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Nordic Mobile Telephone group

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NORDIC MOBILE TELEPHONE

TECHNICAL SPECIFICATION FOR THE MOBILE STATION

CONTENTS

1. GENERAL

1.1 Introduction

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

This document specifies the requirements for the mobile stations (MS) in the system. For detailed information about the system and the interfaces between the system components, reference is made to NMT Doc. 1, "System Description", which is necessary for the use of this document.

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

The mobile stations are to be purchased or leased by the subscribers. They must, however, be type approved by the Telecommunications Administration in the country of the subscriber. In specifying the requirements for type approval, one basic aim has been that to the subscribers, the system shall appear as similar as possible to the fixed telephone network. This applies both to the use of the mobile station, the reliability of signalling, charging and to the services offered.

1.1.1 System concepts

With reference to the detailed system description, NMT Doc. 1, the following lines are intended only as a very brief introduction to the system.

The interface between the system and the fixed telephone network is contained in the mobile telephone exchange (MTX). The base stations (BS) are connected to the MTX which controls the traffic to and from the mobile stations. The switching functions are performed by the MTX.

The base stations are grouped into traffic areas. An MTX may control one or more traffic areas.

At every base station, one channel is used as calling channel and is marked with a special identification signal. One or several of the other channels, when free, are marked with a free traffic channel identification signal. Stand by mobile stations in an area under a base station are locked to the calling channel.

1.1.2 Radio frequencies

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

In order to reduce the inconvenience of having a conversation interrupted when moving from one base station coverage area to another, the system is designed to switch calls in progress from one base station to another base station, controlled by the same MTX.

A mobile station will upon command from the MTX reduce its transmitter output power in the neighbourhood of a base station in order to reduce interference.

1.1.3 Call set-up procedures

1.1.3.1 Call to mobile station

Calls to mobile stations are transmitted simultaneously from all base stations in the traffic area in which the mobile station is operating. When a mobile station has received a calling signal containing its identification, it returns a call acknowledgement on the return frequency of the calling channel, whereupon MTX allocates a traffic channel at the base station where the mobile station has answered the call. The mobile station then switches to the allocated channel. The calling channel, on which all other mobile stations remain, is immediately available for the next call to a mobile station.

1.1.3.2 Call from mobile station

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

1.1.4 Switching call in progress

During a call a continuous out of band supervisory signal (Ø-signal) is generated at the BS (on order from MTX) and sent to the MS, where it is looped back to the BS. The returned Ø-signal is detected and evaluated by the BS which decides if the transmission quality (signal to noise ratio integrated over a certain period of time) necessitates switch-over to another BS.

The MTX orders the BS and also the surrounding BS's to perform signal strength measurements on the radio channel on which the MS is transmitting. For signal strength measuring all BS are equipped with an all-channel monitor receiver (SR). Information about the measurement results enables the MTX to decide to which BS (if any) the call shall be transferred.

The measuring action is also performed by the BS at the beginning of a call in order to determine whether the used BS is suitable.

This measurement is also used to determine whether the received signal from MS is above a certain high level in which case the MTX orders the MS to change to low transmitter output power level.

1.2 Mobile station units

The mobile station consists of 3 major functional units:

- Transceiver unit (including circuits for duplex operation)
- Operational controls unit
- Logic and control unit

Fig. 1.1

In the physical realization of the equipment, the different functional units may be integrated into single packages.

1.2.1 Transceiver Unit

The transceiver unit provides signalling and voice transmission and reception.

The RF band consists of a lower and an upper frequency segment. The lower frequency segment contains 180 transmitting channels with a channel separation of 25 kHz, while the upper frequency segment contains the corresponding 180 receiving channels. The duplex separation is 10 MHz.

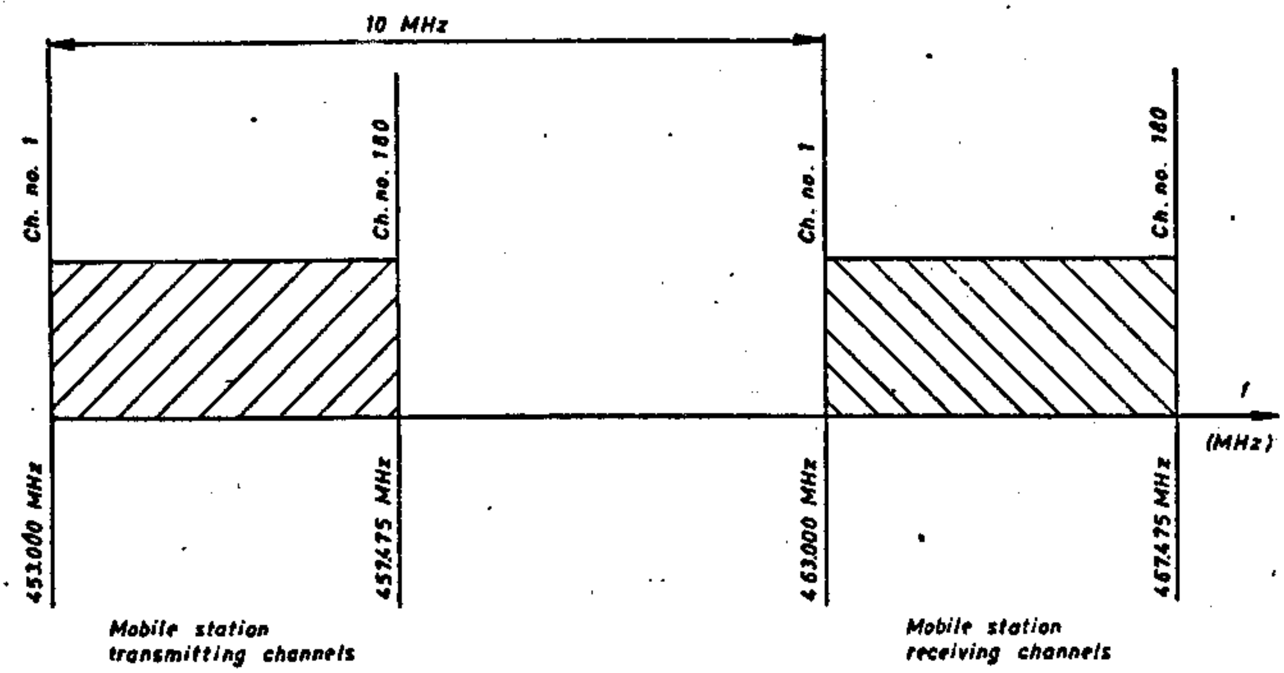


Fig. 1.2

The LF output of the transceiver may be audio signals which are passed to the Operational Controls Unit, or coded signalling information which is passed to the Logic and Control Unit for decoding and appropriate processing.

1.2.2 Operational Controls Unit

The Operational Controls Unit provides the interface between the user and the NMT-system. This functional unit described in Chapter 3 and 4 includes a handset, push-button set, hands-free audio capability and all mobile station controls, indicators and tone signals with which the user interacts.

1.2.3 Logic and Control Unit

The Logic and Control Unit, described in Chapter 5 functions as the master control for the mobile station and encodes and decodes the digital signalling used on the radio path and decides the appropriate action to be taken.

Some of the functions of the Logic and Control Units are:

- Decoding orders from the MTX such as:
  - alerting the user to an incoming call (ringing order)
  - channel command
  - adjusting the transceiver output power
  - identity request
  - releasing the MS at completion of a call or forced release
- Receiving general identification signals from the MTX such as:
  - traffic area identification
  - calling channel identification
  - free traffic channel identification
- Evaluating and ordering the necessary steps to be taken by the mobile station
- Encoding the signalling information to the MTX such as:
  - call initiation from MS (identification)
  - clearing signal when terminating a call
  - updating roaming information
  - dialled digits for call origination
- Providing subscriber signalling information such as:
  - ringing signal
  - roaming alarm
  - malfunction alarm
  - service indicator
  - call received indicator

1.3 General conditions

1.3.1 General requirements

1.3.1.1 Marking of the equipment

The functions of all pilot lamps, terminals and controls as well as the positions of the controls shall be clearly indicated on the equipment.

The equipment shall be clearly marked with the make, type designation and serial number. This rule shall apply also to the sample which is handed in for type approval.

The marking shall be mechanically solid and durable and may, for example, be made by means of engraving, embossing or application of a metal plate.

Furthermore, the Operational Controls Unit shall be provided with a plate which shows the mobile telephone number. This number shall be visible to the user.

The above mentioned markings will be subject to type approval.

1.3.1.2 Warming up period

At the latest one minute after having been switched on to the power supply the equipment shall be fully ready for operation, which shall be taken to mean that all requirements laid down in these present specifications shall be fulfilled.

1.3.1.3 Storage conditions

The mobile station shall withstand storage temperatures between - 40°C and + 70°C without damage.

1.3.2 Terminals

1.3.2.1 Test terminals

The mobile station shall be provided with test terminals which make it possible to measure that the requirements laid down in this specification are fulfilled.

1.3.2.2 Antenna terminal

The antenna terminal is the interface between the antenna and the mobile station including the duplex filter.

1.3.2.3 Voice input and output terminals

The mobile station shall be provided with voice input/output terminals. These terminals are the interfaces between the voice input/output circuit (see chapter 2) and the handset transmitter output/receiver input (see chapter 3).

If the mobile station is equipped with separate microphone and loudspeaker these shall be connected to voice input/output terminals.

Impedances at voice input and output terminals shall be declared by the manufacturer.

1.3.2.4 Arrangement for testing

It is recommended that the MS inside the cabinet, accessible only for service personnel, shall be provided with an arrangement for test purposes which makes it possible to activate the MS in speech condition on any of the 180 radio channels.

The arrangement shall overrule the autonomous time out device.

The methode to be used to select a channel and activate the MS shall be declared by the manufacturer.

Reference is made to paragraph 4.10.

1.3.3 <u>Test of the equipment</u>

1.3.3.1 Application of the test conditions

For all requirements specified in these regulations, type approval measurements shall be carried out under the normal test conditions described in 1.3.4. If so specified, the test shall also be carried out under the extreme test conditions mentioned in 1.3.5.

An example of a mobile station test arrangement is shown in Fig. 1.3.

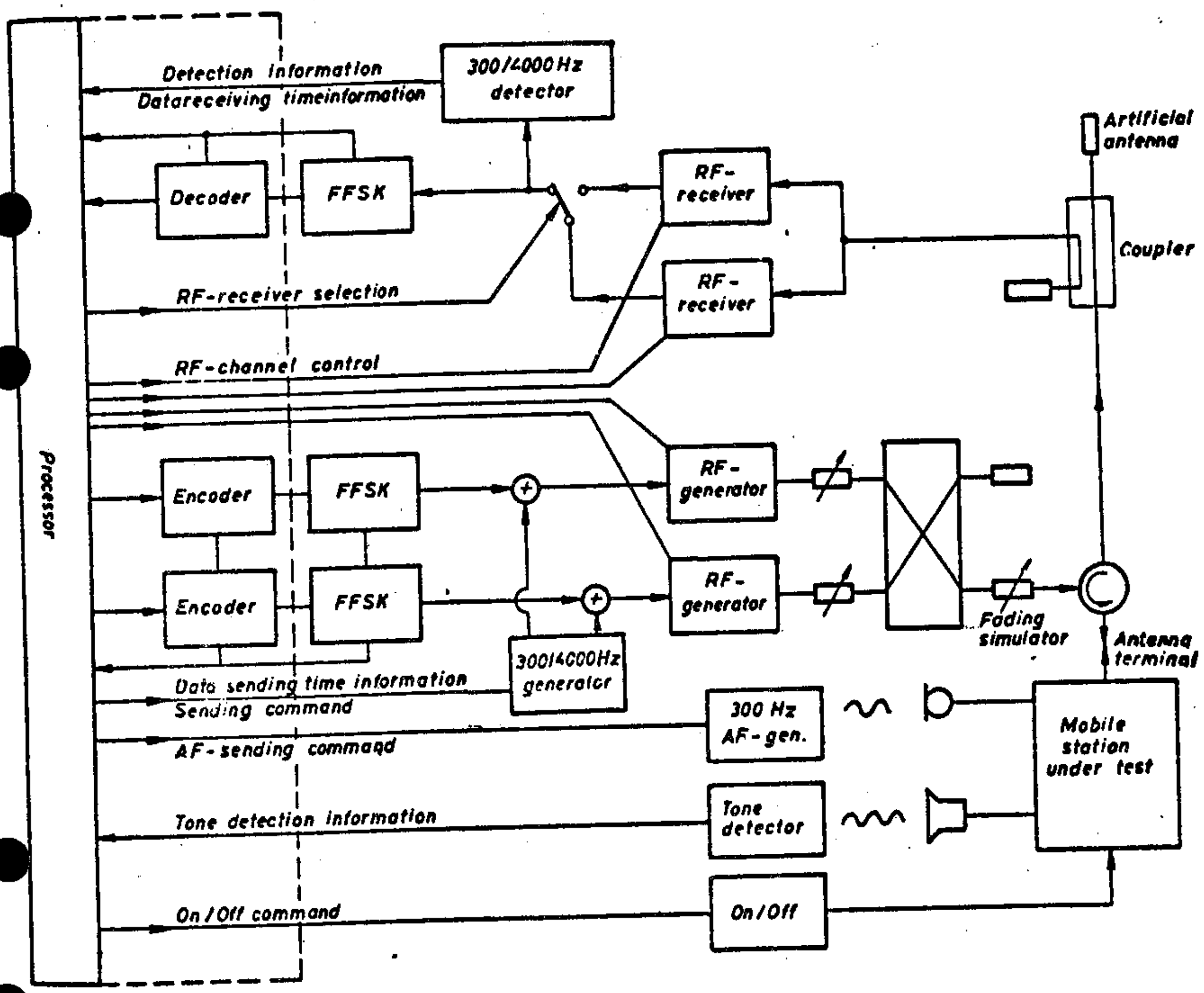


Fig. 1.3

An example of a mobile station test arrangement

1.3.3.2 Power supply

During the type approval tests the power supply of the equipment shall be replaced by an outside power source capable of producing power supply voltages as described in paragraphs 1.3.4.2 and 1.3.5.2. The internal impedance of the power source shall be low enough for its effect on the test results to be negligible.

The power supply voltage shall be measured at the input terminals of the equipment.

If the equipment is provided with a permanently connected power cable, the power supply voltage shall be measured at the point of connection of the power cable to the equipment.

In equipment with incorporated batteries, the power source shall be applied as close to the battery terminals as practicable.

During the testing the power supply voltages shall be maintained within a tolerance of ± 3% relative to the voltage at the beginning of the test.

1.3.4 Normal test conditions

1.3.4.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

Temperature + 15 °C to + 35 °C

Relative humidity 20% to 75%

1.3.4.2 Normal test power source

Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of these specifications, the nominal voltage shall be the declared voltage or any of the declared voltages for which the equipment was designed.

Regulated lead-acid battery power sources of vehicles

If the radio equipment is intended for operation from the usual types of regulated lead-acid battery power source of vehicles the normal test voltage shall be 1.1 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

Other power sources

For operation from other power sources or types of battery (primary or secondary), the normal test voltage shall be that declared by the equipment manufacturer.

1.3.5 Extreme test conditions

1.3.5.1 Temperatures at testing under extreme conditions

At testing under extreme conditions the measurements shall be made in accordance with paragraph 1.3.5.3 at the temperatures of -25°C and +55°C.

1.3.5.2 Power supply voltages at testing under extreme conditions

Regulated lead-acid battery power supplies for use in motor vehicles.

If the radio equipment is intended for operation from the usual types of regulated lead-acid battery power supply of motor vehicles, measurements shall be made at power supply voltages of 1.3 and 0.9 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

Mains voltage

The extreme test voltage for equipment to be connected to an AC mains source shall be the nominal mains voltage ± 10%.

Other power sources

The lower extreme test voltages for equipment with power sources using primary batteries shall be as follows:

1) For the Leclanché type of battery:
   0.85 times the nominal voltage of the battery;

2) For the mercury type of battery:
   0.9 times the nominal voltage of the battery;

3) For other types of primary batteries:
   End point voltage declared by the equipment manufacturer.

For equipment using other power sources, or capable of being operated from a variety of power sources, the extreme test voltages shall be those agreed between the equipment manufacturer and the testing authority and shall be recorded with the results.

1.3.5.3 Procedure for tests at extreme temperatures

Test procedure

Before measurements are made the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilizing period. If the thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour, or such period as may be decided by the testing authority, shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

Before tests at the upper temperature the equipment shall be placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on in the transmit condition for a period of half an hour after which the equipment shall meet the specified requirements.

For tests at the lower temperature, the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for a period of one minute after which the equipment shall meet the specified requirements.

1.3.6 Arrangement for test signals applied to the antenna terminal for receiver testing purposes

Sources of test signals connected to the antenna terminal shall be arranged in such a way that the impedance presented is 50 ohms. This requirement shall also be met if more than one signal source is applied simultaneously.

The levels of the test signals shall be expressed in terms of the EMF at the antenna terminal.

The effect of any intermodulation products and noise produced in the signal generators should be negligible.

1.3.7 Artificial antenna (dummy load)

Tests of the transmitter shall be carried out with a non-radiating non-reactive load of 50 ohms connected to the antenna terminal.

1.3.8 Test modulations

1.3.8.1 Normal test modulation

For normal test modulation, the modulation frequency shall be 1 kHz and the resulting frequency deviation shall be $\pm$ 3.0 kHz. The test signal shall be substantially free from amplitude modulation.

1.3.8.2 Data test modulation

Normal data test modulation is defined as the carrier frequency modulated with frame 15 (see NMT Doc 1) to give a mean frequency deviation of $\pm$ 3,5 kHz.

1.3.8.3 Supervisory signal modulation

Normal supervisory signal test modulation is defined as the carrier frequency modulated with a signal of frequency 4015 Hz to give a frequency deviation of $\pm$ 0.3 kHz.

1.3.9 Definitions of some measuring instruments

1.3.9.1 Adjacent channel power measuring receiver

The receiver for measuring the adjacent channel power shall fulfil the requirements given in CEPT Recommendation T/R 17.

1.3.9.2 Psophometric filter

The psophometric filter which is used in some of the test measurements, shall fulfil the requirements specified in CCITT Recommendation P 53.A (psophometer for commercial telephone circuits).

1.3.9.3 SINAD meter

The SINAD meter needed for receiver measurements is also specified in CEPT Recommendation T/R 17. The psophometric filter needed for SINAD(P)-ratio measurements (see 2.3.7.1) may be included in the SINAD meter.

1.3.10 Vibration test

It is required that the equipment is designed to withstanding a vibration test according to the IEC publication 68-2-6.

10-55 Hz	$\pm$ 0.15 mm	displacement
55-150 Hz	20 m/s^2	acceleration

Sweep rate: 1 octave per minute

Duration: 2 hours in each 3 directions

During the vibration test the equipment shall not be in operation. After the test the equipment shall fulfil the requirements specified in these technical specifications.

1.3.11 Test site and general arrangements for measurements involving the use of radiated fields

1.3.11.1 Test site

The test site shall be on a reasonably level surface or ground.

At one point on the site, a ground plane of at least 5 metres diameter shall be provided. In the middle of this ground plane, a nonconducting support, capable of rotation through 360° in the horizontal plane, shall be used to support the test sample at 1,5 metres above the ground plane. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of $\lambda/2$ or 3 metres whichever is the greater. The distance actually used shall be recorded with the results of the test carried out on the site.

Sufficient precautions shall be taken to ensure that reflections from extraneous objects adjacent to the site and ground reflections do not degrade the measurement results.

1.3.11.2 Test antenna

The test antenna is used to detect the radiation from both the test sample and the substitution antenna, when the site is used for radiation measurements; where necessary, it is used as a transmitting antenna, when the site is used for the measurement of receiver characteristics. This antenna is mounted on a support such as to allow the antenna to be used in either horizontal or vertical polarization and for the height of its centre above ground to be varied over the range 1 - 4 metres. Preferably a test antenna with pronounced directivity should be used. The size of the test antenna along the measurement axis shall not exceed 20% of the measuring distance.

For radiation measurements, the test antenna is connected to a test receiver, capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input. When necessary (for receiver measurements) the test receiver is replaced by a signal source.

1.3.11.3 Substitution antenna

The substitution antenna shall be a $\lambda/2$ dipole, resonant at the frequency under consideration, or a shortened dipole, calibrated to the $\lambda/2$ dipole. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the volume centre of the sample when its antenna is mounted inside the cabinet, or the point where an outside is connected to the cabinet.

The distance between the lower extremity of the dipole and the ground shall be at least 30 cm.

The substitution antenna shall be connected to a calibrated signal generator when the site is used for radiation measurements and to a calibrated measuring receiver when the site is used for measurement of receiver characteristics. The signal generator and the receiver shall be operating at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

1.3.11.4 Alternative indoor site

When the frequency of the signals being measured is higher than 80 MHz, use may be made of an indoor site. If this alternative site is used, this shall be recorded in the test report.

The measurement site may be a laboratory room with a minimum area of 6 metres by 7 metres and at least 2,7 metres in height.

Apart from the measuring apparatus and the operator, the room shall be as free as possible from reflecting objects other than the walls, floor and ceiling.

The site arrangement is in principle shown in Fig. 1.4.

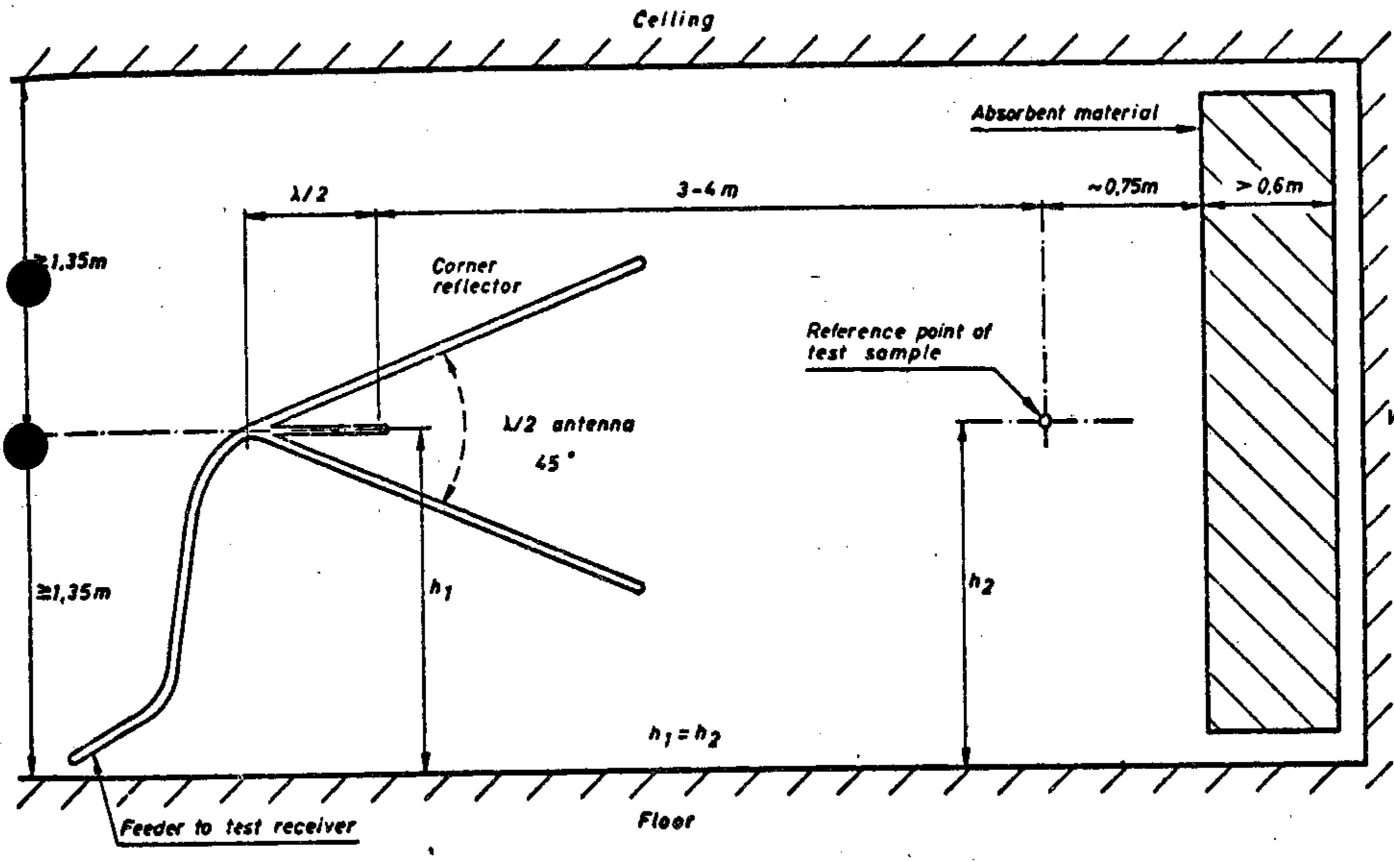


Fig. 1.4

Indoor site arrangement

(shown for horizontal polarization)

The potential reflections from the wall behind the equipment under test are reduced by placing a barrier of absorbent material in front of it. The corner reflector around the test antenna is used to reduce the effect of reflections from the opposite wall and from the floor and ceiling in the case of horizontally polarized measurements.

Similarly, the corner reflector reduces the effects of reflections from the side walls for vertically polarized measurements.

For the lower part of the frequency range (below approx. 175 MHz) no corner reflector or absorbent barrier is needed.

For practical reasons, the $\lambda/2$ antenna may be replaced by an antenna of constant length, allowing it to be used at frequencies corresponding to a length between $\lambda/2$ and λ, as long as the sensitivity is sufficient. In the same way the distance of $\lambda/2$ to the apex may be varied.

The test antenna, test receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method.

To ensure that errors are not caused by the propagation path approaching the point at which phase cancellation between direct and the remaining reflected signals occurs, the substitution antenna shall be moved through a distance of $\pm$ 10 cm in the direction of the test antenna as well as in the two directions perpendicular to this first direction. If these changes of distance cause a signal change of greater than 2 dB, the test sample should be resited until a change of less than 2 dB is obtained.

1.3.12 Receiver rated audio output power

The rated audio output power shall be the maximum power, declared by the manufacturer, for which all the requirements of these specifications are met. With normal test modulation, the audio output shall be measured in a resistive load, simulating the load with which the receiver normally operates. The value of this load shall be declared by the manufacturer.

2. TRANSCEIVER UNIT

2.1 General

The transceiver unit consists of the transmitter and the receiver (including circuits for duplex operation). Regarding portable mobile stations reference is made to annex 1.

2.2 Transmitter

All requirements in section 2.2, unless otherwise specified, shall be carried out and fulfilled in conversation mode (duplex operation). The modulation signal shall be applied to the voice input circuit from an oscillator having a suitable impedance according to 1.3.2.3.

2.2.1 Frequency range and channel separation

The MS transmitter works on frequencies from 453.000 MHz to 457.475 MHz, with a channel separation of 25 kHz. The duplex separation is 10 MHz, giving the corresponding MS-receiver frequencies from 463.000 MHz to 467.475 MHz (See Fig. 1.2).

2.2.2 Number of channels

The number of channels in the NMT-system is 180. Channel No. 1 is the lowest in frequency (in transmitter 453.000, in receiver 463.000 MHz) and channel No. 180 is the highest in frequency (in transmitter 457.475 MHz, in receiver 467.475 MHz).

2.2.3 Frequency error

2.2.3.1 Definition

The frequency error of the transmitter is the difference between the measured carrier frequency and its nominal value.

2.2.3.2 Method of measurement

The carrier frequency shall be measured without modulation and with the MS antenna terminal connected to an artificial antenna.
The measurements shall be made under normal and extreme test conditions.

2.2.3.3 Requirements

The frequency error of the transmitter steady-state frequency shall not exceed $\pm$ 2.5 kHz under normal as well as extreme test conditions.

2.2.4 Transmitter carrier power

2.2.4.1 Definition

The transmitter carrier power is the mean power delivered to the artificial antenna during a radio frequency cycle, without modulation.

2.2.4.2 Method of measurement

The antenna terminal shall be connected to an artificial antenna, and the power delivered to this artificial antenna shall be measured. The measurements shall be made under normal test conditions and under extreme test conditions..

2.2.4.3 Requirements

The available steady-state carrier power output at the antenna terminal into an artificial antenna shall be 15 W $\pm$ 1.5 dB for all channels at normal test conditions, and within + 2 dB and - 3 dB of 15 W at extreme test conditions.
Regarding portable mobile stations reference is made to annex 1.

2.2.4.4 Load test

The transmitter shall be submitted to load tests with continuous transmission during a period of 30 minutes:

- The change in the transmitter output power shall not exceed 2 dB during a load test when the MS is loaded with a resistive impedance giving a standing wave ratio of 2. The test shall be carried out at normal test conditions.
- Without being damaged, the MS shall be able to withstand a load test when it is loaded with a resistive impedance giving a standing wave ratio of 2. The test shall be carried out at extreme test conditions.

Furthermore the MS shall be capable to withstand, without being damaged, a load test when the MS is loaded with an arbitrary load. This is done by leaving the antenna terminal open and by short circuiting it for at least one minute in each case.

2.2.5 Transmitter carrier power control

The MS-transmitter shall be able to reduce the output power with 10 dB $\pm$ 3 dB on all channels as controlled by the Logic and Control Unit after a command from the MTX. Measurements are made under normal and extreme test conditions. An additional step of 10 dB may be required at a later date only on new equipment.

2.2.6 Carrier on/off condition and carrier rise/decay time

Transmitter start-up times and transmitter awake time are defined in Chapter 6.

2.2.7 Transmitter channel switching time

For definition, method of measurement and requirements see chapter 6.

2.2.8 Spurious emissions

2.2.8.1 Definition

Spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with normal test modulation.

The level of spurious emissions shall be measured as:

a) their conducted power level in an artificial antenna

b) their effective radiated power when radiated by the cabinet and structure of the equipment also known as "cabinet radiation".

2.2.8.2 Method of measuring the conducted power level

Spurious emissions shall be measured as the power level of any discrete signal delivered into a 50 ohms load. This may be done by connecting the antenna terminal through an attenuator to a spectrum analyser or selective voltmeter, or by monitoring the relative levels of the spurious signals delivered to an artificial antenna.

The transmitter shall be unmodulated and the measurements made over the frequency range 100 kHz to 2000 MHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

The measurements shall be repeated with the transmitter modulated with normal test modulation.

The same measurements shall also be made when the MS transmitter is in reduced power mode.

2.2.8.3 Method of measuring the effective radiated power

On a test site fulfilling the requirements of paragraph 1.3.11 the sample shall be placed at the specified height on a non-conducting support. The transmitter shall be operated at the carrier power as specified under paragraph 2.2.4, delivered to an artificial antenna without modulation.

Radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 30-2000 MHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

At each frequency at which a component is detected, the sample shall be rotated to obtain maximum response and the effective radiated power of that component shall be determined by a substitution measurement.

The measurements shall be repeated with the test antenna in the orthogonal polarisation plane.

The measurements shall be repeated with the transmitter modulated by normal test modulation.

2.2.8.4 Requirements

The following requirements shall be fulfilled during normal and reduced power modes.

In case a) the spurious emission shall not exceed 0.25 microwatt

In case b) the spurious emission ("cabinet radiation") shall not exceed 2,5 microwatt.

2.2.9 Frequency deviation

The frequency deviation is the maximum difference between the instantaneous frequency of the modulated radio frequency signal and the unmodulated carrier.

2.2.9.1 Maximum permissible frequency deviation without supervisory signal.

Definition

The maximum permissible frequency deviation without supervisory signal is the maximum value of frequency deviation stipulated in these specifications.

2.2.9.2 Method of measurement

The frequency deviation shall be measured at the antenna terminal of the MS connected to an artificial antenna, by means of a deviation meter capable of measuring the maximum deviation, including that due to any harmonics and intermodulation products which may be generated in the transmitter.

The modulation frequency without the supervisory signal shall be varied from 20 Hz to 25 kHz. The level of this test signal shall be 20 dB above the level of the normal test modulation.

2.2.9.3 Requirements

The maximum permissible frequency deviation shall be $\pm$ 4.7 kHz.

2.2.10 <u>Limiting characteristic of modulator</u>

2.2.10.1 Definition

The limiting characteristic of the modulator expresses the capability of the transmitter to be modulated close to the maximum permissible frequency deviation as defined in paragraph 2.2.9.

2.2.10.2 Method of measurement

A test signal with a frequency of 1000 Hz and without the supervisory signal shall be applied to the voice input circuit of the transmitter.

The level shall be adjusted so that the frequency deviation is $\pm$ 1,0 kHz. The level is then increased by 20 dB and the frequency deviation is again measured.

The measurements shall be carried out under normal test conditions and extreme test conditions.

2.2.10.3 Requirements

The frequency deviation shall be between ± (3,7 kHz and 4,7 kHz).

2.2.11 Adjacent channel power

2.2.11.1 Definition

The adjacent channel power is that part of the total power output of a transmitter under defined conditions of modulation, which falls within the bandwidth of a receiver of the type normally used in the system and operating in either of the adjacent channels. This power is the sum of the mean power produced by the modulation, hum and noise of the transmitter.

2.2.11.2 Method of measurement

The adjacent-channel power shall be measured with a power-measuring receiver which conforms to paragraph 1.3.9.1.

The transmitter shall be operated at full-carrier power determined in paragraph 2.2.4 under normal test conditions. The antenna terminal shall be linked to the input of the "receiver" by a connecting device such that the impedance presented to the MS is 50 ohms and the level at the "receiver" input is appropriate.

The transmitter shall be simultaneously modulated with a signal of 1250 Hz and the supervisory signal (4015 Hz ± 0,3 kHz deviation).

The signal of 1250 Hz shall be adjusted to a level 20 dB higher than that required to produce ± 3.0 kHz deviation (without supervisory signal). The "receiver" shall be tuned to the nominal frequency of the transmitter and the variable attenuator in the "receiver" shall be adjusted to a value p dB such that a meter reading of the order of 5 dB above the "receiver" noise level is obtained.

The "receiver" shall then be tuned to the nominal frequency of one of the adjacent channels and the variable attenuator shall be adjusted to a value q dB such that the same meter reading is obtained.

The ratio of adjacent channel power to carrier power is the difference between the attenuator settings p and q. The adjacent channel power is determined by applying this ratio to the carrier power.

The measurement shall be repeated for the other adjacent channel.

2.2.11.3 Requirements

The adjacent-channel power shall not exceed the power level corresponding to 70 dB below the nominal carrier power of the transmitter.

2.2.12 Audio-frequency response of the transmitter

2.2.12.1 Definition

The audio-frequency response is the frequency deviation of the transmitter carrier as a function of modulation frequency at a constant level of the modulation signal.

2.2.12.2 Method of measurement

A modulation signal at a frequency of 1000 Hz is applied to the voice input circuit. Its amplitude is adjusted to such a level that a frequency deviation of $\pm$ 1 kHz is obtained. The frequency deviation is measured while the frequency of the modulation signal is varied between 300 Hz and 25 kHz, its level being kept constant at the same value as at 1000 Hz. The measurement shall be made without the supervisory signal.

2.2.12.3 Requirements

The audio frequency response shall have a 6 dB/octave pre-emphasis between 300 Hz to 3400 Hz. Higher and lower frequencies shall be attenuated.

The tolerances are given in Fig. 2.1.

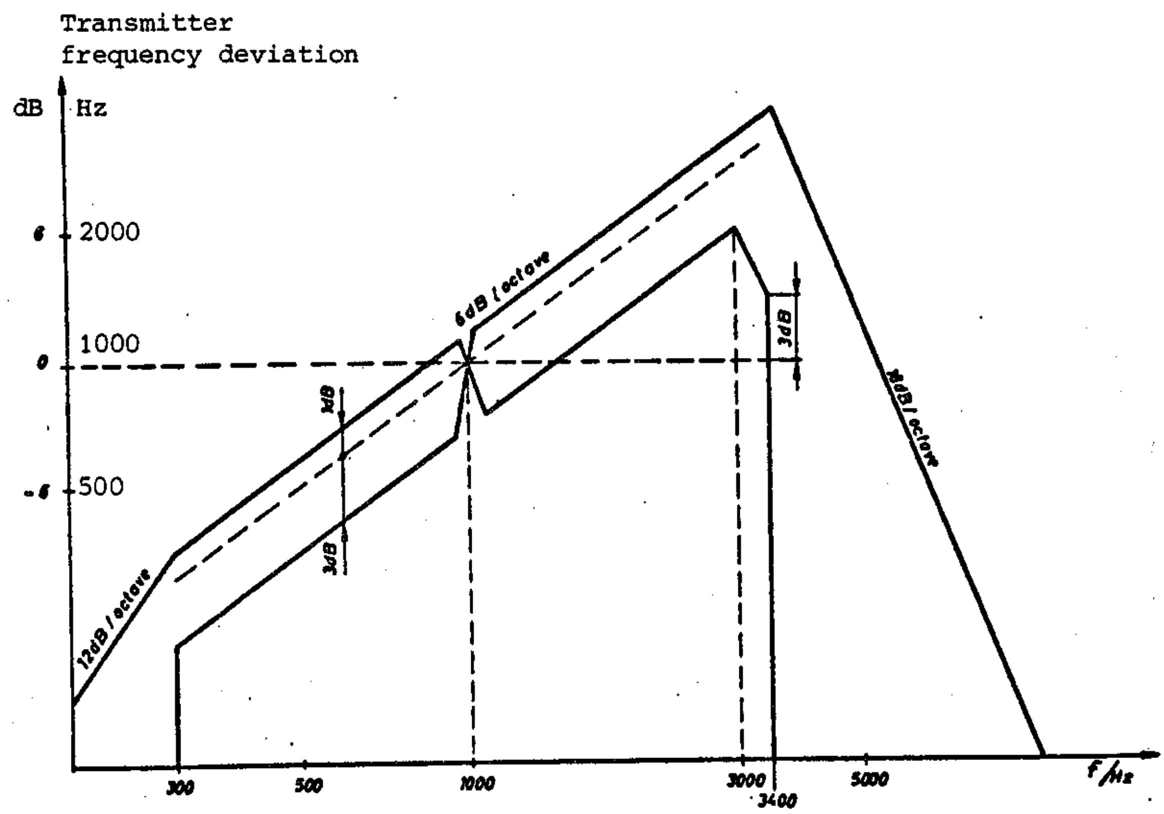


Fig. 2.1
Audio frequency response of transmitter.

2.2.13 Harmonic distortion factor in transmission

2.2.13.1 Definition

The harmonic-distortion factor of a transmitter modulated by an audio-frequency signal is defined as the ratio expressed as a percentage, of the r.m.s. voltage of all the harmonic components of the fundamental audio frequency to the total r.m.s. voltage of the signal after linear demodulation.

With the method described below, when a distortion analyser is used, the hum and noise components are included in the distortion measurement.

2.2.13.2 Method of measurement

The radio-frequency signal produced by the transmitter is applied, by means of a suitable coupler, to a linear demodulator equipped with a de-emphasis network of 6 dB per octave above 300 Hz. The

The response of this network may be flat but not falling below 300 Hz. At normal test conditions, this radio-frequency signal is modulated successively at frequencies of 300, 500 and 1000 Hz with a constant modulation index of 3 (the modulation index is the ratio of the frequency deviation to the modulating frequency) producing 3.0 kHz deviation at the frequency of 1000 Hz.

The harmonic distortion factor of the audio frequency signal is measured at all the frequencies given above.

At extreme test conditions, measurements are carried out at 1000 Hz with a frequency deviation of 3,0 kHz.

2.2.13.3 Requirements

The harmonic distortion shall not exceed 5%.

2.2.14 Relative audio-frequency intermodulation-product level of the transmitter

2.2.14.1 Definition

The relative intermodulation-product level of the transmitter is the ratio, expressed in decibels, of

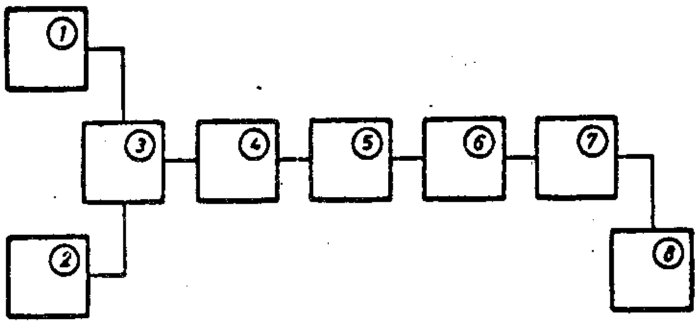
the level of an unwanted component of the output signal caused by the presence of two modulating signals as a result of nonlinearity in the transmitter,

to

the level of one of the wanted output signals measured at the output of a deviation meter.

2.2.14.2 Method of measurements

a) Connect the equipment as shown in Fig. 2.2



1 Audio-frequency generator no 1
2 Audio-frequency generator no 2
3 Audio-frequency combining unit
4 MS transmitter under test
5 Artificial antenna (50 ohm load)
6 Coupler / attenuator
7 Deviation meter
8 Audio-frequency spectrum analyser or selective voltmeter

Fig. 2.2

b) In the absence of an output from audio-frequency generator (2), adjust the audio frequency generator (1) to produce ± 2,3 kHz frequency deviation at a modulating frequency, F_1, of 1000 Hz.

Record the output level of the audio-frequency signal generator.

c) Reduce the output of generator (1) to zero and adjust the output of generator (2) to produce ± 2,3 kHz frequency deviation at a modulating frequency: F_2, of 1600 Hz.

d) Restore the output of generator (1) to the level recorded according to b) and measure the relevant intermodulation products with the selective voltmeter.

Notes: (1) The deviation meter shall be provided with a de-emphasis network of 6 dB per octave.

2.2.14.3 Requirements

The relative intermodulation product level shall not exceed -20 dB.

2.2.15 Residual modulation

2.2.15.1 Definition

The residual modulation of the transmitter is the ratio, expressed in dB, of the audio frequency noise level produced after radio frequency signal demodulation in the absence of modulation by the wanted signal, by the spurious effects of the power supply system, by the modulator or by other causes, to the audio frequency level produced by normal test modulation applied to the transmitter.

2.2.15.2 Method of measurement

a) The normal test modulation, is applied to the transmitter. For RF signal produced by the transmitter is applied by means of a suitable coupler to a linear demodulator.

The demodulator is equipped with a de-emphasis network of 6 dB per octave.

All precautions shall be taken to prevent the measurement results from being affected by emphasis at the low audio frequencies of the internal linear-demodulator noise.

Measurements shall be carried out on the demodulator output signal by means of an r.m.s. voltmeter equipped with a psophometric filter described in paragraph 1.3.9.2.

The modulation is then removed and the level of the residual audio-frequency output signal is again measured.

b) The same method as a) above but without the psophometric filter at the output.
In this case the measurements are carried out by means of a peak-to-peak voltmeter.

2.2.15.3 Requirements

For case a) the residual modulation shall not exceed -40 dB
For case b) the residual modulation shall not exceed -20 dB.

2.2.16 Transmitter audio muting

An input muting device controlled by the Logic and Control Unit shall be provided. The muting shall be capable of causing at least 40 dB attenuation in the audio path. The data transmission shall not begin until the muting has reached an attenuation of 40 dB.

2.3 Receiver

All requirements under section 2.3 with exception of paragraph 2.3.13 shall be fulfilled in duplex operation and the measurements shall be carried out in conversation mode, at the voice output circuit by using a load mentioned in paragraph 1.3.12. The transmitter shall be modulated with a 400 Hz tone giving a frequency deviation of ± 3.0 kHz unless otherwise stated.

2.3.1 Frequency range and channel separation

The MS receiver works on frequencies from 463.000 MHz to 467.475 MHz, with a channel separation of 25 kHz. The duplex separation is 10 MHz, giving the corresponding MS-transmitter frequencies from 453.000 MHz to 457.475 MHz.

2.3.2 Number of channels

The number of channels in the NMT is 180. Channel No. 1 is the lowest in frequency (in receiver 463.000 MHz, in transmitter 453.000 MHz) and channel No. 180 is the highest in frequency (in receiver 467.475 MHz, in transmitter 457.475 MHz).

2.3.3 Duplex separation

The duplex receive channels are assigned on a one to one relationship with the transmit channels, and a constant separation of 10 MHz.

2.3.4 Receiver detection and switching time

Definition, method of measurement and requirements are given in chapter 6.

2.3.5 Reduced channel locking capability

See paragraph 5.2.3.3.

2.3.6 RF carrier detector

The detector level shall be fixed and the opening level shall be − 2 dBuV ± 2 dB.

2.3.7 RF-sensitivity

2.3.7.1 Definition

The sensitivity of the receiver is the minimum RF-signal level at the antenna terminal which, at the nominal frequency of the receiver and modulated with normal test modulation, will produce a power at the voice output circuit at least 50% of the rated output power and a SINAD-ratio of 20 dB measured through the psophometric filter (see paragraph 1.3.9.2).

The SINAD-ratio is the ratio of signal + noise + distortion to noise + distortion. The SINAD(P)-ratio is the SINAD-ratio measured through the psophometric filter.

2.3.7.2 Method of measurement

A signal at the nominal frequency of the receiver and with normal test modulation shall be applied to the antenna terminal. The SINAD meter, (see paragraph 1.3.9.3) and a psophometric filter shall be connected to the voice output circuit. Where possible, the receiver volume control shall be adjusted to give 50% of the rated output power and, in the case of stepped volume controls, to the first step that provides an output power of at least 50% of the rated output power.

The test signal input level at the antenna terminal shall be reduced to 1.0 microvolt E.M.F. under normal test conditions and to 1.5 microvolt E.M.F. under extreme test conditions. In both cases the SINAD(P)-ratio is measured.

Under extreme test conditions, a variation of the receiver output power of ± 3 dB from the value obtained under normal test conditions may be allowed.

2.3.7.3 Requirements

The SINAD(P)-ratio shall be at least 20 dB in both cases.

2.3.8 Co-channel rejection

2.3.8.1 Definition

The co-channel rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal, both signals being at the nominal frequency of the receiver.

2.3.8.2 Method of measurement

Two input signals shall be connected to the antenna terminal via a combining device. The wanted signal shall have normal test modulation. The unwanted signal shall be modulated with a frequency of 400 Hz with a deviation of ± 3 kHz. Both input signals shall be at the nominal frequency of the receiver and the measurement repeated for displacements of the unwanted signal of up to ± 3 kHz.

The transmitter shall be unmodulated during the test.

Initially the unwanted signal shall be switched off and the level of the wanted signal shall be adjusted to 3 dB (1 uV) E.M.F. The unwanted signal shall then be switched on.

The level of the unwanted signal shall be adjusted until the SINAD(P)-ratio measured at the voice output circuit is reduced to 20 dB.

The co-channel rejection ratio is expressed as the ratio in dB of the level of the unwanted signal to the level of the wanted signal at the antenna terminal for which a SINAD(P)-ratio = 20 dB at the voice output circuit occurs.

2.3.8.3 Requirements

The co-channel rejection ratio at any of the specified signal displacements shall be between 0 dB and -8 dB.

2.3.9 Adjacent channel selectivity

2.3.9.1 Definition

The adjacent channel selectivity is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted signal which differs in frequency from the wanted signal by an amount equal to the channel separation.

2.3.9.2 Method of measurement

Two signals shall be applied to the antenna terminal via a combining device. The wanted signal shall be tuned to the nominal frequency of the receiver and be modulated with normal test modulation. The unwanted signal shall be at the nominal frequency of the upper adjacent channel and be modulated with a 400 Hz tone to a frequency deviation of + 3 kHz.

The mobile station transmitter shall be unmodulated during the test.

Initially the unwanted signal shall be switched off and the level of the wanted signal shall be adjusted to 3 dB (1 uV) E.M.F. The unwanted signal shall then be switched on and its level adjusted until the SINAD(P)-ratio measured at the voice output circuit is reduced to 20 dB.

The measurement shall be repeated with the unwanted signal at the nominal frequency of the lower adjacent channel.

The ratios expressed in dB of the level of the unwanted signal to the level of the wanted signal are determined. The adjacent channel selectivity shall then be the lower value of the two ratios.

2.3.9.3 Requirements

The adjacent channel selectivity shall not be less than 70 dB under normal test conditions and not less than 60 dB under extreme test conditions.

2.3.10 Spurious response rejection

2.3.10.1 Definition

The spurious response rejection is a measure of the capability of the receiver to discriminate between the wanted modulated signal at the nominal frequency and an unwanted signal at any other frequency than the wanted and adjacent channels.

2.3.10.2 Method of measurement

Two input signals shall be applied to the antenna terminal via a combining device. The wanted signal shall be at the nominal frequency of the receiver and be modulated with normal test modulation.

Initially the unwanted signal shall be switched off and the wanted input signal adjusted to 3 dB (1 uV) E.M.F. The unwanted signal shall be switched on and modulated with a 400 Hz tone to a frequency deviation of $\pm$ 3 kHz. The input level of the unwanted signal shall be 83 dB (1 uV) E.M.F. The frequency shall then be varied over the frequency range from 100 kHz to 2000 MHz.

At any frequency at which a response is obtained, the input level of the unwanted signal shall be adjusted until the SINAD(P)-ratio of the voice output circuit is reduced to 20 dB.

The spurious response rejection is expressed as the level in dB of the input voltage of an unwanted signal and the input voltage of the wanted signal when the SINAD(P)-ratio of 20 dB, as mentioned above, is obtained.

The transmitter shall be unmodulated during the test.

2.3.10.3 Requirement

The spurious response rejection shall be at least 70 dB.

2.3.11 Intermodulation rejection

2.3.11.1 Definition

The intermodulation rejection is a measure of the capability of the receiver to receive a wanted signal without exceeding a given degradation due to the presence of two unwanted high level signals.

2.3.11.2 Method of measurement

Three signals shall be applied to the antenna terminal via a combining device. The wanted signal A shall be tuned to the nominal frequency of the receiver and modulated to normal test modulation. The unwanted signal B shall be tuned to a frequency 50 kHz above the nominal frequency of the wanted signal and shall be unmodulated. The unwanted signal C shall be tuned to a frequency 100 kHz above the frequency of the wanted signal and be modulated with a 400 Hz tone to a frequency deviation of ± 3 kHz.

The level of the wanted signal A shall be adjusted to 3 dB (1 uV) E.M.F. The level of the two unwanted signals B and C shall be maintained equal and increased in level until the SINAD(P)-ratio measured at the voice output circuit is 20 dB.

The frequencies of signals B and C may be slightly adjusted to get maximum degradation of the SINAD(P)-ratio and their levels adjusted again until the SINAD(P)-ratio is again 20 dB.

The measurement shall be repeated with the two unwanted signals B and C tuned to 50 kHz and 100 kHz, respectively, below the frequency of the wanted signal.

The intermodulation rejection is expressed as the level in dB of the unwanted signals and the wanted signal when the SINAD(P)-ratio of 20 dB as mentioned above, is obtained. The transmitter shall be unmodulated during the test.

2.3.11.3 Requirement

The intermodulation rejection shall not be less than 67 dB.

2.3.12 <u>Blocking</u>

2.3.12.1 Definition

Blocking is a change (generally a reduction) in the wanted output power of a receiver or a reduction of the SINAD(P)-ratio due to an unwanted signal on another frequency.

2.3.12.2 Method of measurement

Two input signals shall be applied to the antenna terminal via a combining device. The wanted signal shall be at the nominal frequency of the receiver and shall have normal test modulation. Initially the unwanted signal shall be switched off and the input level of the wanted signal adjusted to 3 dB (1 uV) E.M.F.

Where possible the output power of the wanted signal at the voice output circuit shall be adjusted to 50% of the rated output power and in the case of stepped volume controls to the first step that provides an output power of at least 50% of the rated output power. Then the unwanted signal is switched on. The unwanted signal shall be unmodulated, and the frequency shall be varied between + 1 MHz and + 10 MHz, and also between - 1 MHz and - 10 MHz, relative to the nominal frequency of the receiver. The input level of the unwanted signal, at all frequencies in the specified ranges, shall be adjusted such that the unwanted signal causes:

a) a reduction of 3 dB in the audio frequency output power of the wanted signal, or

b) a reduction of the SINAD(P)-ratio to 20 dB

whichever occurs first.

This input level is the blocking level at the frequency concerned.

The mobile station transmitter shall be unmodulated during the test.

2.3.12.3 Requirement

The blocking level for any frequency within the specified ranges shall not be less than 90 dB (1 uV) E.M.F. except at frequencies where spurious responses are found.

2.3.13 Spurious emissions

2.3.13.1 Definition

Spurious emissions are any emissions from the receiver and the transmitter in carrier "off" condition.

The level of spurious emissions shall be measured as:

a) their conducted power level in an artificial antenna and

b) their effective radiated power when radiated by the cabinet and structure of the equipment (also known as "cabinet radiation")

2.3.13.2 Method of measuring the conducted power

Conducted spurious emissions shall be measured as the power of any discrete signal at the antenna terminal of the mobile station. The antenna terminal is connected to a spectrum analyzer or selective voltmeter having an input impedance of 50 ohms and the receiver is switched on.

If the measuring receiver is not calibrated in terms of absolute power, the power of any detected components shall be determined by a substitution method using a signal generator.

The measurements shall be carried out within at least the frequency range 100 kHz to 2000 MHz.

2.3.13.3 Method of measuring the effective radiated power

On a test site fulfilling the requirements of paragraph 1.3.11 the sample shall be placed at the specified height on a non-conducting support. The receiver shall be operated from a power source via a radio-frequency filter to avoid radiation from the power leads. The antenna terminal shall be connected to a 50 ohm resistive load. Radiation of any spurious components shall be detected by the test antenna and measuring receiver over the frequency range from 30 MHz to 2000 MHz.

At each frequency at which a spectral component is detected, the sample shall be rotated to obtain maximum response and the effective radiated power of that component shall be determined by a substitution measurement.

The measurement shall be repeated with the test antenna in the orthogonal polarization plane.

2.3.13.4 Requirement

The power of any spurious emission in the specified range of frequencies shall not exceed 2.0 nW.

2.3.14 Harmonic distortion ratio

2.3.14.1 Definition

The harmonic distortion ratio at the voice output circuit is the r.m.s. value of the voltage of all harmonics divided by the r.m.s. value of the total signal voltage.

2.3.14.2 Method of measurement

Test signal of 60 dB (1 uV) E.M.F. and 100 dB (1 uV) E.M.F. at the nominal frequency of the receiver shall be applied successively to the antenna terminal.

At each measurement the volume control of the receiver shall be set in such a manner that the power at the voice output circuit is equal to the rated output power of the receiver.

The test signal shall be modulated successively with 300, 500 and 1000 Hz tones to frequency deviations of $\pm$ 0.9 kHz, $\pm$ 1.5 kHz and $\pm$ 3 kHz respectively.

Under extreme test conditions tests shall be carried out at the nominal frequency of the receiver as well as at plus and minus 1.0 kHz from the nominal frequency. In this case the input signal is modulated only with a 1000 Hz tone to a frequency deviation of $\pm$ 3.0 kHz.

The transmitter shall be unmodulated during the test.

2.3.14.3 Requirement

At all audio frequencies used in the measurement and under all test conditions the harmonic distortion ratio shall not exceed 5%.

2.3.15 Relative audio frequency intermodulation product level

2.3.15.1 Definition

The relative intermodulation product level is the ratio, expressed in dB, of the level of an unwanted component of the output signal caused by the presence of two modulating signals as a result of nonlinearity in the receiver, to the level of one of the wanted output signals measured at the voice output circuit.

2.3.15.2 Method of measurement

Two audio frequency generators A and B shall be connected via a combining device to the modulation input of the radio frequency signal generator.

Adjust the radio-frequency test signal to the nominal frequency of the receiver and the test signal level successively to 20 dB, 60 dB and 100 dB (1 uV) E.M.F.

In the absence of an output from audio-frequency generator B, adjust the audio-frequency generator A to produce a ± 2.3 kHz frequency deviation at a modulation frequency of 1000 Hz. Where possible, adjust the output power to 50% of the rated output power. In case of stepped volume controls the first step that provides an output power of at least 50% of the rated output power shall be used. Record the output level of generator A.

Reduce the output of generator A to zero and adjust the output of generator B to produce a ± 2.3 kHz frequency deviation at a modulation frequency of 1600 Hz.

Restore the output of generator A to the level recorded and measure the level of the 1000 Hz component and of the intermodulation products at the voice output circuit.

The transmitter shall be unmodulated during the test.

2.3.15.3 Requirement

The relative audio frequency intermodulation product level shall not exceed - 20 dB.

2.3.16 <u>Amplitude characteristic of the receiver limiter</u>

2.3.16.1 Definition

The amplitude characteristic of the receiver limiter is the relationship between the level of a specified modulated input signal and the level of the audio frequency signal at the output of the receiver.

2.3.16.2 Method of measurement

A signal at the nominal frequency of the receiver with normal test modulation and at a level of 3 dB (1 uV) E.M.F. shall be applied to the antenna terminal. Where possible the audio frequency output power shall be adjusted to 25% of the rated output power. In case of stepped volume control the first step that provides an output power of at least 25% of the rated output power shall be used. The input signal shall be increased to 100 dB (1 uV) E.M.F. and the audio frequency output power shall be measured again.

2.3.16.3 Requirements

At the change in the input power specified above the change in the output power shall not exceed 3 dB.

2.3.17 <u>AM-suppression</u>

2.3.17.1 Definition

AM-suppression is the capability of the receiver to suppress amplitude modulated signals. It is expressed as the ratio in dB of the audio power at the voice output circuit with normal test modulation to the audio power with a specified amplitude modulation.

2.3.17.2 Method of measurement

A test signal at a level of 20 dB (1 uV) and 60 dB (1 uV) E.M.F. at the nominal frequency of the receiver shall be applied to the antenna terminal successively. The signal shall initially have normal test modulation and the receiver output power shall be set to the nominal output level. The normal test modulation shall then be replaced by amplitude modulation to 30% with a 1000 Hz tone. The audio power shall be measured again. It may be necessary to make this measurement with a selective voltmeter.

2.3.17.3 Requirement

The AM-suppression shall not be less than 30 dB.

2.3.18 <u>Noise and hum</u>

2.3.18.1 Definition

The "noise and hum" of the receiver is the ratio, expressed in dB, of the audio frequency noise and hum level resulting from the spurious effects of the power supply system or from other causes to the audio frequency power produced by a medium-level RF signal modulated by normal test modulation applied to the antenna terminal.

2.3.18.2 Method of measurement

A test signal at a level of 30 dB (1 uV) E.M.F. at a carrier frequency equal to the nominal frequency of the receiver and modulated to the normal test modulation, is applied to the antenna terminal. A psophometric filter is connected to the voice output circuit. The audio frequency output power control, if any, shall be adjusted to the rated output power.

The output signal is measured by a r.m.s. voltmeter.

The modulation is then removed and the audio frequency output level measurement is repeated.

The measurement shall be repeated using the same method as above but without the psophometric filter.

The output signal is measured by means of a peak-to-peak voltmeter.

2.3.18.3 Requirements

With the psophometric filter the receiver "noise and hum" ratio shall not exceed - 40 dB.

Without the psophometric filter the receiver "noise and hum" ratio shall not exceed - 20 dB.

2.3.19 Audio frequency response

2.3.19.1 Definition

The audio frequency response of the receiver expresses the variations of the audio frequency output level as a function of the input signal modulation frequency at the input.

2.3.19.2 Method of measurement

A test signal of 60 dB (1 uV) E.M.F. at a frequency equal to the nominal frequency of the receiver is applied to the antenna terminal. The test signal shall have normal test modulation.

Where possible, the output power shall be adjusted to 50% of the rated output power. In case of stepped volume control the first step that provides an output power of at least 50% of the rated output power shall be used. This setting is not altered during the test.

The frequency deviation at 1000 Hz is then reduced to ± 1 kHz. The frequency deviation is maintained constant while the modulation frequency is varied between 20 and 5000 Hz.

The measurement is repeated with a test signal having a frequency equal to the nominal frequency of the receiver plus or minus 1.0 kHz.

The transmitter shall be unmodulated during the test.

2.3.19.3 Requirement

The audio level relative to the value at 1 kHz at constant frequency deviation shall be as given in Fig. 2.3.

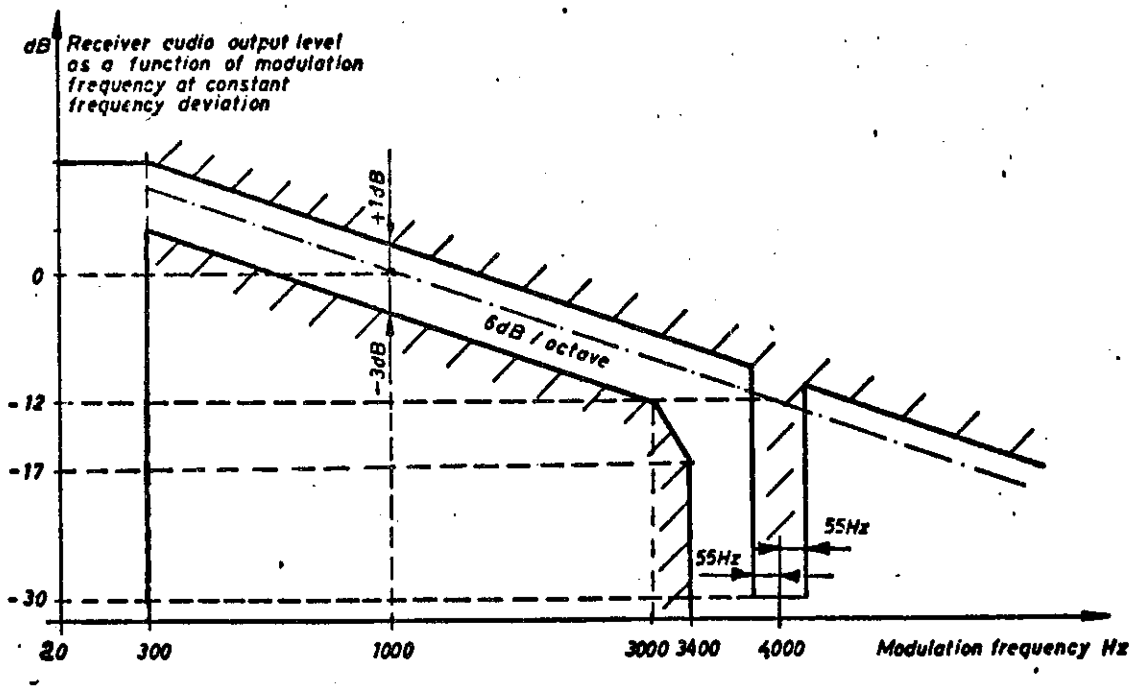


Fig. 2.3

Receiver audio output

2.3.20 Receiver audio muting

An output muting device controlled by the Logic and Control Unit shall be provided. The muting device shall be capable of causing at least 40 dB of attenuation in the audio path.

3. OPERATIONAL CONTROLS UNIT

The Operational Controls Unit is the interface between the user and the NMT-system. This functional unit includes a handset, hands-free capability, and all mobile station controls, indicators and tone signals with which the user interacts.

3.1 Mobile telephone number (identification)

The mobile station is identified by a 6 digit mobile telephone number: $X_1 \ldots X_6$, and an additional code Z designating the country. The complete identification on the radio path is thus $ZX_1 \ldots X_6$.

This number shall only be changeable by means of modifications inside the mobile station at a qualified service level. Such changes can only be authorized by the Telecommunications Administration. A plate which shows the assigned 6 digit mobile telephone number $X_1 \ldots X_6$ shall be visible to the user.

3.2 On/off switch

On/off switch shall be provided to switch the power on or off.

3.3 Handset

A handset shall be provided. The microphone in the handset shall be of the linear (non-carbon) type, e.g. electrodynamic, electromagnetic or electret. The handset shall not include a sidetone circuit.

The handset may also include visual indicators, control switches and push-buttons. All indications shall be visible and all switches and buttons shall be available for operation also when the handset is on hook.

3.3.1 Handset transmitter (microphone)

3.3.1.1 Sensitivity

The sensitivity of the microphone must be such that if an acoustic signal of 1000 Hz is applied to the microphone with a free field sound pressure level of 94 dB above 2×10^{-5} Pascal, the frequency deviation of the transmitter frequency shall be between 3.0 and 4.5 kHz.

3.3.1.2 Frequency response

With the exception below, the acoustic-to-electric frequency response of the handset transmitter must fall within the template shown in Fig. 3.1 when the handset is terminated in the impedance declared for the voice input terminal according to 1.3.2.3.

However, the acoustic-to-electric response may fall outside the tolerance area in a maximum of three arbitrary nonadjacent frequency intervals, each having a width of one-third of one octave (i.e. the ratio between the limiting frequencies of such an interval is 1.26).

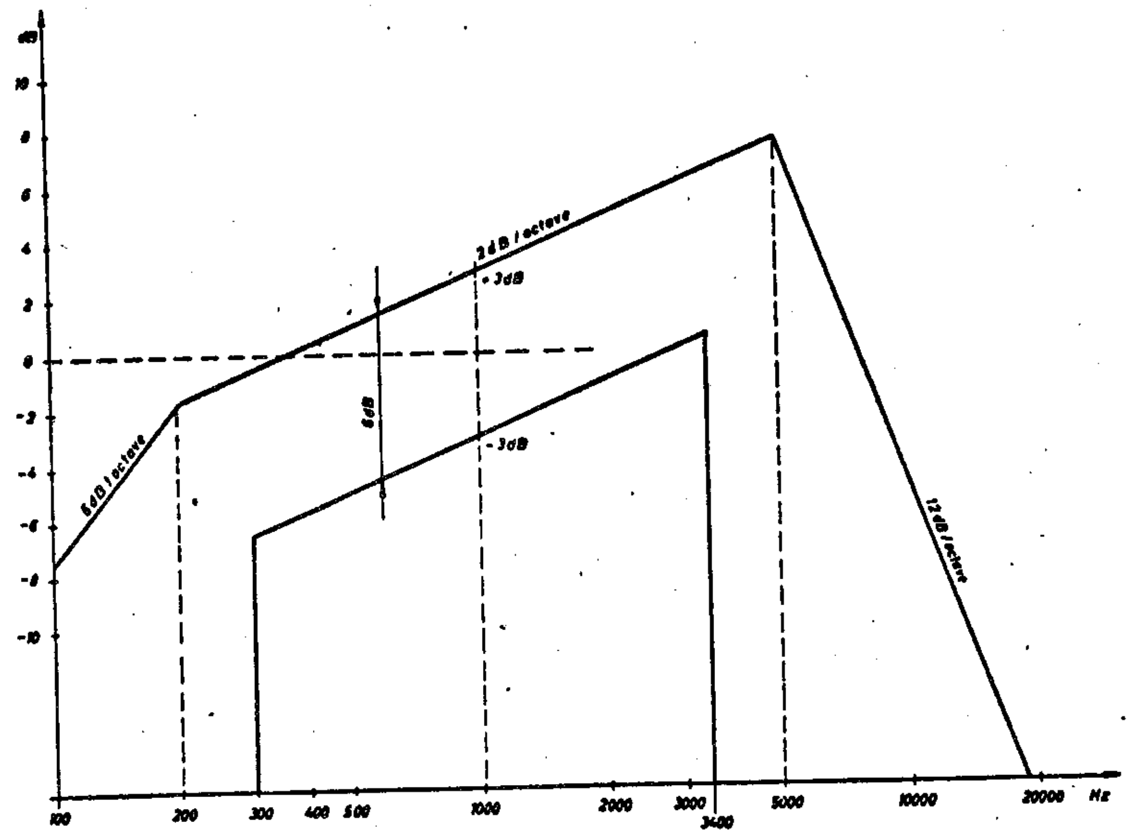


Fig. 3.1

Handset transmitter acoustic-to-electric frequency response.

3.3.1.3 Harmonic distortion

For measurement of the harmonic distortion, an acoustic signal with a frequency of 1000 Hz and a sound pressure of 94 dB above 2×10^{-5} Pascal is applied to the microphone.

The harmonic distortion of the signal delivered into an impedance equal to the impedance of the voice input circuit as declared by the manufacturer shall not exceed 5 per cent.

3.3.2 Handset receiver

Measurements on the handset receiver shall be performed using an acoustic coupler ("artificial ear") complying with CCITT Rec. P.51, The sound level of the handset receiver shall not be affected by the setting of the loudspeaker volume control (if so equipped). If the handset is equipped with a sound level volume control it is recommended that the range of adjustment is - 10 dB to + 15 dB relative to the nominal setting of the volume control. The requirements in the following paragraphs refere to the case when the volume control is set to its nominal position.

3.3.2.1 Sensitivity

When an electric signal of a frequency of 1000 Hz and a level corresponding to an RF deviation of $\pm$ 3 kHz is fed to the handset via an impedance equal to the impedance declared for the voice output circuit, the sound pressure level into the acoustic coupler shall be in the range 85 - 95 dB above 2×10^{-5} Pascal.

3.3.2.2 Frequency response

With the exception below, the electric-to-acoustic frequency response of the handset receiver must fall within the template shown in Fig. 3.2 when the handset is fed via the impedance declared for the voice output terminal.

However, the acoustic-to-electric frequency response may fall outside the tolerance area in a maximum of three arbitrary, non-adjacent frequency intervals, each having a width of one-third of one octave.

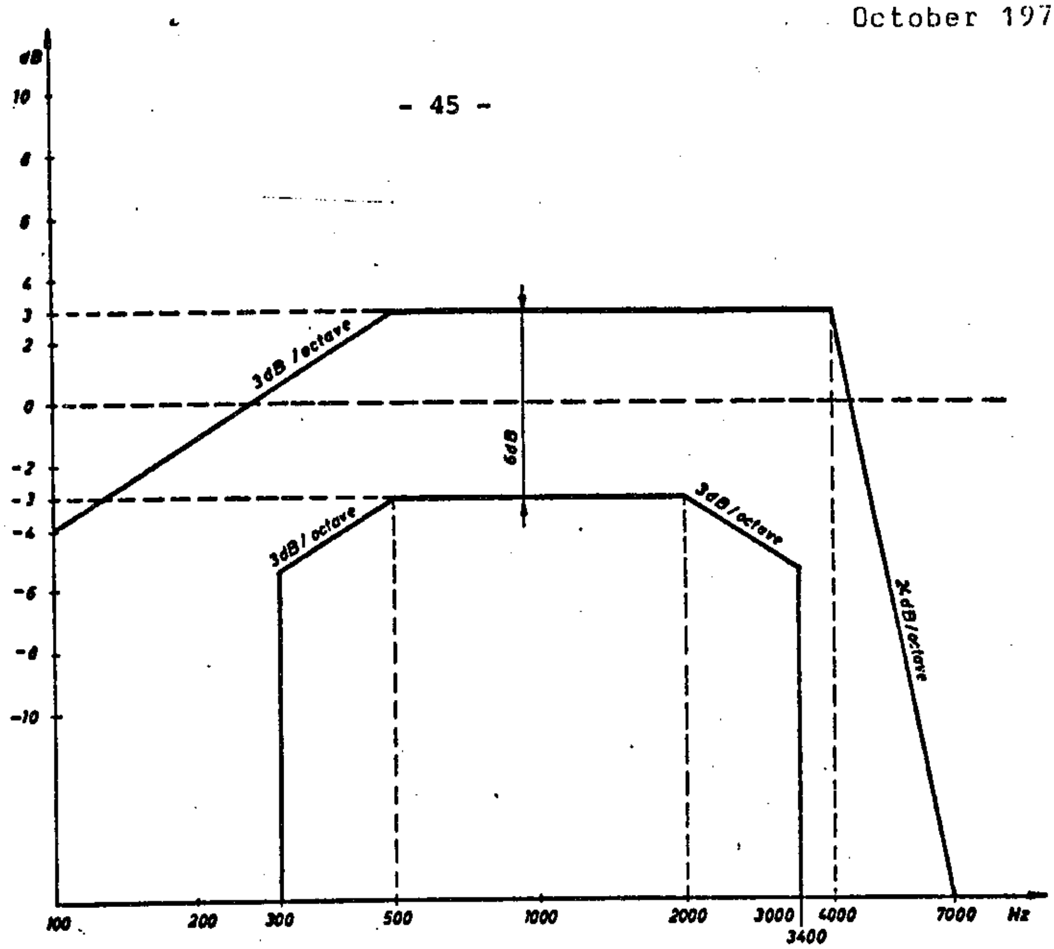


Fig. 3.2.

Handset receiver electric-to-acoustic frequency response

3.3.2.3 Harmonic distortion

For measurement of the harmonic distortion, a signal of frequency of 1000 Hz is applied to the handset receiver via an impedance equal to the impedance of the voice output circuit at a level corresponding to an RF deviation of $\pm$ 3 kHz. The harmonic distortion shall not exceed 5 per cent.

3.3.2.4 Maximum sound level of handset receiver

To protect the user from ear damage, the maximum impulsive sound level from the handset receiver shall not exceed 120 dB above 2×10^{-5} Pascal. This requirement shall be valid for any operating condition, any setting of controls, and any combination of modulating frequencies and modulation indexes.

3.4 "Hands-free" operation - "Hands-free" button

Operation of the mobile station in "Handset" mode as well as in "Hands-Free" mode shall be foreseen. For this purpose the mobile equipment shall permit simultaneous connection of a handset as well as a fixed mounted microphone with a associated loudspeaker. Furthermore a special "Hands-Free" button shall be provided.

In case of a mobile installation for both operation modes the following requirements shall be fulfilled:

- A separate "Push-to-talk" button shall be provided.
  Pressing this button shall in hands-free mode:
  - open the microphone audio path, and
  - close the loadspeaker audio path.

The audio path shall be connected to the handset or, alternatively to the fixed microphone and loudspeaker, depending on the mode. The functions under different conditions are given in paragraph 4.6.

The sensitivity of the fixed microphone if so equipped shall be set by the manufacturer. The user shall have no access to any sensitivity adjustment. Regarding portable mobile stations reference is made to annex 1.

3.5 Volume Control

If an additional loudspeaker is provided, an audio volume control shall be provided. The volume control should provide an adjustment range of at least + 15 dB to - 10 dB relative to the nominal sound level. With the mobile station in the "Hands-Free mode" it shall not be possible to close the receiver audio path, i.e. the minimum setting of the volume control shall still permit the user to notice when speech (of a normal level) is present.

3.6 Switch hook

A switch hook device shall be provided to indicate to the Logic and Control Unit whether the handset is on-hook or off-hook.

3.7 Dialling facilities

3.7.1 Push-button set

A 12-button set shall be provided:

- 10 digit buttons (1,2,3,4,5,6,7,8,9,0)
- and buttons for * and #

The buttons shall be arranged in accordance with one of the arrangements shown below:

a) 1 2 3
   4 5 6
   7 8 9
   * 0 #

b) 7 8 9
   4 5 6
   1 2 3
   0 * #

c) 1 2
   3 4
   5 6
   7 8
   9 0
   * #

d) 1 2 3 4 5 *
   6 7 8 9 0 #

For special purposes a 16-button set may be used. The buttons shall be arranged in accordance with one of the arrangements shown below:

e) 1 2 3 A
   4 5 6 B
   7 8 9 C
   * 0 # D

f) 7 8 9 D
   4 5 6 C
   1 2 3 B
   0 * # A

g) 1 2
   3 4
   5 6
   7 8
   9 0
   * #
   A B
   C D

h) 1 2 3 4 5 * A B
   6 7 8 9 0 # C D

Note:

In Finland, Sweden and Norway one of the alternatives a, c, d, e g or h shall be used.

In Denmark one of the alternatives b,c,d,f,g or h shall be used.

The push-button set shall be available for use in "on-hook" condition.

It is recommended that the area of the button should be at least 1 cm^2 and that the space between the centres of two adjoining buttons should be at least 16 mm.

The push-button set shall be designed in such a way that the subscriber easily can notice that a button has been pushed. For example by excursion (0,5-3 mm) and resistive force (0,6-1,2 Newton) or combined with a digit display. For traffic safety reasons the buttons shall be easily discernible and manoeuvrable even in poorly illuminated surroundings.

3.7.2 Dialled digits memory

The MS shall be provided with a dialled digits memory with a storage capacity of 16 digits. A digit memory indicator or a display shall be provided (see paragraphs 3.10.4 and 3.11.2).

3.8 Acoustic signals

3.8.1 Ringing signal

An acoustic ringing signal having a duration of approximately 1 sec shall be provided to inform the user of an incoming call (MTX ⟶ MS).

The ringing signal shall be generated locally in the mobile station and be activated by a ringing order from the Logic and Control Unit (Frame 5.a(L=9) in signalling scheme MTX ⟶ MS).

3.8.2 Malfunction alarm

An acoustic signal different from the ringing signal shall be generated locally when the MS is not able to finalize the call attempt i.e. when the MS due to malfunction has left the traffic channel and is locked to or searching for a calling channel. The signal informs the user that he shall replace the handset or press the Hands-Free button depending on mode. The user may now make a new call attempt. The malfunction alarm shall also be activated if the user initiates off hook when the MS is in signalling scheme D (roaming information).

3.9 Country selector

A country selector shall be provided which determines a group of traffic areas (corresponding to the mobile telephone network of one country) which the mobile station communicates with. The traffic area groups are characterized by Y_1 in the traffic area number Y_1Y_2 as shown in the table below.

Value of Y_1	Country
0000-0100	Spare
0101	Denmark
0110	Sweden
0111	Norway
1000	Finland
1001-1111	Spare

The mobile subscriber selects country manually when travelling from one country to another. It shall be possible to select at least the values of Y_1 corresponding to the four countries mentioned above.

The selected country shall be indicated and be clearly visible to the user whenever the MS is in "power on" condition.

The information about the selected country (Y_1) shall be memorized for at least one week when the MS is in "power off" condition. See also paragraph 5.2.1.1.

3.10 Visual indicators

The following visual indicators shall be provided.

3.10.1 On/off indicator

The "on/off indicator" informs the user whether power supply is actually applied to the MS or not (e.g. by means of push-button illumination).

The indicator (illumination) colour shall be white.

3.10.2 Service indicator

The "service indicator" informs the user that the MS is locked to a calling channel. The indicator shall be switched off when the MS loses the locking to the calling channel.

The indicator colour shall be green.

3.10.3. Call received indicator

The "call received indicator" informs the user that a call has been received. This is controlled by the Logic and Control Unit.

The indicator shall turn off when the handset is lifted or the "Hands-Free" button is activated.

The indicator colour shall be yellow.

3.10.4 Digit memory indicator

If a display is not supplied, the MS shall be provided with a "Digit memory indicator".

The memory indicator tells the user the state of the dialled digits memory and shall operate in the following way:

- As soon as the dialled digits memory has received the first digit, the memory indicator shall be "switched on"
- The memory indicator shall be "switched off" when
  - . all digits in the memory have been sent to the MTX or,
  - . the user has applied a "cancellation procedure" during dialling.

The indicator colour shall be white.

3.10.5 Roaming alarm indicator

The "roaming alarm indicator" informs the user that the automatic updating procedure has not been successful. The user may then repeat the updating procedure by lifting the handset or pressing the "Hands-Free" button.

The "roaming alarm indicator" shall be turned off again as soon as roaming updating confirmation is received. The user then replaces the handset or presses the "Hands-Free" button.
The indicator colour shall be red.

3.11 Supplementary facilities

3.11.1 "Abbreviated dialling"

The "Abbreviated dialling" may be included in the MS as an abbreviated number store provided that the signalling procedure from MS to MTX during setting up a call is in accordance with the procedure specified in NMT Doc. 1.

The recommended procedures are given in paragraph 4.8.

3.11.2 Display

If a dialled digit display is provided the number of displayed digits shall be at least 8, but 16 digits is recommended. The last selected digits shall always be displayed. In addition to the digits 0 - 9, the display shall be able to handle * and #.
If the MS is so equipped, it must also be able to handle the characters A - D.

The figures of the display must be clearly visible and in a normal installation a figure height of 7 - 8 mm is preferable. The possibility to adjust the brightness of the display is also advantageous.

3.11.3 Data transmission from MS

Data transmission may be possible via the push button set already available in the MS. In this case the 1200 baud FFSK signalling from MS is converted to MFT signalling by means of an MFT converter in the MTX. Spesifications may be issued at a later date.

3.11.4 Possible other facilities

The mobile station may be provided with other facilities, e.g. possibility of connecting separate data modems such as the modems already in use in the telephone networks.

4. OPERATIONAL PROCEDURES

In the following operational procedures it is presumed that the MS has gone from "power off" to "power on" condition.

4.1 Call from MS to MTX

State: Power "on", on-hook.

User action	MS-Response
Dial digits on push-button set	Digits stored in dialled digits memory
Lift handset or press "Hands-Free" button	Service indicator "off" (if activated) MS hunts for free traffic channel - when found, digits are transmitted to MTX
	(Answer)
(Conversation)	(Conversation)

4.2 Answer call from MTX to MS

State: Power "on", on-hook, service indicator "off", ringing signal, call received indicator "on"

User action	MS-Response
Lift handset or press "Hands-Free" button	Ringing signal stopped Call received indicator "off" Speech path through-connected for conversation
(Conversation)	(Conversation)

or

State: Power "on", off-hook, service indicator "off", ringing signal, call received indicator "on", malfunction alarm

User Action	MS-Response
Replace handset	Malfunction alarm stopped
Lift handset or press "Hands-Free" button	Ringing signal stopped Call received indicator "off" Speech path through-connected for conversation
(Conversation)	(Conversation)

4.3 Call clearing

State: Power "on", off-hook, service indicator "off", speech path through-connected

User Action	MS-Response
Replace handset or press "Hands-Free" button	Audio path disconnected MS back to standby

4.4 Unsuccessfull call attempt or interrupted call

State: Power "on", off-hook, service indicator "on", malfunction alarm

User Action	MS-Response
Replace handset or press "Hands-Free" button	Malfunction alarm stopped MS ready for new call attempt

4.5 Manual roaming updating

State: Power "on", on-hook, roaming alarm

User Action	MS-Response
Lift handset or press "Hands-Free" button	Service indicator "off" (if activated). Roaming alarm turned off (when roaming updating confirmation is received from MTX)
Replace handset or press "Hands-Free" button	MS back to standby

4.6 "Handset" and "Hands-Free" operation

State	User's action	MS action
Handset "on-hook" (MS standby) no roaming alarm	Handset "off-hook" or "Hands-Free" button pressed	Call MS → MTX initiated
Handset "on-hook" (call MTX → MX received)	Handset "off-hook" or "Hands-Free" button pressed	Call MTX → MS answered
Handset mode Handset "off-hook" (conversation)	Handset "on-hook"	Call cleared
	"Hands-Free" button pressed	Transfer to "Hands-Free" mode
"Hands-Free" mode Handset "off-hook" (conversation)	Handset "on-hook"	No action
	"Hands-Free" button pressed	Call cleared
"Hands-Free" mode Handset "on-hook" (conversation)	Handset "off-hook"	Transfer to handset mode
	"Hands-Free" button pressed	Call cleared

"Hands-Free" mode is conversation by means of the fixed mounted microphone and loudspeaker utilizing the "Push-to-talk" button. "Handset" mode is conversation by means of the handset.

4.7 Country selection

User Action	MS-Response
Select country on country selector	MS accepts only traffic areas Y_1Y_2 of that country

4.8 Abbreviated dialling (Supplementary facility)

The procedure of using the abbreviated number store is to be decided by the manufacturer, having in mind that the possibility of changing the content by mistake shall be as small as possible.

If the push-button set in the MS is used for programming, cancellation and check of the content of the number sender, and for activating the number sender during a call set-up, the following procedures shall be used:

State: Power "on", on-hook

User action	MS-Response
Programming	
Dial $-*X_1X_2*S_1S_2..S_n$#	Digits stored in dialled digits memory
-*	The telephone number $S_1S_2...S_n$ is stored in the abbreviated number store. Dialled digits memory is cleared.
Cancellation	
Dial - # X_1X_2 #	Digits stored in dialled digits memory
- *	Cancellation is done for this abbreviated number in the abbreviated number store. Dialled digits memory is cleared.
Check (if display is available)	
Dial - X_1X_2	Digits X_1X_2 is shown on the display
-#	The corresponding telephone number is shown on the display. The last digits are displayed if the telephone number is longer than the display capacity.
-#	The display is cleared.
Activation of the abbreviated number store	
Dial the abbreviated number X_1X_2	Digit X_1X_2 are stored in dialled digits memory.
Dial #	The actual telephone number corresponding to the abbreviated number is stored in dialled digits memory.
Lift handset or press "Hands-Free" button	Service indicator "off" MS hunts for a free traffic channel - when found, digits are transmitted to MTX.
	(Answer)
(Conversation)	(Conversation)

X_1X_2 (or only X_1) is the abbreviated number, and
$S_1S_2....S_n$ is the corresponding telephone number.

The code #* indicates that a programming/cancellation in the abbreviated number store shall be done.

Cancellation of wrong dialled information shall be done by dialling ##.

4.9 Dialled digits memory

The dialled digits memory shall store the digits dialled by the user in on-hook condition. This includes also * and # and if so equipped even A to D.

The memory shall be cleared when

- all the digits have been sent to the MTX
- the user has applied a "cancellation procedure" (##) during dialling,

Repeated call attempts (to the already dialled and stored address) may be performed, but neither automatically nor by lifting the handset or pressing the "Hands-Free" button. A possible solution in the MS is to dial a special abbreviated number (e.g. 0#) to restore the last dialled number in the dialled digits memory.

4.10 Additional use of the push-button set

The NMT system will be equipped with many facilities realized in the MTX. Some of them can be controlled from the MS via its push-button set. Therefore the push-button set must not be used for other internal procedures than specified in para. 4.8 and 4.9 without approval from the Telecommunication Administration.

This notwithstanding, the MS may be equipped with a local mode intended for use by service personnel. It must not be possible to enter this mode except by use of a switch inside the MS cabinet not accessible to the subscriber.

In this mode, procedures for use of the push-button set may be decided by the manufacturer. Any information that has entered the MS in local mode must be deleted when returning to normal mode.

VR2C2

5. LOGIC AND CONTROL UNIT

5.1 General

The Logic and Control Unit functions as the master control for the mobile station and encodes and decodes the digital signalling used on the radio path and decides the appropriate actions to be taken.

The main functions to be carried out by the Logic and Control Unit are mentioned in paragraph 1.2.3.
The content in this chapter describes how these functions shall be carried out and consists of:

- task descriptions
- input/output state relations, and
- explanatory flow diagrams which are included to supplement the understanding of the signalling procedures specified in NMT doc. 1.

Requirements for the signalling equipment in the MS is covered in NMT doc. 1. Additional signalling requirements relating only to the MS is covered in this chapter, and chapter 6.

5.2 Task descriptions

All tasks are overruled by Autonomous timeout as described in paragraph 5.6.6.

5.2.1 Stable states

In the following, three main stable states of the MS are described:

- off condition
- standby state (on hook or electrically on hook) and
- conversation state

The procedures to be carried out by the Logic and Control Unit depends on,

- in which of these stable states the MS is at the outset, and
- to which stable state the MS is ordered by the user or the MTX

Transferring the MS from one stable state to another is described in the signalling procedures in NMT doc. 1, the input/output state relations (5.3) and the explanatory flow diagrams (5.4).

5.2.1.1 OFF condition

The MS is in OFF state when the ON/OFF switch is turned OFF or if the voltage supplied to the MS falls below V volts (as specified by the manufacturer). In this state no external power shall be applied to the MS. In off condition the following information shall be stored in the MS:

- the traffic area number Y_1Y_2 recorded and stored at the moment the MS was switched OFF,
- the roaming alarm status information, and
- preprogrammed addresses (numbers) in the case the MS is equipped with "abbreviated dialling" facilities.

This information shall be maintained in the OFF condition for at least one week.

5.2.1.2 Standby state

In this state the MS rests on a calling channel with valid traffic area number and calling channel mark /¯or combined calling/traffic mark_7 and the channel number is the same as in the RF-synthesizer. The MS is ready for reception or initiation of a call.

If the MS loses the lock to the calling channel according to NMT doc. it starts the search for calling channel procedure (see paragraph 5.2.3.3).

The identification match is checked once per frame. If the MS receives identity in frame 2a it leaves the standby state and enters the signalling scheme B.

If the user initiates a call, the MS leaves the standby state and enters the search for traffic channel procedure (see paragraph 5.2.3.4).

When the MS leaves the calling channel the Logic and Control Unit shall store this channel number for use when the call is finished.

In the standby state the service indicator is activated.

5.2.1.3 Conversation state

The MS reaches the conversation state after completion of signalling schemes A, B or C. In this state the speech path is through connected in the MS and the supervisory signal is looped back to BS. The data receiver is engaged in order to receive channel order or clearing from MTX.

The MS leaves this state upon input either from user or from the signalling from MTX. If the user terminates the call and replaces the handset, the MS closes the speech path and the supervisory signal loop and enters the clearing sequence from MS.

If the MS receives release order the speech path and the supervisory loop are closed, and the MS enters a clearing sequence from MTX.

The state is also left if the MS receives channel order, and then enters signalling scheme C. This will turn the MS back to conversation state afterwards.

5.2.2 <u>DC power start up</u>

The power start up task shall be executed whenever the battery voltage to the mobile station changes from below V volts to above V volts. The value for V is stated by the manufacturer.

The power start up task shall

- place the transmitter in the carrier-off state
- place the transmitter and receiver audio circuits in the muted position
- clear all the registers except Y_1Y_2, roaming alarm status and preprogrammed addresses
- start the search for calling channel procedure (see para. 5.2.3.3).

5.2.3 Search for channels

5.2.3.1 Definitions

Valid traffic area number is the number of the traffic area where the MS is roaming updated.
The initial channel is the channel on which the MS starts scanning.
Scanning is to look systematically (one by one) for an RF channel according to the requirements in paragraph 5.2.3.2.
A scan is one complete search through all 180 RF channels.
"Electrically on hook" is the state where the MS is internally "on hook" although the handset is not in its cradle. The state is released by replacing the handset to the cradle.
Roaming flag set is the state where the MS searches for a free marked traffic channel in the new traffic area in order to execute roaming updating (scheme D).

5.2.3.2 Channel acceptance procedure

This section contains the requirements for accepting a calling channel or a free marked traffic channel.

When the MS stops the receiver on an RF channel N it shall check whether the channel is modulated with an FFSK signal or not. If no FFSK signal is detected within 20 ms the receiver goes to channel N+1. The specified 20 ms includes the channel switching time.

If an FFSK signal is detected the MS shall check that there is a match between the received channel number information and the synthesizer setting. Then the Y_1Y_2 shall be checked. Y_1 shall match the setting of the country selector (see paragraph 3.9). Y_2 shall be checked for a match with the stored traffic area information. The MS shall check that the relevant channel mark is received. If there is a mismatch in the check the MS shall switch to next channel. All these checks shall be carried out in T''' (two frames) after switching to the channel.

After the channel has been accepted the criteria to continue to be locked at the channel is that $N_1N_2N_3$ P(12) Y_1Y_2 is received regularily. However, two complete frames can be lost between two correct frames.

5.2.3.3 Search for calling channel

This procedure is initiated after DC power start up or if the MS goes mechanically or electrically on hook.
Whenever the MS enters this procedure after leaving a signalling scheme (A,B,D and clearing) or standby state, it shall start the scan on the previous calling channel.

Entering this procedure from any other state, the MS shall start the scan from any channel as initial channel. For each channel the MS shall execute the channel check described in paragraph 5.2.3.2. When a calling channel with a valid traffic area number is found, the MS shall lock to this channel and go to standby.

During the first scan the MS shall accept a channel which has an RF level above 24 dBuV and it shall reject channels which have RF level below 16 dBuV.
If a new traffic area number Y_1Y_2' (within the same traffic area group Y_1) is detected, the MS shall enter the state test for roaming. The MS shall however continue to search for the previous traffic area number Y_1Y_2 (stored in MS) during two complete scans. If Y_1Y_2 is not detected, the MS shall search for and accept any Y_1Y_2, including the previous Y_1Y_2. When a new Y_1Y_2' is accepted, the MS shall replace the stored Y_1Y_2 with the new Y_1Y_2' and enter the state roaming flag set.
The MS shall then search for a traffic channel mark Y_1Y_2' to activate signalling scheme D. After completion of signalling scheme D the MS shall return to the new calling channel. If signalling scheme D is not successfully completed the MS shall enter the roaming alarm state. Also in this case the MS shall return to the new calling channel.
If a mobile subscriber initiates a call while the MS is searching for a calling channel, the MS shall leave this procedure and start searching for a traffic channel as described in paragraph 5.2.3.4.

5.2.3.4 Search for free marked traffic channel

The search for a free marked traffic channel shall start from a channel selected at random. The purpose of this procedure is to distribute the call attempts evenly among all free marked traffic channels. During the first scan the MS shall accept a channel which has an RF level above 24 dBuV and it shall reject channels which have RF level below 16 dBuV.

Free traffic channels are used when entering signalling schemes A and D. The particular tasks to be executed by the MS while running through these schemes depend on the status information in the MS. The different cases are described below.

I Signalling scheme A

If no free traffic channel is found during 15 scans, the MS shall go "electrically on hook".

A necessary condition for entering scheme A is that the MS is off hook or the "Hands-Free" button is activated. There are three possibilities depending on the status information.

I.1) No roaming flag, no roaming alarm
I.2) No roaming flag, roaming alarm
I.3) Roaming flag, no roaming alarm

I.1) This is the normal case for an ordinary call. When the MS has locked to a free traffic channel it enters scheme A.

I.2) In this case the MS shall accept any traffic channel which is in accordance with the country selector. A successful completion of scheme A will result in updating the MS and a call may be placed. The traffic area number Y_1Y_2 belonging to this channel shall be stored as the updated traffic area.

I.3) This is the case where the MS goes off hook while searching for a free traffic channel as described for scheme D (II.1). The MS shall execute the actions described in I.1 and in addition update itself.

II Signalling scheme D

Scheme D is initiated only when the MS is on hook.

II.1 Roaming flag, no roaming alarm.

The MS is in a state where it has the information that Y_1Y_2 has changed to Y_1Y_2'. It shall now hunt for a traffic channel with a traffic area marking $Y_1Y'_2$ and enter scheme D.

If the MS does not find a free traffic channel within 15 scans, it clears the Y_1Y_2' and enters the search for calling channel procedure. The information about the traffic area group Y_1 shall not be cleared in the MS.

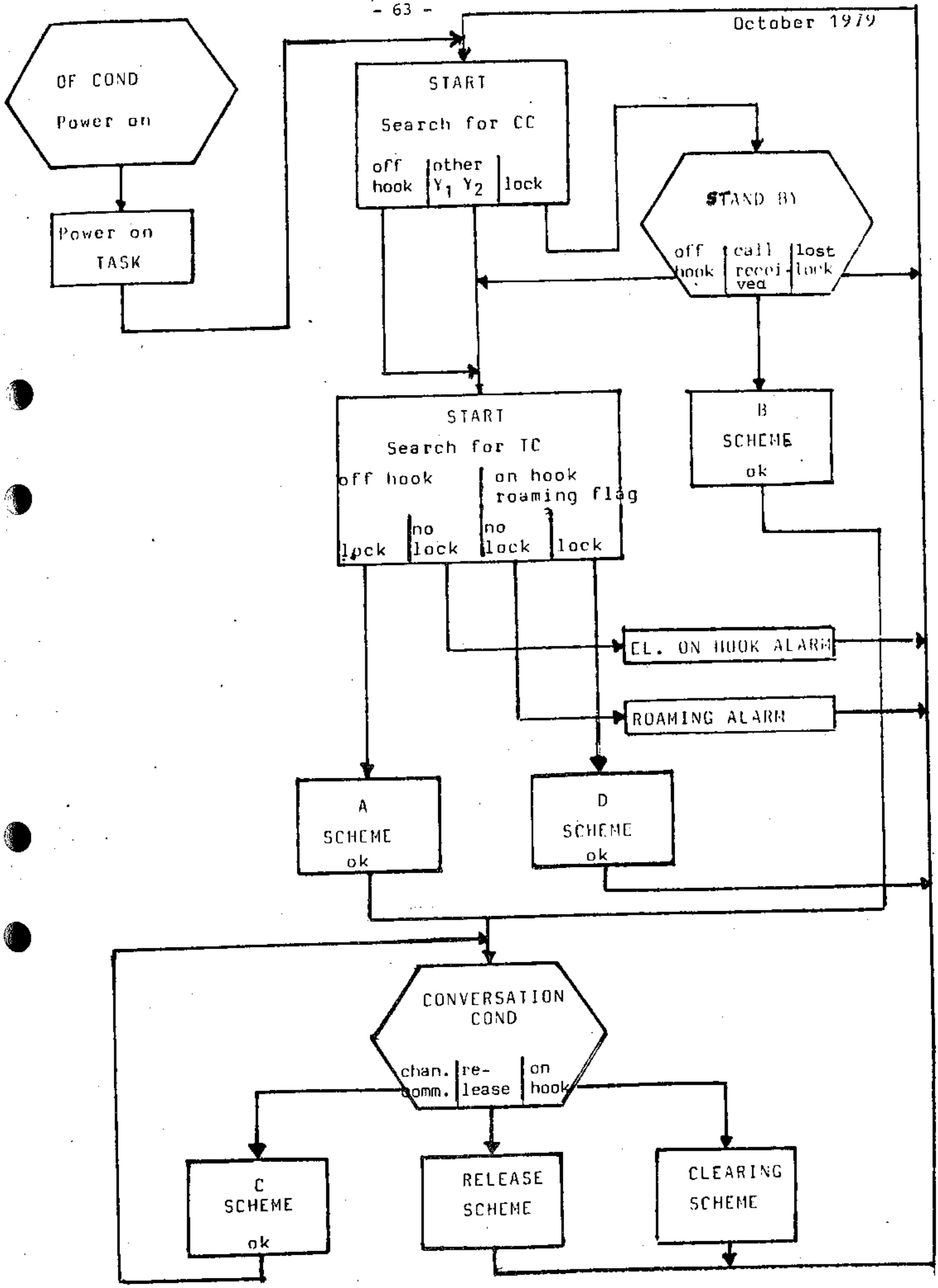

OF COND
Power on
Power on
TASK
START
Search for CC
off hook
other Y_1 Y_2
lock
STAND BY
off hook
call received
lost lock
B
SCHEME
ok
START
Search for TC
off hook
on hook roaming flag
lock
no lock
no lock
lock
EL. ON HOOK ALARM
ROAMING ALARM
A
SCHEME
ok
D
SCHEME
ok
CONVERSATION COND
chan. comm.
re-lease
on hook
C
SCHEME
ok
RELEASE
SCHEME
CLEARING
SCHEME

Fig. 5.1

5.2.4 User initiated on-hook in the signal schemes

All signalling schemes where the MS is in off hook state are overruled by on hook initiated by the user.

If the MS goes on hook

- before sending identity on identity request, the MS shall go directly back to last calling channel,
- after sending identity on identity request, the MS executes clearing sequence.

5.3 Input-output-state relations

5.3.1 General

The tasks described by chapter 5.2 are connected to each other by the different procedures and signalling schemes. The input/output state relations of the Logic and Control Unit are described in a state table. In those tables some of the signalling schemes are broken down to the level corresponding to the flowdiagrams. Therefore some additional logical states have to be defined.

- Wait for address complete
- Wait for identity check
- Wait for channel order on calling channel
- Wait for proceed to send
- Wait for roaming updating conformation
- Transmit dialled number
- Number selection
- Ringing
- Conversation
- Clearing
- Release

5.3.2 State description

Wait for identity request

This is the state where the MS is waiting for an identity request (frame 3b) from MTX in order to be allowed to go on in signalling schemes A, B, C and D.

The state is overruled by a time out device set to T ms. If this runs out the MS shall go:

- "Electrically on hook" and back to last calling channel from scheme A
- Back to last calling channel from scheme B
- Back to last old traffic channel in scheme C
- Back to new calling channel and activate the roaming alarm indicator from scheme D.

Wait for channel order on the calling channel is the state which is reached after receiving a call from MTX on the calling channel. It is overruled by a time out device, set to T ms which forces the MS into standby state when run out.

Wait for proceed to send is the state in signalling scheme A, where the MS waits for permission to send the stored dialled digits to MTX (frame 5a (L=3)).(It is overruled by a time out device set to T ms. The MS shall then initiate MS-clearing (see 5.2.4) and goes "electrically on hook".)

Wait for roaming updating confirmation is the state where the MS is waiting in scheme D for a confirmation (frame 5a (L=3)) that the roaming updating is registered in the MTX. This must be received within T ms, otherwise the roaming alarm indicator shall be activated and the MS shall initiate clearing.

Transmit dialled number is the state following the proceed to send (frame 5a (L=3)) in scheme A.

Ringing is the state where the ringing order from MTX is received, and the user is alerted that there is a call.

All these states are overruled by reception of forced release from MTX or time out in MS.

Note: T = 1107 ms (eight frames)
T' = 553 ms (four frames)
T'' = 30 $\pm$ 2,5 ms
T''' = 277 ms (two frames)

Initial state	Input: from user	Input: from MTX	Response: to user	Response: to MTX	Response: in MS	Next state
1. Off condition	Power on		Power indicator on		MS to initial chan.	Search for CC
2. Standby		CC with valid Y_1Y_2	Service ind. on			Standby
3. Standby		Call to MS		Transmit acknowl.		Wait for chan. order
4. Standby	Off hook		Service ind. off		Store CC number MS to random chan.	Search for TC (scheme A)
5. Standby	Change of country selector		Service ind. off		MS initiates scanning	Search for CC (of new country)
6. Standby	Push button set activated		Digit memory ind./ display activated		Digits stored in dialled digits mem.	Standby
7. All states	Power off		Power ind. off		Store Y_1Y_2. Store roaming alarm status information (Store preprogrammed addresses)	Off condition
8. Standby		Loss of CC lock	Service ind. off		MS initiates scanning	Search for CC
9. Search for CC		CC with valid Y_1Y_2	Service ind. on		Lock to CC	Standby
10. Search for CC		No CC			MS to next channel	Search for CC
11. Search for CC		CC with unvalid Y_1Y_2			MS to next channel	Search for CC
12. Search for CC		No CC with valid Y_1Y_2 detected in 2 scans. CC with unvalid Y_1Y_2 detected twice			Replace old Y_1Y_2 with new Y_1Y_2. MS to random chan.	Search for TC (sch.D)
13. Search for CC	Off hook				MS to random chan.	Search for TC (scheme A)
14. Search for TC (scheme A)		TC with valid Y_1Y_2		Transmit seizure		Wait for ident. request. (Scheme A)

Initial state	Input		Response			Next state
	from user	from MTX	to user	to MTX	in MS	
15. Search for TC (scheme A)		No TC with valid Y_1Y_2			MS to next chan.	Search for TC (scheme A)
16. Search for TC (scheme A)		No TC with valid Y_1Y_2 in 15 scans	Malfunction alarm on		MS to any channel. MS electrically on hook	Search for CC
17. Search for TC (scheme A)	On hook				MS to previous CC	Standby
18. Search for TC (scheme D)		TC with valid Y_1Y_2 (new traffic area)		Transmit roaming updating seizure		Wait for ident request (scheme D)
19. Search for TC (scheme D)		No TC with valid Y_1Y_2 in 15 scans			Disregard Y_1Y_2. Any acceptable Y_2 MS to any channel	Search for CC
20. Search for TC (schemeD)	Off hook		Roaming alarm indicator on		MS to random channel	Search for TC (scheme A)
21. Wait for chan. order		Channel order received	Service indicator off		MS to the ordered channel	Wait for ident request (scheme B)
22. Wait for chan. order		No channel order received			Remain on same chan.	Standby
23. Wait for chan. order	Off hook		Service indicator off		MS to random channel	Search for TC (scheme A)
24. Wait for ident. request (scheme A)		Identity request received		Transmit identity followed by idle		Wait for roam. updating conf. (scheme A)
25. Wait for ident. request (schemeA)		No ident. request received	Malfunction alarm on		MS to previous CC MS electrically on hook	Standby
26. Wait for ident request (scheme A)		Forced release	Malfunction alarm on	Transmit clearing	MS to previous CC MS electrically on hook	Standby

Initial state	Input: from user	Input: from MTX	Response: to user	Response: to MTX	Response: in MS	Next state
27. Wait for ident. request (scheme A)	On hook				MS to previous CC	Standby
28. Wait for ident. request (scheme B)		Identity request received		Transmit identity		Wait for ringing order
29. Wait for ident. request (scheme B)		No ident. req. received			MS to previous CC	Standby
30. Wait for ident request (scheme B)		Forced release		Transmit clearing	MS to previous CC	Standby
31. Wait for ident. request (scheme B)	Off hook				MS to random channel	Search for TC (scheme A)
32. Wait for ident. request (scheme C)		Identity request received	(conversation on new TC)	Transmit identity	Open speech path. Through connect supervisory signal.	Conversation
33. Wait for ident. request (scheme C)		No ident. req.	(conversation on previous TC)		MS to previous TC. Open speech path. Through connect supervisory signal.	Conversation
34. Wait for ident. request (scheme C)		Forced release		Transmit clearing	MS to previous CC	Standby
35. Wait for ident. request (scheme C)	On hook			Transmit clearing	MS to previous CC	Standby
36. Wait for ident. request (scheme D)		Ident. request received		Transmit ident. for roaming followed by idle		Wait for roaming updating conf. (scheme D)

Initial state	Input		Response			Next state
	from user	from MTX	to user	to MTX	in MS	
37. Wait for ident request (scheme D)		No ident. req. received	Roaming alarm indicator on		MS to new CC	Standby
38. Wait for ident request (scheme D)		Forced release	Roaming alarm indicator on	Transmit clearing	MS to new CC	Standby
39. Wait for ident request (scheme D)	Off hook		Malfunction alarm on		No action Proceed scheme D	Wait for iden. request (scheme D)
40. Wait for roaming updating conf. (scheme D)		Received roaming updating conf.	Roaming alarm indicator off (if activated)	Transmit clearing	MS to new CC	Standby
41. Wait for roaming updating conf. (scheme D)		No roaming updating conf. received	Roaming alarm indicator on	Transmit clearing,	MS to new CC	Standby
42. Wait for roaming updating conf.(sch.D)	Off hook		Malfunction alarm on		No action. Proceed scheme D	Wait for roam updat. conf. (scheme D)
43. Wait for roaming updating conf.(sch.D)		Forced release	Roaming alarm indicator on	Transmit clearing	MS to the new CC	Standby
44. Wait for roaming updating conf. (proceed to send)(sch.A)	(dialled digits memory not empty)	Received roaming updating conf.	Roaming alarm off (if activated)	Transmit preselected number followed by idle frames	Open speech path. Through connect supervisory signal.	Wait for address complete
45. Wait for roaming updating conf. (proceed to send)(sch.A)	(dialled digits memory empty)	Received roaming updating conf.	Roaming alarm off (if activated) Malfunction alarm	Transmit clearing	MS to previous MS electrically on hook	Standby
46. Wait for roaming updating conf. (proceed to send)(sch.A)		No roaming updating conf. received	Malfunction alarm on	Transmit clearing	MS to previous CC MS electrically on hook	Standby

Initial state	Input: from user	Input: from MTX	Response: to user	Response: to MTX	Response: in MS	Next state
47. Wait for roaming updating conf.(proceed to send)(sch.A)	On hook			Transmit clearing	MS to previous CC	Standby
48. Wait for address complete		Address complete received			Stop transmit idle frames.	Conversation
49.						
50. Wait for address complete		No address complete received within 30 seconds	Malfunction alarm on	Transmit clearing	Close speech path. MS to previous CC MS electrically on hook	Standby
51. Wait for address complete	On hook			Transmit clearing,	Close speech path. MS to previous CC	Standby
52. Wait for address complete		Forced release received	Malfunction alarm on	Transmit clearing,	Close speech path MS to previous CC electrically on hook	Standby
53. Wait for ringing order		Ringing order received	Ringing signal Call received indicator on		Generate ringing signal. Activate call indicator	Wait for ringing order
54.						
55. Wait for ringing order	Off hook		Call received indicator off	Transmit answer	Open speech path. Through connect supervisory signal.	Conversation
56. Wait for ringing order		Forced release received		Transmit clearing,	MS to previous CC	Standby
57. Conversation	On hook			Transmit clearing,	Close speech path. Disconnect supervisory signal. MS to previous CC.	Standby CC

Initial state	Input		Response			Next state
	from user	from MTX	to user	to MTX	in MS	
58. Conversation		Forced release	Malfunction alarm on	Transmit clearing	Close speech path. Disconnect supervisory signal. MS to previous CC. MS electrically on hook	Standby
59. Conversation		Channel order			Close speech path. Disconnect supervisory signal. MS to ordered TC	Wait for ident. request. (scheme C)
60. All states	see paragraph 5.6.6 (autonomous time out		Power indicator off		Power off Store Y_1Y_2 Store roaming alarm status information (Store preprogrammed addresses)	Off condition

5.4 Flowdiagrams

The flow diagrams in this paragraph are explanatory guidelines only and are not exhaustive. They are not intended as detailed design schemes.

5.4.1 Standby (flowdiagram Fig. 5.2)

An explanation of the main principles in standby state is given in paragraph 5.2.

5.4.2 Call MS ⟶ MTX (signalling scheme A) (Flowdiagram Fig. 5.3)

After locked to a traffic channel the MS proceeds with the "call MS ⟶ MTX" procedure. The following comments apply.

Transmit seizure

The MS shall transmit seizure (two frames 10b) with start T'' after the end of the received frame 1 a/b (see also paragraph 5.6).

Identity check received

The MS shall receive indentity check (frame 3b) within T after having transmitted the seizure (10b) above, in order to proceed the call.

Transmit identification

The MS shall transmit four frames 10b with start T'' after the end of the received frame 3b above.

Digit transmission

The digits in the dialled digits memory are transmitted continuously after receiving frame 5a (L = 3).

Turn off roaming alarm

When the frame 5a (L = 3) is received and if the roaming alarm is on, the MS har been updated in the MTX and the alarm shall be turned off.

Open loudspeaker and microphone

The speech path shall be opened when the MS has received 5a (L=3). However, the voice input circuit (microphone) is closed during digit transmission (see paragraph 5.5.4).

Note: T = 1107 ms (eight frames)
T' = 553 ms (four frames)
T'' = 30 $\pm$ 2,5 ms
T''' = 277 ms (two frames)

5.4.3 Call MTX ⟶ MS (signalling scheme B) (See flowdiagram Fig. 5.4)

After having obtained Z $X_1 .. X_6$ match, the MS has to start the "call MTX ⟶ MS" procedure.

The following comments apply.

Transmit acknowledge

The MS shall transmit a shortened frame 10a with start T'' after the end of the received frame 2a. (See paragraph 5.6).

Received channel order

The MS shall receive channel order (frame 2b) within T after transmission of acknowledge (10b) in order to proceed. The MS changes to TC $N_a N_b N_c$.

If no channel order is received, the MS logic shall go back to stand-by on the same calling channel as before.

Received identity check

The identity check (frame 3b) must be received within T' after reception of channel order (frame 2b).

Ringing order

Ringing order (frame 5a (L = 9)) is received within T after transmission of identity check (frame 3b).

When reception of ringing order the MS shall generate ringing signal according to paragraph 3.8.1.

If no ringing order is received, the MS shall go back to stand by after having sent MS clearing to MTX.

B-answer

When MS goes "off hook" frame 13a (L = 14) shall be transmitted in T'.

5.4.4 MS clearing (Flowchart Fig. 5.5)

When MS goes "on hook" frame 13 a (L = 1) shall be transmitted in T'. Then MS goes back to stand by on the same calling channel as before.

5.4.5 Forced release from MTX (Flowchart Fig. 5.6)

When MS receives frame 5a (L = 15) it shall follow the same procedure as stated in paragraph 5.4.4.

5.4.6 Switching call in progress (signalling scheme C) (Flowchart Fig. 5.7)

When the MS receives a channel order during conversation the transmitter shall be stopped and the speech path shall be closed.

The MS changes to the new TC $N'_1N'_2N'_3$ after storing $N_1N_2N_3$.

If the change of channel fails for some reason (no identity check on TC $N'_1N'_2N'_3$) the MS goes back to the old TC ($N_1N_2N_3$).

5.4.7 Updating roaming information (signalling scheme D) (Flowchart Fig. 5.8)

See also paragraph 5.4.2.

After having found a traffic channel in the same Y_1Y_2 as the calling channel the MS transmits frame 11. The procedure is similar to the call MS ⟶ MTX procedure.

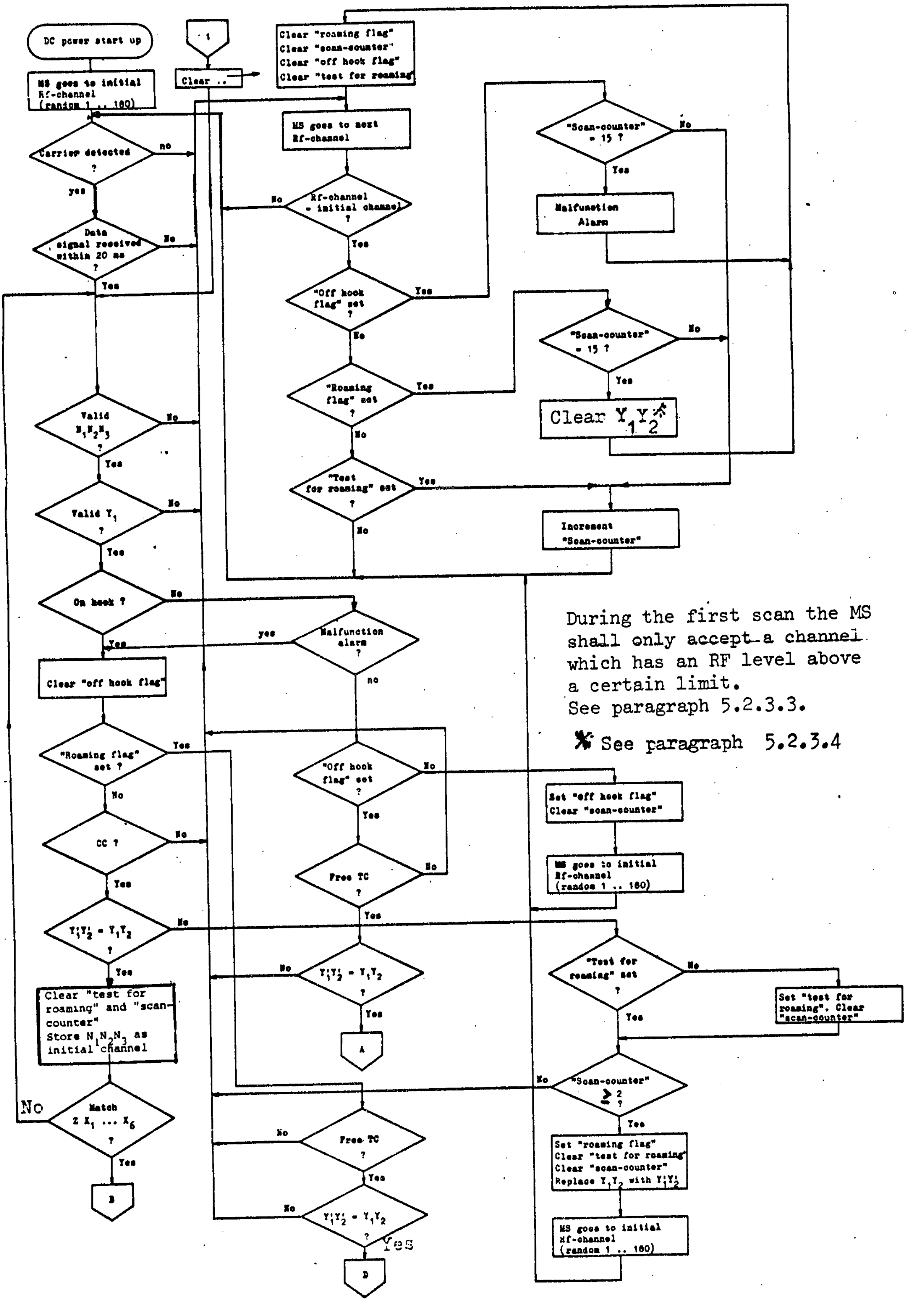
When frame 5a (L = 3) is received, the MS has been updated in MTX.

If frame 5a (L = 3) is not received, the roaming alarm shall be activated.

October 1979

Malfunction alarm shall, if activated turn off when the MS goes on hook.

MS Standby flow diagram



During the first scan the MS shall only accept a channel which has an RF level above a certain limit.
See paragraph 5.2.3.3.

* See paragraph 5.2.3.4

Fig. 5.2

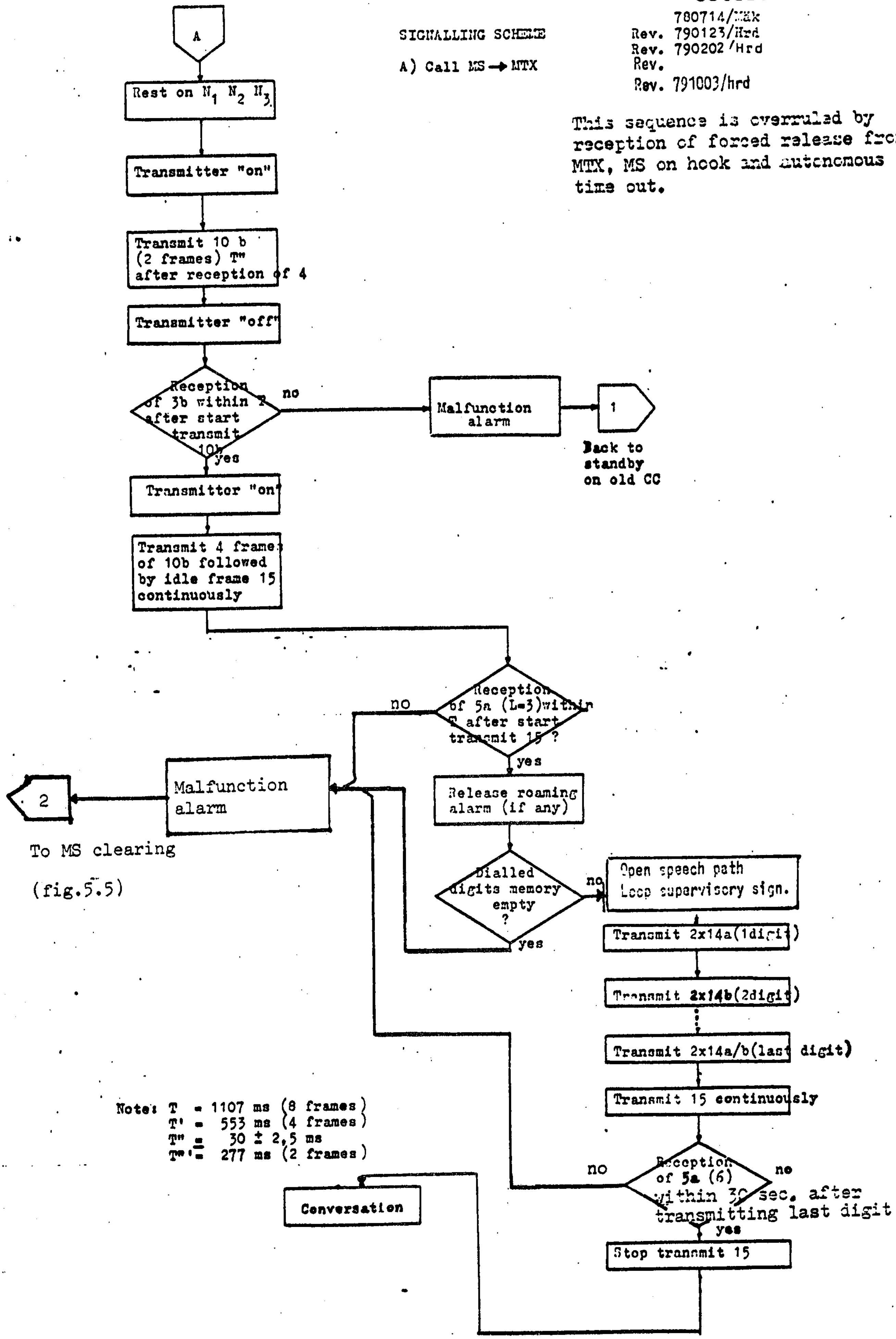
October 1979

780714/MMk
Rev. 790123/Hrd
Rev. 790202/Hrd
Rev.
Rev. 791003/hrd

SIGNALLING SCHEME

A) Call MS → MTX

This sequence is overruled by reception of forced release from MTX, MS on hook and autonomous time out.



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

Fig. 5.3

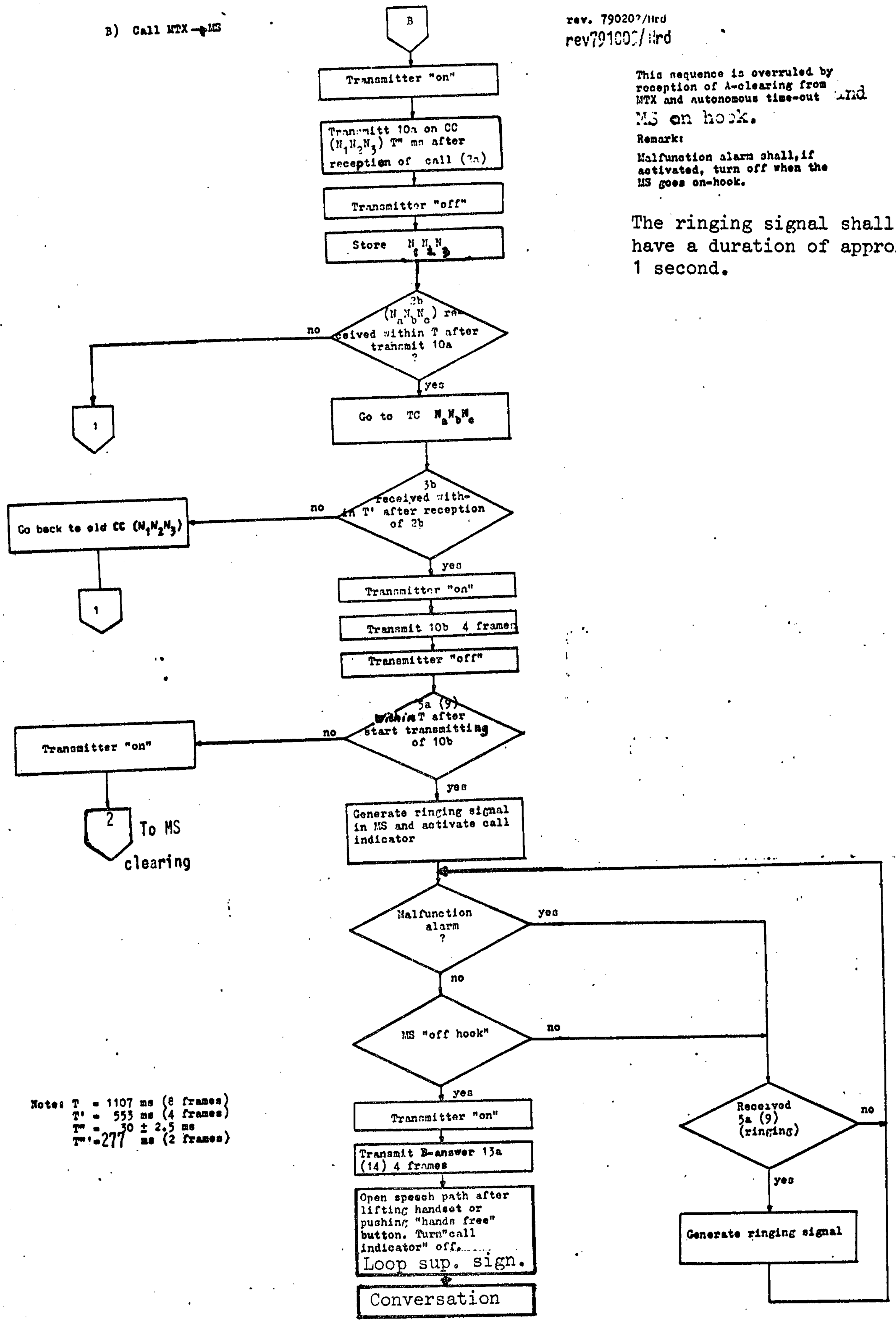
B) Call MTX→MS

rev. 79020?/Hrd
rev791003/Hrd

This sequence is overruled by reception of A-clearing from MTX and autonomous time-out and MS on hook.

Remark:
Malfunction alarm shall, if activated, turn off when the MS goes on-hook.

The ringing signal shall have a duration of approx. 1 second.



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

Fig. 5.4

780714/Mäk
rev. 790202/Hrd
Rev. 791003/Hrd

Mobile station "on hook" or forced release due to mobile station

MS Clearing

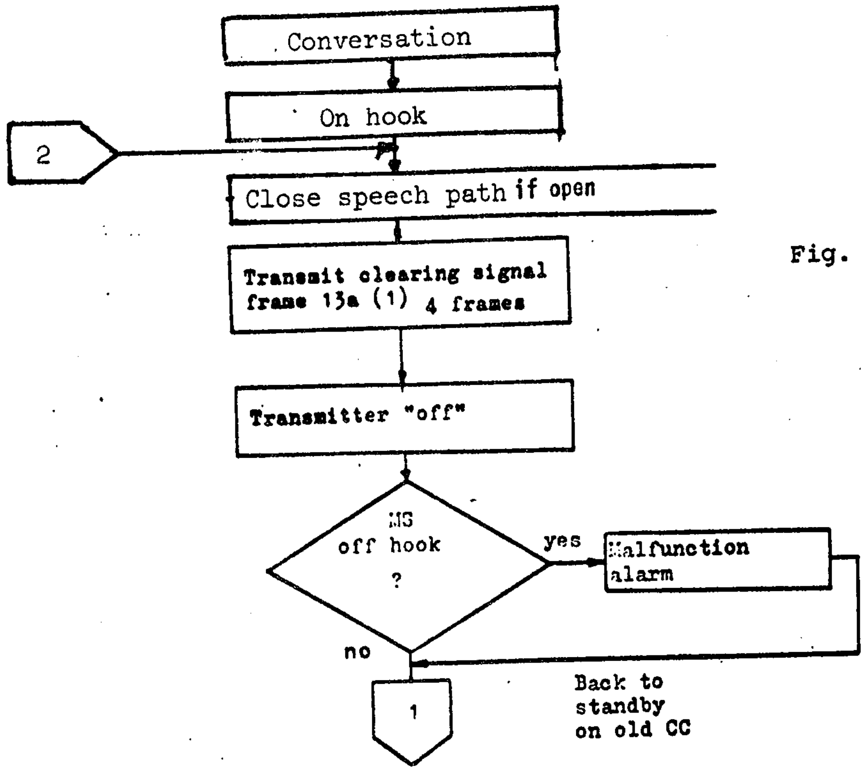


Fig. 5.5

Fixed subscriber "on hook" or forced release from MTX.

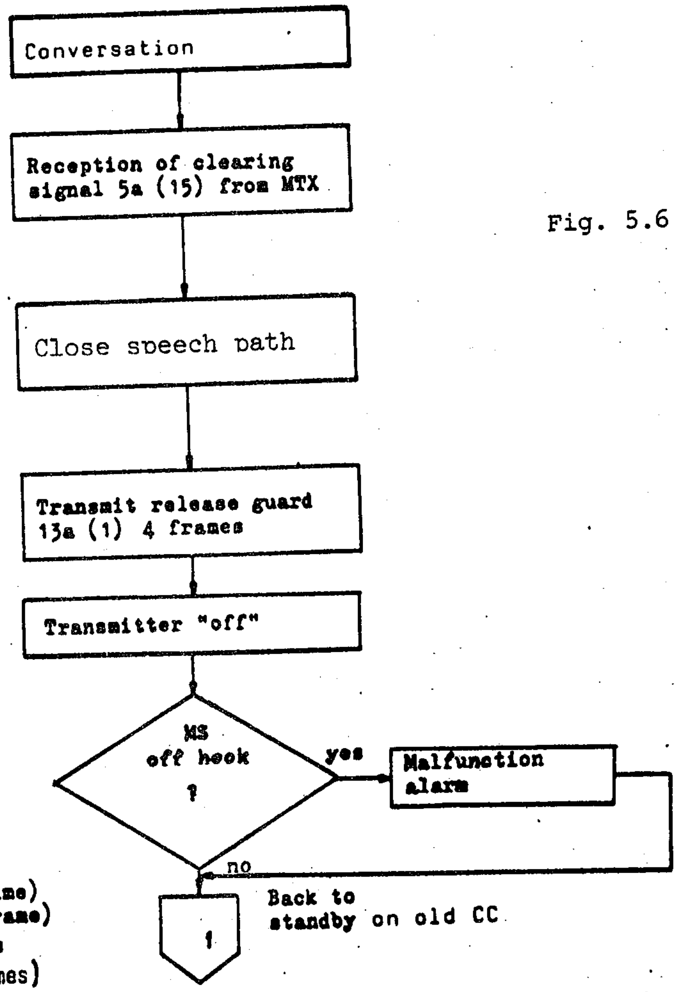
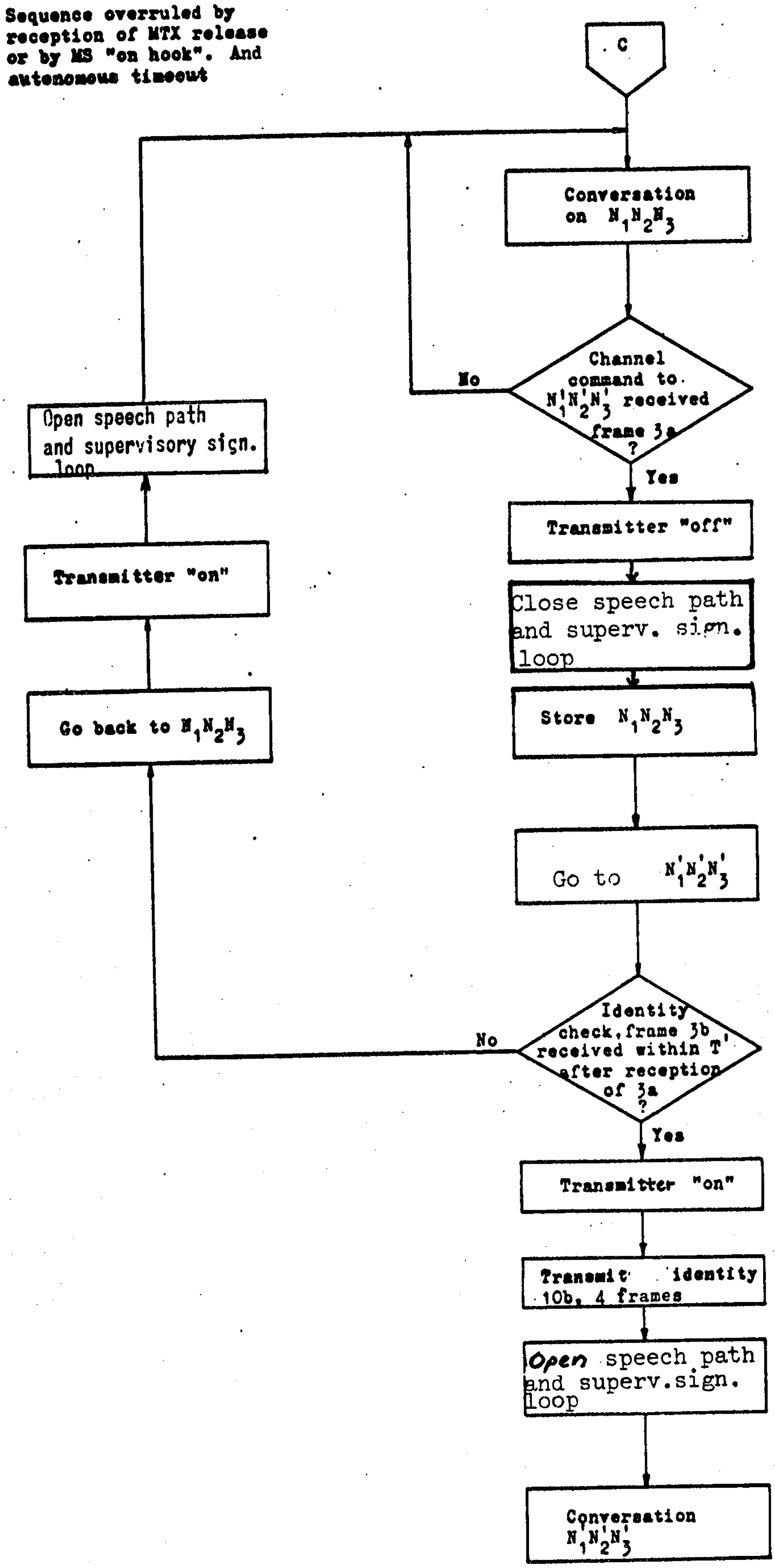


Fig. 5.6

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

C) Switching call in progress from $N_1N_2N_3$ to $N_1'N_2'N_3'$



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

Fig. 5.7

780728/Mäk
rev. 790202/Hrd
Rev.791003/Hrd

D Updating roaming information.

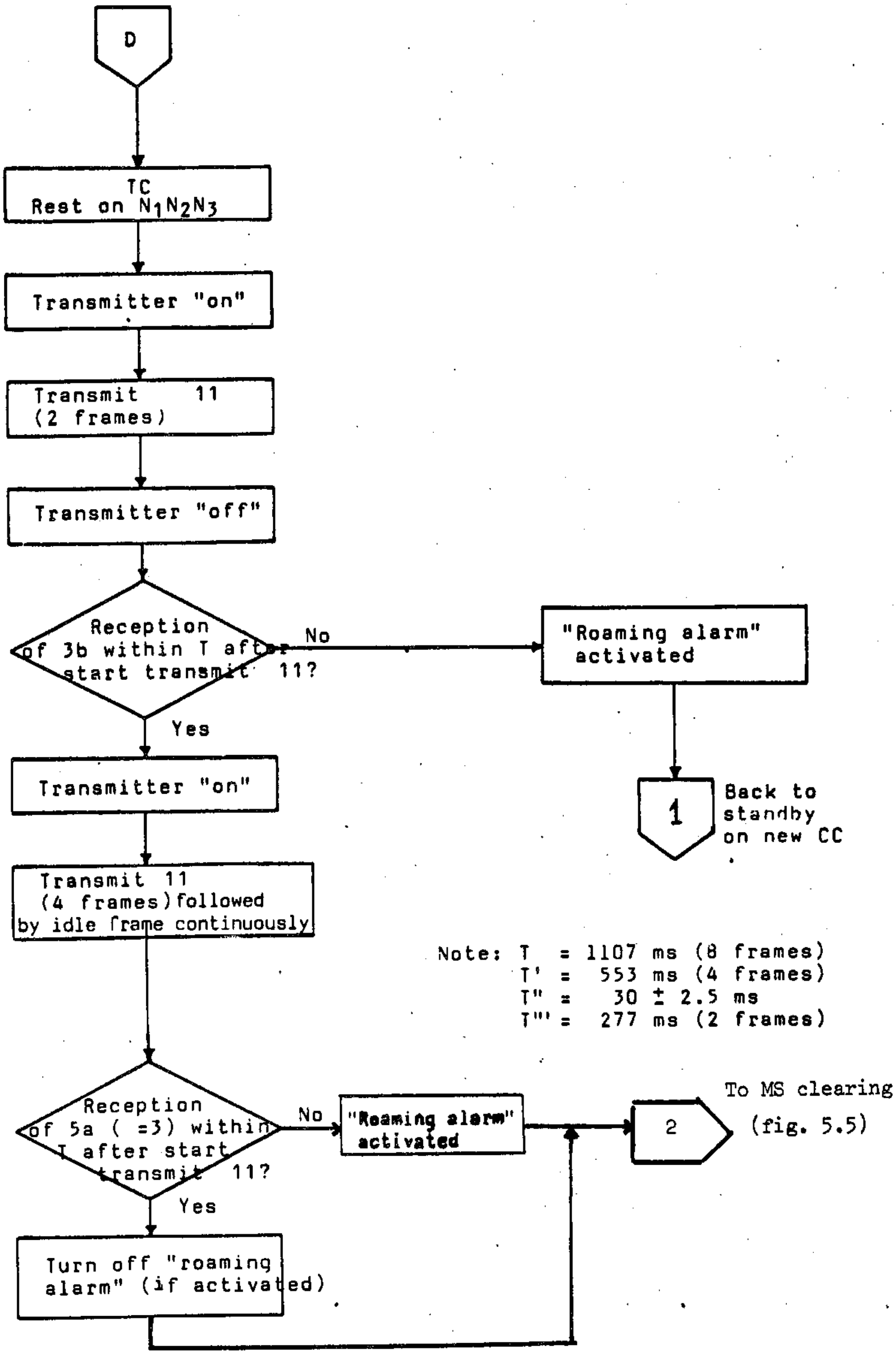


Fig. 5.8

5.5 Signalling equipment for 1200 baud FFSK

5.5.1 General description

Exchange of signals between MTX and MS is performed by means of 1200 baud FFSK binary signalling.

The characteristics and requirements for the FFSK signalling system and equipment is dealt with in NMT doc. 1.

5.5.2 FFSK modulation in MS

Pre-emphasis

The FFSK signal shall be modulated in such a way that it is influenced by a preemphasis similar to that applied to the voice input circuit.

Deviation

The FFSK signal shall produce a mean RF frequency deviation of 3,5 $\pm$ 0,5 kHz.

Group delay distortion

The distortion of the transmitted FFSK signals shall be measured according to paragraph 6.1.6.

5.5.3 FFSK signal receiver

The overall performance requirements for the FFSK signalling reception capability is specified in paragraph 6.1.7.

5.5.4 Splitting in MS

Encoding

When the MS transmits an FFSK signal, the voice input circuit and the supervisory signal loop shall be automatically closed.

Decoding

After reception of the frame synchronization it is checked whether the following six information bits all have the value 0. If so, the audio output is muted. Opening of the audio path is delayed T''' after reception of the last frame.

5.5.5 FFSK signalling detection time

The FFSK signalling receiver shall inform the Logic and Control Unit whether the RF channel is modulated with an FFSK signal or not.

This information (about an RF channel N+1) shall be provided within 20 ms after the moment the Logic and Control Unit ordered the transceiver to switch from RF channel N to RF channel N+1.

5.6 Timing in the MS

5.6.1 Time constants in the signalling procedure

The time constant used in performing the signalling procedures shall be the following multiples of the time needed to transmit a 1200 baud signalling frame.

T = 1107 ms (eight frames)
T' = 553 ms (four frames)
T'' = 30 $\pm$ 2,5 ms
T''' = 277 ms (two frames)

5.6.2 Timing between the signalling directions in MS

All timing in the signalling are specified with reference to the end of the received frame.

Definitions

The time skew

The time elapsed from the end of a received frame to the end of a partly overlapping transmitted frame is called the time skew. Fig. 5.9 shows an example with a time skew of T_s ms.

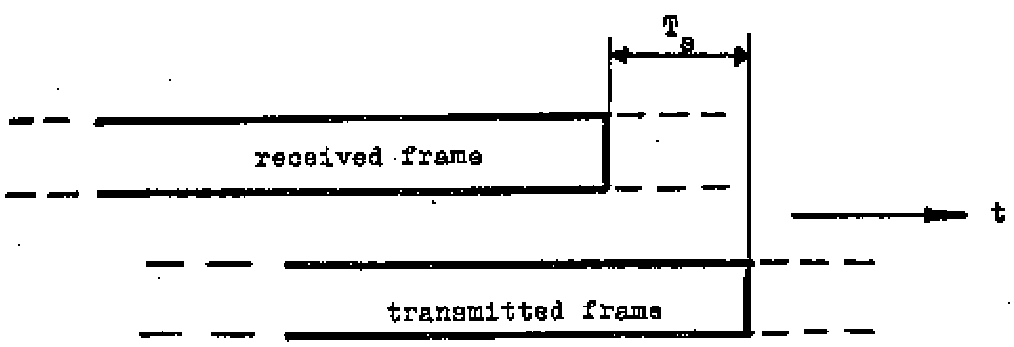


Fig. 5.9

Time skew

The response time of the MS is the time elapsed from the end of the received message to the end of the transmitted message (answer). Thus the response time will be an integral number of frame times plus the time skew. Fig. 5.10 shows an example of a response time of one frame plus a skew time of T_S.

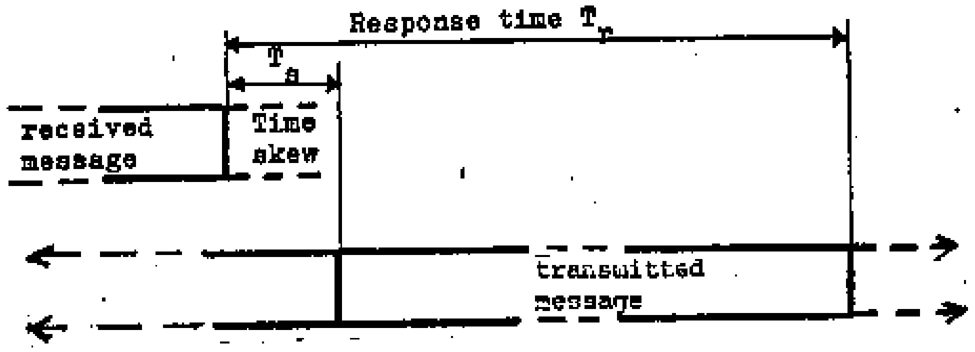


Fig. 5.10

Response time

5.6.3 Timing of call acknowledgement on calling channel

When receiving a call, frame 2a, MS shall start to transmit acknowledgement, frame 10a, within 30 ± 2,5 ms.

In order to decrease the risk of interference between two acknowledgements on the same calling channel, frame 10a shall not be transmitted in its full length. As stated in NMT Doc. 1 this frame shall be coded in the same way as frame 10b. The transmitter in the MS shall however be closed after 112 ms after the starting point of bit sync, i.e. the transmitter shall be closed after Y_{106} has been sent.

See Fig. 6.3.

5.6.4 Deleted

5.6.5 Timing of seizure on traffic channel

The response time for seizure, frames 10b, 11 and 12, shall be one frame time plus a skew time of 30 ± 2,5 ms after the detection of frame 4, free traffic channel indication.

5.6.6 Autonomous timeout

A timer separate from and independent of all other logic functions must be running continuously whenever power is applied to the transmitter of the MS. Sufficient reset command must be interspersed throughout the Logic and Control Unit to ensure that the timer never expires as long as the proper sequence of operations is taking place. If the timer expires, a failure is assumed and the power must be switched off the unit.

The time allowed for the timer is 30 seconds.

One of the functions of the timer is to switch off power when MS is transmitting and no RF carrier is detected (See 2.3.6) within 30 s. Bursts of RF carrier up to 1 sec. are not considered.

The power on/off switch must be switched off and turned on before the station is allowed to continue its normal operation.

5.7 Transceiver interface

5.7.1 RF power control

The Logic and Control Unit gives control signals "carrier on/off" and power level "high/low" to the transceiver. The MTX controls the power level of the MS by means of bit no. 2 and 3 in N_1 (high power 11, low power 10, 01 and 00) in the channel numbers $N_1N_2N_3$ of all signalling frames in direction MTX to MS. The same combination $N_1N_2N_3$ is returned in the signalling to the MTX. If the MS is designed for an additional power reduction (see paragraph 2.2.5) the code reserved for this shall be 01. An MS not equipped with this facility shall treat the codes 01 and 00 as 10.

5.7.2 RF frequency control

The RF frequency of the transceiver is directly controlled by the Logic and Control Unit.

The received channel number $N_1N_2N_3$ is coded in BCD.

5.7.3 Audio muting (see paragraphs 2.2.16, 2.3.20 and 5.5.4)

The audio input circuit and the audio output circuit are muted by control signals from Logic and Control Unit, in accordance with signalling schemes, flow charts and state tables.

5.7.4 RF carrier detector

RF carrier detector shall inform the Logic and Control Unit and autonomous timeout device whether an RF carrier is present or not. See also 2.3.6.

6. SYSTEM TESTS

The Logic and Control Unit is checked together with the transceiver by a number of RF tests.

6.1 Performance tests

6.1.1 Signalling sensitivity measured by call reception probability

This test corresponds to the test in paragraph 2.3.7.

Call reception probability is defined as the probability of receiving frame 10a from the MS after having sent frame 2a (with the identification of the MS) to the MS during the RF-conditions specified in the following paragraphs.

a) An RF-signal with a level of 1 µV E.M.F. (50 ohms) modulated with frame 1a to a mean frequency deviation of ± 3,5 kHz is applied to the antenna. Once per 13 frames, frame 2a with the identification of the MS is transmitted (twelve frames 1a followed by one frame 2a)

b) Same as in case a) but with an RF level of 3 dB above 1 µV E.M.F. and a mean frequency deviation of 1,75 kHz.

For both cases the requirement is minimum 95% call reception probability.

6.1.2 Co-channel data rejection

This test corresponds to the test in paragraph 2.3.8.
The wanted signal with modulation as in paragraph 6.1.1a shall have a level 3 dB above 1 uV E.M.F and the unwanted signal with the same type of modulation but from a source independent from the source used for the wanted signal shall have a level of 5 dB below 1 uV E.M.F.

The requirement is minimum 95% call reception probability.

6.1.3 Adjacent RF-signal decoding degradation

This test corresponds to the test in paragraph 2.3.9.
The wanted signal with modulation as in paragraph 6.1.1a shall have a level of 3 dB above 1 uV E.M.F. and the unwanted signal level with modulation as in paragraph 6.1.2 shall be 70 dB above 1 uV E.M.F.

The requirement is minimum 95% call reception probability.

6.1.4 RF intermodulation decoding degradation

This test corresponds to the test in paragraph 2.3.11. The wanted signal, modulated as in paragraph 6.1.1 a, shall have a level of 3 db above 1 uV E.M.F. and the two unwanted signals modulated as in paragraph 2.3.11 shall have a level of 70 dB above 1 µV E.M.F.

The requirement is minimum 95% call reception probability.

6.1.5 Signalling sensitivity in presence of RF signal fading measured by call reception probability

The test is carried out in a same way as in paragraph 6.1.1a but with a fading simulator (Rayleigh) connected between the system simulator and MS. The test shall be made at simulated vehicle speeds of 10, 50 and 90 km/h.

The requirement is 95% call reception probability for an RF signal level with an RMS value of 10 dB above 1 uV E.M.F.

Note: The fading simulator may consist of 2 non-correlated digital pseudorandom generators with 3rd order digital filters to shape the noise power spectra. The bandwidth corresponds to the doppler shift of the simulated speed. The two noise sources modulate two RF signals 90° out of phase. It can be shown that the combined signal has a Rayleigh distributed amplitude.

6.1.6 Data signal distortion

The distortion of the transmitted data signal from the MS is measured in accordance with a measuring set-up shown in Fig. 6.1. The MS shall be continuously modulated with normal data test modulation as defined in paragraph 1.3.8.2.

The error rate is analyzed for different S/N ratios. The required S/N ratio for error rate 10^{-4} is compared with the S/N ratio required for the same error rate when the reference FFSK transmitter is used (See NMT Doc 1)

For the error rate 10^{-4} the increase in S/N when measuring the MS shall be less than 0,5 dB compared with the reference measurement.

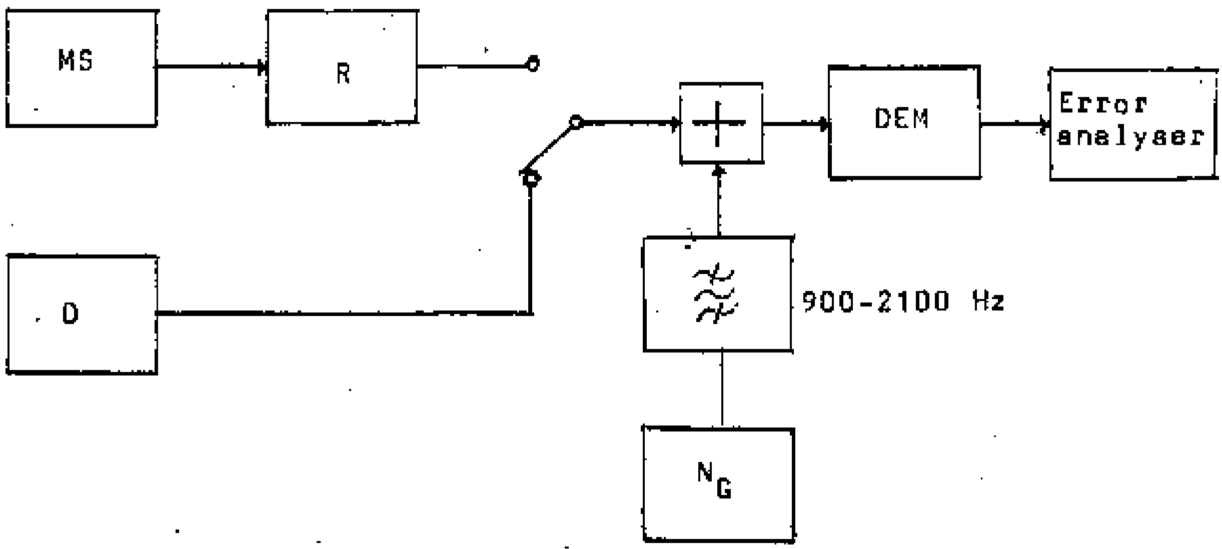


Fig. 6.1

MS — mobile station under test

D — reference FFSK transmitter

R — reference RF receiver with deemphasis

N_G — noise generator

DEM — reference FFSK demodulator

6.1.7 **Ability to interpret distorted data signals**

The distorsion of data signals received by the MS consists mainly of group delay distorsion, stemming from the connection MTX - BS and to a lesser extent from the BS circuitry. The ability of the MS to interpret data signals with group delay distorsion is measured by feeding the MS with an RF signal modulated by predistored data signals. The RF signal shall be modulated to an average frequency deviation of ± 3,5 kHz, using the same test procedure as in paragraph 6.1.1a. The modulating signal shall be fed through a distortion circuit with a group delay characteristic as shown in Fig. 6.2.

The required RF input signal level for 95% call reception probability shall not exceed the level necessary for 95% call reception probability measured without the distortion circuit by more than 1 dB.

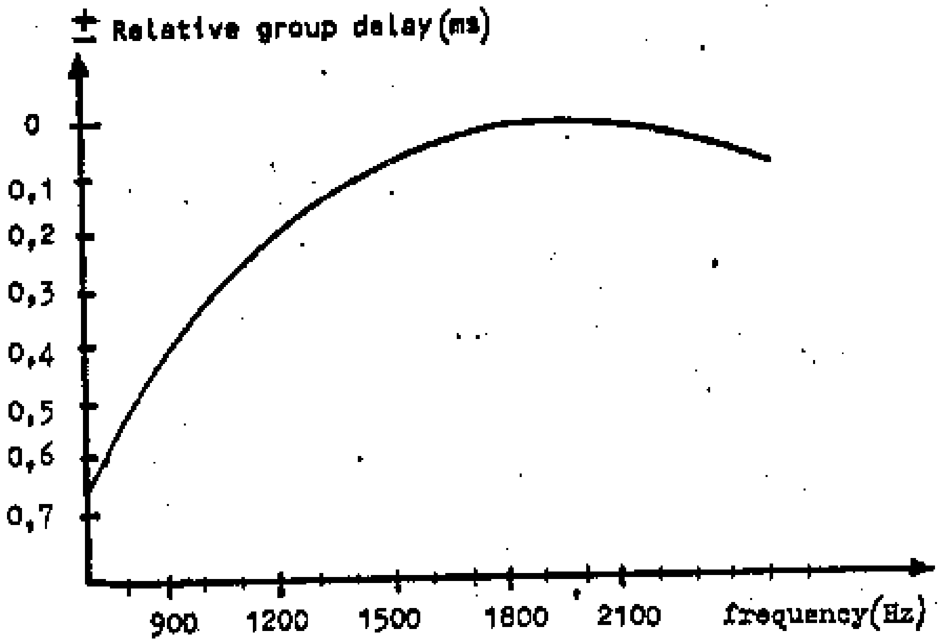


Fig. 6.2

Group delay of distortion circuit

6.2 Time constants

The following time constants are tested as described below.

6.2.1 Receiver switching time to next channel and FFSK detection time

6.2.1.1 Requirement

The receiver switching time to next channel and FFSK detection time shall not exceed 20 ms.

6.2.1.2 Deleted

6.2.1.3 Deleted

6.2.2 Transmitter start-up times

6.2.2.1 Definition

The transmitter reaction time is the time elapsed between the end of the calling frame (2a) and the beginning of the call acknowledgement frame (10b) indicated as t_3 in fig. 6.3. The following partial times are of interest:

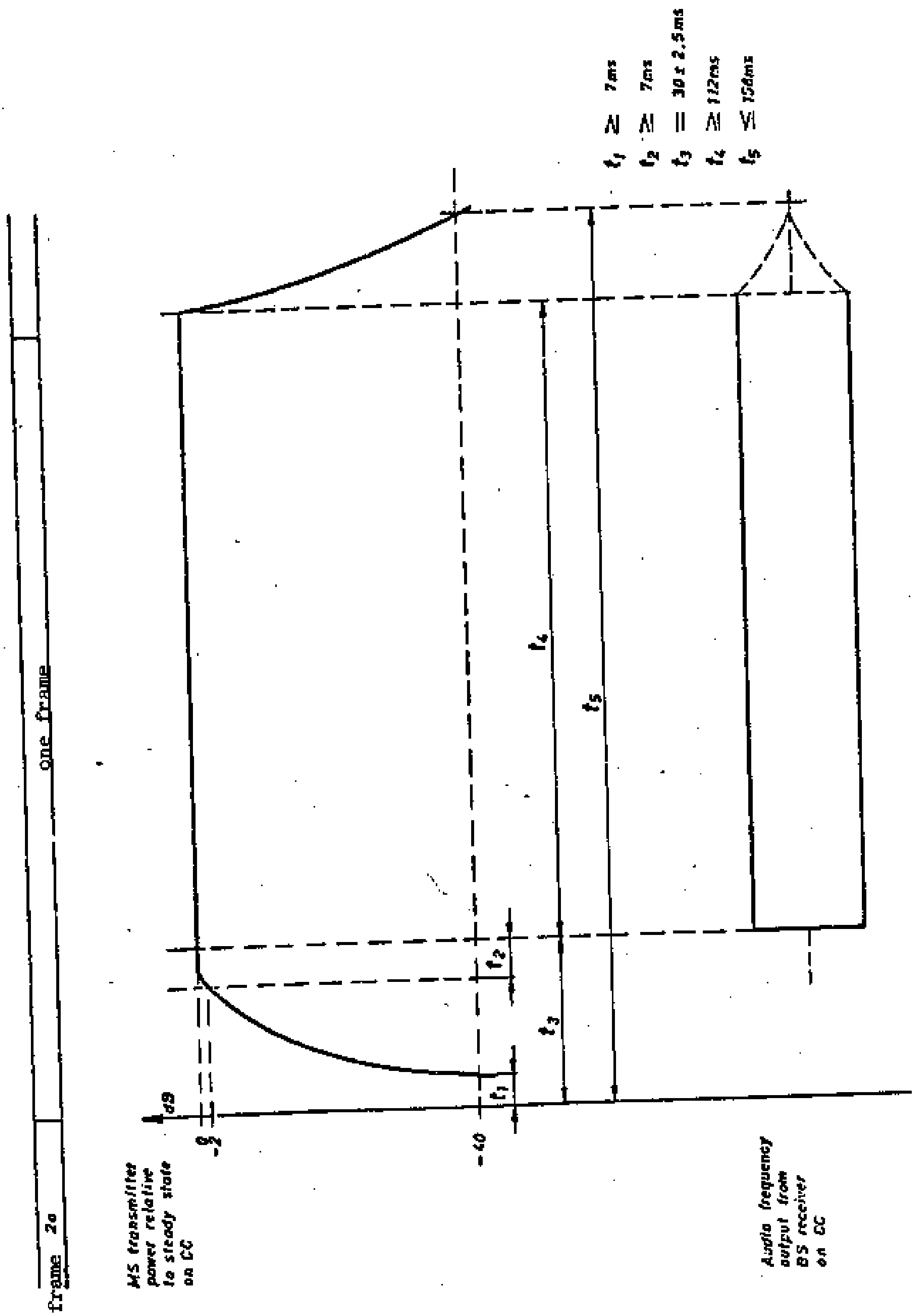

t1 ≥ 7ms
t2 ≥ 7ms
t3 = 30 ± 2,5ms
t4 ≥ 112ms
t5 ≤ 150ms
one frame
frame 2a
MS transmitter power relative to steady state on CC
Audio frequency output from BS receiver on CC
dB
0
-2
-40
t1
t2
t3
t4
t5

Fig. 6.3

The time elapsed from the end of the calling frame until the transmitter output power is 40 dB below its steady-state value is indicated as t_1 in fig. 6.3.

The time elapsed from the transmitter output power reaches a value 2 dB below its steady-state output power until the beginning of the call acknowledgement frame is indicated as t_2 in fig. 6.3.

Because of the reaction time of the base station squelch, the MS must always wait t_2 before data signalling starts.

6.2.2.2 Requirements:

$t_1 \geq 7$ ms

$t_2 \geq 7$ ms

6.2.3 Call acknowledgement on CC

The length of the call acknowledgement frame is indicated as t_4 in fig. 6.3. The time is minimum 112 ms (determined by the parameters of the signalling system).

6.2.4 Transmitter awake time

The transmitter awake time is defined as the time elapsed from the end of the calling frame (2a) until the transmitter output power has decayed to a value 40 dB below its steady-state value and is indicated as t_5 in fig. 6.3. The maximum length is 158 ms.

6.3 Ø-signal loop and transceiver coupling

6.3.1 Supervisory signal deviation

The supervisory signal as received and demodulated in the receiver is looped to the modulator without regeneration and shall produce a transmitter frequency deviation equal to the frequency deviation of the received supervisory signal within a tolerance of $\pm$ 10%.

Frequency = 4000 Hz continuous ($\pm$ 55 Hz)
Frequency deviation from the base station = $\pm$ 0,3 kHz ($\pm$ 30 Hz)

6.3.2 Transceiver coupling

Any coupling from the receive path to the transmit path or vice versa must be sufficiently small to prevent excessive echo from returning to the base station, as specified in the following.

1. The ratio in dB between the frequency deviation of the transmitted signal and that of the received signal at any modulation frequency shall be attenuated in accordance with the figure shown below. During this measurement, the acoustic path between the handset receiver (earpiece) and microphone shall be blocked by connecting the handset receiver to an artificial ear.

2. If, at any modulation frequency, the transmitter is modulated to give a frequency deviation of Δf, the level at the voice output circuit of the receiver, caused by any coupling between the receiver and the transmitter, shall be at least 25 dB below the level at the same point when an RF signal with a frequency deviation of Δ f is fed to the receiver.

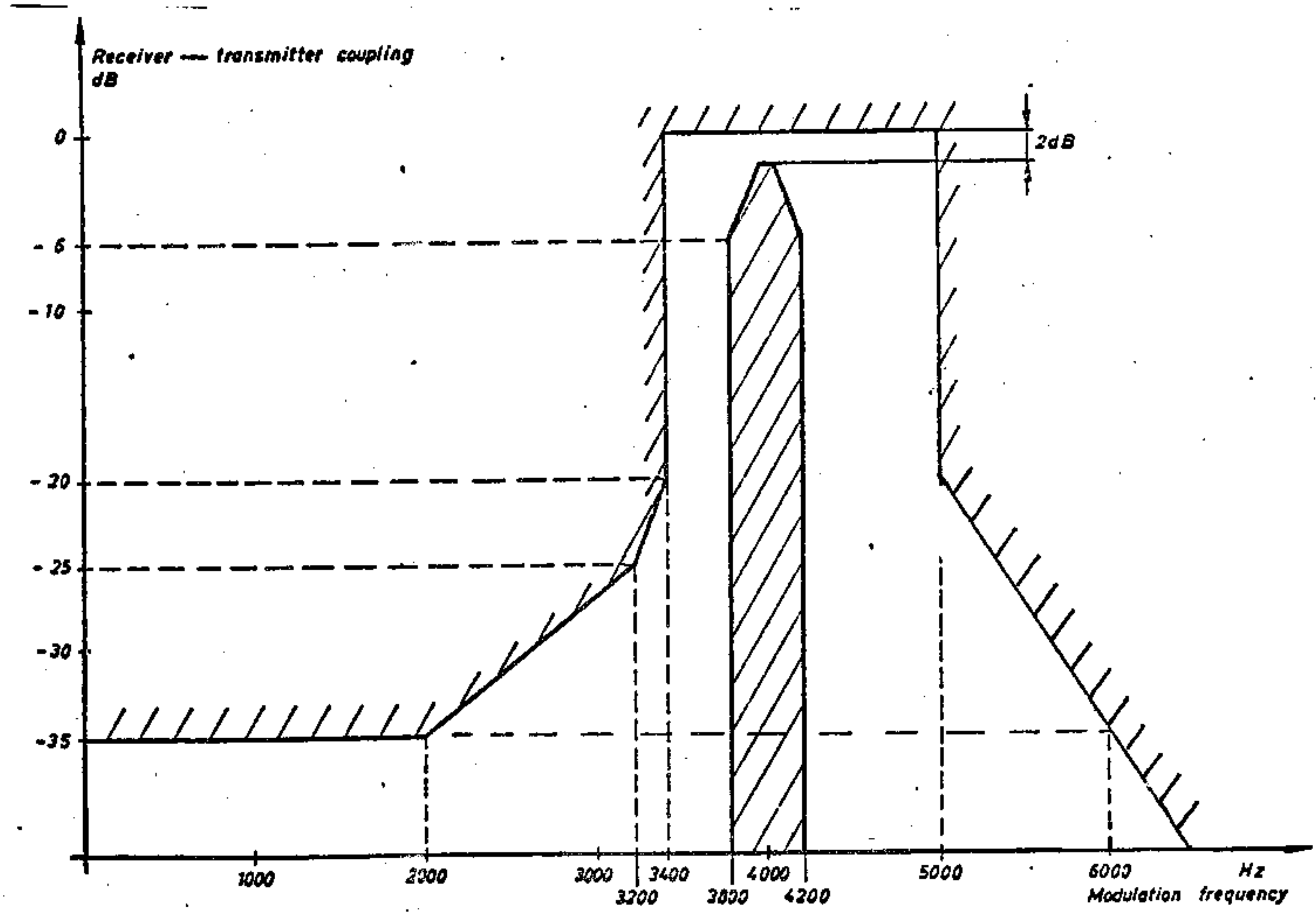


Fig. 6.4

6.4 Acceptance of signals

In the following signal schemes an error is placed in the frames and the error is then shifted cyclic through the frame and acceptance/rejection of the frame according to the schemes are checked.

This test is performed at high signal levels in order to control where the errors are placed.

The requirements in NMT Doc. 1 paragraph 4.7 are checked.

6.5 Functional tests

The functional testing of the MS consists of a number of exercises. These exercises are carried out in order to test the operation of the logic in the MS. All the tests are carried out at an RF-signal level of 10 dB/uV, and shall be successfully completed.

The tests are summarized below:

- o Calling Channel Seizure
- o Traffic Channel Seizure
- o Call MTX → MS
- o Call MS → MTX
- o Clearing from MS
- o Clearing from MTX
- o Switching Call in Progress
- o Roaming Up-dating
- o TX-power Control
- o Country Selector
- o Autonomous Time Out

Plus the supplementary facilities if so equipped:

- o MFT Converter IN/OUT
- o Subscriber with Priority
- o Tariff Information (Coin Box)
- o Abbreviated Dialling
- o "Hands-Free" Operation

6.6 Statistical test

The tests in paragraph 6.5 are repeated using a fading simulator in the RF path. The mean RF input signal level shall be 10 dBuV. The different signalling schemes in paragraph 6.5 are repeated a number of times. During this test the MS must not lock in an abnormal state.

GENERAL INFORMATION CONCERNING TESTS, TYPE APPROVAL, FEES AND MARKING AV MOBILE EQUIPMENT TO BE USED IN THE NORDIC MOBILE TELEPHONE SYSTEM (NMT)

In connection with tests and type approval of mobile equipment to be used in the NMT system manufacturers/agents have to notice the following:

1. APPLICATION FOR TESTING

Equipment to be used in the NMT system shall be tested in accordance with NMT Doc. 3, Technical Specification for the Mobile Station, for type approval by the Telecommunications Administration in the Nordic country (Denmark, Finland, Norway or Sweden) in which the manufacturer/agent is resident. An application for testing shall be made in writing to the Administration.

The application for testing shall contain information about the make and type designation of the equipment and shall be accompanied by a complete technical description (4 copies) of the equipment, containing e.g., circuit diagrams, flowcharts, PCB layouts and lists of components. Furthermore it shall be informed if the particular type designation has previously been used in connection with type approval procedure in a Nordic country. The type designation shall be approved by the administration.

Enclosed with the application there shall be a test report (4 copies) comprising the manufacturers results obtained from measurements in accordance with the equipment specification. The report shall clearly state any deviation from the measurement methods in the said document. The testing Telecommunications Administration shall then decide whether the test report is acceptable.

All documents presented with the type approval application are the property of the Telecommunication Administration and may be distributed to the other Nordic Administrations.

The applicant shall denominate person(s) to whom technical queries about the equipment can be addressed.

2. SELECTION OF EQUIPMENT FOR TESTING

Normally, the manufacturer shall present a specimen chosen from the production series for the testing. If the type approval is granted on the basis of tests made on a prototype, the corresponding production equipments shall in any relevant respect be identical with the specimen tested.

3. APPROVAL

All equipment of an approved type shall fulfil the specifications in NMT Doc. 3. It shall be a condition of a type approval that all equipment made of the type are identical with the specimen tested, as regards circuit diagrams, components, software and assembling.

Equipment which are not electronically and mechanically identical, must not wear the same type designation. If modifications are made, a new type designation must be given. This will require a new approval if the modifications have any relation to the specifications in force. The Nordic Telecommunications Administrations shall determine at their discretion whether types of equipment are identical in accordance with the above or whether new approval are necessary.

It shall be a condition of the continuing validity of a type approval that, for the purpose of control tests, a Nordic Telecommunications Administration may at any time freely select specimens of the type of equipment in question from the stock of the manufacturer/agent or importer, possibly, dealer. In the event that through this, or in some other way it is ascertained that the type of equipment does not fulfil the specifications in NMT Doc. 3 or, if otherwise, the conditions of the approval are disregarded, the approval may be cancelled both for equipment which have already been put to use and for equipment of the type in question which have not yet been put to use.

The approval shall solely cover conditions which bear upon the regulations laid down by the Nordic Telecommunications Administrations and does not aim at covering the possible requirements of other authorities in respect of the stations and their installation in general.

4. TEST AND APPROVAL FEES

Information concerning the test and approval fees can be obtained by contacting the relevant Telecommunications Administration.

5. MARKING OF THE EQUIPMENT

The equipment shall be clearly marked with the make, type designation, and serial number; this rule shall apply also to the sample which is handed in for testing. The marking shall be placed in such a manner on the equipment that it is easy to inspect when the equipment is mounted as specified by the manufacturer.

The marking shall be mechanically solid and durable and may, for example, be made by means of engraving, embossing or application of a metal plate.

6. TYPE APPROVAL IN MORE THAN ONE NORDIC COUNTRY

When type approval is granted in one of the Nordic countries, type approval in another Nordic country may be obtained by the following procedure.

The agent in the country for which type approval is sought shall in writing apply to the Telecommunications Administration for type approval. Enclosed with the application there shall be a copy of the type approval certificate already given by another Nordic Telecommunications Administration. The manufacturer/agent shall confirm that the equipment for which type approval is sought is in every respect identical with the equipment already type approved by the other Administration.

It is up to the Administration whether an approval will be based on the documentation or new test will be required.

October 1979

NMT Doc 3

Annex No. 2

1. PORTABLE MOBILE STATIONS

A portable mobile station is a portable or transportable equipment, containing its own power sources and fitted with an antenna mounted on the equipment.

1.1 Technical Requirements

The portable mobile stations shall fulfil the requirements in NMT Doc. 3, except for paragraphs 2.2.4.3, 2.2.5 and 3.4. Regarding portable mobile stations these paragraphs are modified as follows:

Paragraph 2.2.4.3: The available steady-state carrier power output at the antenna terminal into an artificial antenna shall be either 2 W $\pm$ 1,5 dB or 15 W $\pm$ 1,5 dB for all channels at normal test conditions, and within + 2 dB and - 3 dB of 2 W respective 15 W at extreme test conditions.

Paragraph 2.2.5: Addition to the present text:
Portable mobile stations with a nominal output power of 2 W will not need an additional power reduction step of 10 dB at a later date.

Paragraph 3.4: "Hands-free" operation need not be foreseen.
In case "Hands-free" possibilities are provided, all the requirements in paragraph 3.4 shall be fulfilled.