate the availability in the network out to the TMS.

The TMS will generate a call, using an automatic number sender, to a fixed subscriber and on a specific radio-channel, decided by the maintenance staff via I/O-device.

Functional description of the TMS:

- Calls to the TMS will be handled as an ordinary call.
- The ringing-signal in the TMS will start the test-tone 1200 Hz 5 sec/5 sec silence.
- After 20 sec the MS will release the connection.
- After approx. 5 sec the number sender will start establishing a new call from TMS to the fixed subscriber. The TMS locks on a test-marked channel instead of a traffic channel. When the B subscriber answers, sends the test-tone 1200 Hz 5 sec/5 sec silence.
- After 20 sec the TMS will release the connection.

8.8 INTERFACES, MAN-MACHINE SYSTEM

This section deals with the communication between the exchange and the maintenance staff, and also between the exchange and the I/O-devices.

The man-machine language for the MTX shall be designed taking into consideration the work in progress within CCITT.

Printer display and key-board shall use CCITT alphabet no. 5.

Standardized interface as V.24, X.21 and X.25 shall be used.

Standardized format, F1.

Max characters per line is 72.

The number of lines per form may be 66.

Information presented in this format can be displayed on most of the alphanumerical displays available on the market. However, the number of lines which can be displayed at the same time on these device is in general not more than 20 to 25 lines.

The MTX shall be equipped with I/O-devices, such as:

Duplicated disc unit. Duplicated tape drives for event recording, coredumps, traffic data and storage of billing data (800 bpi using 2400 ft tape, 9 tracks.)

Duplicated display and key-board unit for the control terminal. The units shall use 2400-9600 bits/sec signalling speed.

Hardcopyprinter with a printing speed not less than 300 char/sec. The noise from the printer shall not exeed 50 dB(A).

8.8.1 I/O-system

The exchange of information between the maintenance staff and the exchange control system shall be possible via both local and distant terminals. The MTX shall be equipped with facilities for preventing and restricting certain commands from distant terminals.

The MTX shall also be equipped with facilities for simultaneously use of terminals, for grouping of different functions and setting of priority between terminals.

The design of the I/O-system shall be such as future changes and extensions can be carried out in a simple way.

8.8.2 Input and output via I/O-devices

Input and output shall take place from some type of terminal equipment. The outputs shall be in text en clair and job orientated, so that the required measures are easy to carry out.

The following inputs and outputs, among others, shall be carried out from the I/O-devices:

- Input of subscriber data
- Input of data for blocking and deblocking of subscribers
- Input of data for blocking and deblocking of subscriber services
- Printout of fault recording
- Printout of disturbance supervision
- Printout giving blocked devices
- Printout giving faulty circuits
- Printout giving the state of individual devices
  Input of data for controlling test connections
- Input of data for tracing connections
- Stopping and controlling the central unit at the desired point of the

program
- Locating a device in a certain state
- Disconnecting certain time supervision.

8.8.3 Requirements for I/O-devices

The requirements in this paragraph are to a great extent dependent on the type or types of I/O-devices that will be used in the MTX. However, certain guidelines can be given:

- All I/O-devices shall be of the plug-in design so that they can easily be removed for service or repair.
- The function of the system shall be independent of the design of I/O device.
- It shall be possible to keep the preserve printouts for the maintenance work.
- Printout from the I/O-devices must be in large and clear text. It must be easy to read and must not contain any caracters that can be misread.
- If a fault occurs in an I/O-device, the device shall be blocked automatically.
- It shall be possible to initiate function testing of the I/O-device by means of a command.
- Standardized interfaces and data format shall be used to the greatest possible extent.
- It shall be possible to use all necessary I/O-devices at the same time, and for all possible commands.

8.8.4 Command and printout language

The command and printout language shall be designed taking into consideration the work in progress within CCITT.

8.8.5 Alarm system

By alarm system is meant all functions for indicating, transmitting and acknowledging alarms.

The goal of the alarm system shall be:

- Each situation that causes an operational disturbance of importance or that requires a manual action shall give an alarm.
- The alarm message shall make clear within what period of time a manual action is required.
- The alarm message shall give detailed information about the cause of the alarm, so that the correct action can be decided upon.

- It shall be possible to send alarm messages to a superior operation centre.

- It shall be possible to make an enquiry regarding the existing overall alarm condition (A, B and C alarms) of the system from an I/O-device, alarm panel or from a maintenance centre (central operation supervision). The answer shall comprise the current alarm messages. Each alarm message shall be started with an alarm class designation, which states the period of time within which action must be taken. If the alarm list is full, subsequent alarms must be printed out directly with special marking.

The alarm classes shall be as follows:

A ALARM: Action must be taken immediately irrespective of when the alarm is obtained. On other times than normal working hours, the alarm shall be retransmitted to a supervision centre.

B ALARM: Action shall be taken as soon as possible during normal working hours.

C ALARM: Action can be deferred without any serious consequences, but not for more than one week.

D ALARM: Action can be deferred for quite a while and can be carried out in connection with other work.

8.8.6 Alarm panel

The alarm conditions shall be indicated on an alarm panel in the control room and in the room where the cause of the alarm occurs. Alarm and printout shall also be obtained on the I/O-device. Alarm classes A and B shall be provided with an acoustic alarm. The maintenance staff must be able to switch off the signal in such a way that a new signal is obtained if another alarm occurs. The alarm panel shall be in operation only when the MTX is manned. In addition, suite and rack fuses shall give special alarm indications in the racks.

It must be possible, when desired, to send whole alarm messages or parts of them to an operational and maintenance center during those hours that the mobile telephone exchange is not manned.

8.8.7 Transmission of alarms from the base stations

The MTX must be able to receive alarm messages from the various base stations in the region and also transmit them to responsible regional O&M-centers.

The alarm messages shall contain data about the base station, the alarm class and possibly also about the cause of the alarm as described in NMT Doc. 1. and NMT Doc. 900-1.

Actual BS-alarms shall be stored in an own alarm list.

To ensure correct state and administration on the BS, when a channel is put into service after all kinds of restarts, blockings and test-connections, the MTX shall send general channel reset towards the BS. The function is described in NMT Doc. 1. and NMT Doc 900-1.

8.8.8 Alarm acknowledgement

The main rule is that an alarm is acknowledged by means of a command, and the system then accepts the acknowledgement and gives the acknowledgement time in the form of a printout.

Alarms, the causes of which are indicated by local alarm panels, shall be acknowledged by eliminating the cause of the alarm (for example by changing the blown fuse). The I/O-device shall give a printout when the alarm cause has been eliminated. The printout shall contain the acknowledgement time and a statement that the fault has been cleared.

8.8.9 Busy indication for devices

The maintenance staff must be able to read off all busy devices and switch links by means of the I/O-device. Indications shall be given for single devices or groups of devices.

8.8.10 Numbering of devices and switches

Numbering of devices and switches is to be found in the exchange labelling, documentation, printouts and commands. The same form of numbering shall be applied generally for the contacts that the operating and maintenance staff have with the system. The numbering is to indicate the type of device or switch and its geographical position in the exchange.

8.8.11 Label

Each rack shall be provided with a label that gives the serial number of the rack.

Each shelf must be labelled with its serial number and the corresponding numbering shall also be given on the rack.

Test points on the printed board assemblies shall have a clear and unambiguous designation which shall be printed on the board.

The device shelves shall be provided with designations for each position in the shelf. There must also be space for complementary information such as device designation, switch inlet, etc.Printed board assemblies delivered to the administration should have the article number printed on the front of the board handle. This number should be placed either at the top or the bottom of the handle in order to make room for the administration's designation.

The foil of the printed circuit board should be marked with the number of the circuit diagram for the board.

8.9 MISCELLANEOUS

8.9.1 Mechanical construction

The mechanical construction of racks, plugs, jacks, covers etc. shall facilitate maintenance, e.g. they must not be mounted in such a way that extensive dismantling work is necessary in order to get at the equipment.

8.9.2 Service jacks

Each rack is to contain service jacks.

8.9.3 Voltage jacks

Battery jacks for the required voltages shall be provided in each rack and at the test jacks.

8.9.4 Possibility of answering calls to the MTX

It must be possible to answer calls to the MTX maintenance staff in every rack.

8.9.5 Documentation

It is of importance that meticulous handling descriptions and instructions are prepared, so that the risk is eliminated of involuntary and unnecessary disturbances because of faulty operation (see chapter 14).

8.10 MAINTENANCE OF BS

In the MTX there will be a command function which will initiate the transmission of frame 22 where the variables V_1...V_6 are parameters. The command can be given towards a data channel or a non traffic carrying channel. The transmission of the frame is performed according to 4.4.2.3 in NMT Doc.900-1.

Frame 27 which is received on a data channel or a non traffic carrying channel results in a printout where the channel identity (N_1,N_2,N_3), traffic area (Y_1,Y_2) and the circuit identity are stated. The variables V_1...V_6 are printed out without processing.

Frame 28, received on a channel results in a printout where the channel identity (N_1,N_2,N_3) and the circuit identity are stated. The variables V_1...V_4 are printed out without processing. Further, the value 6 in a preselected V-parameter results in line blocking of the device as well as value 9 in the same V-parameter results in deblocking. The printout can be handled by the alarm system according to the specified alarm class.

Only these frames 28, received by the MTX, which are defined in the table (NMT Doc.900-1 para 4.3.3.9) are printed out e.g. V_1=10,V_2=15,V_3=0 "Antenna fault level 1" and V_1=6,V_2=15,V_3=3 "Spare" "

NOTE: The above mentioned maintenance of BS is also included in the new generation of basestations for NMT-450 delivered from 88/89.

9 SIGNALLING

9.1 GENERAL

9.1.1 Signalling interfaces

The MTX shall provide the following signalling interfaces:

- 1200 Bauds binary signalling with mobile stations on calling channels, traffic channels and access channels (NMT-900 only):
- ordinary telephone network signalling including common channel signalling on trunk circuits connecting the MTX to a transit exchange in the telephone network;
- MFC signalling with other MTX:s on the trunk circuit with the transit telephone exchange or on separate telephone circuits, fixed connections between MTX:s, and common channel signalling with other MTX:s via national and international signalling networks;
- 1200 Bauds binary signalling on calling channels, traffic channels or access channels (NMT-900 only) and/or separate data links for remote control of base station functions.
- X.25 or CCITT signalling system no.7 for signalling between the MTX and the AR.

9.1.2 Call set-up and disconnect procedures

The procedures and signalling for establishing connections with mobile subscribers should in principle and as far as possible be the same as those applied in the telephone network.

The MTX shall through-connect speech path on the following indications:

- answer from mobile subscriber on traffic channel;
- address-complete indication from the telephone network or another MTX;
- analysis of subscriber number length in cases where no address-complete indication is given from the telephone network.

The MTX shall disconnect a call

- when clear-forward or clear-backward is received from the subscriber on traffic channel:
- after time supervision upon disappearence of supervisory signal;
- when clear-forward is received from the telephone network;
- after time supervision upon clear-backward from the telephone network.

When setting-up a call, the MTX shall check its internal processes, react upon the signalling information received and provide time supervision in such a way that unsuccessful call attempts are released and appropriate audible information, tones or recorded announcements, is always given to the subscriber. If the MTX does not receive a normal reaction from the MS in a clearing sequence, the MTX shall isolate the TC in 10-60 sec. as commanded after releasing the channel.

9.2 SIGNALLING BETWEEN MTX, BS AND MS

The MTX is connected to BS:s via 4-wire, circuits, either of FDM, PCM or physical type. For the exchange of messages between MTX and MS, 1200 Bauds binary signalling is used.

A detailed specification for the signalling between MTX, BS and MS, including coding of mobile telephone signals and signalling procedures is given in NMT Doc. 900-1 and NMT Doc. 1.

9.3 SIGNALLING BETWEEN MTX AND THE TELEPHONE NETWORK

The MTX is connected to the public telephone network via trunk circuits to a transit telephone exchange. These trunk circuits are 4-wire, circuits, either of FDM, PCM or physical type.

The interface with the MTX, signalling systems and signalling procedures for the trunk circuits, are the standard ones for the national telephone network concerned. They are described below for each of the Nordic countries.

Detailed interface and signalling system specifications as well as procedures for the setting-up of national, international and special service calls are given in national specifications.

9.3.1 Denmark

Signalling between MTX and transit exchange in the telephone network shall be according to Telefontilsynets Cirkulaere nr. 20: Specifikation nr. 3 for line signalling and specification nr. 7 for register signalling and specifikation 11 for common channel signalling. They are together identical to the CCITT specifications for Signalling System R2, and signalling system no. 7 supplemented with some special signals for the Danish network.

Line signalling (Specifikation nr 3)

The line signalling is continuous and uses an outband signalling frequency 3825 Hz. Tone on the line corresponds to closed contacts in the relay sets. MTX shall be capable of working with 4 signalling wires per circuit in a balanced signalling. The current in the signalling wires must not exceed 50 mA.

The MTX shall accept frames according to the requirements in section 4.7 in NMT Doc.1 and NMT Doc. 900-1.

The MTX shall in addition be capable of analysing a sequence of identical frames and combine these frames in order to check whether the sequence can be accepted or not. The precise requirement for this analysis will be specified later.

Example on coding of some major line signals:

Signalling codition	From outgoing exch	From incoming exch
Idle	tone	tone
Seizure	no tone	tone
Register signalling (MFC)	no tone	tone
Before answer	no tone	tone
Answer (speech condition)	no tone	no tone
Clear-backward	no tone	tone
Clear-forward before answer or during clear-backward	tone	tone See cirk. 20, spec 3, Fig. 3-25, page 25
Clear-forward during answer	tone	no tone
Release-guard	tone	tone
Blocking	tone	no tone

Register signalling (Specifikation nr. 7).

Register signalling shall be according to the R2 specification for national application, i.e. with 6 frequencies in the forward direction and 5 frequencies in the backward direction.

The following signals are used between MTX and the transit telephone exchange.

Forward signals

Signal	Group I	Group II	
1	Digit 1	Subscriber without priority	National
2	2	Operator and subscriber with priority	
3	3	Special equipment	
4	4	Coin box (with priority)	
5	5	Operator who whishes through-connection to subscr. with absent-subscr. service	
6	6	Data transmission	
7	7	Subscriber	International
8	8	Data transmission	
9	9	Spare	
10	0	Operator wishing forward-transfer facility	
11	Spare	Subscriber without priority	
12	Request not accepted	Oper. and subscr. with priority	Special service calls to other numbering area
13	Access to special equipm.	Special equipment	
14	International prefix	Coin box (with priority)	
15	a) End-of-pulsing b) Special routing	Operator wishing trunk offering facility etc	

Backward signals

Signal	Group A	Group B
1	Send nex digit (n+1)	Put connection under control of incoming end
2	Send last but one digit (n-1)	Absent or transferred subscriber
3	Change over to Group B	Subscriber line busy signals
4	Congestion	Congestion
5	Send calling party's category	Vacant number
6	Set-up speech conditions	Subscriber line free, charge
7	Send last but two digits (n-2)	Subscriber line free, no charge
8	Send last but three digits (n-3)	Subscriber line out of order
9	Send first digit	Spare
10	Change-over to other type of signalling	Spare

The signalling program may be extended with backward signals of types C, D and Z (see Telefontilsynets Circulaere nr 20, Spec. nr 7). However, this extension is not required in the MTX from the out-set.

9.3.2 Finland

Channel associated signalling

Discontinuous out-band signalling is used for line signalling and pulsed multi-frequency signalling, so called MFP signalling and national MFC-R2 signalling, is used for register signalling between MTX and transit exchange in the telephone network. Signalling shall be according to the following national Finnish specifications.

National requirement for R2-signalling
National common channel signalling system
National requirements for MFP-signalling system (PKE44760).

Line signalling (MFP)

The line signalling is discontinuous with signal durations and coding as shown below. An out-band frequency 3825 Hz is used with a nominal sending level of -18 dBm0. The interface between MTX and the carrier equipment has two DC signalling wires where positive polarity corresponds to tone on the line.

Signal	Duration in ms Forward ⇒ backward signal ⇐	
Seizure	150	
	⇒	
Proceed-to-send	150	
	⇐	
1) transit	150	150
	⇐	⇐
2) terminal	100	
End-of-selection	150	
	⇐	
1) subscr. free	600	
	⇐	
2) subscr. busy		
Congestion	600	
	⇐	
Answer	150	
	⇐	
Clear-backward	600	
	⇐	
Clear-forward	600	
	⇒	
Release-guard	600	
	⇐	
Blocking	continuous	
	⇐	

Minimum pause between two different signals in the same direction = 300 ms.

Register signalling (MFP)
Register signals are sent only in the forward direction and in a 2 out of 6 frequency code. Pulse signal duration is 50 ms and the pause between signals is 50 ms. Nominal sending level is -8 dBm0 for each frequency. The specifications for signal sender and receiver are to a large extent the same as for CCITT:s signalling system R2. Signalling frequencies and coding of signal are as shown in the following table.

Signalling frequency (Hz)

Digit	540	780	1020	1260	1500	1740
1	X	X				
2	X		X			
3		X	X			
4	X			X		
5		X		X		
6			X	X		
7	X				X	
8		X			X	
9			X		X	
10				X	X	
11	X					X
12		X				X
13			X			X
14				X		X
15					X	X

The sending of register signals is controlled by backward line signals:

1) Reception of a transit proceed-to send signal initiates sending of the three (to Helsinki) or four first digits of the national significant number.

2) Reception of a terminal proceed-to-send signal initiates sending of the subscriber number.

3) In 2), the subscriber number is preceeded by register signal 13 (operator category) where appropriate.

Common Channel Signalling

In Finland common channel signalling system number 7 will be used between exchanges interconnected with digital circuits. The national channel specifications are based on CCITT, Red book, Recommendations. Following specifications exist:

National MTP, published in 1985.
National TUP, published in 1985.

9.3.3 Norway

Digit trunk interface, 2.048 kbit/s, will be applied for trunks to the telephone network. Common channel signalling and/or channel associated signalling applying discontinuous line signalling with national MFC interregister signalling are used for signalling between MTX and transit exchanges in the telephone network.

The following national specifications will be used as reference:

(1) Norwegian Telecommunications Administration Specification and Technical Requirements for Digital Public Telephone Exchanges.

(2) Norwegian Telecommunications Administration Specifications and Technical Requirements for Common Channel Signalling, Signalling System No. 7.

Digital trunk interface

The implementation of the digital trunk interface in the MTX shall fulfil the requirements specified in section C.3 - Transmission, of (1).

Synchronization

The implementation of the synchronization function in the MTX shall fulfil the requirements specified in section C.4 - Synchronization, of (1).

Automatic actions in case of transmission faults or exchange - internal faults.

The implementation of the digital trunk interface and the signalling function shall fulfil the requirements specified in subsection C.6.4 - Automatic options in case of transmission faults or exchange - internal faults, of (1).

Common channel signalling

In Norway, common channel signalling, Signalling System No. 7, will be used between digital telephone exchanges interconnected with digital trunks. For all control signalling, the national TUP (NTUP) will be used. It is planned to introduce the National ISUP (NISUP) in 1987. For international applications TUP according to CCITT Recommendations (ITUP) will be used.

The SCCP will be introduced in the network in 1986 and initially used for transfer of operation and maintenance information between digital telephone exchanges and operation and maintenance centers using OMUP.

It should be noted that NTA specifications for Signalling System No. 7 are based on CCITT Red Book Recommendations.

National signalling network

In principle a four-level hierarcical signalling network is planned to be developed. The major signalling network levels are, from higher to lower levels.

- National level providing a national level signalling network by linking together regional signalling networks, i.e. on interregional signalling network,

- Regional level providing regional signalling networks by linking together local signalling networks.

- Local level providing local signalling networks.

MTX:s using common channel signalling will be connected to nodes on national level (interregional STP's) and/or nodes on regional level (regional STP's).

Initially one but in the future two nodes on the national level signalling network will act as STP's in the international signalling network between the Nordic countries.

MTP

The implementation of the MTP shall fulfil the requirements specified in chapter D. - Specifications for the Message Transfer Part, of (2). Only functions for SP-operation are required.

SCCP

The implementation of the SCCP shall fulfil the requirements specified in chapter E. - Specifications for the Signalling Connection Control Part, of (2).

TUP

The implementation of the TUP shall fulfil the requirements specified in section G.2 - National Telephone User Part, of (2).

ISUP

The implementation of ISUP shall fulfil the requirement specified in chapter I. - Specifications for ISDN User Part, of (2).

Interregister signalling

The implementation of the national MFC interregister signalling in the MTX shall fulfil the requirements specified in subsection C.6.9 - MFC interregister signalling, of (1).

Operation and Maintenance

The implementation of the operation and maintenance functions in the MTX shall fulfil the requirements specified in subsections E.3.1 - Basic principles and E.3.5 - Trunks, signalling devices and connected equipment in section E.3 - Supervision and test functions, of (1).

Operation and maintenance

The implementation of Signalling System No. 7 in the MTX shall fulfil the requirements specified in chapter C. - Specification for operation and maintenance of the signalling system, of (2).

Channel associated signalling

In Norway, discontinuous line signalling with national MFC interregister signalling will be used if MTX:s are connected to analogue telephone transit exchanges and if MTX's are connected to digital telephone transit exchanges when common channel signalling is not applied.

Line signalling

The implementation of discontinuous line signalling in the MTX shall fulfil the requirements specified in subsection C.6.5 - Discontinuous line signalling, of (1).

9.3.4 Sweden

Digital trunk interface, 2048 kbit/s, will be applied to connect trunk circuits to the telephone network. This is also the case where the speech circuit is included in FDM system. In this case equipment (PCM MUX) is used to convert from analogue to digital interface.

Common channel signalling in form of CCITT Signalling System number 7 and channel associated signalling applying continuous line signalling in timeslot 16 and a pulsed multi frequence system as a register signalling system will be used for signalling between MTX and the national telephone exchanges. For international calls a CCITT R2 based register signalling system is used.

Line signalling

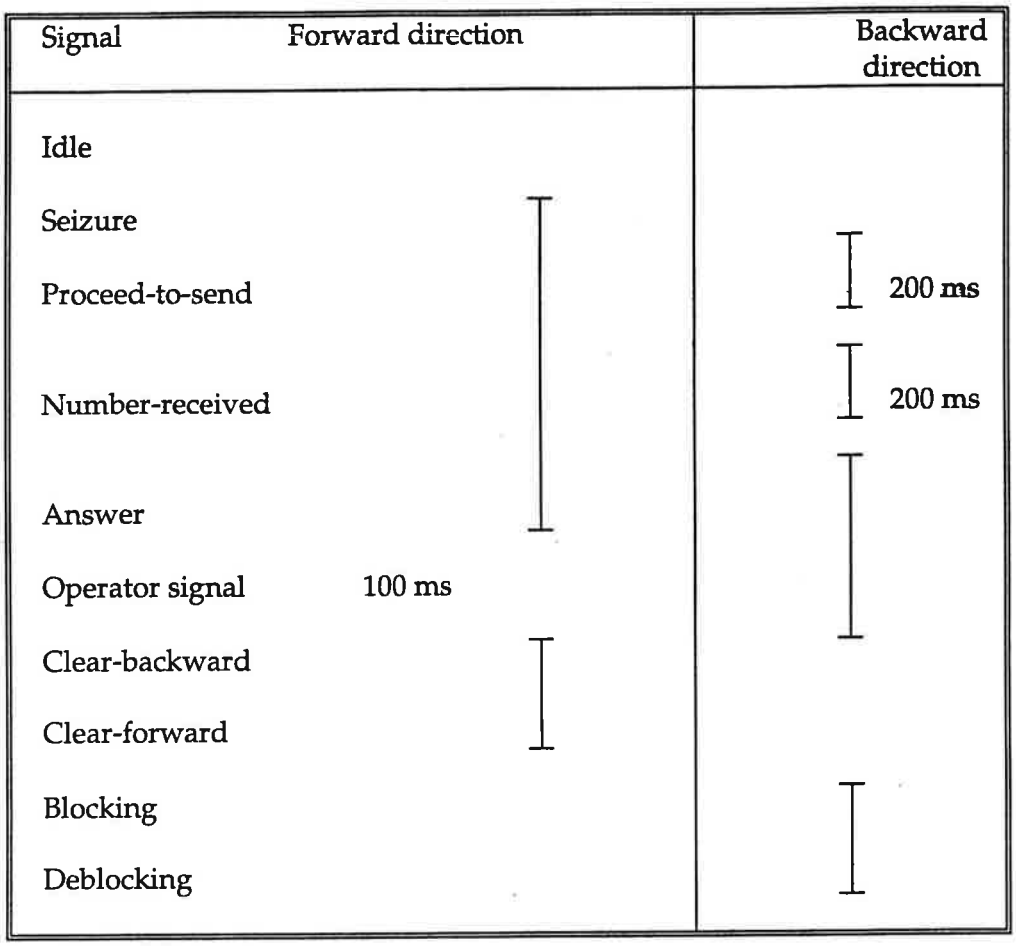
In Sweden continuous out slot signalling using timeslot 16 is used.This signalling is similar to the one bit version of CCITT R2, system where value C corresponds to toneless condition in FDM system.

In the case where at least a part of the speech circuit is included in FDM circuit the pilot alarm must be transmitted to the NMT exchange. For this purpose the b bit is used.

The signalling will be conveyed in timeslot 16 and interfaced with the exchange using 64 kbit/s signalling channel.

The signalling conditions and coding of the signals in the timeslot alotted to the concerned speech channel is given below.

Signalling condition = value 0



Register signalling

The normal register signals are sent link-by-link (overlap with dialling) in Swedish telephone network. They are sent in a 2 out 6 frequency code using the forward MFC frequencies of the CCITT R2 system. Pulse signal duration is 70 ms and the pause between signals is 70 ms. Nominal sending level for each frequency is -8 dBm0. At present only 5 signalling frequencies, corresponding to the digit signals 1-9,0, are utilized.

For setting-up an outgoing international call, the MTX sends first in accordance with above, a special routing code = 009I_1I_2 and changes the to compelled MFC signalling according to the R2 specification starting with code 14 (international prefix = 009). When speech connection is set-up to the outgoing CT the compelled MFC signalling starts. For this signalling four special groups of signals in the backward direction: C, D, Z and Y are used in addition to the MFC signals specified in the R2 specification. For radio paging calls the same signalling principle is used as for international calls. 6 forward and 5 backward signalling frequencies are used.

Common channel signalling

In Sweden Common Channel signalling in form of Signalling system number 7 will be used between digital telephone exchanges interconnected with digital circuits. Signalling system number 7 will be introduced during 1985 in all digital exchanges in the network. For call control signalling, a Swedish version of Telephone User Part (GK-1) will be used. An uppgraded version of TUP (GK-2) or a preversion of Integrated Service Part (GK-2) will be introduced during 1987. At the same time the SCCP, mainly used for realising complex supplementary services will be introduced.

The MTP used, when introducing signalling system number 7 in the Swedish network is based on the yellow book.

During 1986-87 this version will be uppgraded to also cover the requirements from 1984 years version of the CCITT recommendation (red book).

MTP

The implementation of the MTP shall fullfill the Main requirement specification for MTP2, Nsn 84 047.

SCCP

The implementation of the SCCP shall fullfill the Main requirement specification for SCCP1, Nsn 84 048.

TUP

The implementation of the TUP shall fullfill the Main requirement specification for GK2, Nsn 84 049.

9.4 SIGNALLING BETWEEN MTX:s

9.4.1 General

Two types of signalling between MTX:s can be distinguished:

1. Signalling for forwarding of a call to a mobile subscriber.

2. Signalling for exchange of other information between MTX:s.

In the first case the connection between the MTX:s is set-up through the telephone network over which the call is forwarded.

In the second case the information may be exchanged over:

a) switched telephone circuit (the same as case 1);
b) dedicated telephone circuit;
c) separate signalling network for common channel signalling.

For a) and partly b) the same applies as for case 1 above. Signalling in case 1 and a) is split up in two stages, a first stage when the connection is set-up between the MTX:s and a second stage with MFC end-to-end signalling between the MTX:s. In case b) the first stage is eliminated.

Case c) requires implementation of Signalling System No.7, MTP, SCCP, MUP and HUP as described in NMT Doc.900-2 Annex 3. It should be noted that it is possible to use common channel signalling without the SCCP function.

9.4.2 Setting-up of a connection MTX-MTX in the telephone network

The setting-up of a connection in the telephone network between MTX:s will be governed by the technical conditions in the different national networks. In principle three methods have been agreed:

1. Common channel signalling according to national specifications.

2. The "code 15" method for MFC.

3. The "digit filling" method.

After received acknowledgement of code 15 with A6 or last digit 9 is sent, MTX signalling is initiated between the two MTX:s.

It shall be possible to use all alternatives. Method 2 and 3 applied to the four Nordic national telephone networks are described below; for details see national specification.

9.4.2.1 Denmark

In the Danish network the code 15 method may be used.
For setting up a connection between Danish MTX:s the originating MTX sends $OM_1M_2X'_1X'_2C_{15}$ or $OM_1M_2X'_1X'_2999$ to the incoming MTX.

For setting up a connection to an MTX in another country the Danish MTX sends $C_{14}I_1I_2$ (I_3) $M_1M_2X'_1X'_2C_{15}$ or $C_{14}I_1I_2$ (I_3) $M_1M_2X'_1X'_2$ 9999 or $C_{14}I_1I_2$ (I_3) M_1M_2 $X'_1X'_2$ 999.

The number is analysed and the call is routed via a Danish N-exchange according to ordinary rules for international calls. After acknowledgement of C_{15} or a with A_6 the two MTX exchanges change over to end-to-end MFC signalling.

For setting up a connection from an MTX in another country a Danish N-exchange receives $OM_1M_2X'_1X'_2$ C_{15} or $OM_1M_2X'_1X'_2$ 999.

The call is treated as an ordinary incoming international call.

9.4.2.2 Finland

In the Finnish network, the code 15 method may be used.

For routing between Finnish MTX:s, the number group $M_1M_2X'_1X'_2C_{15}$ is used, where $X'_1X'_2$ defines the address MTX.

The acknowledgement of C_{15} with A6 causes change-over to MFC end-to-end signalling.

For setting-up a connection to an MTX in another country, the Finnish MTX sends:

$C_{11}I_1I_2M_1M_2X'_1X'_2C_{15}$ or $C_{11}I_1I_2M_1M_2X'_1X'_29999$ for routing through the Finnish network and Helsinki CT sends

$OM_1M_2X'_1X'_2C_{15}$ or $OM_1M_2X'_1X'_29999$ to the address country.

For setting-up a connection from an MTX in another country to a Finnish MTX $OM_1M_2X'_1X'_2C_{15}$ or $OM_1M_2X'_1X'_29999$ are received over the international circuit.

Incoming and outgoing international calls between MTX:s are in other respects treated as ordinary international calls.

9.4.2.3 Norway

In the Norwegian network the code 15 method may be used.

For setting-up a connection between Norwegian MTX:s, the originating MTX sends $OM_1M_2X'_1X'_2C_{15}$ or $OM_1M_2X'_1X'_29999$ to the incoming MTX.

For setting-up a connection to an MTX in another country, the Norwegian MTX sends

$095I_1I_2$ (I_3) $M_1M_2X'_1X'_2C_{15}$ or $095I_1I_2$ (I_3) $M_1M_2X'_1X'_29999$

or $095I_1I_2$ (I_3) $M_1M_2X'_1X'_2999$.

For setting-up a connection from an MTX in another country, the incoming Norwegian CT receives $OM_1M_2X'_1X'_2C_{15}$ or $OM_1M_2X'_1X'_2999$. The CT performs then the appropriate interworking with the Norwegian procedures for routing to the address MTX.

9.4.2.4 Sweden

In the Swedish network, the digit filling method must be used in a first stage.

For setting-up a connection between Swedish MTX:s, the number group $OM_1M_2X'_1X'_29999$ is used where $X'_1X'_2$ indicate the address MTX. The outgoing MTX changes-over to end-to-end MFC-signalling when the last 9 is sent and answer is received and each transit exchange through-connects speech path when it has repeated this digit. Digits $X'_1X'_29999$ are also repeated to the address MTX which upon reception of these changes-over to end-to-end MFC signalling.

For setting-up a connection to an MTX in another country the Swedish MTX sends first 009 I_1I_2 (I_3) for routing to the outgoing Swedish CT (see para 9.3.4). After change-over to end-to-end MFC signalling the number $C_{14}I_1I_2$ (I_3) $M_1M_2X'_1X'_2C_{15}$ or $C_{14}I_1I_2$ (I_3) $M_1M_2X'_1X'_29999$ is sent from MTX to CT. CT sends $OM_1M_2X_1'X_2'C_{15}$ or $OM_1M_2X'_1X'_29999$ to the address country and through-connects speech path when C_{15} or last digit 9 is acknowledged with A6.

For setting-up a connection from an MTX in another country, the incoming Swedish CT receives $OM_1M_2X'_1X'_29999$ or $OM_1M_2X'_1X'_2C_{15}$ in MFC code and acknowledges C_{15} with A6. This information is translated to $OM_1M_2X'_1X'_29999$ for setting-up through the Swedish network. When the last transit exchange has repeated the last digit 9 to MTX, it through-connects the speech path between the two MTX:s.

9.4.2.5 Signalling on international circuits

On international circuits with R2 signalling, the information sent for setting-up a connection between MTX:s in different countries is:

$OM_1M_2X'_1X'_2C_{15}$ or $OM_1M_2X'_1X'_29999$.

Signals X'_1, X'_2 and C_{15} may be acknowledged with signal A12. Retransmission shall then start with OM_1M_2.

When signal C_{15} or last digit 9 is acknowledged with A6, end-to-end MFC-signalling shall be according to para 9.4.3.

Should international circuits with CCITT:s signalling system No. 4 be used for connections between MTX:s, the following information is sent:

$OM_1M_2X'_1X'_2C_{15}$ or $OM_1M_2X'_1X'_29999$	I - 15 ..... or $X'_1X'_29999$
In No. 4 code	MFC-code

When I-15 or last digit 9 is acknowledged with A1, end-to-end MFC signalling is established between the two MTX:s.

If calls between international MTX:s are routed in international transit, standard transit signalling procedures for the R2, No. 4 signalling or common channel signalling systems respectively are used.

9.4.3 MFC signalling end-to-end between MTX:s

In MFC networks, the through-connection of speech path between the two MTX:s (including any repeating MFC register as e.g. outgoing international MFC register) is achieved by acknowledging code 15 or last digit 9 with A6 if not achieved earlier in normal MFC procedure. With the digit filling method each transit exchange through-connects speech-path after having repeated the last digit 9.

The outgoing MTX starts the end-to-end MFC-signalling with signal I15. This means that MTX:es in MFC networks send two signals I15, the first acknowledged with A6 and the second with A1. An MTX working with the digit filling method sends I15 after having sent out the last digit 9.

MFC signalling end-to-end between international MTX:s shall be in accordance with the specification for the CCITT R2 system. However, between MTX:s some special codings and procedures are employed which are detailed in the following subparagraphs. 6 signalling frequencies are used in both directions. Time supervision and actions to be taken upon time outs as specified for CCITT R2 apply to the exchange of signals end-to-end between MTX:s. However, a prolonged time-out for reception of acknowledgement of the first end-to-end signal (I-15) may be required.

When time-out occurs due to absence of first incoming MFC signal in an MTX working with the digit filling method, congestion tone shall be sent (for the possible event of wrong dialling by a subscriber). When the incoming MTX detects a signalling error or unreasonable information received, a special fault indication shall be sent and retransmission of last message shall take place (see further para 9.4.3.1, tables 3,4 and 5 and para 9.4.3.3.). When the outgoing MTX detects a signalling error, the connection shall be released.

9.4.3.1 Coding of MFC signals between MTX:s

Two groups of meanings are allocated to forward signals, Group I and II, as in the R2 specification. Likewise, two groups of meanings, Group A and B, are allocated to backward signals.

In addition, a third group of meanings of the signals, called Group R, is used in both directions to indicate applicable service restrictions.

These groups of meanings are given in the following tables.

Table 1: Group I Forward signals

Designation of the signal	Meaning of the signal
I-1	Digit 1
I-2	Digit 2
I-3	Digit 3
I-4	Digit 4
I-5	Digit 5
I-6	Digit 6
I-7	Digit 7
I-8	Digit 8
I-9	Digit 9
I-10	Digit 0
I-11	* Signal from push-button set
I-12	# " " " " "
I-13	Test call indicator
I-14	Special information indicator
I-15	- End of pulsing - First end-to-end signal from outgoing MTX

Signal I-14 is used to indicate special information transfer between MTX:s for e.g. updating of roaming information.

Table 2: Group II Forward signals

Designation of the signal	Meaning of the signal	
II-1	Subscriber without priority	
II-2	Subscriber with priority	
II-3	Maintenance equipment	
II-4	Trunk-offering	
II-5	Operator	
II-6	Data transmission	
II-7	Ordinary MS	Roaming MS categories Change over to the receptions of R signals
II-8	MS with priority	
II-9	Portable MS	
II-10	Mobile coin-box	
II-11	Data-transmission	
II-12	Spare	
II-13	Send service restriction indication	
II-14	Not used	
II-15	Not used	

Signals II-7 - II-11 are used when sending MS category from the outgoing MTX (initiating). They are only used for updating traffic and are in other cases translated to II-1.

Signal II-13 is used in reply to signals A-7 - A-11 when MS category is sent from incoming MTX.

Signal II-14 and II-15 are not used in order to avoid confusion with signals I-14 and I-15.

Table 3: Group A Backward signals

Designation of the signal	Meaning of the signal	
A-1	Send next digit (n+1)	
A-2	Message completed service activated in MTXH	
A-3	Address- or message complete. Change over to the reception of Group B signals	
A-4	Congestion	
A-5	Message complete, service not activated in MTXH	
A-6	Address- or message complete	
A-7	Ordinary MS	Message-complete with MS category indication Change over to reception of Group R signals
A-8	MS with priority	
A-9	Portable MS	
A-10	Mobile coin-box	
A-11	Data-transmission	
A-12	Wrong security code	
A-13	Send identity of outgoing MTX	
A-14	Special information indicator acknowledgement	
A-15	Fault indication	

Signals A-7 - A-11 are used when sending MS category from the incoming MTX:

Signal A-12 is used to interchange the meanings of the Group I and Group A signal, i.e. the forward frequency combinations are given Group A meaning and the backward frequency combinations are given Group I meaning.

Signal A-14 is used to acknowledge signal I-14.

Signal A-15 is used to indicate signalling error and unreasonable information received.

Table 4: Group B Backward signal

Designation of the signal	Meaning of the signal
B-1	Spare
B-2	Send special information tone (changed number) (Not used at present)
B-3	Subscriber line busy
B-4	Congestion
B-5	Unallocated number (Not used at present)
B-6	Subscriber's line free, charge
B-7	-"- -"- -"-, no charge (Not used at present)
B-8	-"- -"- -"-, out of order (Not used at present)
B-9	Spare
B-10	No call acknowledgement
B-11	Spare
B-12	Spare
B-13	Send service restriction indication
B-14	Not used
B-15	Fault indication (c.f. A-15)

Signal B-10 is sent when no call acknowledgement is received from MS.

Signal B-13 is used in reply to signals II-7 - II-11 when MS category is sent from outgoing MTX.

Table 5: Group R forward and backward signals

Group R signals are sent in reply to signals II-13 and B-13 and give supplementary information to signals A-7 - A-11 and II-7 - II.11 respectively. After sending and reception of an R signal, the meanings of forward and backward signals are changed back to Group I and Group A meanings respectively.

Designation of the signal	Meaning of the signal	
R-1	No service restriction	
R-2	Suspended from outgoing calls	
R-3	" " international calls	
R-4	" " calls to non-Nordic countries	
R-5	No service restriction	X)
R-6	Suspended from outgoing calls	
R-7	Suspended form international calls	
R-8	Suspended from calls to non-Nordic counties	
R-9	Spare	
R-10	Spare	
R-11	Spare	
R-12	Spare	
R-13	Spare	
R-14	Spare	
R-15	Fault indication (c.f. A-15)	

The signals R-5 - R-8 will be used to inform MTXV that this subscriber has activated a call transfer service. This information will be transmitted to the MS on a per call basis as a special clearing signal, see NMT Doc 900-1.

For MS:s with one of the categories vacant number, blacklisted, changed number or interception, signal R2 is sent towards MTXV.

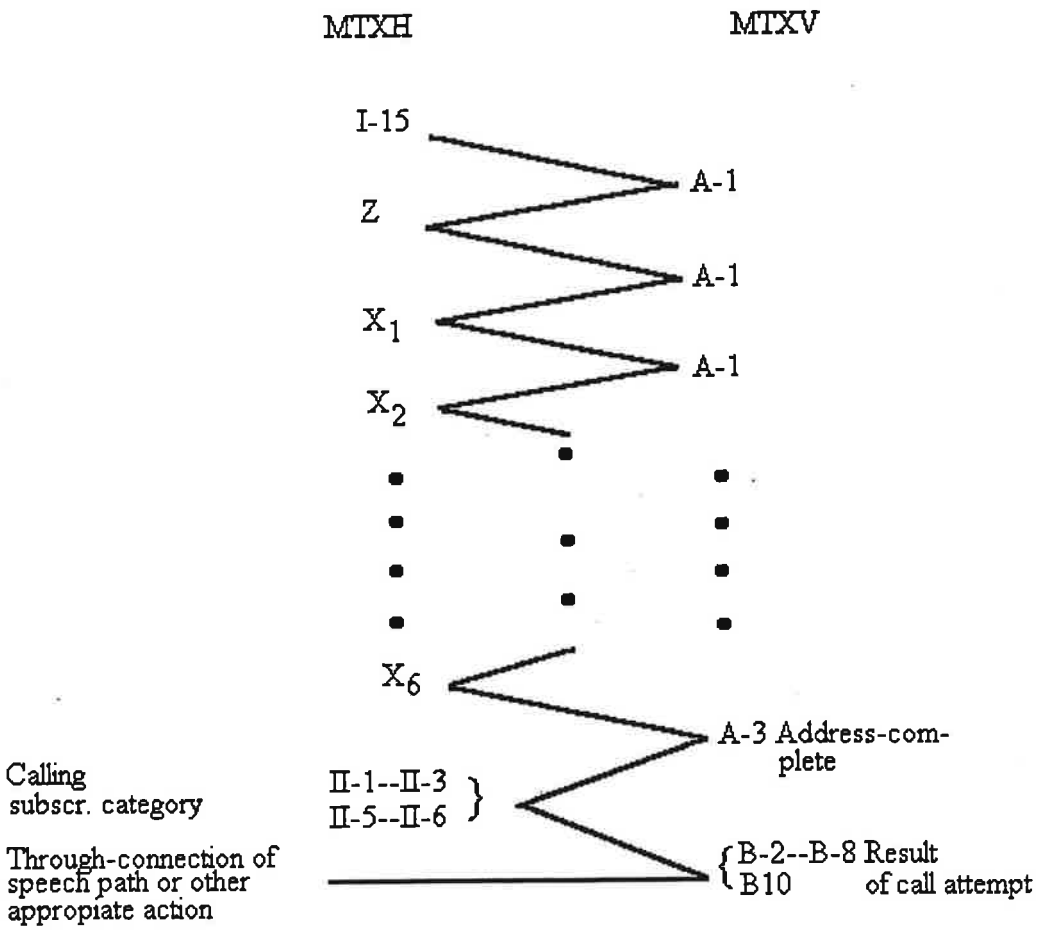
x) Incoming calls prohibited.

9.4.3.2 Forwarding of calls to mobile subscribers

As this case relates to a normal call set-up, the signalling procedures are in accordance with the R2-specification (except for the first code 15).

In this case, the outgoing MTX shall suppress the first answer received. This case is applicable to:

forwarding of call from MTXH to roaming subscriber;



9.4.3.3 Exchange of other information between MTX:s
(see diagram: Examples of information exchanged, below.)

The exchange between MTX:s of the following types of messages is specified now, but additional types may be required later.

a) MTXV updates information about roaming subscribers in MTXH. This requires transfer from MTXV to MTXH of the identity of MTXV ($Z'X'_1X'_2$) and or more MS numbers and for each MS number transfer of MS category from MTXH to MTXV.

b) MTXH cancels roaming information in an earlier MTXV. One or more MS numbers are transferred from MTXH to earlier MTXV.

c) MTXH updates MS category information which is stored in MTXV. MS number with category is transferred from MTXH to MTXV.

d) MTXH cancels MS category information which is stored in other MTX:s according to c).

e) MTXV transfers to MTXH information received from a roaming MS for the control of special services in MTXH.

In this case, the setting up of a connection between MTX:s takes a long time in relation to the time to send a message. Further the time requirements for this type of information updating are such that messages may be collected for more subscribers before they are sent out. Therefore the signalling is arranged to permit consecutive transfer of all types of messages on the same connection.

When sending these messages between MTX:s, each type of message is indicated by a special information indicator (signal I-14) followed by a digit U, indicating the type of message. The incoming MTX responds to the special information indicator by a special acknowledgement signal (signal A-14) to secure full synchronism between outgoing and incoming MTX:s.

The digit U indicates the following types of messages:

U-1 MTXV updates roaming information in MTXH

U-2 MTXH updates category information in MTXV

U-3 MTXH cancels roaming and category information in other MTX:s

U-4 MTXV sends to MTXH special service control information received from a roaming MS in the same order as received from the MS. The information transferred may be for activation, inactivation or verification of special services. MTXH informs MTXV whether the information is accepted/confirmed or not. If the subscriber is updated in MTXV but MTXH has another exchange registered as MTXV, the subscriber shall be cancelled in the earlier MTXV (U-3). An U-2 message shall be sent to the new exchange if necessary.

U-5 - U15 Spare

In order to get a uniform signalling procedure and to facilitate check and fault tracing, the identity of the outgoing MTX ($Z'X'_1X'_2$) is always sent first when transferring special information. When the incoming MTX detects a signalling error, signal A-15, B-15 or R-15 (depending on position in signalling sequence) is sent to the outgoing MTX. The outgoing MTX shall then retransmit the identity or the last message sent starting with signal I-14 (or I-15).

If A-15, B-15 or R-15 is received during the retransmission, the connection shall be released.

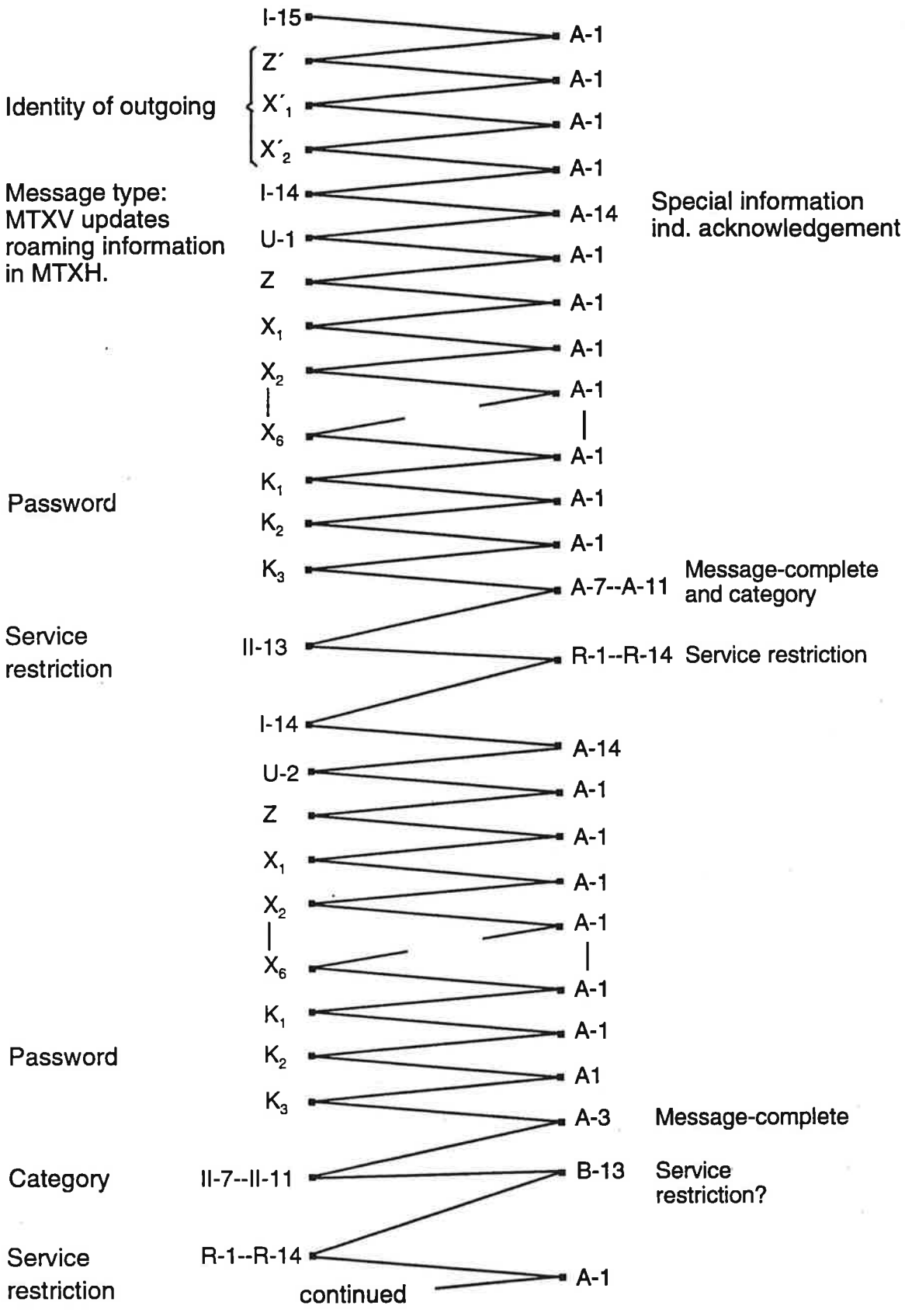
If A-12 is received by outgoing MTX in response to K_3, then the subscriber is removed from the visiting register after a number of attempts with wrong security code and MTXH will then send an U-2 message with restriction value R-2 or an alarm will be printed out or both blocking of the subscriber from outgoing calls and an alarmprintout (See sequence diagram: Updating messages, false roaming subscriber, below.)

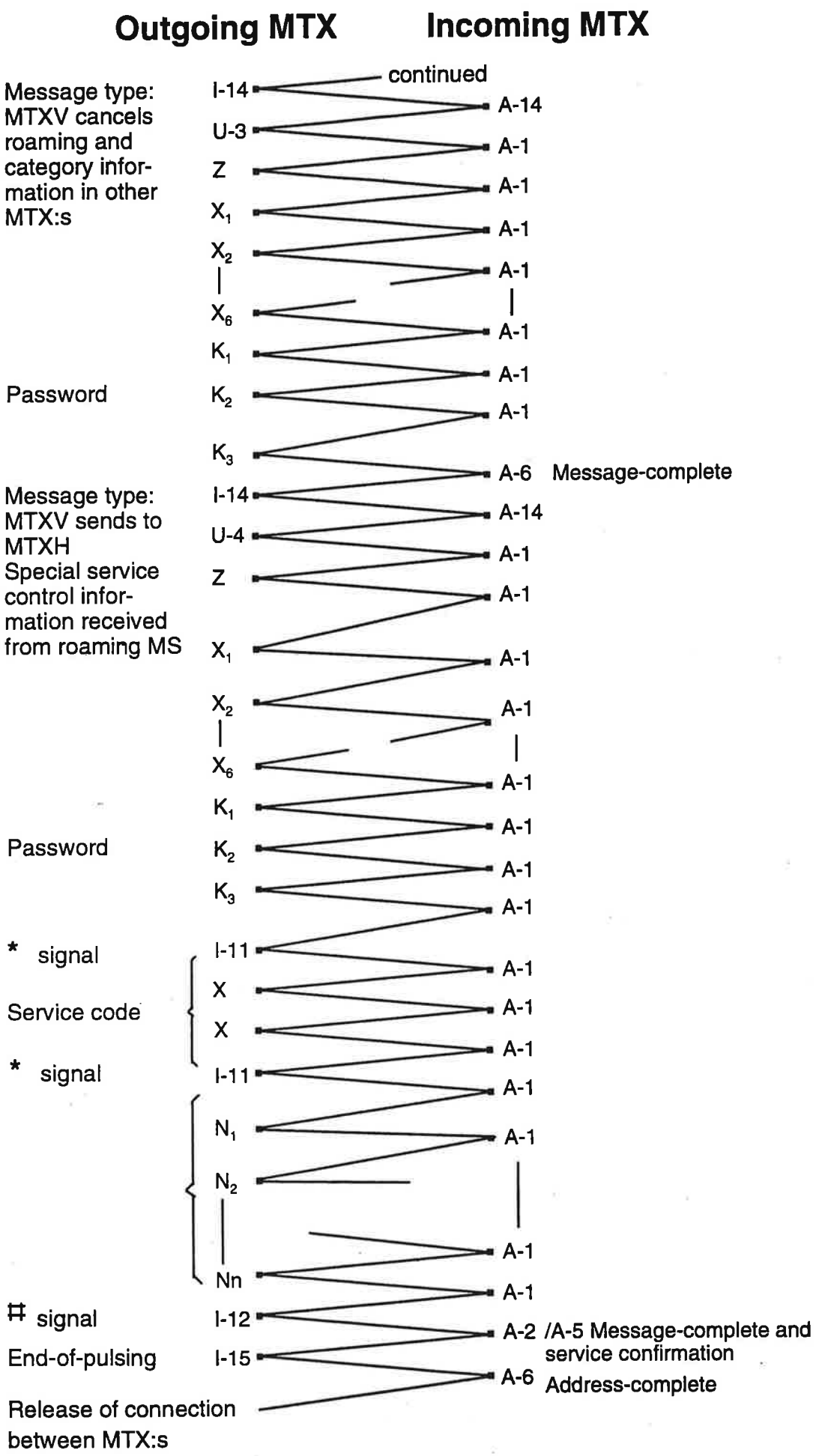
The number of attempts is selected by an exchange parameter (value range 1-16, default value = 3).

If A-12 is received by outgoing MTX as response to K_3, then the subscriber is removed from the visiting register.

If I-15 is received by incoming MTX after transmission of A-1 as response to X_6, then this means that no $K_1K_2K_3$ will follow. Incoming MTX continues with A-7 - A-11. This is to maintain compatibility with the signalling specified in NMT Doc.2. (NMT-450).

Example of information exchanged:

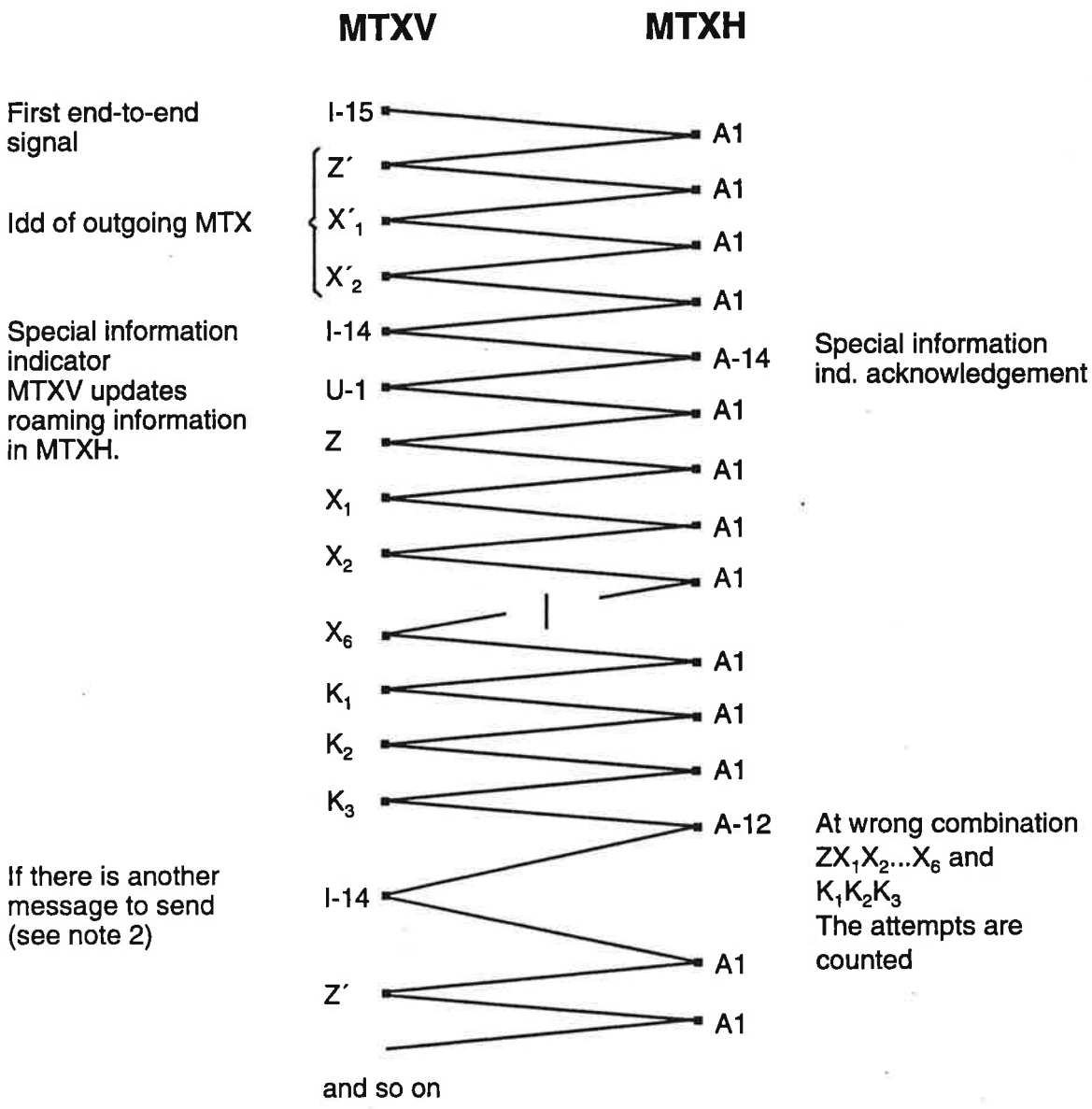



Outgoing MTX
Incoming MTX
continued
Message type: MTXV cancels roaming and category information in other MTX:s
I-14
A-14
U-3
A-1
Z
A-1
X1
A-1
X2
A-1
X6
A-1
K1
A-1
Password
K2
A-1
K3
A-6
Message-complete
Message type: MTXV sends to MTXH Special service control information received from roaming MS
I-14
A-14
U-4
A-1
Z
A-1
X1
A-1
X2
A-1
X6
A-1
K1
A-1
Password
K2
A-1
K3
A-1
* signal
I-11
A-1
Service code
X
A-1
X
A-1
* signal
I-11
A-1
N1
A-1
N2
A-1
Nn
A-1
signal
I-12
A-2
/A-5 Message-complete and service confirmation
End-of-pulsing
I-15
A-6
Address-complete
Release of connection between MTX:s

Updating messages for false roaming subscriber:

First to n - 1 attempt to update a false roaming subscriber

(see note 1)

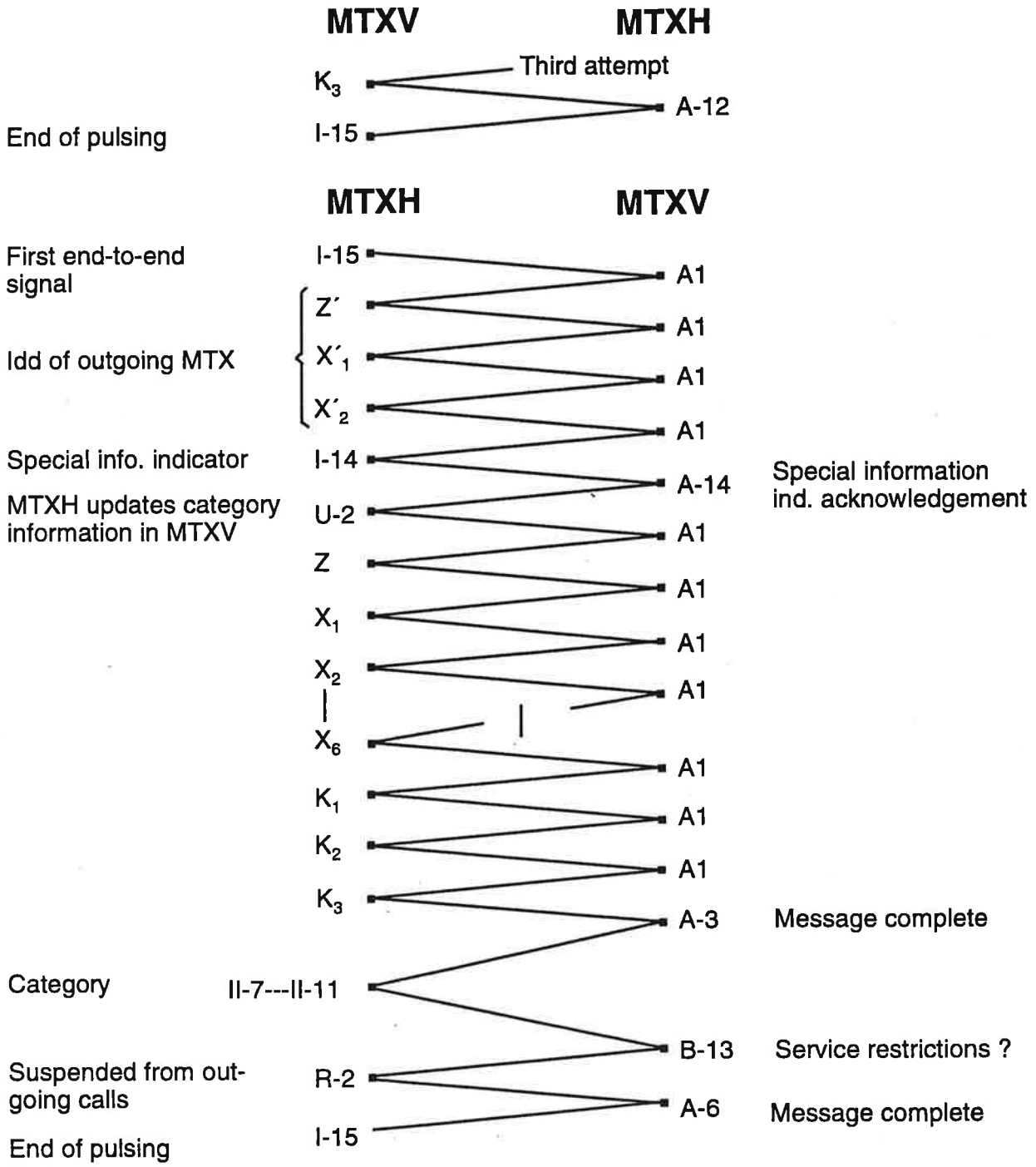


Note 1: n = preset value for number of attempts.
(Default value for n = 3)

Note 2: If there is no other messages to be sent from MTXV I-15 will be sent instead of I-14

After n attempts to update a false roaming subscriber, MTXH answers with a U-2 message

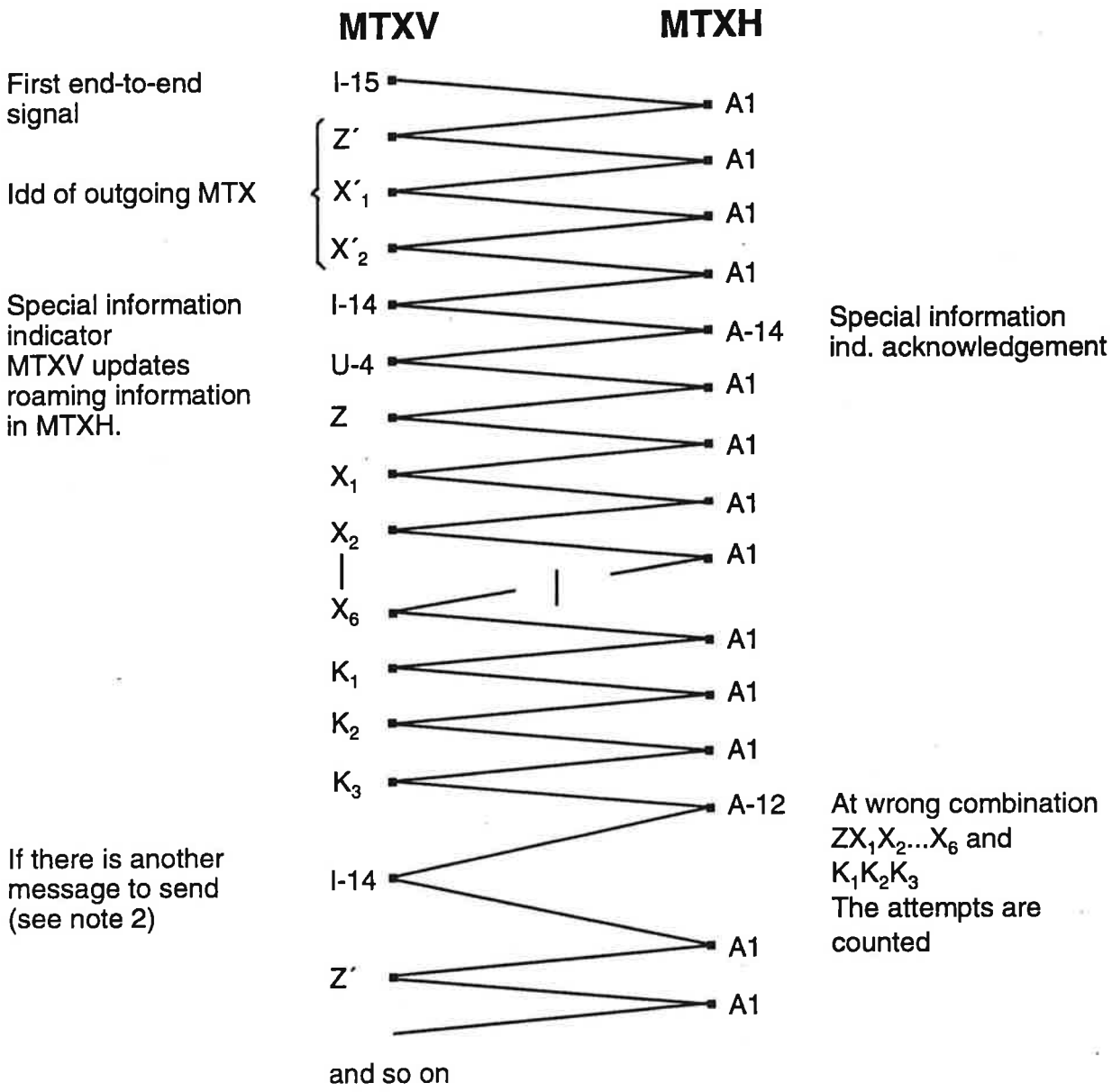
(see note 1)



Note 1: n = preset value for number of attempts.
(Default value for n = 3)

First to n - 1 attempt to send a U-4 message from a false subscriber

(see note 1)

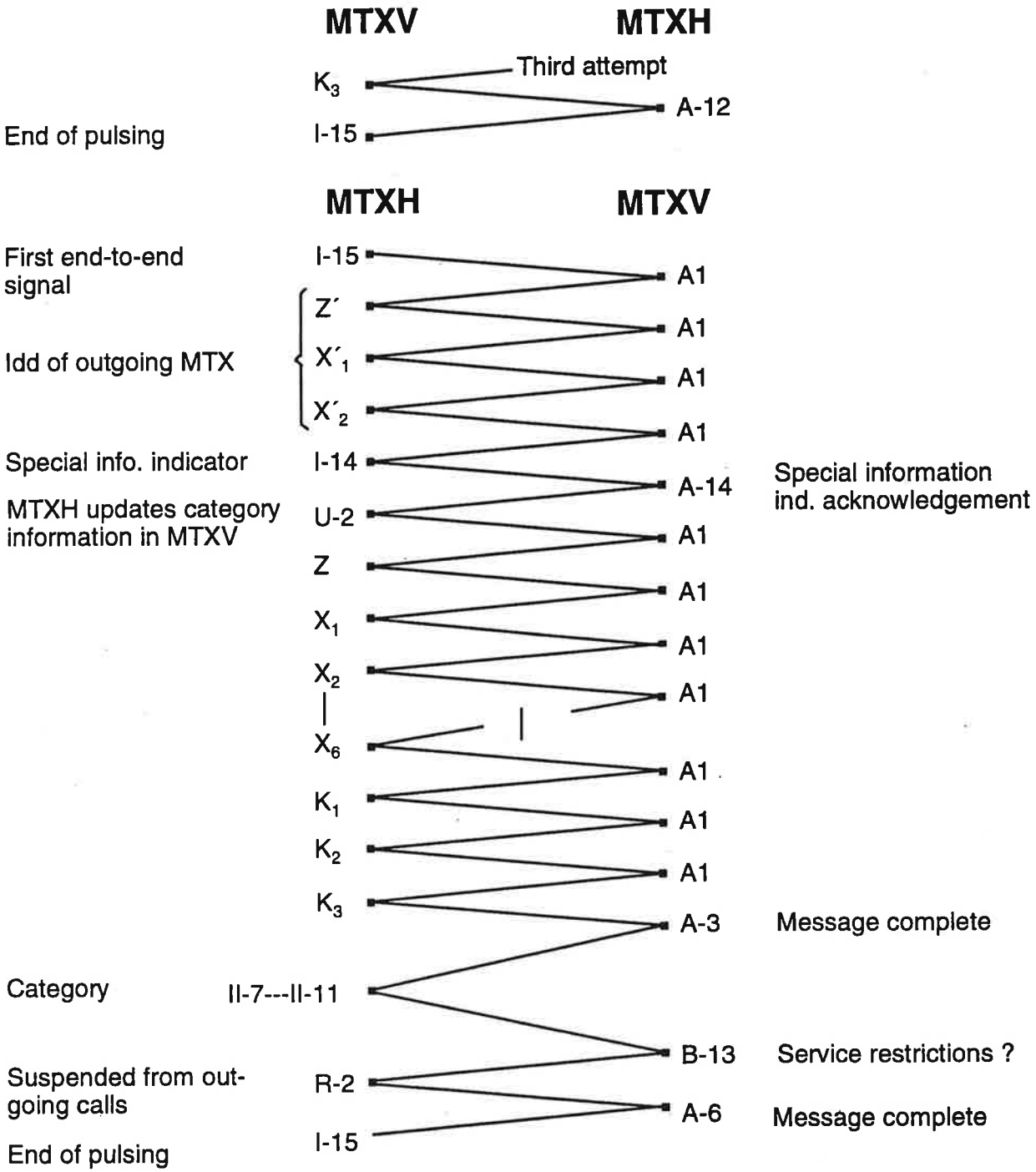


Note 1: n = preset value for number of attempts.
(Default value for n = 3)

Note 2: If there is no other messages to be sent from MTXV I-15 will be sent instead of I-14

After n attempts to send U-4 message from a false subscriber MTXH answers with a U-2 message

(see note 1)



Note 1: n = preset value for number of attempts.
(Default value for n = 3)

9.5 SIGNALLING BETWEEN MTX AND BASE STATION

Two types of signalling between MTX and base station are required:

1. Each calling and traffic channel shall provide for basic signalling functions, such as

   - remote start and stop of transmitters in BS;
   - remote control of supervisory (ϕ) signal between BS and MS.

This signalling is part of the signalling schemes and codes for 1200 Bauds binary signalling between MTX and MS.

2. Remote control of signal strength measurements and other more detailed management and maintenance actions in BS. This signalling shall be arranged in either of the following ways:

   - as 1200 Bauds binary signalling on idle, free marked or busy channel;
   - as 1200 Bauds binary signalling or nationell adapted signalling on a dedicated separate data link between MTX and BS.

A detailed specification for these two types of signalling is given in NMT Doc. 1. and NMT Doc.900-1.

9.6 AUDIBLE INFORMATION

The MTX shall provide for sending of the following audible information to the calling subscriber in appropriate situations:

1) dial tone;
2) ringing tone;
3) busy tone;
4) congestion tone;
5) special information tone;
6) trunk offering tone;
7) recorded announcements.

The characteristics of audible tones in the Nordic countries are given below.

9.6.1 Denmark

Dial tone:	Continuous tone
Ringing tone:	Interrupted tone: 1000 ± 100 ms tone and 4000 ± 400 ms pause. First ringing tone 1000 ± 100 ms
Busy and congestion tone:	Interrupted tone: 250 ms ± 25 ms tone and 250 ms ± 25 ms pause

All these tones have a frequency of 425 ± 25 Hz

The sending level is -9 ± 2.5 dBm

For Danish MTX:es, ringing signal and ringing tone shall not be synchronous.

Special information tone: According to the CCITT specifications (three consecutive tones).

9.6.2 Finland

Dial tone:	Continuous tone
Ringing tone:	Interrupted tone: 1000 ± 250 ms tone and 4000 ± 1000 ms pause
Busy and congestion tone:	Interrupted tone; 300 ms and 300 ms pause. Tone + pause 500 .... 700 ms. Tone/pause = 0.67 ... 1.7
Trunk offering	This information consists of four periods of equal tone: length, which are repeated 30 ± 2 times/minute. In the beginning of the two first periods, the tone is given in 200 ms ± 40 ms. The other two periods are silent. The tone is fed into the point of cross connection whenever an operator or any other justified person is doubleconnected to a busy line.

All these tones have a frequency of 425 ± 25 Hz. The sending level is -6.9 dBm.

Special information tone: According to the CCITT specification (three consecutive tones).

9.6.3 Norway

Dial tone:	Continuous tone
Ringing tone:	Interrupted tone: 1000 ms ± 10% tone and 4000 ms ± 10% pause. First ringing tone 700 - 1100 ms.
Busy tone:	Interrupted tone: 500 ms ± 10% tone and 500 ms ± 10% pause.
Congestion tone:	Interrupted tone: 250 ms ± 10% and 250 ms ± 10% pause.

All these tones have a frequency of 425 ± 25 Hz and a harmonic content less than 5%.

The sending level is -8 ± 2 dBm.

Special information tone: According to the CCITT specification (three consecutive tones).

The implementation of the tones for Norway shall fulfil the requirements specified in subsection C.6.3 - Level and characteristics for tones, ringing current and recorded announcements, of Specifications and Technical Requirements for Digital Public Telephone Exchanges, (2).

9.6.4 Sweden

Dial tone:	Continuous tone
Ringing tone:	Interrupted tone: 1000 ± 100 ms tone and 5000 ± 500 ms pause First ringing tone: 300 ± 600 ms.
Busy tone:	Interrupted tone: 250 ± 25 ms tone, 250 ± 25 ms pause.
Congestion tone:	Interrupted tone: 250 ± 25 ms tone, 750 ± 75 ms pause.

All these tones have a frequency of 425 ± 15 Hz and a harmonic content less than 2%. The sending level is -10 ± 1 dBm0.

Special information tone: According to the CCITT specification (three consecutive tones).

9.7 TIME SUPERVISION

The MTX shall be flexible with regard to time supervision. It shall be by command possible to put individual time supervisions in and out of service and to change the timings.

The following basic supervision of setting-up and clearing of calls is required and shall result in appropriate actions in the MTX.

Call from MS:

- Address complete indication is not received within 40 sec after proceed to send is sent.
- Answer signal is not received within 3 min after end-of-selection.
- Supervisory signal is interrupted longer than 20 sec in speech condition (time supervision in BS).
- Clearing signal from calling subscriber is not received within 90 sec after clearing signal from called subscriber.

Call to MS:

- Answer signal is not received within 30 - 60 sec after ringing order.
- Supervisory signal is interrupted longer than 20 sec in speech condition (time supervision in BS).

- No time supervision upon clearing signals from calling or called party, i.e. first party release.

Additional time supervision is required for the different signalling systems to be handled by the MTX, for special subscriber services and for management and maintenance functions. Details about these timing requirements are given elsewhere in this specification, in NMT Doc. 1 and NMT Doc. 900-1 and in national specifications.

9.8 SIGNALLING BETWEEN MTX AND AR.

9.8.1 General

The following is a specification for the communication protocol between the MTX and the authentication register. The purpose of this communication is to transfer triplets of RAND, SRES and BKEY belonging to a subscriber, according to the NMT-SIS specifications, from the AR to the MTX. This communication may be initiated by either the MTX or the AR.

9.8.2 Protocol

9.8.2.1 Information block layout

Data shall be transmitted in blocks. These blocks are referred to as information blocks.

The layout of an information block is shown in figure 9.8-1.

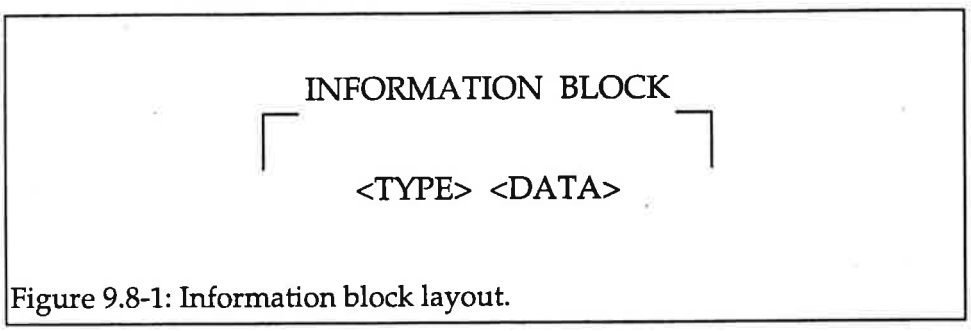


Figure 9.8-1: Information block layout.

9.8.2.2 MTX - AR link protocol

The communication protocol between MTX and AR shall be according to CCITT X.25 (1984)

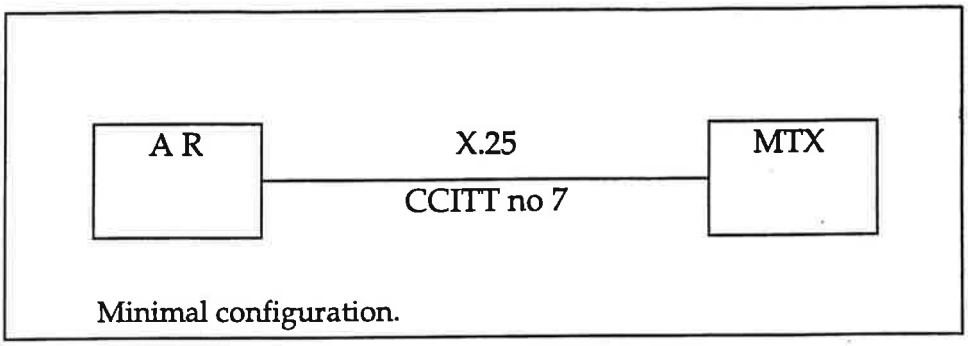
Both the MTX and the AR must be able to process X.25 messages for setup (MTX must have the X.25 destination address for the connected AR), call supervision and release.

The use of Closed-User-Group and Fast-Select service facility will be considered by the Administration.

9.8.2.3 Failure situation.

9.8.2.3.1 Introduction.

The NMT-system with NMT-SIS implemented, consists of at least two functional blocks: the MTX and the AR.



Minimal configuration.

Under normal conditions, the AR shall be able to answer any request for triplets from the MTX within 1 seconds.

9.8.2.3.2 Availability performance of the MTX.

The MTX shall primary handle calls and traffic, independent of the availability of the AR function. Refreshing triplets shall not be regarded as a primary function for traffic handling during AR failure.

The availability performance of the MTX, as specified in Chapter 16 of NMT Doc.900-2/NMT Doc.2, shall not be influenced by the SIS function

9.8.2.3.3 Definition of AR failure.

If the AR is unable to answer a request for triplets from an MTX, in time, due to:

- AR overload condition.
- hardware failure.
- software failure;

then the situation is considered as being an AR failure

9.8.2.3.4 AR processing capacity.

The AR processing capacity shall be sufficient for the calculation and distribution of triplets for the number of calls in progress per hour for 300.000 subscribers, when the MTX serving these subscribers are loaded with the maximum of expected call attempts.

The capacity of the AR shall be large enough to take steps against possible harmful effects of overload. The generation of wrong triplets by the AR due to overload condition shall be impossible.

When the actual AR loading approaches the capacity limit, an alarm shall be generated.

Beyond the prescribed full AR capacity, there shall be a reserve of 40 %, in order to cover traffic peaks and as a security margin.

9.8.2.3.5 MTX operation during AR failure.

When the MTX detects an AR failure, the MTX shall be able to authenticate the MS with random use of stored old triplets.

9.8.2.4 Message types defined.

TYPE		DATA
H'00	Request for triplet (RT)	Originating MTX Subscriber no. No.of triplets
H'01	Transfer of triplet (TT)	Originating AR Subscriber no. Number of triplet/s
H'02	Transfer of triplet (TA)	Originating AR Subscriber no. Number of triplet/s
H'03	No transfer of triplet (NT)	Originating AR Subscriber no. Reason
H'04 } H'FF	For future use	---

9.8.2.5 Messages defined.

Request for RAND/SRES/BKEY

<TYPE> ::= H'00
<data> ::= <IDD><MSNB><N>
<IDD> ::= Identity of originating MTX
(3 bytes (octets))
<MSNB> ::= Mobile subscriber number
(7 bytes (octets))
<N> ::= Number of triplets requested
(1 byte (octet))

Transfer of RAND/SRES/BKEY initiated by MTX

<TYPE> ::= H'01
<data> ::= <ID_AR><MSNB><N><KEYS>*
<ID_AR> ::= Identity of originating AR
(4 bytes (octets))
<MSNB> ::= Mobile subscriber number
(7 bytes (octets))
<N> ::= Number of triplets following
(1 byte (octet))
<KEYS> ::= <RAND><SRES><BKEY>
(13 bytes (octets))
<RAND> ::= Selected random digits
<SRES> ::= Signed response
<BKEY> ::= Key for B-number encryption

Transfer of RAND/SRES/BKEY initiated by AR

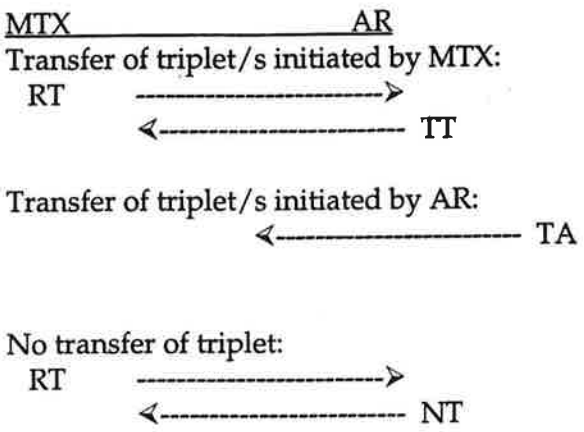
<TYPE> ::= H'02
<data> ::= <ID_AR><MSNB><N><KEYS>*
<ID_AR> ::= Identity of originating AR
(4 bytes (octets))
<MSNB> ::= Mobile subscriber number
(7 bytes (octets))
<N> ::= Number of triplets following
(1 byte (octet))
<KEYS> ::= <RAND><SRES><BKEY>
(13 bytes (octets))
<RAND> ::= Selected random digits
<SRES> ::= Signed response
<BKEY> ::= Key for B-number encryption

No transfer of RAND/SRES/BKEY

<TYPE> ::= H'03
<data> ::= <ID_AR><MSNB><REASON>
<ID_AR> ::= Identity of originating AR
(4 bytes (octets))
<MSNB> ::= Mobile subscriber number
(7 bytes (octets))
<REASON>::= Reason for no transfer of triplet
(2 bytes (octets))

9.8.2.6 Sequences

Possible message sequences between MTX and AR :



10 SWITCHING IN MTX

Digital network shall fulfil the requirements stated by CCITT and CEPT.

10.1 FOUR-WIRE SPEECH PATH

The selecting network shall be designed for connecting through all traffic by means of a four-wire speech path.

10.2 ACCESSIBILITY IN THE SWITCHING NETWORK

It must be possible to connect each incoming line to any outgoing line. This shall be possible to perform in all expansion stages of the selecting network.

10.3 SELECTION OF LINES

10.3.1 Individual selection

For measurement or test purposes it is necessary to engage a certain individual line. Due to the difficulty to reach an individual line when it is free, it shall be possible to reserve it during any occupation in progress so that individual selection can take place immediately after a finished call.

10.3.2 Order when selecting a line

In order to avoid that a faulty line, which permits busying, is not engaged by repeated calls, the selection of a free line in an outgoing route shall take place in such a way that the starting point for search is varied, e.g. by being moved forward one step for each call.

10.3.3 Repeated connection attempts

On e.g. the following occasions at least one and at most two renewed connection attempts shall be made when

- the establishment of call is prevented due to faulty equipment;
- internal blocking in the switching network;
- unsuccessful speech path control at common channel signalling. Not applicable for the establishment of calls to another MTX.

10.4 BLOCKING IN THE SWITCHING NETWORK

Having an average load per inlet of 0.75 Erlang the probability of not being able to establish a connection from an arbitrary incoming circuit to a selected free circuit in any desired route shall not exceed 5% (individual selection). This implies, in conjunction with the requirements of one or more reselections in the case of an unsuccessful first attempt, that the resulting blocking due to the switching network will be less than 0.2% to a route having more than one free circuit.

The above-mentioned blocking values shall be valid also under a bias load of traffic to and from MTX towards mobile of up to 10%. By bias load is meant the ratio between the load for the group of links in question and the average load per similar link route in the whole exchange.

10.5 CONNECTION AND DELAY TIMES

10.5.1 Delay at through-connection

By through-connection time is meant the time from when sufficient information has been received to enable the starting of the connection of the switching network until there exists a speech contact between the incoming circuit or signalling device and the outgoing circuit. The time consists of a function time which is independent of the traffic and a waiting time which is dependent of the function time as well as the calling intensity towards the control equipment.

By over-load is meant a 10% increase of the traffic and/or a 40% increase of the calling intensity, in both cases compared with the max. rated figures. The over-load is envisaged to last for at least one hour. The following demands on the through connection time are put forward.

At ordinary traffic a maximum of 1% of the connections may have a throughconnecting time exceeding 500ms.

At over-load a maximum of 10% of the connections may have a through-connecting time exceeding 500ms.

10.5.2 Connection of signal receiving devices

By register-connection-time is meant the time from when a calling signal (engagement signal) has been received in the incoming repeater until a proceed-to-send signal (input signal) is sent from the register or a corresponding device. This time consists of a traffic-independent function time and a waiting time which depends on the function time as well as on the calling intensity towards the registers.

The following demands are put forward for register-connection time.

The function time for register connection must not exceed 200ms.

Provided that free registers (or corresponding devices) are available, a maximum of 1% of the connections may during ordinary traffic have a register-connection-time which exceeds 500ms.

At over-load a maximum of 10% of the connections may have a register-connection-time which exceeds 500ms.

10.6 PARALLEL CONNECTION IN THE SWITCHING NETWORK

In the Nordic telephone network there are certain operator services which require an operator call to a subscriber to be handled in a special way, e.g. parallel connection to a subscriber, when he is already busy (Trunk offering). The switching network must permit such parallel connections on 4-wire path. If the administration so wishes, it shall be possible to send a special tone which indicates that an operator is connected. The specification of the tone is given by the administration.

10.7 REGISTER BLOCKING

The blocking rate shall be $\leq 0.1\%$.

10.8 PUSH-BUTTON DATA TRANSMISSION

In the mobile station the ordinary 12 push-button set possibly complemented with 4 extra buttons A-D, are used for simple datatransmission.

For this case MTX shall be provided with switchable equipment for conversion of 1200 Bauds signalling from the mobile station into the push-button signalling of MFT type used in the telephone network (see CEPT Rec.T/TTT4). The switching network must permit the switching in and out of a converter on a speech connection, caused by the signals "MFT converter in" and "MFT converter out" sent from the MS.

The detailed requirements for push-button data transmission from the MS is given in the NMT Doc. 1. and NMT Doc. 900-1. It shall be noted, that the requirements in the NMT Doc. 900-1 shall be fulfilled concerning speech path control, (splitting and muting).

11 ENVIRONMENT

11.1 GENERAL

The environmental conditions are stated in national specifications. The requirements for the MTX can therefore be more rigid than following specifications, additional requirements may be agreed between the supplier and the Administrations.

11.2 TEMPERATURE AND RELATIVE HUMIDITY

The temperature and relative humidity will be measured 1.5 metres above floor, and 0.5 metres from the equipment.

Fig.11.1 shows the relationship between temperature and relative humidity in two different areas.

The following requirements apply:

a) The equipment shall during it's entire lifetime (see para15.2) operate and satisfy all specifications when the environmental conditions are within area 1.

b) The equipment shall during a period of maximum 1day under working condition withstand without damage temperature and humidity according to area 2, but not including area 1.

When the relationship between temperature and humidity returns to area 1, the equipment shall return to normal operation conditions automatically.

11.3 VIBRATION

The equipment shall function satisfactorily even at accelerations of 0.1g within the frequency range 10-100Hz.

11.4 AUDIBLE SOUND

If a unit incl. I/O-devices generates a continuous or discontinuous audible sound, the level shall not exceed 50dB (A) measured at a distance of 1 metre with a sound level meter specified in recommendation 123 of IEC.

11.5 ELECTROMAGNETIC WAVES

The equipment shall not be disturbed by an electromagnetic field of 1 V/m at frequencies up to 1 GHz and 10 V/m at frequencies above 1 GHz.

The equipment shall not give out electromagnetic waves stronger than 10 V/m within the frequency range 150 kHz to 1 GHz, measured at a distance of 10 metres.

11.6 STATIC ELECTRICITY

The equipment shall not be disturbed if a 250 pF ceramic or mica condensor charged to 15kV is discharged to a point which normally can come into contact with persons or objects.

11.7 DUST

The equipment must function satisfactorily even if the dust amounts to 500µg/m³".

11.8 MECHANICAL DIMENSIONS

Cabling between racks shall be at the top of the racks, and necessary height in the room must not exceed 3.4 metres. Under transportation and mounting no unit must weigh more than 500kg.

The floor loading shall not exceed 300kP/m². It is preferred that the MTX shall not require conducting or two-layer floor.

11.9 SAFETY FROM FIRE

All materials must be chosen in consideration of reducing fire risks, i.e. the materials shall with acceptable result withstand the following test.

A sample of the material is set afire by putting it to the warmest part of a non lighting flame from a 10mm Bunsen's burner. The flame shall in this way work upon the sample for 10seconds. After the Bunsen's burner has been moved away, the material may only burn at the place put on fire, and the flame shall have disappeared within 10seconds.

Burning material shall not produce any toxic fumes.

If this requirement cannot be met for a certain material, this material has to be approved by the administration.

11.10 CONSTRUCTION

The equipment shall be so designed and constructed that, in normal and abnormal use, it causes no danger to persons or surroundings.

Wire ways, storage hooks for flexible cables etc. shall be smooth and free from sharp edges.

All exposed metal parts of equipment frames, distributing frames and others in the system shall be constructed of materials properly plated against harmful corrosion and rust.

11.11 PROTECTION AGAINST ELECTRIC CHOCK AND ENERGY HAZARDS

The equipment shall be so constructed that there is adequate protection against accidential contact with parts at dangerous voltages. It shall not be possible to touch with the test finger the functional insulation of parts at voltages above 250V.

The enclosure of the equipment shall have no openings giving access to parts at dangerous voltages other than openings for the use and working of the equipment. If such openings are used, sufficient protection against contact with parts at dangerous voltages shall be provided.

There shall be no energy hazards in operator access areas.

Dangerous voltages denotes nominal voltages above 50V.

Functional insulation denotes the insulation necessary for the proper functioning of the equipment, and for basic protection against electric chock.

Energy hazard denotes a hazard that exists at any live part of a piece of equipment if, between the exposed live part and an adjacent exposed metal part of different polarity, there exists a potential of 2 V or more and an available continuous power level of 240 volt-amperes or more, or a reactive energy level of 20joules or more. Above 50 V peak or d.c. the protection against electric chock will also protect against energy hazards.

Test finger denotes the "Standard test finger" described in IEC publ. 435 (Safety of data processing equipment), page 144.

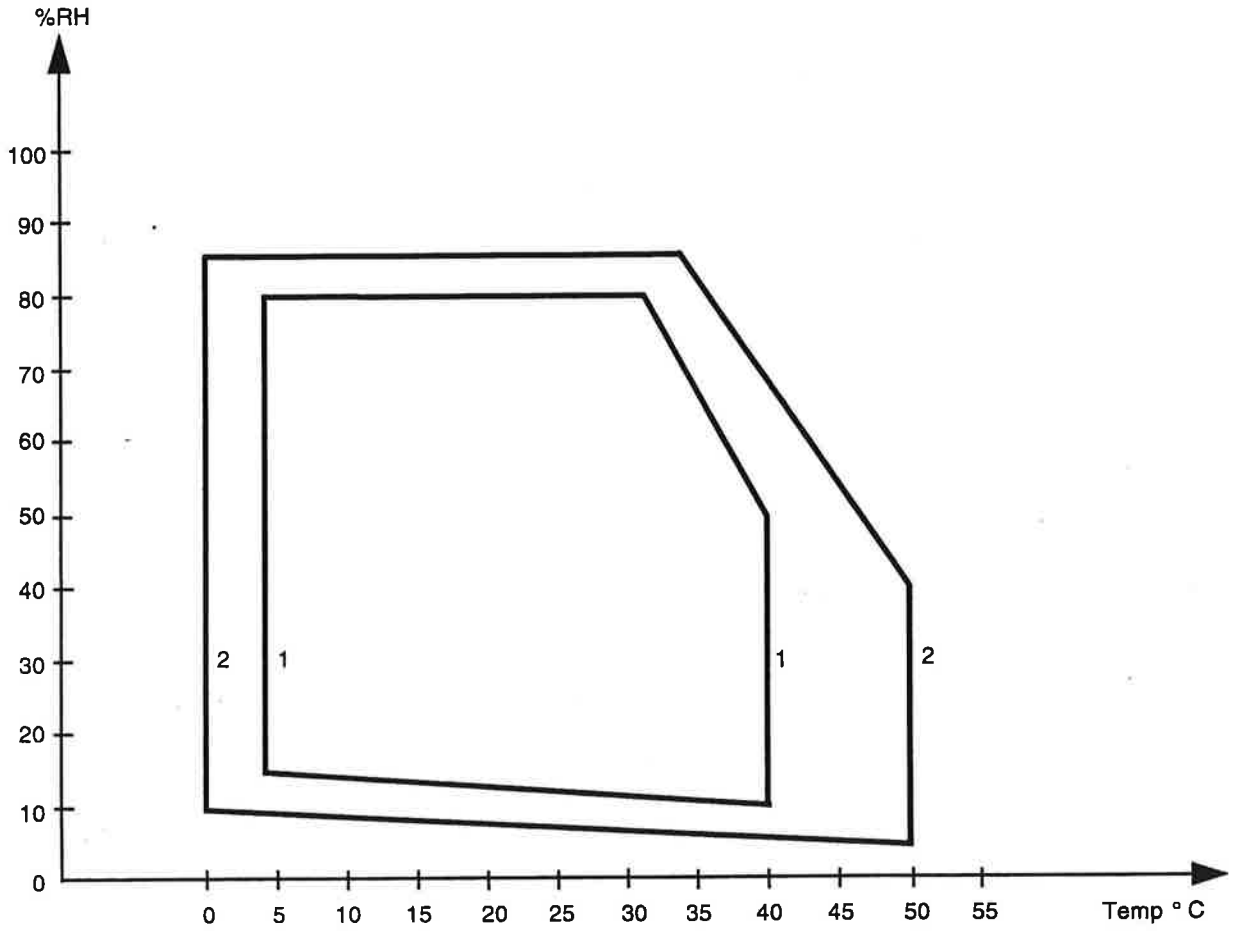


Fig. 11.1 Temperature and relative humidity

12 POWER SUPPLY

12.1 GENERAL

The individual types of equipment in the network shall be capable of being powered in accordance with the following.

12.2. SUPPLY VOLTAGES

12.2.1 MTX

The MTX's should be offered for connection to -48 V DC. For I/O units (such as printers and visual displays) the mains voltages of 220 V AC may be used.

12.2.2 Efficiency

Power supply equipment connected to 220 V AC or -48 V DC and used for supplying various system voltages shall have a total efficiency of at least 0.7 at full load.

12.3 AC VOLTAGE SOURCE

12.3.1 Specifications of voltage source

The equipment shall be capable of being connected to an AC voltage source with the following characteristics:

12.3.1.1 Voltage

Nominal value:	220 V
Range of variation	198 to 242 V

12.3.1.2 Frequency

Nominal value:	50 Hz
Range of variation:	48.0 to 52.0 Hz

12.3.1.3 Form factor

Nominal value:	1.11
Range of variation:	1.08 to 1.14

12.3.1.4 Harmonic distortion

Harmonic distortion	0 to 10%.

12.3.1.5 Impedance

To be specified later.

12.3.2 Safety requirements

The electrical assembly and the components in direct connection with the power network shall satisfy all relevant requirements in the national Power Current Regulations.

12.4 DC VOLTAGE SOURCE

12.4.1 Specification of DC voltage source

The equipment shall be capable of being connected to a DC voltage source (battery source) with the following characteristics:

12.4.1.1 Voltage

Nominal value:	48 V
Range of variations:	40.5 to 57 V

Within the range of variation, voltage jumps of ±6 V may occur on connection and disconnection of battery cells. The positive terminal of the battery is connected to earth.

12.5 VOLTAGE DISTRIBUTION

The equipment shall be capable of being connected to the existing power supply systems without any special arrangements. The Tender shall contain information stating what requirements apply to the individual equipment types in regard to voltage distribution. If any special material is required to be used, this shall be included in the Tender.

12.6 EARTHING

Earthing of the equipment shall be possible via an earth distribution system.

12.7 POWER CONSUMPTION

The Tender shall contain information stating the power consumption of the indivudual equipment types. The power consumption shall be stated for each of the voltages used and shall be stated in such a manner that the power consumption for any stage utilization can be derived therefrom.

12.8 TRANSIENT AND NOISE VOLTAGES

The equipment in the exchange shall be able to tolerate transient and noise voltages from the power supply equipment.

Transient and noise voltages generated by the MTX towards the power supply equipment shall be kept inside specified limits.
The allowed limits are to be found in the national specifications.

13 FLEXIBILITY

13.1 OVERLOAD CAPACITY AND PROCESSING TIME

When the common equipment in the MTX (code receivers, code transmitters and processor system) are operated beyond the maximum operating limit allowed (overload), the exchange shall be able to locate and analyse the overload, as well as to take steps to counteract undesired effects resulting from the overload. At the same time, the exchange shall retain maximum operation capacity, regardless of the volume of traffic offered, and also prevent that the steps taken to counteract overload cause other exchanges to be overloaded. See para 2.7 concerning processing time.

13.1.1 Overload of common traffic-handling units

The number of waiting blocked calls towards a group of common traffic handling units shall be registered and if a preset value has been exceeded one of the following methods could be used to counteract the overload.

- delayed deblocking of the incoming circuits;
- time determined blocking of the incoming circuits.

The MTX shall be prepared for interchanging network management signals with the telephone network.

13.1.2 Overload of processor system

The execution rate of programmes on the lowest traffic handling level shall be registered and/or the calls-in progress rate shall be registered. Here, the overload criterion shall be a lower execution rate during a presetable period than a presetable minimum value, alternatively, that the number of waiting calls following a pre-setable number of successive registrations, is in excess of a presetable maximum value.

When overload of the processor system occurs, the following steps could be taken:

- delayed de-blocking of the lines controlled by the processor concerned;
- time-determined blocking of the above-mentioned lines.

The steps taken shall cease when the execution rate during a presetable period is higher than a presetable maximum value, alternatively, when the call in progress rate, following a presetable number of successive registrations, is lower than a presetable minimum value.

It shall be possible to perform the necessary presetting of values by man machine orders and to obtain print-out reports on current state and steps taken.

13.2 COMPUTER CAPACITY RESERVE

13.2.1 Data processing capacity

The data processing capacity shall be sufficient for the reception, processing and surveillance of the prescribed number of calls in progress per hour, with the prescribed number or periods of waiting and refused calls, and also suffice for the simultaneous registrations and surveillance, taking steps and making of measurements etc., while the MTX is operated at maximum capacity. In particular the capacity shall be large enough to take steps against the harmful effects of overload (see para13.1), yet at the same time maintain the stipulated traffic handling capacity while the already mentioned traffic measurements and situation analysis are being carried through.

Hardware measurements devices and other units like e.g. microprocessors may be included in order to satisfy requirements.

Beyond the prescribed full capacity of the call processing system, there shall be a reserve of 40%, in order to cover traffic peaks, and as a safety margin.

13.2.2 Data storage capacity

The data storage capacity shall cover all prescribed on-line information. When the MTX is operated correctly without errors, information shall not be lost due to limited data storage capacity, including delayed delivery of data to the mass storage.

In relation to the data storage capacity necessary for the MTX, there shall be a simple possibility for the later addition of a reserve capacity of at least 100%.

To the outer mass storage it shall be possible to add in practice unlimited capacity. The transmission to the mass storage shall be effectuated at speeds adapted to the specific mass storage type.

13.2.3 Programme storage capacity

The programme storage capacity shall cover all prescribed on-line functions. In relation to the programme storage capacity necessary for the MTX there shall be a possibility for the later addition of a reserve of at least 100%. Besides, there shall be a possibility to use additional programme storages with the same capacity as the ordinary storage.

The possibility of adding mass storage shall in practice be unlimited in scope and it shall be possible to enter the desired programmes into the ordinary programme storages at speeds adapted to line printers and magnetic tape, as well as to discs.

13.3 MODIFICATION AND ADDITION OF FUNCTIONS

The reserves in the data and programme storages mentioned in para 13.2 are intended to be used when modifications are to be made and functions added.

Changes in the programmes and additions to the programmes due to changes and additions in the function specifications shall be provided/delivered ready to be read directly into the programme storage, i.e. including loading in such a way that the changes in the programme include addressing and adjusting to the programme storage and existing programmes of the MTX concerned.

13.4 CHANGE AND ADDITION OF EQUIPMENT. FURTHER DEVELOPMENT

The block division of the data storage etc. and the rack division shall be proportioned to the smallest block size and give the possibility for further development.

It shall also be possible to develop further the processor system and the transfer component at reasonable steps and without interrupting the operation.

14. DOCUMENTATION

14.1 GENERAL

By documentation is meant here all the written and drawn information required for operation and maintenance of the MTX.

To facilitate the use, filing, copying and revision of documents, they shall be supplied in the form of different media dependent on the applications, e.g. photographic material may be appropriate for seldom used documentation, but

- all documents must be transferable to paper copies;
- hardware diagrams must be suppliable in transparent form.

All notations, abbreviations and the like shall be standardized, in accordance with international standards when existent.

The structure of the document library shall be systematic and readily understandable.

The list of contents in the documentation shall be sufficiently detailed, unambiguous and easy to understand.

All documents shall be delivered in three copies/exchange. Further copies shall be available.

The documentation shall be delivered arranged in sets and placed in folders in format A4. The latter does not apply to transparencies of drawings and component lists.

The administration is granted the right to make copies at its own expense of all documents for its own use.

The documentation shall be written in the national language or in English stated by the administration.

The documentation shall be kept up to date by the contractor by delivery of three copies of each modified document.

For purposes of operation and maintenance, one complete set of documents shall be delivered with a functionally oriented, alphabetically arranged retrieval system.

Before every change of equipment in the exchange shall all new documentation for both hardware and software be delivered.

14.2 CONTENTS AND QUALITY OF THE DOCUMENTATION

14.2.1 General documentation

The general documentation, which shall comprise, inter alia, general survey diagrams and descriptions of hardware and software, shall serve as guidance in respect of the more detailed documents dealt with in the following sections. Special regard shall be paid to requirements of understandability and clarity.

The general functional documentation shall describe all individual characteristics of the MTX. It shall describe the functions as a whole and indicate, with references when required, where detailed particulars are documented. It shall comprise, inter alia trunking diagram, layouts and general survey diagrams. In these documents the terms and notations used shall as far as possible be system-independent so that the document may be used by personnel not possessing a thorough knowledge of the exchange.

14.2.2 Diagrams, drawings and descriptions of hardware equipment

Diagrams and drawings of hardware equipment shall be classified and grouped into series so arranged that information can be easily found. They shall show at least the following:

- the external design of the equipment;
- the internal design of the equipment;
- wiring to other eqipment;
- power distribution;
- electrical function of the equipment;
- placing and terminal numbers of the components;
- list of components with type marking;
- test points in the equipment;
- normal values at test points, such as:

the voltage levels during normal operation, pulse shapes and pulse lengths at the points where pulse measurement is appropriate.

The descriptions shall cover at least the following points:

- applications of the equipment;
- functional requirements;
- operational instructions;
- testing instructions;
- maintenance instructions.

14.2.3 Documentation for software

The program documentation shall describe in detail the function of the individual programmes and of the programme interwork down to the instruction and programme sequence level. For this purpose use should be made, inter alia blocking diagrams, flow charts and programme lists both in source language and machine language with associated comments and verbal descriptions.

In addition detailed programme inter work descriptions shall be made available to the administration.

Data structures must be completely described. The use of filing principles shall be indicated. Data structures shall also be described in clear graphic form.

It shall be possible to update all documentation concerned in a simple manner.

14.2.4 Index tables and operational tables

All tables necessary for operation and maintenance of the exchange shall be delivered ready for use.

Tables should be arranged according to the order of search or search number pertinent to each case.

The network component documentation shall include a summary of application - specific variables with indication, for example, of time measurement results, number of test stores, etc.

14.2.5 Operation and maintenance manuals

Manuals for operators containing complete adequate documentation of operating instructions for the MTX shall be supplied. The manual shall enable the operators to handle the MTX and to proceed when data or system problems occur. The manual shall contain command, operation and maintenance procedures. The initializing, restart and other emergency procedures to be followed if the MTX faults must be specified in detail.

There shall be a description for each I/O-device, setting forth the aim and operational purpose of all control and indication devices in the equipment.

Conditions, operation and maintenance instructions for alternation of values assigned to application - specific variables shall exist.

If it is necessary to take more than two corrective measures in a given sequence, they shall be explained "point by point". If there are very dangerous points, they should be underscored in the explanation in order to avoid major operational disturbances and stoppages.

Expected results after the taking of corrective measures shall be indicated in descriptions, operation and maintenance manuals.

The necessary information for carrying out a task shall be obtainable from one or as few as possible places in the documentation. Intermediate results shall be obtainable from the system and from the documentation in such a form that manual calculating operations are avoided as far as possible in the course of the work.

14.2.6 Directions for fault tracing

- It shall be possible unambiguously to determine the appropriate action on the basis of fault output.

- Instructions shall exist which, on the basis of a fault output, indicate the appropriate fault tracing method.

- On the basis of fault output it shall also be possible to determine which diagnostic programme to use, if such is required.

15 QUALITY ASSURANCE

15.1 QUALITY ASSURANCE MANUAL AND PRODUCTION FLOW DIAGRAMS

Contractors quality assurance activities used in the design and production of the MTX shall be in accordance with a quality assurance manual which clarifies in detail quality policy, quality organization and quality system of the contractor. A copy of the quality assurance manual in force as at the data of conclusion of the contract shall be delivered to the administration simultaneously with the tender, and of main subcontractors the contractor shall have delivered quality surveillance reports before the conclusion of the contract.

For each production item (printed boards, printed board assemblies, card racks, wirings etc.) the contractor also shall have supplied to the administration the production flow diagram. Each flow diagram shall clarify the type of tests, measurements and inspections with AQL values and other inspection criteria to establish an effective quality assurance in the production of the item.

Before the start of and during the production the administration shall have the right to carry out quality surveillance at the contractor's and subcontractor's works. If any quality problem is found in the surveillance, the contractor shall without delay implement such corrections and changes in the equality surveillance and/or production procedures as have been mutually agreed upon between the contractor and the administration. The production shall not start or continue before the administration has accepted the result of the quality surveillance.

To subcontractors the contractor shall apply the quality surveillance prior to the start of subcontractor's production. Contractor shall also perform receiving inspection for items manufactured by subcontractors. After prior consent from the administration, the contractor may grant authorized release to the subcontractor and the receiving inspection may wholly or partly be replaced by an extract from quality audit valid for the subcontractor in question.

The quality assurance shall be applied to development and production of hardware and software, and also to modified parts and spare parts to be delivered under the contract.

15.2 QUALITY OF COMPONENTS

The contractor shall use highly reliable components. The components shall be suitable for circuit construction taken both nominal values and stability in account. Such components shall be used to fulfil the reliability and maintainability requirements. The contractor shall make sure that also components delivered by different suppliers or different series of the production as well as components used by subcontractors fulfil the same requirements in regard to reliability and lifetime.

The components shall be specified as assessed quality components (ref. British Standard 9000 and CECC) which means that contractor's specifications shall cover criteria for manufacturer qualification and type specification and conformance inspection taking in account environment, life time and reliability objectives. The life time of the MTX in the specified environment (see para 11.1) shall not be less than 40 years. The life time is the period from the Actual Date of Delivery of the MTX to the end of constant failure rate period.

In the production the contractor and subcontractors shall use specified component types and vendors detailed in lists delivered to the administration. These lists shall be delivered as soon as the design of units or subunits are finished and not less than one month before the start of the production in question. On the basis of the component lists and the reliability predictions of the MTX, the administration has the right to check the quality assurance aspects of the component types (qualification, conformance). If any non-conformance is found, the administration has the right to require the contractor to remedy the non-conformance prior to the production.

15.3 QUALITY OF DESIGN

The design of the MTX shall aim at achieving high stability and a minimum need of tuning and adjusting. Grouping on all levels shall be such as in sures convenient use and maintenance of the equipment. The equipment shall also be easy to install and extend. Modularity with well defined interfaces shall apply in the functional design.

Before the start of any production the administration shall have the right to review the design rules applied by the contractor, taking into account relevant environmental conditions, life time and reliability and maintain ability requirements, and to require remedies to be made to insure that requirements will be complied with. The review of the design rules might, if the administration so decides, be carried out by an expert group set up by the administration and placed at the contractors work.

15.4 ENVIRONMENTAL TESTS

The resluts of the environmental tests for the MTX or sub-units thereof shall be supplied to the administration by the contractor. In case the failure analysis shows a failure as a type defect the contractor shall take corrective actions prior to the start of the production. Such design rules and production methods shall be applied which will insure that MTX will comply the environmental demands.

15.5 QUALITY OF PRODUCTION

The production of the contractor shall follow the principles, methods and practices defined in the quality assurance manual and program flow diagrams.

16 AVAILABILITY PERFORMANCE

16.1 GENERAL

16.1.1 Introduction

Availability performance is the ability of the equipment to be in a state to perform the required function at a stated instant of time or in a stated interval of time and under stated condition.

The availability performance is dependent on the defined objectives, the availability performance activities carried out during the different phases of the equipment's life cycle and on the physical and administrative conditions. The life cycle consist of the following phases:

- design and development phase,
- manufacturing and installation phase,
- operation and maintenance phase.

The availability performance consists of the sub-elements reliability performance, maintainability performance and maintenance support performance.

16.1.2 Application

The availability performance specification applies to hardware, software and documentation of an MTX exchange according to the specification of material.

The requirements apply to a normal operating period. The first 6 months after cut-over are considered to be the run in period. Separate requirements are applicable to this period.

The exchange shall be used as intended and the operation and maintenance personnel shall have adequate training and experience.

When extensions of changes in hardware or software functions are introduced during the evaluation period, their effects on measures must be taken into consideration.

The requirements are valid under condition that the environmental conditions according to the recommended area in the environmental specification for the exchange are fulfilled.

16.2 TERMINOLOGY AND DEFINITIONS

16.2.1 General terminology and definitions

The general terminology used in according to NT-R, Doc-3 and corresponds to IEC Publication 271 and CCITT Recommendation G.106.

16.2.2 Special terminology and definitions

a. Relevant failures

Any software or hardware failure except failures belonging to one of the following classes are classified as relevant.

- Failures due to operational and maintenance personnel's unauthorised actions or neglect.

- Failures due to events and actions during transport and installation outside contractor's control and responsibility.

- Failures due to physical, thermal, chemical or electrical environment outside the environmental specification.

- Failures due to other failures not being repaired within 4 hours. (Applies to redundancy situations or failure combinations.)

- Secondary failures, except for restarts/reloads, see note.

- Intermittent failures (one relevant failure is counted when the failure is found). The fault is to be corrected during a preset time. Otherwise the failure is classified as relevant.

- Failures due to changes in the maintenance and redundance structure of other reasons than repair of relevant failure.

- Failures due to that notified amendments have not been introduced into the exchange.

- Failures due to work and equipment not covered by the evaluation.

Note: Where concerning evaluation of reliability all restarts/reloads shall be included.

b. Software failure

Error of the program code or data which together with the operating state of the system causes deviation from the specified system function.

c. Relevant time, active repair time

The time required by the maintenance staff to localize an correct a failure, and to perform the necessary function checkout to assure the failure is corrected.

Active repair time does not include times dependent on the maintenance support performance (i.e. administrative times, waiting times for spares, personnel etc.) and times in connection with non-relevant failures.

d. Restart

By restart is meant the automatic measures taken to return the MTX to a state in which the traffic handling is resumed on a normal scale after a serious disturbance caused by a hardware or software failure.

The restart can affect the whole equipment or a subsystem, e.g. groups of trunks or base station channel.

e. Minor restart

Minor restart implies that the state "Calls can not be handled" shall not exceed a duration of 30 sec., and that calls in progress are not disconnected.

All connections in setting up phase, on the other hand, are cut off.

f. Major restart

Major restart implies that calls in progress are also disconnected. The duration of the major restart without reloading is less than 30 sec.

g. Reloading

Reloading implies input both of administrative and switching programmes and data through the input/output devices of the MTX. The duration of reloading is less than 3 min. The loading time includes also the time spent on adjustment of the MTX reloaded state and other manual routines.

h. Complete MTX failure

By complete MTX-failure is meant the following two situations.

(I) At least one of the following condition occurs and has a duration of more than 1 minute.

- calls can not be handled
- all calls disconnected

(II) At least one of the following conditions occours and has a duration of more than 5 minutes.

- more than 50 % of the base station channels out of service.
- more than 50 % of the incoming or outgoing trunks out of service.

16.3 REQUIREMENTS OF AVAILABILITY PERFORMANCE

16.3.1 Asymptotic availability

The objective is that the asymptotic (predicted) availability shall be at least 99,9962 %.

Evaluation: Prediction with the following input parameters.

a) administrative + logistic time = 1 hour
b) administrative + logistic time = 2 hours

The predictions must contain information that make it possible to evaluate the results.

16.4 REQUIREMENT OF RELIABILITY PERFORMANCE

16.4.1 Failure intensity for hardware

The total failure intensity of the hardware will depend on e.g. the number of base station channels and trunks. Generally it is expected that the total failure intensity will consist of a constant term owing to common equipment and one or several terms depending on the number of base stations channels and trunks, traffic capacity or other elements.

The contractor shall specify a detailed formula including the size - and the nonsized dependent component.

Acceptable value:

$\lambda = 0{,}015 \cdot N$ failures/year
where N : total number of termination points installed.
Compliance evaluation
- method : NT-R, SPEC-E 2.5
- test parameters: $\alpha = ß = 10\ \%$

The requirements include failure in specified operation and maintenance equipment, and I/O equipment is an integrated part of the equipment.

16.4.2 Intensity of total restarts

Attempts to correct failures in the software automatically (restarts) are indications on software design failures or hardware failures. Thus the intensity of restarts should be low although the operational disturbances caused by single restarts are limited.

The following requirements apply to intensities of restarts affecting the whole MTX.

Depending on the system structure of the Exchange it is assumed that there could be restarts affecting limited groups. Requirements for these will depend of the consequens. The contractor shall specify the predicted restarts intensity and number of lines affected.

If it can be assumed probably that some restarts occurring in a burst are generated of one single failure, only one (the most serious) restart shall be counted.

Restarts in connection with complete MTX failure shall be excluded in the evaluation of restart rate.

Manually initiated restarts, which are carried out, when no other maintenance procedure is prescribed, shall be counted as relevant.

Rate of major restarts without reloading

Acceptable value

$\alpha_0 = 3$ restarts/year

Compliance evaluation

- Method: NT-R, SPEC-E 3.5
- Test parameters: $\alpha \cong ß \cong 10\ \%$

Rate of major restarts with reloading

Acceptable value:

$\alpha_0 = 1$ restarts/year

Compliance evaluation:

- Method: NT-R, SPEC-E 2.5
- Test parameters: $\alpha \cong ß \cong 10$ %

Rate of minor restarts

Acceptable value:

$\alpha_0 = 10$ restarts/year

Compliance evaluation:

- Method: NT-R, SPEC-E 2.5
- Test parameters: $\alpha \cong ß \cong 10$ %

Rate of complete MTX failure

Acceptable value:

$\alpha_0 = 0{,}033$ failure/year

Compliance evaluation according to the flow chart in Fig. 16.4.1.

16.5 REQUIREMENT OF MAINTAINABILITY PERFORMANCE

16.5.1 Fractile of repair time

Both hardware and software failure shall be included.

Acceptable value:

$P_O = P_r (T_r < 2h) = 0.95$ (i.e. 95 % of repair times less than or equal to 2 h)

T_r : repair time.

Compliance evaluation:

- Method: NT-R, SPEC-E 3.5
- Test parameters: $\alpha \cong ß \cong 10$ %

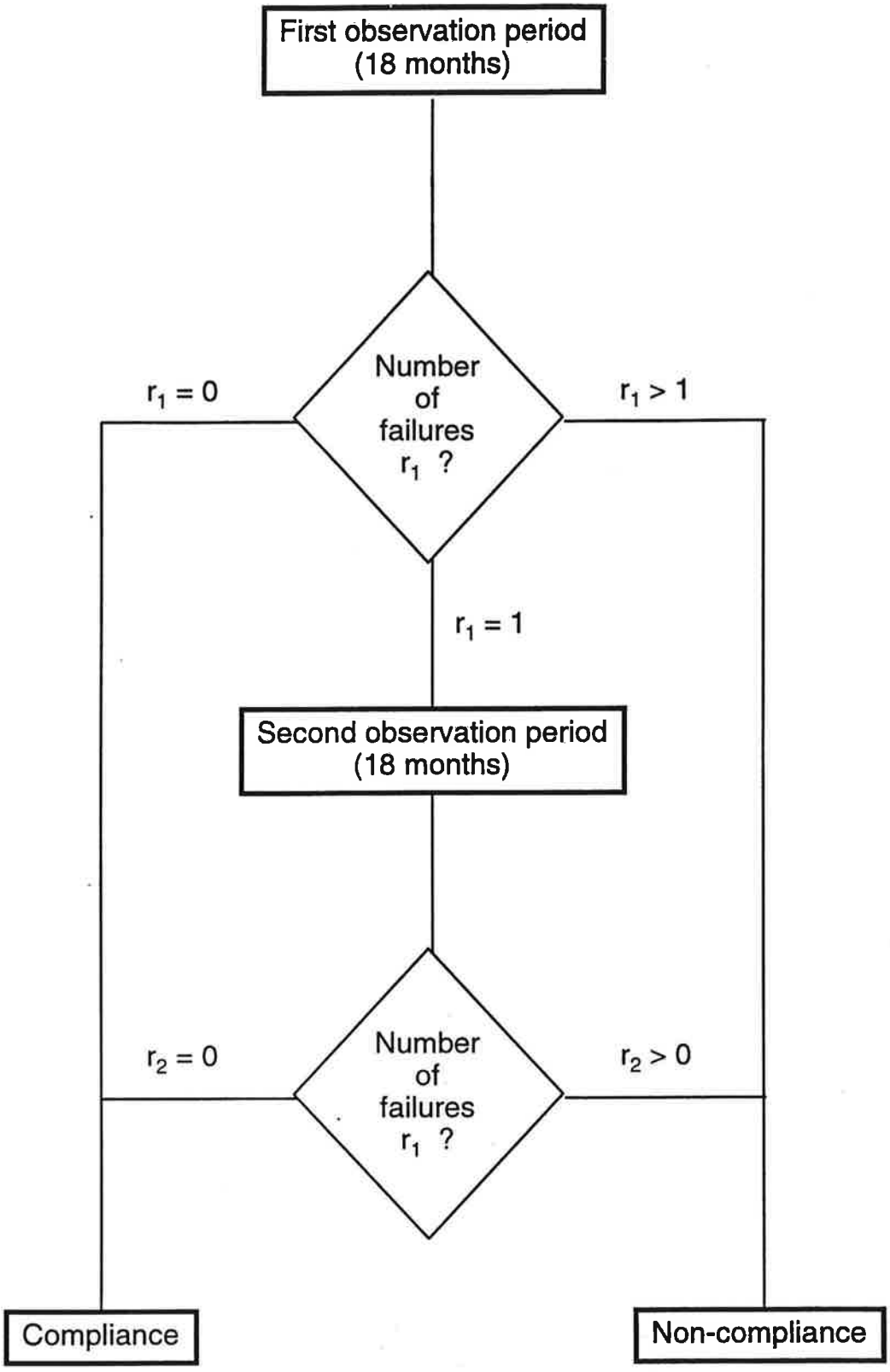

First observation period
(18 months)
Number
of
failures
r_1 ?
$r_1 = 0$
$r_1 > 1$
$r_1 = 1$
Second observation period
(18 months)
Number
of
failures
r_1 ?
$r_2 = 0$
$r_2 > 0$
Compliance
Non-compliance

Fig. 16.4.1

16.6 DATA COLLECTION AND TREATMENT

During the period from cut-over until the end of the first observation period (or when applicable until the end of the second observation period), data collection according to prescribed rules is made and at the end of the period data treatment and statistical analysis are made. Failure reports and failure analysis reports will be based on the principles set up in NT-R SPEC-B 6 and mutually agreed upon.

As a part of the evaluation, the observed data may be analysed in order to indicate significant trends and other properties of the process.

The conclusion at the end of the observation may be one of the following:

a) Requirements complied with.

b) Requirements compiled with, but the statistical analysis indicates a deteriotation process.

c) Requirements not complied with.

d) Requirements not complied with, but the statistical analysis indicates a reliability growth.

In case b) and d), collection of more data and/or further analysis may be necessary to give information about the long-time properties of the MTX.

16.7 REFERENCE

References to NT-R, SPEC-E relate to the documents "Evaluation of Reliability" Revision B, april 1984.

References to NT-R, SPEC-B relate to the document "Basic Reliability Specifications for Telecommunication" Revision B, dec. 1983.

Both prepared by the NT-group Reliability Methodology.

17 SOFTWARE

17.1 NOTES OF INTENTION

17.1.1 General

The requirement specification for software is divided as follows:

- Application programme;
- Control and surveillance programme;
- Test and maintenance programme;
- Programme development.

17.1.2 Comprise of software

The contractor shall provide all software needed for the operation and maintenance of the MTX.

The requirements made in this chapter concern software only. Nevertheless, the contractor shall take the necessary steps e.g. in hardware design, in order to facilitate the use of these functions as intended.

Software shall be built up on the basis of well defined modules, whose function to the largest extent possible shall be independent of those of other modules, and which, separately or linked together, form a function block. By grouping these modules appropriately, it shall be possible to create new function blocks without comprehensive reprogramming.

The contractor shall state the estimated total volume for necessary programmes, both in the primary and the secondary storage. Besides, he shall provide information as to the proportion of software which has been developed and is available in the form of standard programmes.

17.1.3 Software reliabilty

The software shall be designed in such a way that its reliability corresponds to the requirements specified in chapter 16.

17.1.4 Software documentation

The software documentation shall be designed in such a way that operators may procure necessary information concerning the operation and maintenance of the MTX system and that experienced programmers may effectuate additions and modifications in the application programme. When the MTX is to be loaded with new software, all documentation concerned shall be updated (see chapter 14).

17.1.5 Programming standard

The contractor shall indicate that the software has been developed in accordance with a good programming standard.

The contractor shall describe the progamming rules applied (top-down, structured programming etc.).

The contractor shall describe which type(s) of programming language is used for the different software elements, and also motivate the choice of language.

A language at a higher level than assembler shall be used for progamming of the MTX.

17.2 APPLICATION PROGRAMME

17.2.1 Software for function block

The contractor shall provide all application programmes necessary for the achievement of the system functions required.

Besides the application programmes the following programming functions shall be provided when required:

- Updating routines for the introduction of new data.
- Operating and maintenance functions.

17.2.2 Properties of application programme

The application software shall be well modulized. Each module shall be defined by means of a small number of inputs and outputs and the module shall be tested separately with simulated input and output.

To prevent serious disturbances in the system, all information to the application programmes shall be properly tested.

Routines of a general character included in the application programme, and which are relatively comprehensive, e.g. certain mathematical standard calculations/estimations, conversion routines, printout routines etc. shall be made out as subroutines. The interface between these standard routines shall be documented.

17.3 CONTROL AND SURVEILLANCE PROGRAMME

17.3.1 Operation system elaboration

An operation system shall be provided for the control and surveillance of soft and hardware.

The operation system shall organize the work of the system by a system configuration satisfying current reliability requirements (see chapter 16).

To prevent error dispersion in the system, it is necessary to take "failsoft" properties into consideration when designing the programme. "Failsoft" properties prevent the occurrence of errors in one part of the system from leading to errors in other part of the system. The extent to which "failsoft" properties are needed depends on the error rate allowed in the different system units (see chapter 16).

Besides, the operation system shall be designed for operation of a reduced capacity usually initiated automatically or manually initiated modifications of the system configuration. These are either caused by discovery of an error in a system unit, or by the desire to modify the system configuration, in order to introduce programme corrections etc.

Since the MTX will be in continuous operation, it must be possible to disconnect redundant units from the system for purposes of service and maintenance.

The transition from normal to reduced system configurations shall be effectuated either automatically or manually.

17.3.2 Control analysis

Control analysis shall take place in accordance with current rules concerning control languages in computer-controlled telephone exchanges (as mentioned in para 8.8.4).

17.3.3 Fault-handling routines

When a fault is discovered in a part of the system, either by a fault-diagnosis programme (see para 17.4.1) or by a monitoring unit built into the hardware, the operational system shall take the necessary steps to disconnect the faulty functional unit and also store this information in such a way as to render subsequent fault localization possible. The disconnected function unit shall be indicated and the cause of the fault given.

The fault-handling routines shall contain procedures for the transition to alternate processor, for the change of files, changed addressing, feedingout to alternate I/O-devices etc.

17.3.4 Restarting and reloading

The system shall have loading routines rendering possible automatic restarting according to the following:

- Minor restart.
  Connections in call position must not be affected. Only certain data to be restituted.

- Major restart.
  All connections are affected. Total programme system is loaded and data are loaded with initial data.

The loading of a complete system programme or parts thereof shall be performed automatically, from disc or comparable storage or from parallel-working computer in a duplicate system. It shall also be possible to perform the loading automatically/manually from mass storage.

17.3.5 Maintenance of the software system

New version of the software system shall be possible to load and test without disturbing the overall traffic handling capacity of the MTX.

The entire software system including permanent office data and dynamic exchange data (e.g. command and event log.) shall be stored on a disc or comparable media. When system fails the original programme and data shall be automatically loaded from mass storage. The total loading process should not take more than 3 minutes.

17.4 TEST AND MAINTENANCE PROGRAMMES

17.4.1 On-line testing

For the tracing of faults in the system, on-line testing programmes shall be available. These testing programmes shall periodically check the main part of the system units. In case of serious faults, the system shall pass from normal to reduced operation (see para 17.3.1). The position of the faulty unit shall be indicated, and the cause of the fault given.

Background programmes shall be available for more detailed fault analysis (se para 17.4.2).

17.4.2 Background-performed tests

For advanced tracing of faults, low-priority background programmes shall be available for the testing of system units.

Low-priority background programmes shall be used in the system to test the different data areas and hardware units.

It shall also be possible to load new and special programmes for tracing and failures.

17.5 PROGRAMME DEVELOPEMENT

17.5.1 General

New function requirements will call for changes in the software. It shall be possible to perform changes and additions in certain parts of the software without affecting the remaining parts.

The following programme development facilities shall be available:

- Assembly compiler;
- If necessary, compiler for high level languages;
- Tracing, dumping, printing and copying programmes;
- Programmes for the reorganisation of files;
- Programmes for programme testing (interpretative test);
- Library and file-handling routines;
- Auxiliary programme for test of wiring etc. during installation.

17.5.2 Production of system programmes

The contractor shall provide compilers for the proposed progamme languages in order to make possible programme development. A compiler for a high level language shall have an expansion factor less than 1.5 both for time consumption and memory volume.

Less comprehensive programme changes shall be stored as separate programme corrections in the system, if this does not have a harmful effect on the modularity of the programme system.

In the event of more comprehensive programme changes, and if such a large number of programme corrections have been made, that they result in handling difficulties or capacity reduction, the system shall be reloaded with an updated system programme.

In order to commence an operation test and when the exchange is taken over, a maximum of 2 % of the instructions for a block may have the form of programme corrections. These shall be well documented, and shall not be so comprehensive that the capacity of the system is reduced.

17.5.3 Programming system generation

The contractor shall take the necessary steps to make it possible to update the software by programming personnel in the administration. That means that the contractor shall deliver a complete symbolic copy of all necessary programmes on magnetic tape each time a new version of the programming system is released. This means that the production of the final code tape can be done by the administration concerned either on a similar computer or by cross compiling on another type of computer.

18 SWITCHING CALL IN PROGRESS: SUPERVISORY SIGNALLING AND MS OUTPUT POWER REGULATION

18.1 INTRODUCTION

In order to allow economical use of frequencies, the system permits small coverage areas. As a consequence of using small coverage areas the probability of reaching the coverage limit of a base station during a call increases. In order to reduce the inconvenience of this, it is considered necessary to enable the system to switch calls in progress from one BS to another controlled by the same MTX. It shall also be possible to switch calls between BS:s belonging to different national MTX:s, when common channel signalling is introduced.

18.2 SWITCHING CALL IN PROGRESS

In the text below the procedures related to detection of the Ø-signal frequency (correct/incorrect) in the signal strength measurement, are valid for NMT-900 only.

18.2.1 General

During a call a continuous supervisory tone within the frequency range 3945 to 4055 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 signal is detected and evaluated by the BS which indicates if the transmission quality necessitates MS power regulation, switch-over to another BS or disconnection of the call. BS sends information about the evaluation results to the MTX.

In case of switching call in progress, the MTX transmits to the actual and to the surrounding base stations a request for signal strength measurements on the radio channel on which the MS is transmitting. In order to be assured that the measured signal comes from the right MS, the base stations also detect the frequency of the looped supervisory tone (only NMT-900). If some other supervisory tone than the one given by MTX in the measurement order is found, the base station informs about the actual RF-level and that an incorrect Ø-signal is received. Information about the measurement results enables the MTX to decide to which BS (if any) the call should 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 that the signal strength on the used BS is sufficient. For signal strength measuring all BS:s are equipped with a signal strength receiver, (SR) which also includes supervisory tone detectors (only NMT-900). These receivers are remotely controlled by the MTX. To a specific BS with only one SR the MTX shall send the measurment orders in sequence.

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

18.2.2 Conditions

The procedure for switching call in progress is initiated by three different criteria:

1. immediately after address complete at the start of a call set-up MTX order signal strength measurement on the actual BS in order to assure that the signal strength is sufficient. If this is not the case the MTX initiates signal strength measurements on the actual and the surrounding base stations. If a more appropriate BS is found, the call is if possible switched over to this BS.

2. after reception of message from BS indicating that supervisory signal (Ø-signal) level is below 1:st limit but above 2:nd limit, see para 18.2.4, and the MS is transmitting with maximum permitted power. If the MS previously has been ordered to reduce power ,the MTX shall instead order the MS to the highest permitted power level on the actual BS.

3. after answer on a channel in the "base-band" the call shall be switched to another TC outside the "base-band" as soon as possible. (Only for NMT-900)

When a handover is to be performed, following a signal strength measurement, the MTX shall switch the call to the chosen BS, and if possible to a channel outside the dedicated channel band. If no such channel is available, the call shall be switched to a channel in the dedicated channel band, and thereafter the MTX spontaneously shall try to perform handover to a channel outside the dedicated channel band at the same BS without a new signal strength measurement. The time between repeated attempts is the same as used according to paragraph 18.2.4, alternative a), i.e. adjustable between 5 to 20 seconds. The same time is used for both cases. The above paragraph is only valid for NMT-900.

18.2.3 Measuring and switching procedure

According to the procedure of MS output power regulation (see para 18.3.2,), the input level on the used TC shall be measured at the all channel monitor receiver SR on the BS in use, ordered by the MTX immediately at the start of a call.

If the measured level exceeds a certain value (LLS) set by command via I/O-device, no further measurements are ordered. If the value is below the treshold, the MTX shall initiate signal strength measurements on the actual and the surrounding BS:s and possibly switching call in progress.

The measurements shall be carried out on a maximum of sixteen surrounding base stations.

When the MTX investigates whether a (better) BS is available or not, the MTX shall select the appropriate (surrounding) base station(s) and transmit measuring orders on to the(se) BS(:s) and to the actual BS. This order contains the number N_a N_b N_c of the channel to be measured and the number of the Ø-signal (Only for NMT-900) used by the actual BS.

The supervisory unit (SU) at the BS receives measuring order and switches the signal strength receiver (SR) to channel N_a N_b N_c. The maximum switching time is 40 ms.

The average signal strength measured during a measuring time of 100 ms is quantized in 64 levels and the value obtained and the Ø-signal number given by the MTX are then transmitted back to the MTX. If BS finds some other Ø-signal than the one given by the MTX in the measurement order, it transmits measurement result with an indication that the received Ø-signal is incorrect fØ=0101. If the incorrect Ø-signal is returned from the neighboring BS, the MTX shall ignore it, and when receiving from the actual BS, the MTX shall act as corresponding to $R_{n1}R_{n2}$=00 (<0 dB µV E.M.F). The above procedures related to detection of the Ø-signal frequency (correct/ incorrect) are only valid for NMT-900.

The MTX shall store the highest and second highest alternative value of R_{n1} R_{n2} together with the corresponding base station $B'_1B'_2B'_3$ and $B''_1B''_2B''_3$, and the value of $R_{n1}R_{n2}$ for the actual BS in use.

If surrounding BS's have a different maximum permitted MS-power level or belongs to another MTX, this shall be taken into account. When MTX has received all measurement values or has waited a predetermined time interval, a decision is made whether switching call in progress shall be performed or not.

The time interval is specified by means of command for each MTX in steps of one second.

If the value R'_{n1} R'_{n2} is at least a certain predetermined number of levels (out of the 64 possible) higher than the value R_{n1} R_{n2}, the call is switched to the BS B'_1 B'_2 B'_3 if that BS has a free or idle TC available. Measurement result with "incorrect Ø-signal" from surrounding BS's shall be ignored. The number of levels is set by means of command for each BS:s, i.e. for each actual BS and specific neighboring BS:s. The criteria for switching may in this way be different depending on what type the neighboring BS is.

If that BS has no free or idle TC available, the procedure is repeated with the second best BS, comparing the values $R''_{n1}R''_{n2}$ and $R_{n1}R_{n2}$ using the same criterion.

If the second BS also has no TC available "switching call in progress" shall be queued on the first BS $B'_1B'_2B'_3$ for a predetermined time from 0 to 5 seconds. This queue shall have priority over the queue handling outgoing call.

If R'_{n1} R'_{n2} and R''_{n1} R''_{n2} do not fulfill the predetermined criterias and R_{n1} R_{n2} is above a predetermined level (MLS) the MTX shall order switching call in progress to another channel within the same base station B_1 B_2 B_3.

The actual switching of a call in progress must only take place after that speech condition has been established, i.e. the call set-up signalling between MS and MTX has been completed (after address complete).

18.2.4 Supervisory signal control

Immediately after speech condition has been established or at switching call in progress the MTX shall send a channel activation order including "start Ø-signal" (frame 20 (A=3) or frame 20(A=14) (Only NMT-900)) to the BS channel equipment.

The BS channel equipment generates and transmits the supervisory signal towards MS where it is looped back to the BS on the return frequency of that channel.

The BS channel equipment detects the Ø-signal received (from MS) and evaluates the S/N value in relation to two limits.

As a result of the evaluation during speech condition one of the following signals may be sent to the MTX as Ø-signal alarm.

a) received Ø-signal below 1:st limit

b) received Ø-signal below 2:nd limit.

The frame "received Ø-signal below 1:st limit" is repeated after 20 or 60 seconds selectable in the BS if the criteria i still fulfilled. The frame "received Ø-signal below 2:nd limit" is repeated after 20 seconds if the criteria is still fulfilled. The 60 seconds period above is only valid for NMT-900, and new generation of NMT-450 basestations from 1988/89.

MTX shall when receiving signal:

a) order the MS to increase the output power level to the highest permitted power if the MTX previously has ordered reduced power on the actual channel. If this is not the case, the MTX shall initiate signal strength measurements and possible switching call in progress. If the "switching call in progress" is unsuccessful, new attempts shall be done with t seconds interval during the following 60 seconds. Time t shall be adjustable between 5 to 20 seconds.

b) disconnect the call.

When the call is cleared, MTX shall send signal: "stop sending of Ø-signal" to the BS.

18.2.5 Continuous Signal Strength Control during Speech Condition.

In order to define the coverage area in the small cell configuration the BS evaluate continuously the signal strength received from the MS during speech condition.

This is valid for NMT-900, and for the new generation of basestations for NMT-450 delivered from 1988/89

This evaluation is started when BS receives an order from MTX including "start Ø-signal" frame 20(A=3) or frame 20(A=14) (Only NMT-900). If the average signal strength is below a certain value l_H the BS sends corresponding Ø-signal alarm:

a) received Ø-signal below 1:st limit

If the average result is below a certain value l_L; the BS sends :

b) received Ø-signal below 2:nd limit.

The alarms are repeated every 20 second or 60 second (case a) only) selectable in BS. The action in MTX shall be according to para 18.2.4. The limits l_H and l_L in BS are for NMT-900 given by MTX in the frames "start transmitter" (frame 20(A=15) or frame 20(A=14) according to NMT Doc.900-1 , or set locally at BS. For NMT-450 these limits l_H and l_L are only set locally at the BS.

18.3 MS OUTPUT POWER REGULATION

18.3.1 Conditions

The need for regulation of output power in MS will occur when:

1. using small-cell structure in order to obtain the desired coverage area.

2. using conventional net structure and the MS is in a position close to the BS. This might be done in order to reduce the probability that a "near by" MS shall cause blocking or intermodulation on another channel on which a "far away" MS is transmitting.

3. In case of Ø-signal alarm, and MTX previously has ordered MS to reduce the output power according to item 2 above. The first step is to increase the MS power level back to the highest permitted power on the actual BS.

18.3.2 Power regulation order

The MS output power is controlled by MTX and the highest permitted power is informed in the relevant signalling frames from the MTX. The information is included in the channel number $N_1N_2N_3$ in which the second and third bit of digit N_1 define the power level. See NMT Doc.1. and NMT Doc.900-1.

Immediately after a call set-up the input level at the BS shall be measured. The measurement result is sent to MTX.

If the measured level exceeds a certain value (ULS) which can be set by a command from an I/O-device, the MTX shall send a new channel order to the MS. This channel order shall instruct the MS to go to the same base station and the same channel ($N_1N_2N_3 = N_aN_bN_c$), but this time the two bits in digit N_1 shall denote low power 00. The relation between the MS power and power bits is defined in NMT Doc.1. and NMT Doc.900-1.

18.4 EXCHANGE OF INFORMATION BETWEEN MTX AND BS

The exchange of information between the MTX and BS:s for the functions specified in this chapter is performed by means of 1200 Bauds binary signalling. Ø-signal control signals and MS output power regulation signals are sent on each individual channel. Signals for signal strength measurements may be sent in the following ways listed in the order of priority:

- on a dedicated separate data channel;
- on any idle traffic channel;
- on any free traffic channel or combined channel;
- on actual traffic channel.

When a traffic/combined channel, free or "actual" is used for exchange of information between the MTX and the BS, signal strength measurement orders shall be given priority over signals from MS:s. The BS splits the backward direction of the traffic channel during the measurement and signalling, and sends back measurement results.

Signal strength measurement orders are only sent on the actual traffic channel when no dedicated data channel, idle or free traffic channel is available on this BS.

Detailed specifications for the signalling arrangement and signalling procedures used are given in NMT Doc.900-1 and Doc.1.

18.5 SWITCHING DATA

The MTX must have tables indicating the surrounding BS:s for each BS within its area. Such data must be changeable from I/O-devices in the MTX according to e.g. changes in the configuration of base stations.

Information about maximum permitted MS-power on each BS and the different kind of MS-categories must also be stored in the MTX.

19 PRIORITY TRAFFIC

19.1 MS WITH PRIORITY

In order to give certain mobile subscribers better access to the system than ordinary mobile subscribers during busy hours, these MS:s are provided with a priority facility, giving them the possibility to make calls on CC. This facility is of particular importance during busy hours when all traffic channels on a base station are occupied.

Priority does not imply the interruption of other established calls, and is only effective on the radio path. A special priority button on the MS must be activated in order to allow the use of the priority facility.

Normally the subscriber with priority possibility shall establish calls as an ordinary subscriber, i.e. without activating the priority button. The MS shall then in all aspects operate as an ordinary MS.

If there is an incoming call to an MS with priority while queuing for a free TC, the incoming call shall be rejected and busy tone or busy signal is sent towards the calling subscriber.

19.2 CALL FROM MS WITH PRIORITY

The signalling procedure for this facility is shown in NMT Doc. 900-1. If a mobile subscriber with priority wishes to make a call without using his priority facility, the handset is lifted or the Hands-Free button is activated (i.e. the priority button is not activated).

If the mobile subscriber with priority wishes to use his priority facility (no idle TC:s), he activates the priority button in "on-hook" condition after the desired number has been dialled and stored in dialled digits memory.

When the MS then initiates a priority call, the MS has to wait until the CC is free before seizure signal can be sent. MTX receives the call, and checks the MS category (priority). If the MTX can assign an idle TC on this BS at once, channel order is given on CC. After identity check on TC, the procedure continues as a call from an ordinary MS.

If no idle TC is available on this BS, he is placed in a priority queue in the MTX. This is indicated by the MTX transmitting a fictitious channel order on the CC to the priority MS, upon which the MS activates a visual signal to the subscriber (for example light in the priority button).

If the MS has not received a call within 120 sec., the priority indicator is switched off, but already after 90 sec, the MTX shall take the MS out of the priority queu. During the 90 sec. the mobile station remains in the queue until a TC is assigned. As long as priority mobile stations are queuing under BS, no TC will be assigned for use for ordinary mobile stations. When a TC is available the MTX calls the MS in question in the same way as an ordinary call to an MS. When the subscriber with priority answers, the call, answer signal is sent towards the MTX and priority indicator is switched off. Then the procedure continues as a call from an ordinary MS. If no acknowledge is received from the priority MS within 2 call attempts, the MS is taken out of the queue and the call is abandoned.

If the subscriber does not answer the call, the call will be taken out of the queue and abandoned.

If the user initiates a priority call while MS is locked to a combined CC/TC, the MS performs a normal call set-up procedure immediately and ringing signal sequence is generated locally, alerting the user to lift the handset.

If the MS during scanning, with the priority indicator on, detects a combined CC/TC or TC, the MS shall generate a normal call and alert the user to lift the handset by generating ringing signal sequence locally.

If the MS locks to a new BS in the same TA with the priority indicator on, a priority call is initiated immediately and the MS is cancelled from the queue in the former BS. If no idle TC is available on the new BS, the MS is placed in the priority queue for this BS.

If the MS leaves the TA where it has been queued, scanning for combined CC/TC or TC scanning for CC/TC or TC in the new TA is started. If the MS detects a combined CC/TC or TC a normal call set-up procedure is initiated and a ringing sequence is generated locally, alerting the user to lift the handset. The MS is cancelled from the priority queue in the former TA and the priority indicator is switched off.

If the normal call set-up procedure has failed in the new TA, the MS scans for a CC in the new TA, where a priority call is generated. When the priority call in the new TA is detected, the MTX requests identity on CC and a fictitious channel is given. The MS is now queued on the new BS and cancelled from the queue in the former BS. If the identity procedure has failed, the roaming indicator is switched on and the priority indicator switched off.

If the MS goes "off hook" after the priority button is activated, the priority indicator shall be switched OFF and a normal call should be performed. The MS shall then be taken away from the priority queue.

The priority facility shall only be available in the country in which the MS is registered. This shall be accomplished in the MS by locking the priority function when there is a mismatch between the mobile stations's nationality digit (Z) and the Y_1 - value allocated to this digit.

19.3 PRIORITY TRAFFIC IN EMERGENCY SITUATION

In an emergency situation it may be desirable to reserve a number of channels for calls from priority subscribers. Via I/O-devices the MTX is ordered not to make these channels free for calls from ordinary MS:s (TC:s), although the traffic should indicate such an action.

20 BATTERY SAVING MOBILE STATIONS (BMS)

20.1 INTRODUCTION

For hand-held mobile stations it is especially important to reduce the battery consumption to an absolute minimum. In NMT-900 and NMT-450 i a special type of mobile station is therefor introduced, having a battery saving function capable of reducing the power consumption of the mobile station when it is locked on to a calling channel and is waiting for a call from MTX. In the following, this type of mobile station is called BMS (battery saving mobile station) and is allocated a special category in the MTX.

Until the MUP is implemented, the category for handheld mobile stations may be used.

When a BMS is waiting for a call on a calling channel, it will save battery power by turning off the radio receiver for relatively long periods (battery saving periods or sleeping periods). Only for quite short periods will the BMS "wake up", turn on the radio receiver and listen on the radio channel to find out whether there is a call from MTX. When the BMS is sleeping during a battery saving period, the MTX will place any call to BMS on a queue, not transmitting the calls until the BMS is awake again after the end of the battery saving period.

In the following it is described how battery saving function works for BMS waiting for a call on a calling channel. The same principle will apply to BMS waiting for a call on a combined CC/TC channel.

20.2 BMS GROUPS

The battery saving mobile stations are divided according to the least significant digit of the mobile subscriber number into five groups with approximately the same number of BMS in each group. The division is described in further detail in NMT Doc.900-1, para 4.3.3.14.3 . All BMS within one group will have simultaneous sleeping periods, but there will be time lags between the sleeping periods of the various groups. Under normal conditions, when traffic on the calling channel is modest, all BMS groups will be asleep nearly all the time, but by turns an individual group will wake up, listen for the waiting calls, which are subsequently transmitted via the calling channel, and then go to sleep for a new battery saving by order sent from MTX.

20.3 SIGNAL FRAME FORMAT FOR BMS ORDERS

A BMS is brought to sleep by an order transmitted from MTX via the calling channel in a calling channel indication frame 1.a, 1.a' or 1.a" (if a combined CC/TC is concerned, the order also will be transmitted in frame 1.b). Such battery saving order, also called sleeping order or a BMS order, is characterized by the value of H_1, H_2, H_3 and H_7 in the signal frame field for additional information. The values of H_1 and H_2 will be 14 (H'E), respectively 11 (H'B). The value of H_7 will indicate to which BMS group the sleeping order applies. The value of H_3 indicates how long the BMS should be asleep, as described in NMT Doc.900-1, para 4.3.3.14.3

The H_3 value will be the same for all calling channels within the traffic area and shall be determinable by operator command for each traffic area individually. The default value of H_3 shall be 2, corresponding to the time it takes to transmit 40 signal frames.

20.4 BATTERY SAVING PERIODS

The MTX shall control the battery saving periods in a flexible manner, so that the time intervals between the sleeping periods for each individual BMS group on each individual calling channel get as short as possible. This means that the time intervals between two sleeping periods for a BMS group on a calling channel will normally only take the time necessary for transmitting waiting calls, transmitting any other high priority signals and transmitting a new battery saving order. To obtain this, the battery saving periods shall be controlled individually for each calling channel and each BMS group, and each calling channel shall have its own independent queue function by means of which it will be able to store calls for each BMS group during the sleeping periods.

20.5 CALL HANDLING DURING PEAK TRAFFIC PERIODS

It is of decisive importance that the battery saving function should not in any way reduce the call handling capacity during periods with extra high traffic loads on the calling channels. This applies to BMS as well as normal MS. Nor shall the battery saving function be able to affect the system such that the call congestion for normal MS becomes worse than for BMS, or reversely, during peak traffic periods. Consequently the battery saving periods shall not be activated until all waiting signals for traffic handling have been transmitted via the calling channel and free capacity is available for transmitting sleeping orders. And consequently, calls to normal MS and BMS shall always be transmitted at the same priority, only with the limitation that calls for BMS will have to wait if the BMS group in question is not awake.

20.6 PRIORITY ON THE CALLING CHANNEL

To ensure optimal traffic handling and optimal utilization of the battery saving function, it is necessary that signals of different types should be transmitted via the calling channel at a specific mutual priority. The various signal types belong under six different priority groups, which are transmitted via the calling channel in the following order of priority :

I	Channel orders to normal MS and BMS.
II	New calls to normal MS and BMS.
III	Repeated calls to normal MS and BMS.
IV	Battery saving orders to BMS groups.
V	Signal strength measurement order on combined CC/TC channels, if allowed.
VI	Signal frames for indication of calling channel.

All signals with higher priority will always be transmitted before signals with lower priority.

Signals in the same priority group will always be transmitted at the same priority. This means that the signal which has been waiting for the longest period will be transmitted first, apart from new calls to BMS, which will have to wait if the relevant BMS group is sleeping.

In the following, a closer description is given on how the signals are processed and transmitted within each individual priority group.

20.7 TRANSMISSION OF NEW CALLS TO NORMAL MS AND BMS

Each calling channel is associated with a queue in MTX for new calls. Before calls are transmitted to a mobile station, the call will be placed at the back of this queue for all the calling channels that are to transmit the call.

As soon as free capacity is available on a calling channel for transmitting a new call, this queue will be searched through to find a call ready to be transmitted. The queue is searched through from the beginning. Calls to sleeping BMS are skipped; but the first call to a normal MS or to a BMS which is awake will be taken out from the queue. This call will be transmitted via the calling channel, and at the same time it will be placed on another queue for repeated calls.

A call to a mobile station can maximally wait in a call queue for the buffer time indicated in para 3.7. The queue for new calls must therefor have space for precisely the number of calls that can be transmitted within the buffer time. If the MTX receives more calls for mobile stations than can be accommodated in a queue for a calling channel, the call shall be rejected by sending congestion signal towards A-subscriber.

20.8 TRANSMISSION OF REPEATED CALLS TO NORMAL MS AND BMS

Each calling channel is also associated with a queue in MTX for repeated calls. When a new call is transmitted via the calling channel, the call is moved from the queue for new calls to the queue for repeated calls. The call is to be inserted at the back of this queue, and at the same time it must be indicated when, at the earliest, the repeated call may be transmitted. (The normal time and the shortest time between first and second calls are indicated in para 3.7).

As soon as the capacity is available on the calling channel for transmitting repeated calls, it will be examined in this queue whether the first repeated call has been waiting long enough to be transmitted. If so, the call is removed from the queue and transmitted via the calling channel.

It should be noted that repeated calls to BMS and normal MS will be transmitted in exactly the same manner without regard to the battery saving periods for BMS. Accordingly, the BMS should be so designed that it will keep awake during the periods which there is a chance that it will receive a repeated call. This will be the case, i.e. when the BMS has been switched off, has performed hand-over, or has had poor receiving conditions during a waking period.

Also repeated calls are only allowed to wait for certain buffer time before being transmitted via the calling channel (see para 3.7). The queue for repeated calls should therefore have space for precisely so many calls as can be transmitted within this buffer time.

20.9 CANCELLATION OF CALLS

To utilize the capacity of the calling channels maximally, it is important for waiting calls to a mobile station to be removed immediately when the mobile has answered on the calling channel, when the A-subscriber clears the call, or when the maximum buffer time for the call has expired.

As soon as the MTX has received the acknowledgement of a call via the calling channel, the call shall immediately be removed from the queues for new calls and the queues for repeated calls on all calling channels. After this, the MTX will proceed to establish the call connection.

Similarly, the MTX shall remove the call from all queues after a clearing signal from A-subscriber. The MTX shall then undertake clearing of the connection.

Finally, the MTX shall remove the call from all queues as soon as the maximum buffer time indicated in para 3.7 has expired. After this, the MTX shall reject the call by sending a congestion signal towards the A-subscriber.

20.10 TRANSMISSION OF CHANNEL ORDERS TO NORMAL MS AND BMS

When the MTX has received acknowledgement of a call via a calling channel, the call shall be cancelled immediately on all calling channels where it is still waiting to be transmitted, see above. After this, the MTX shall transmit a channel order on the calling channel on which the mobile station has answered.

The channel order shall immediately be placed on a queue for channel orders to the calling channel. As channel orders are always transmitted at the highest priority, it will already be transmitted in the next signal frame on the calling channel. The queue for channel orders should therefore merely have space for a single channel order.

20.11 TRANSMISSION OF BMS ORDERS

When the waiting calls for a waking BMS group have been transmitted, a sleeping order shall normally be transmitted to the BMS group as quickly as possible. However, it shall be ensured that there are time lags between the sleeping periods of the BMS groups, so that after the sleeping periods they will awake individually, and the individual BMS group will be able to receive new waiting calls while the other BMS groups are sleeping. In some cases it will therefore be necessary to delay the transmission of a sleeping order to a waking BMS group. This will occur when several BMS groups are awake at the same time.

Every time a BMS group is put to sleep by transmitting a sleeping order, it shall thus be examined in the MTX whether there are more BMS groups awake, in order to determine whether transmission of the sleeping order to the next following group should be delayed. The following two cases may come into question:

I All other BMS groups are sleeping.
In that case a sufficient time lag has already been established between the BMS groups, and for transmission of the sleeping order to the next BMS group a time delay equal to zero may be indicated.

II One or more BMS groups are awake.
In that case there are no time lags between the waking periods of the BMS groups, and for transmission of the sleeping order to the next BMS group a time delay should be indicated, in the following called the BMS intermediate group period or T_{BIG}.

As soon as free capacity is available on the calling channel for transmitting sleeping orders, it shall be examined in MTX whether there is a waking BMS group. If this is the case, it shall be examined whether for transmission of a sleeping order to the BMS group a time delay has been indicated which has not yet expired. If this is not the case, a sleeping order will be transmitted to the BMS group in question, and at the same time it will be marked for the group in question that it is asleep, and the time for the next awakening of the group will be indicated. -furthermore, a time delay will be indicated for transmission of a sleeping order to the next BMS group as described above.

The BMS intermediate group period, T_{BIG}, shall be determinable per traffic area by command to MTX. T_{BIG} shall be indicated as the number of signal frame periods and shall be determined by the length of the sleeping period and the number of BMS groups. The default value for T_{BIG} is calculated according to the following formula:

$T_{BIG} = (L+1)\ //\ (B+1)$
where L = length of the sleeping period,
B = the number of BMS groups,
// is the symbol for integer division.

In case the length of the sleeping period is changed for a traffic area, T_{BIG} shall be updated automatically to the new corresponding default value, calculated according to the formula.

20.12 TRANSMISSION OF SIGNAL STRENGTH MEASUREMENT ORDERS ON COMBINED CC/TC CHANNELS

On combined CC/TC channels, signal strength measurement orders shall be transmitted to BS if calls are in progress on all other channels. However, two signal strength measurement orders are never allowed to be transmitted on the channel immediately after each other.

Signal strength measurement orders will only be transmitted on combined CC/TC channels when no signals with higher priority according to para 20.6 are waiting for transmission.

20.13 TRANSMISSION OF SIGNAL FRAMES FOR INDICATION OF CALLING CHANNEL

When no other signals are waiting to be transmitted via the calling channel, ordinary channel indication frames are transmitted, frame 1.a, 1.a', 1.a" or 1.b.

20.14 CALLS TO VISITING SUBSCRIBERS

In rare cases subscriber data for visiting MS's under MTXV can be deleted. On calls to such MS's the MTXV cannot determine whether a normal MS or a BMS is concerned. If the MTXV has the battery saving function activated, all calls to MS where subscriber data is missing, shall therefore be transmitted as calls to BMS.

20.15 STATISTICAL FUNCTIONS FOR BMS

The MTX shall be extended to include a number of special measuring functions for observing the efficiency of the battery saving function. The following measurements shall be performable for each individual channel:

-Measurement of the number of calls to each BMS group.

-Measurement of the average number of calls on the queue for new calls.

-Measurement of the average number of calls on the queue for repeated calls.

-Measurement of the ratio between sleeping periods and wakingperiods for each individual BMS group.