Recommendation T/R 24-04 (Edinburgh 1988)

RADIOCHARACTERISTICS OF SHORT RANGE RADIO (SRR) IN THE 900 MHz-BAND USING DIGITAL TECHNIQUES

Recommendation proposed by Working Group T/WG 16 "Radio Equipment and Systems" (RES)

Text of the Recommendation adopted by the "Telecommunications" Commission:

"The European Conference of Postal and Telecommunications Administrations,

considering

(a) that modern technology allows low-power radio transmitter-receiver (transceiver) and multi-channel trunking mode in the 900 MHz band for Short Range Radiocommunication between mobile and base stations or between mobile stations using digital modulation for the transmission and reception of voice and data at a gross bit rate of 16 kbit/s,

(b) that this technology can improve frequency economy,

(c) that this technology can largely avoid interference by using only free channels,

(d) that such equipment can solve problems of Administrations, in meeting the demand for short range radiocommunications, for instance in urban areas,

(e) that it is desirable for CEPT Administrations to have common regulations and technical specifications,

(f) that frequency coordination between Administrations, intending to introduce Short Range Radio (SRR) will be eased, thanks to the principles of the system,

(g) that common regulations and technical specifications will ease border crossing and facilitate the temporary use of Short Range Radio equipment in foreign countries,

(h) that Short Range Radio may be accomplished both in a single frequency simplex mode and in a two frequency semi duplex mode, which can coexist,

(i) that Administrations may adopt either the single frequency simplex mode system or the two frequency semi duplex mode system, or both,

recommends

1. that, as far as national regulations permit, the members of the CEPT should permit the use of SRR equipment in the non-public Land Mobile Service under the technical conditions in the Annexes,
2. that for the type approval tests the methods of measurement described in the relevant sections of the present Recommendation should be used,
3. that the test reports should be in conformity with CEPT Recommendation T/R 71-02 E,
4. that, in drawing up test reports, the Administrations should as far as possible follow the order of the tests and numbering of the paragraphs used in the Annexes and adopt the nomenclatures in the Annexes of this Recommendation.
5. that CEPT members should allow on a bilateral basis the border crossing and the temporary use of SRR equipment, which has been type-approved and is marked in accordance with the relevant Annex,
6. that the technical characteristics of SRR equipment operating in a single frequency simplex mode or two frequency semi duplex mode mentioned in the present Recommendations, should be used for the development of equipment.
7. that CEPT members shall evaluate the technical characteristics given in Annexes A and B at an appropriate time when the necessary development of equipment has taken place."

Contents

ANNEX A. GENERAL SPECIFICATIONS

1. DESCRIPTION

1.1. General

A Short Range Radio (SRR) is a low power radio transmitter-receiver (transceiver) of the non-public land mobile service intended to provide Short Range Radiocommunications using voice or data in the single frequency simplex mode in the frequency band 933-935 MHz or in the two frequency semi duplex mode in the frequency bands 933-935 MHz, paired with 888-890 MHz.

Direct digital modulation of the carrier is used to send the selective signalling code and voice and/or data messages.

SRR is equipment with:

— an automated multichannel access technique without the assistance of a central controller, and
— a reprogrammable read only memory facility (see Clause 15.).

SRR uses a selective signalling code which is described in Clause 12.; a part of the selective signalling code may be prescribed by the licence authority in order to uniquely identify the equipment and hence the licencee. Operation of SRR should only be possible when the reprogrammable read only memory facility is correctly programmed.

1.2. Single Frequency Working

When the single frequency mode is used, two way communication is possible from hand portable to hand portable stations, portable to vehicle mobile stations, mobile to mobile stations, portable to base stations and vehicle mobile to base stations, as required by the user.

All single frequency stations operate in the simplex mode.

In the standby mode, all stations are receiving on one or other of the control channels.

1.3. Two Frequency Working

When the two frequency mode is used, two way communication is possible between the base station and hand portable or vehicle mounted mobile stations.

When the two frequency mode is used, a base station may also be used as a repeater station to allow portable to portable, portable to mobile and mobile to mobile station two way communication over increased ranges compared to those achieved with single frequency working.

To permit other base stations to monitor the use of a traffic channel, all two frequency base stations, whether in the repeater mode or base station mode, operate in the full duplex mode with continuous transmission and reception on the traffic channel, while it is in use.

In order to enable monitoring of the traffic channels to permit selection of a free traffic channel, all two frequency base stations are to be capable of receiving either on base station transmitting frequencies or on mobile station transmitting frequencies, but not both at once.

In the standby mode a two frequency base or repeater station is receiving on one of the control channels.

When searching for a free traffic channel a two frequency base or repeater station is scanning the base station transmitter frequencies.

When operating on the selected traffic channel a two frequency base or repeater station is receiving on the selected traffic channel mobile transmit frequency.

2. PRINCIPLES OF OPERATION

2.1. Single Frequency Simplex Working

2.1.1. *The system provision*

The system makes use of 2 control channels to administer 75 traffic channels for voice and or data two way communication. Channels 02 and 78 are not used being reserved for additional control channels for two frequency operation.

2.1.2. *The selective signalling code*

The selective signalling code is designed to set up an appropriate two way communication channel, so that communication by voice or data may follow. The selective signalling code also identifies the station originating the call and contains the identity of the station or stations being called. The composition of the signalling code is described in Clause 12.

2.1.3. *Setting up a call*

In order to set up the two way communication channel, the station initiating the call has to locate a free channel. The station initiating the call can be a mobile or a base station.

The equipment is designed to operate on two designated control channels. In the standby mode a station is normally receiving on the first control channel. It changes to and receives on the second control channel if spurious signals are present on the first one for more than 5 seconds.

After receiving on the second control channel for 5 seconds, it switches back automatically to the first control channel. If spurious signals are still present on the first control channel the procedure is repeated, indefinitely if necessary.

A spurious signal is any signal above the threshold level of maximum usable sensitivity which is not recognised as control channel data.

2.1.4. *Initiating an individual call*

To initiate a call, the operator selects the unique calling code of the wanted mobile or base station and activates the call function. The station initiating the call then scans once the allocated channels to find a free channel and stores that channel number in its memory. It then returns to the first control channel and monitors the control channel to ensure it is free.

If the control channel is free it then transmits the full selective signalling code comprising the address code of the wanted station, the free channel number previously located, a command code used to indicate any special mode of operation, the address code of the call initiating station and its nationality code.

However, if the control channel is already in use at that time, then the calling station must wait either:

i) to the end of an acknowledgement code word (identified by bit No. 1 being "0" in each part of the address code words), or

ii) at least 200 ms after the end of a selective signalling code word, to allow i) to take place should the called station be in range and available.
The selective signalling code words are transmitted in 160 ms. The 200 ms wait therefore allows for 40 ms Rx to Tx switching time.

To minimise delay in finding a free channel each station will scan for a free channel in accordance with Appendix 1.

After the transmission of the full selective signalling code word, the calling station then switches to receive on the control channel and waits for 200 ms for an acknowledgement code word from the wanted station. If an acknowledgement code word is received, both stations switch to the already identified traffic channel and monitor it for 200 ms to ensure the identified traffic channel is free, at which point the calling station sends the full selective signalling code and waits again for 200 ms for a further acknowledgement code word from the wanted station. If received, the call ready indicator on the calling station operates. The call ready indicator on the wanted station operates on the first press to talk transmission by the calling station. The call ready indicator may be an audible or visual indication or both.

If no further acknowledgement code word on the traffic channel from the wanted station is received, the calling station returns to the standby mode on the calling channel.

Similarly the called station will return to standby on the control channel after 500 ms if it does not receive the selective signalling code word from the calling station on the traffic channel.

In the event of a further attempt by the operator of the calling station to call the same wanted station, the calling station when scanning for a free channel will commence at the previously chosen traffic channel plus one. This is to minimise the chance of selecting the same traffic channel, which was not suitable, a second time.

2.1.5. *Absence of acknowledgement*

If an acknowledgement code word from the called station is not received on the control channel, the following procedures are implemented.

At time intervals the calling station repeats automatically, in accordance with Appendix 3, the full selective signalling code whilst still on the first control channel. It switches to receive after each transmission for 200 ms to monitor for an acknowledgement code word from the wanted station. As soon as an acknowledgement code word is received, the sequence of events described in 2.1.4. is followed.

If after the total of three attempts by the calling station no acknowledgement code word is received from the wanted station, the calling station repeats the procedures outlined above on the second control channel.

The selection of the second control channel is timed out in five seconds for reversion to the first control channel.

2.1.6. *The channel scanning cycle*

In order to complete the channel scanning cycle as rapidly as possible, the station dwells on an occupied channel for not more than 50 ms. When an apparently unoccupied channel is located, the dwell time increases to 1.0 second to ensure that any use of the channel is identified. Only when a channel is unoccupied for 1.0 second is it identified as a free channel.

As described above, the stations which will have switched to the originally identified free channel are inhibited from transmitting until the channel has been monitored again, either to be free for 200 ms, or until the full selective signalling code which includes their address code is received. Detection of any other address code or other signals above the threshold level causes the stations to switch back to the first control channel and the call ready indicators will not operate.

2.1.7. *Identification for monitoring purposes*

The full selective signalling code word is transmitted automatically at the beginning of each transmission on the traffic channel.

2.1.8. *Limitation of congestion on traffic channels*

To limit congestion on the system each station is fitted with a time-out timer to limit the communication period. The timer prevents any one way voice or data transmission exceeding a duration of one minute. An audible warning signal is given after 50 seconds.

If any station is receiving a signal on the traffic channel for one minute without receiving a correctly decoded selective signalling code, the station returns immediately to the standby mode on the control channel.

If, during the one minute period a correctly decoded unwanted selective signalling code word is received, the station returns to the standby mode on the control channel.

The arrangements described in the above two paragraphs are to limit the period of possible overhearing of an unwanted transmission, when the wanted communication has been terminated and the same traffic channel is seized by another station.

If a station receiving on a traffic channel does not receive the wanted carrier signal above the threshold level for 10 seconds, the station returns to the standby mode on the control channel.

2.1.9. *User indicators*

To give the user confidence of his station's operation and to indicate the loading of the system, the following indicators are recommended.

The first indicator denotes the station is switched on and in the standby mode.

The second indicator denotes that the station is calling the wanted station or stations on the control channel or is scanning for a free channel.

The third indicator is the call ready indicator which denotes that the scanning sequence to select a free traffic channel has been successfully completed and communication on the traffic channel may begin.

The indicators can be visual, audible or both.

2.1.10. *Group calls (optional)*

The user can elect to set up a number of his own licenced units to form a group of unlimited size. The user selects one of his unit's addresses and programmes each of the group units as follows.

The group/individual call control on each unit wishing to be part of the group is set to group. The user selects the group address and enters it into the memory. The unit is then ready to receive a call from any member of the group.

Usually this procedure is carried out once, normally when the system is installed. All the user's mobile stations will then respond to their own unique address, or to the group address which is also unique to the group.

As a non mandatory facility supplied at the manufacturer's discretion, the user may set up multiple groups, each group of the multiple groups using one of the user's addresses.

To call the group from a mobile or base station, the call initiating station must first set his group/individual call control to group and activate the call function.

The calling station then automatically selects a free channel as previously described and then transmits the full selective signalling code word on the control channel.

With group calls a command code is transmitted by the call initiating station as part of the selective signalling code word to inhibit transmission of the acknowledgement code word by the group of wanted mobile stations.

After the initial activation of the call function by the calling station, it and all the group of wanted mobile stations receiving the call switch to the traffic channel and their call ready indicators operate.

If after waiting for 200 ms, there is no detection on the traffic channel of any other user's selective signalling code word by the calling station, the call ready indicator operates on the calling station.

Any one of the group of wanted mobile stations is free to reply to the calling station as soon as the full selective calling code is received.

Each station's group selective signalling code word and its identity is transmitted automatically at the beginning of each transmission on the traffic channel.

No acknowledgement procedures on group calls are used on either the control channels or the traffic channels.

If no station is transmitting or receiving a valid voice or data communication as determined by detection of a full selective signalling code word for 5 seconds, the station returns to the standby mode on the control channel.

2.2. Two Frequency Semi Duplex Working

2.2.1. *The system provisions*

The system makes use of 4 control channels to administer 75 traffic channels for voice and/or data two way communication. All channels are two frequency. The 4 control channels are channels 01; 02; 78 and 79.

The regulatory authority, when granting the license, assigns the user one of the control channels.

2.2.2. *The selective signalling code*

The selective signalling code is designed to set up an appropriate two way communications channel, so that communication by voice or data may follow. The selective signalling code also identifies the station initiating the call and contains the identity of the station being called.

The base station has its own unique identity (the selective signalling code) allocated by the licensing authority. To avoid mobile units having to transmit two calling codes, one to the base station and one to the wanted mobile unit, using the base station as a repeater, the base station is programmed to respond automatically to all of the licencee's mobile stations only.

The command code being part of the selective signalling code (see Section 12.) is used by a call initiating mobile or base station to indicate whether a single or two frequency unit is making the call.

2.2.3. *Setting up a call mobile to mobile via a repeater base station*

2.2.3.1. Normal procedure

The procedure for setting up a call initiated by a mobile unit to another mobile unit is performed in two separate actions as follows:

i) the call initiating mobile station establishes contact with the repeater base station,

ii) the repeater base station establishes contact with the wanted mobile station.

To initiate a call, the mobile station operator selects the unique address code of the wanted mobile unit and activates the call function. The call initiating mobile item monitors the associated control channel in the band 933-935 MHz to ensure it is free. If it is free the call initiating mobile transmits the full selective signalling code with the traffic channel code set to zero. The control channel is monitored by the call initiating mobile in the 933-935 MHz band and is considered free if a single frequency call set up (identified by the single frequency command code) is in progress, or no other signals are present.

It is not considered free if a two frequency call set up is in progress. In that case the call initiating station must wait either:

i) to the end of an acknowledgement code word (identified by bit No. 1 being "0" in each part of the address code words).

or

ii) at least 200 ms after the end of a selective signalling code word, to allow i) to take place should the called station be in range and available.

The selective signalling code words are transmitted in 160 ms. The 200 ms wait therefore allows for 40 ms Rx to Tx switching time.

The base station repeater receives the incoming call from the call initiating mobile station and, if valid, re-transmits the selective calling code when the control channel is available. The repeater base station receiver monitors the control channel in order to avoid contention, as described in 2.1.4.

The call initiating mobile station switches to receive on the control channel and utilises the retransmitted selective calling code from the repeater base station as an interim acknowledgement. The calling initiating mobile then waits for 5 seconds for an acknowledgement from the wanted called mobile via the repeater.

Upon receipt of the initiating mobile call, the base station stores in its memory the address code and country code of the initiating caller mobile station and the address and nationality code of the wanted mobile station.

When the called mobile station has made an acknowledgement, the base station then scans once the base station transmitting allocated traffic channels to find a free channel and stores that channel number in its memory.

The base station scanning takes place on the base station transmitting frequencies which necessitates a receiver capable of receiving on the base station transmitting frequencies and the mobile station transmitting frequencies.

Alternatively, a second receiver is used at the base station to continuously monitor for free traffic channels to give an immediate allocation to the mobile stations.

To minimise delays in finding a free channel each base station will scan for a free channel in accordance with Appendix 1.

The repeater base station then returns to the control channel and transmits twice with an interval of 40 ms, the full selective signalling code including this time the free traffic channel number previously located.

All stations now switch to the free traffic channel with the base station operating in repeat mode. The call initiating mobile sends the full selective signalling code after 40 ms and then waits up to 200 ms for an acknowledgement code word from the wanted mobile station.

If the call initiating mobile correctly decodes only one of the go to channel full selective signalling code words then it shall wait for 240 ms before sending the full selective code on the traffic channel.

If no acknowledgement code word is received from the wanted mobile station by the call initiating mobile station, the latter returns to the control channel.

If received, the call ready indicator on the call initiating mobile station operates. The call ready indicator on the wanted mobile station operates on the first press to talk transmission by the calling station. The call ready indicator may be an audible or visual indication or both.

If the repeater base station and the wanted mobile station do not receive the full selective signalling code from the call initiating mobile station on the free traffic channel, withing a period of 440 ms after the end of the second transmission of the repeater station carrying the full selective signaling code including the free traffic channel number, the repeater station and the called station return to the control channel.

2.2.3.2. Absence of acknowledgement

The call initiating mobile follows the procedures as outlined for single frequency operation with the exception that the call initiating station regards the repeater base station calling message to the called wanted mobile as an interim acknowledgement, which then inhibits any further retries by the call initiating mobile.

When communication has been established between the caller and repeater base station, the repeater base station is held in the repeat mode on the control channel station, i.e. its transmitter is active to deter unsolicited attempts by other mobile and base units to use the control channel and also to make sure that the acknowledgement from the called mobile is immediately re-transmitted to the call initiating mobile.

In order to limit congestion on the control channel only one retry by the base station is allowed following the procedure in Appendix 3 paragraph (a).

Note. If other single and/or two frequency mobiles are correctly monitoring the control channel, the retry contention problems are significantly reduced because the repeater base station transmitter has been active. Retry is then only covering the case where contention occurred on the first try or the mobile station was in a fading mode.

2.2.4. *Setting up a call mobile to base station*

2.2.4.1. Normal procedure

The procedure for setting up a call initiated by a mobile unit to a base station is as follows:

To initiate a call the mobile station operator selects the unique address code of the wanted base station and activates the call function. The call initiating mobile then monitors the associated control channel in the 933-935 MHz band to ensure it is free. If it is free (see Section 2.2.3.) the call initiating mobile transmits the full selective signalling code with the traffic channel code set to all zeros, and switches to receive for 200 ms to await acknowledgement from the base station.

Upon receipt of the selective signalling code the base station recognises its own unique address code as an indication that it is the wanted station. The base station transmits an acknowledgement code with the traffic channel number set to all zeros.

After receiving this acknowledgement the call initiating mobile waits on receive for traffic channel information from the base station.

The base station scans for a free traffic channel in accordance with Appendix 1 and then transmits twice with an interval of 40 ms the full selective calling signal including the channel number. The base station now switches to the traffic channel and waits for up to 440 ms for a selective signalling code from the call initiating mobile. Upon receipt of this full selective signalling code including the channel number, the call initiating mobile switches to the traffic channel and transmits a full selective signalling code, and waits for an acknowledgement on receive for 200 ms.

If the call initiating mobile correctly decodes only one of the go to channel full selective signalling code words then it shall wait for 240 ms before sending the full selective code on the traffic channel.

If the base station does not receive the latter full selective signalling code then it returns to the control channel.

If the base station receives the latter code then it transmits an acknowledgement.

If the call initiating mobile station does not receive the latter acknowledgement it returns to the control channel.

2.2.4.2. Absence of acknowledgement

If no initial acknowledgement code word from the base station is received on the control channel, the following procedures are implemented.

At time intervals the calling station repeats automatically, in accordance with Appendix 3, the full selective signalling code whilst still on the control channel. It switches to receive after each transmission for 200 ms to monitor for an acknowledgement code word from the base station. As soon as an acknowledgement code word is received, the sequence of events described in 2.2.4.1. is followed.

If after the total of three attempts by the calling station no acknowledgement code word is received from the wanted station, the calling station reverts to standby.

2.2.5. *Setting up a call. Base station to mobile station*

As it is the base station that initiates the call, it is the call initiating station that scans for the free channel.

The procedure therefore for setting up the call is identical to that for single frequency working as previously described.

In order to enable other base stations operated by other licencees to monitor that the two frequency channel is in use, the base station initiating the call transmits continuously on the traffic channel while the call is in process.

This ensures that while a mobile station is transmitting and the base station receiving, another base station does not identify the traffic channel is free because it is out of range from the mobile station but in range of the base station.

2.2.6. *Group calls with two frequency working*

The procedure described in paragraph 2.1.10. for single frequency working is also applicable to two frequency working for base station to mobile station calls. The use of a command code to identify a group call and the consequent inhibition of the acknowledgement code is the key feature of the group call procedure. The procedure does not include mobile to mobile group calls.

2.2.7. *Call termination*

The procedure for terminating an established call requires a positive action. This action shall be performed by means of a pushbutton or similar device such as an on-hook-switch.

This action will result in the transmission of the Bit Sync. (Preamble), as specified in Section 12., for one second, in order to terminate any transmission and reception on the traffic channel. The communicating mobiles, base station or repeater return to standby on the control channel.

2.2.8. *Other general information*

The paragraphs 2.1.6., 2.1.7. and 2.1.9. in the section dealing with single frequency working also apply to two frequency working.

3. FREQUENCY BAND FOR SRR EQUIPMENT

The frequency band for SRR equipment operating in the single frequency simplex mode uses band 933-935 MHz.

The frequency band for SRR equipment operating in the two frequency semi duplex mode uses the bands 933-935 MHz and 888-890 MHz.

4. CARRIER FREQUENCIES AND CHANNEL NUMBERS

The following carrier frequencies with their associated numbers shall be used.

Single frequency operation:

933.0250 MHz Transmitting and Receiving	Channel 01
933.0500 MHz Not available	Channel 02
933.0750 MHz Transmitting and Receiving	Channel 03
933.1000 MHz Transmitting and Receiving	Channel 04
933.1250 MHz Transmitting and Receiving	Channel 05
933.1500 MHz Transmitting and Receiving	Channel 06
and then at 25 kHz intervals up to:	
934.9500 MHz Not available	Channel 78
934.9750 MHz Transmitting and Receiving	Channel 79

Two frequency operation (base station frequencies):

933.0250 MHz Transmitting 888.0250 MHz Receiving	Channel 01
933.0500 MHz Transmitting 888.0500 MHz Receiving	Channel 02
933.0750 MHz Transmitting 888.0750 MHz Receiving	Channel 03
933.1000 MHz Transmitting 888.1000 MHz Receiving	Channel 04
933.1250 MHz Transmitting 888.1250 MHz Receiving	Channel 05
933.1500 MHz Transmitting 888.1500 MHz Receiving	Channel 06
and then at 25 kHz intervals up to:	
934.9500 MHz Transmitting 889.9500 MHz Receiving	Channel 78
934.9750 MHz Transmitting 889.9750 MHz Receiving	Channel 79

5. CONTROL CHANNELS

For single frequency simplex working channels 01 and 79 are used as control channels. Channel 01 is used as the first control channel. For two frequency semi duplex working channels 01, 02, 78 and 79 are used as control channels.

The same control channel numbers are used for single and two frequency channels.

6. CHANNEL SEPARATION

The channel separation for SRR equipment is 25 kHz.

7. MODE OF OPERATION

The mode of operation for single frequency mobiles and single frequency base stations is simplex.

The mode of operation for two frequency mobile stations is simplex.

The mode of operation for two frequency base stations is duplex (including optional repeater mode).

8. MODULATION

On the control channels the method of modulation is Gaussian Minimum Shift Keying (GMSK) (0.70) at 1000 bit/s. On the traffic channels the method of modulation is GMSK (0.25) at 16 kbit/s (see CCIR report 903). Channel coding and framing will reduce the usable bitrate to 13 kbit/s (see Clause 13.).

9. SYNTHESIZERS AND PLL SYSTEMS

The transmitter shall be inhibited when the synthesizer is out of lock.

10. TIME LIMITATION ON CHANNEL OCCUPANCY

In the event that the emission on the control channel continues due to any fault in the radio equipment, the emission shall cease automatically within 1 minute.

11. THRESHOLD LEVEL FOR RF SENSING TIME

To determine the availability of a channel the SRR shall be equipped with an RF level detector which provides an RF sensing facility.

A channel shall be considered as idle if the median value of the input voltage is not higher than 2 microvolt (e.m.f.).

12. THE SELECTIVE SIGNALLING CODE

The selective signalling code word is transmitted on the control channel and consists of two data code words after bit and frame synchronisation, as follows:

Bit Sync. (Preamble)	16 bits
Frame Sync.	16
Acknowledgement Code	1
Traffic Channel Code	7
Call Code of Wanted Station	24
Country Code of Calling Station	8
Command Code	4
Reserve	4
Cyclic Redundancy Check	16
License Code of Network	24
Call Code of Calling Station	24
Cyclic Redundancy Check	16
Total	160 bits

All numbers are encoded in binary with the exception of the Country Code, which is encoded in binary coded decimal. The most significant bit is transmitted first.

The transmission begins with a 16 bit preamble of bit reversals 1010...10 so that the receiver data demodulator can acquire bit synchronisation.

The frame begins with a 16 bit synchronisation word, to enable the receiver decoder to etablish code word framing, is as illustrated below:

Bit Number:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bit Value:	1	1	0	0	0	1	0	0	1	1	0	1	0	1	1	1

(Bit number 1 is transmitted first)

An acknowledgement code word is the full signalling code word with the ackowledgement bit changed to 0.

The licence code of the network operated by a single user is allocated by the regulatory authority. Such a network is a closed system. If the regulatory authority wishes to operate open systems, then the 24 bits allocated to the licence code are all 0's. The licence code cannot be changed by the user.

The call code giving the station identity of all station units is unique to each station and are normally programmed in by the manufacturer. They cannot be changed by the user.

The country code is a decimal two digit number translated into BCD (2 times 4 equals 8 bits) which represents the country which has issued the user licence or authorised the use of the equipment. The decimal numbers of the country code are given in Appendix 2.

The command code comprising 4 bits is used to indicate special modes of operation such as group call and two frequency working. Unless otherwise specified, all the bits are set to zero. For group call the command code is set to 0001, for two frequency working 0010 and both together 0011.

The free traffic channel code is the decimal channel number of the selected free traffic channel translated into a binary number of 7 bits in accordance with the format given in Appendix 4.

The cyclic redundancy check of 16 bits for encoding and error checking is calculated in three steps:

First, fifteen check bits are appended to the 48 information bits by encoding them in a (63, 48) cyclic code. For encoding, the information bits 1 to 48 may be considered to be the coefficients of polynomial having terms from X^{62} down to X^{15}. This polynomial is divided modulo 2 by the generating polynomial $X^{15} + X^{14} + X^{13} + X^{11} + X^{4} + X^{2} + 1$. The fifteen check bits, code word bits 49-63 correspond to the coefficients of the terms from X^{14} to X in the remainder of polynomial found at the completion of the division. The (63, 48) cyclic code has a minimum distance of 5 and so guarantees detection of up to 4 bit errors in one code word.

Second, the final check bit of the (63, 48) cyclic code (code word bit 63) is inverted to protect against misframing in the decoder.

Third, one bit is appended to the 63 bit block to provide an even bit parity check of the whole 64 bit code word. The overall parity bit ensures that all odd numbers of errors can be detected, so the overall 64 bit code guarantees that up to 5 bit errors can be detected.

At the receiver each code word may be checked for errors by recalculating the check bits for the received information bits. Any difference between the received check bits and the recalculated check bits indicates that the received code word contains errors.

It is left to the manufacturer whether identification of an error is used to reject the whole selective signalling code word or whether to take advantage of the code's potential error correction capability before taking the decision whether or not to reject the word.

13. THE CODING SYSTEM

The coding system used for data transmission and reception is left to the manufacturer's discretion.

The speech coding algorithm for use with voice transmission and reception will be in accordance with the standards of the GSM Digital Pan European Specification for cellular radio (13 kbit/s).

14. TYPE-APPROVAL MARK

The CEPT approval mark shall consist of the indication CEPT-SRR followed by one, two or three characters, indicating the country where the equipment has been type-approved, as specified in Appendix 2.

The minimum height of the characters shall be 2 mm.

The equipment shall be permanently marked with the CEPT-approval mark in a visible place even after the equipment has been installed. The marking shall be legible and durable.

15. MECHANICAL AND ELECTRICAL DESIGN

15.1. Controls

Those controls and components which, if maladjusted, might increase the risk of interference or improper functioning of the equipment shall not be accessible to the user.

15.2. **Indication of the Communication Frequency and Control Signal Information**

The frequency actually used during a transmission or reception, including the channel number to express that frequency, and the content of the control signal received shall neither be indicated nor be accessible to the user.

Precautions should be taken against extension of the usable frequency range by the user, e.g. the physical and electrical design of the channel switching system shall permit operation in not more than the above mentioned 79 channels.

15.3. **Call code selection**

The transceiver shall be equipped with a call code selector, which makes it possible to select any call code in the range from 0000000 to 9999999 to call any wanted station with a call code within that range. The user has no access to the licence code.

15.4. **Programming of the Unique Address Code and Licence Code**

The transceiver shall be provided with a reprogrammable read only memory facility which meets all of the following functional and technical requirements:

(a) means shall be provided to enable the transceiver functions to be operated by the user, only after entering, by a suitable external facility, the unique licence code, country code and unique address call code allocated by the regulatory authority or by an authorised organisation recognised by the regulatory authority;

(b) when the regulatory authority does not require each transceiver to be allocated a licence code, the unique address call code and country code may be entered by the manufacturer as an authorised organisation before despatching the transceiver to a distributor or user. The manufacturer would allocate the unique address call code from a block of numbers allocated to the manufacturer by the regulatory authority;

(c) the user shall have no access to the means of entering the licence code, country code and address call code and shall not have any means of changing any of the codes;

(d) the user shall have no means of erasing any of the codes;

(e) means shall be provided to maintain the integrity of all the codes when the power supply is removed;

(f) the integrity of all the codes shall be maintained under normal and extreme test conditions;

(g) the control channel for two frequency working, assigned by the regulatory authority, is also programmed by an authorised organisation, in accordance with the conditions of the user licence.

15.5. **Power**

The equipment shall be constructed in such a way that an increase of the output power cannot be easily achieved.

16. **RF SPECIFICATION SUMMARY**

Frequency band:	933 to 935 MHz for single frequency working 933 to 935 MHz and 888-890 MHz for two frequency working 933 to 935 MHz for two frequency base station transmitters
Channel separation:	25 kHz
Type of modulation:	GMSK (0.25) at 16 kbit/s (speech and data) GMSK (0.70) at 1 kbit/s (signalling)
Number of channels:	79 total
Channel allocation:	4 control channels 01, 02, 78 and 79 75 traffic channels 03 to 77
Channel 01 frequency:	Single frequency working: 933.0250 MHz transmitting and receiving Two frequency working: 933.0250 MHz base transmitting 888.0250 MHz mobile transmitting

Channel 79 frequency:	Single frequency working: 934.9750 MHz transmitting and receiving Two frequency working: 934.9750 MHz base transmitting 889.9750 MHz mobile transmitting
Transmitter maximum rated carrier power:	5 W
Transmitter frequency error:	±2.5 maximum
Transmitter adjacent channel power:	— 70 dB relative to carrier for channels 1 and 79 — 50 dB relative to carrier for channels 3 to 77 inclusive The adjacent channel power needs not be below 0.2 microwatt
Transmitter spurious emissions: (transmitter operating and in stand by position)	From 9 kHz to 30 MHz under consideration 0.25 microwatt maximum from 30-1000 MHz 1.0 microwatt maximum from 1-12.5 GHz
Transmitter Intermodulation: (two frequency base station installations only)	60 dB minimum
Receiver maximum usable sensitivity:	better than +6 dB relative to 1 microvolt e.m.f. for bit error rate (BER) of 10^{-2}
Receiver co-channel rejection:	−18 dB minimum
Receiver adjacent channel selectivity:	50 dB minimum
Receiver spurious response rejection:	60 dB minimum
Receiver intermodulation response:	55 dB minimum
Receiver blocking:	80 dB minimum
Receiver spurious emissions:	From 9 kHz to 30 MHz under consideration 2 nanowatt over range 30 to 1000 MHz 20 nanowatt over range 1 to 12.5 GHz

ANNEX B. TECHNICAL SPECIFICATIONS

1. GENERAL

1.1. External Antenna

This specification applies to equipment fitted with an antenna socket to which an external antenna may be coupled directly or by a suitable feeder cable.

1.2. Test Conditions, Power Sources and Ambient Temperatures

1.2.1. *Normal and extreme test conditions*

Type approval tests shall be made under normal test conditions, and also, where stated, under extreme test conditions.

The test conditions and procedures shall be as specified in Clauses 1.2.2. to 1.2.5.

1.2.2. *Test power source*

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

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

During tests, the power source voltages shall be maintained within a tolerance ±3% relative to the voltage at the beginning of each test.

1.2.3. *Normal test conditions*

1.2.3.1. 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%

Note. When it is impracticable to carry out the tests under the conditions stated above, a note to this effect, stating the actual temperature and relative humidity during the tests, shall be added to the test report.

1.2.3.2. Mains voltage

1.2.3.2.1. 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.

1.2.3.2.2. Regulated lead-acid battery power sources on vehicles

When 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.).

1.2.3.2.3. 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.

1.2.4. *Extreme test conditions*

1.2.4.1. Extreme temperatures

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in Clause 1.2.5., at the lower and upper temperatures of −15° C to +55° C.

1.2.4.2. Extreme test source voltages

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

1. for the Leclanché, Nickel Cadmium, or the Lithium-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;
4. when the equipment is intended for operation from the usual types of regulated lead-acid battery power sources of vehicles the extreme test voltages shall be 1.3 and 0.9 times the nominal voltage of the battery (6 volts, 12 volts, etc.);
5. the extreme test voltage for equipment to be connected to an AC mains source shall be the nominal mains voltage ± 10%.

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.

1.2.5 *Procedure for tests at extreme temperatures*

1.2.5.1. Test procedure

Before measurements are made, the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched on but the transmitter is not keyed during the temperature stabilising period. If the thermal balance is not checked by measurements, a temperature stabilising period of a 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.

1.2.5.1.1. Procedure for equipment designed for intermittent operation

The specification calls for a time-out timer to be fitted limiting the maximum total transmission time to 3 minutes. The equipment is therefore designated as for intermittent operation.

Before tests at the upper temperature the equipment is switched on to the standby condition and placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on for one minute in the transmit condition, followed by four minutes in the receive condition, after which the equipment shall meet the specified requirements.

For tests at the lower temperatures the same procedure is used.

1.3. **General Conditions**

1.3.1. *Principles of test procedure*

The characteristics of the voice circuits of the equipment, which involve digital speech with an analogue to digital converter for the transmitter and a digital to analogue converter for the receiver, do not lend themselves to instrument measurements of the RF characteristics.

Therefore, all measurements are made at the data input to the transmitter and the data output from the receiver, at the full bit rate independent of any forward error detection and/or correction.

Equipments that do not have an input/output socket for the data facility, either internally mounted or mounted on an external surface can be temporarily modified to provide a suitable facility. Alternatively, a method of test acceptable to the testing authority can be proposed by the manufacturer.

The manufacturer is responsible for supplying any ancillary equipment that is necessary to ensure that the signal generators used for the receiver tests have identical modulation characteristics with that used in the equipment transmitter.

All measurements are made with a bit rate of 16 kbit/s unless otherwise stated.

1.3.2. *Arrangements for test signals applied to the receiver input*

Sources of test signals for application to the receiver shall be connected in such a way that the impedance presented to the receiver is 50 ohms.

This requirement shall be met irrespective of whether one or more signals are applied to the receiver simultaneously.

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

1.3.3. *Receiver mute or squelch facility*

The receiver mute or squelch circuit shall be made inoperative for the duration of the type-approval tests.

1.3.4. *Normal test signal and normal test modulation*

The normal test signal used to modulate signal generators for receiver tests and the transmitter are chosen from the following as appropriate.

- Signal M1, consisting of a pseudo random bit sequence of 511 bits (according to CCITT Recommendation V.52) repeated as necessary.
- Signal M2, consisting of a radio frequency signal, modulated by an audio frequency signal of 800 Hz with a deviation of 1 kHz.

1.3.5. *Impedances*

All the input and output impedances at radio frequency and other terminals of the equipment shall be as agreed between the manufacturer and the testing authority.

1.4. **Test Site and General Arrangements for Measurements Involving the Use of Radiated Fields**

1.4.1. *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 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.

For equipment which is not intended to be worn on a person, the sample should be tested using a non-conducting support.

The sample shall be placed with its side of largest area on the metal plate. To meet the requirement that the antenna is vertical while maintaining contact with the metal plate, it may be necessary to use a second metal plate, attached to the first. This metal plate shall be 10×15 cm in size and shall be hinged to the first plate by its 10 cm edge in such a way that the angle between the plates can be adjusted between 0° and 90°. The hinge point shall be adjustable so that the centre of the sample can be placed above the centre of the circular plate. In the case of samples whose length along the antenna axis is less than 15 cm, the sample shall be arranged so that the base of the antenna is at the edge of the hinged plate.

Equipement which is intended to be worn on a person shall be tested using a simulated-man test fixture as support.

The simulated-man test fixture comprises a standard container filled with salt water.

The container shall have the following dimensions:

— Height	1.7 m (± 0.1 m)
— Inside Diameter	300 mm (± 5 mm)
— Sidewall Thickness	5 mm (± 5 mm)

The container shall be filled with a salt (NaCl) solution of 1.49 g per litre of distilled water.

The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of approximately 3 metres. 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.

1.4.2. *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 the horizontal or vertical polarisation and for the height of its centre above ground to be varied over the range 1 to 4 metres. Preferably test antennae 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 level of signals at its input. When necessary (for receiver measurements) the test receiver is replaced by a signal source.

1.4.3. *Substitution antenna*

When mesuring in the frequency range up to 1 GHz the substitution antenna shall be a half wave dipole, resonant at the frequency under consideration, or a shortened dipole, calibrated to the half wave dipole. When measuring in the frequency range above 4 GHz a horn radiator shall be used.

For measurement between 1 and 4 GHz either a half wave dipole or a horn radiator may be used. 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 external antenna 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 measurement 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 network.

1.4.4. *Alternative indoor site*

Provided it is recorded in the test report use may be made of an indoor site.

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 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 polarised measurements.

The site arrangement is in principle shown in Figure 1 (T/R 24-04).

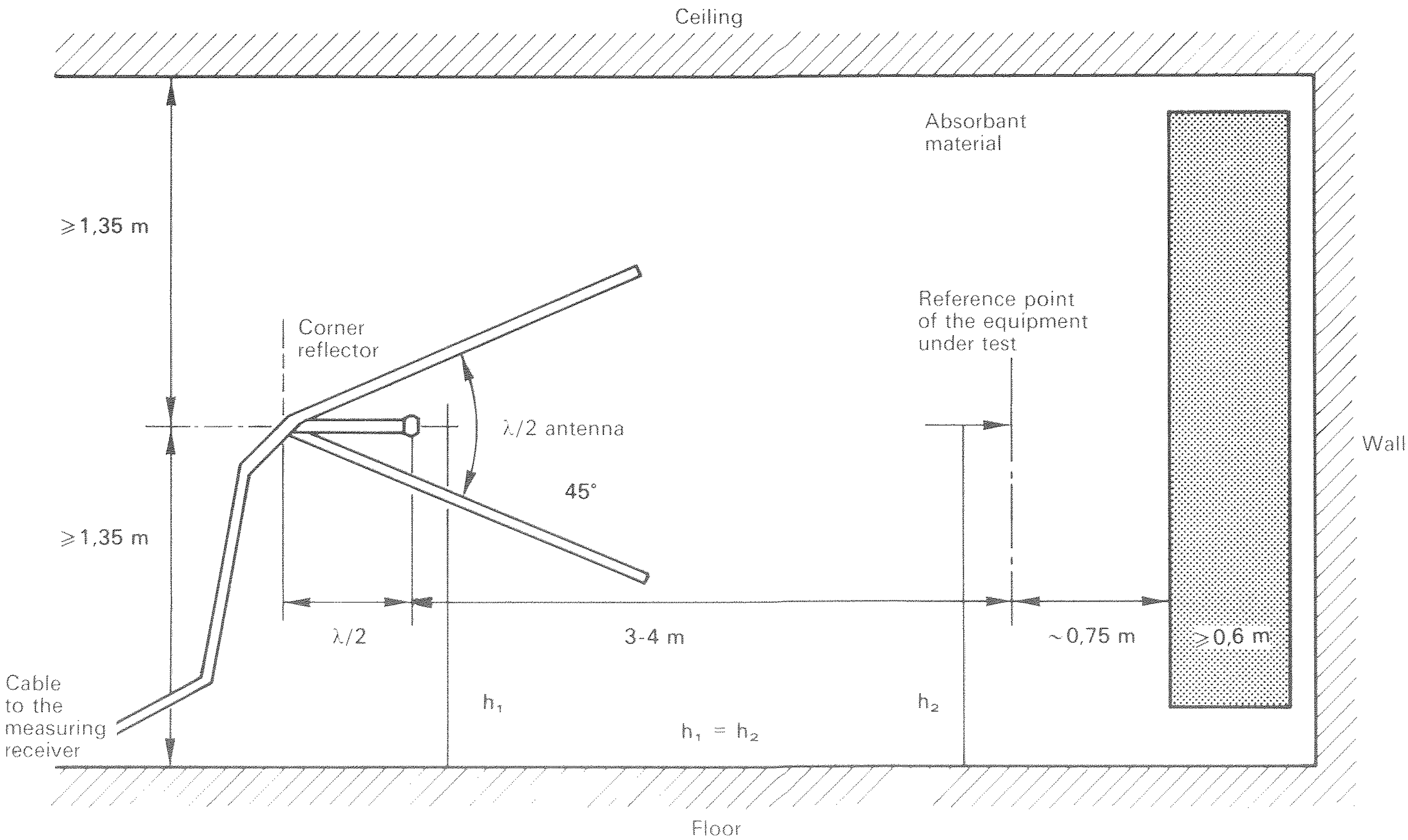


Figure 1 (T/R 24-04). Indoor site arrangement (shown for horizontal polarisation).

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

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

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 ± 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.

1.4.5. *Modes of operation of the transmitter*

For the purpose of the measurement according to this Recommendation there should be a facility to operate the transmitter in an unmodulated state for measurement of the frequency error and spurious emissions.

The method of achieving this should be agreed between the manufacturer and the testing authority.

A temporary modification to the transmitter to enable it to transmit in the unmodulated state, which does not affect the level of spurious emissions compared to the level without the modification, is acceptable.

2. TRANSMITTER

2.1. Frequency Error

2.1.1. *Definition*

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

2.1.2 *Method of measurement*

The equipment shall be connected to a dummy load of the appropriate impedance. The carrier frequency shall be measured in the absence of modulation. The measurement shall be made under normal test conditions (Clause 1.2.3.) and extreme test conditions (Clauses 1.2.4.1. and 1.2.4.2. applied simultaneously).

2.1.3. *Limit*

The frequency error shall not exceed ±2.5 kHz in both normal and extreme test conditions.

For portable equipments having integral power supplies, the tolerance given shall not be exceeded over a temperature range of 0 to 30 C.

2.2. Carrier Power

2.2.1. *Definition*

The rated carrier power is the mean power delivered to a dummy load of 50 ohms. If the manufacturer wishes to use a different impedance this must be agreed between the manufacturer and the testing authority.

2.2.2. *Method of measurement*

The transmitter shall be connected to a dummy load of 50 ohms and the power delivered to this dummy load shall be measured.

The measurement shall be made under normal test conditions (Clause 1.2.3.) and extreme test conditions (Clauses 1.2.4.1. and 1.2.4.2. applied simultaneously).

2.2.3. *Limits*

The rated carrier power shall be declared by the manufacturer and shall not exceed 5 watts.

The carrier power under the specified conditions of measurement (Clause 1.2.3.) and at normal test conditions shall be within ± 1.5 dB of the rated carrier power.

The carrier power under extreme test conditions shall be within +2 dB and −3 dB of the rated output power.

If the equipment is provided with a facility of reducing the carrier power, the requirements of this specification shall also be met when the transmitter is operating at reduced power.

2.3. Adjacent Channel Power

2.3.1. *Definition*

The adjacent channel power is that part of the total power output of a transmitter under defined conditions of modulation, which falls within a specified passband centred on the nominal frequency of either of the adjacent channels. This power is the sum of the mean power produced by the modulation, hum and noise of the transmitter.

2.3.2. *Methods of measurement*

2.3.2.1. General remarks

Two methods are proposed, the results of which are equivalent. Administrations are requested to use one or both of these methods. The method applied shall be stated in the test reports.

2.3.2.2. Method of measurement using a power measuring receiver

The adjacent channel power may be measured with a power measuring receiver which conforms with Clause 2.3.2.3. (referred to in Clauses 2.3.2.2. and 2.3.2.3. as the "receiver").

(a) The transmitter shall be operated at the carrier power determined in Clause 2.2. under normal test conditions (Clause 1.2.3.). The output of the transmitter shall be linked to the input of the "receiver" by a connecting device such that the impedance presented to the transmitter is 50 ohms at a level that is appropriate.

(b) With the transmitter modulated by a normal test signal (M1) according to Clause 1.3.4. the tuning of the "receiver" shall be adjusted so that a maximum response is obtained. This is the 0 dB response point. The "receiver" attenuator setting and the reading of the meter shall be recorded.

Measurements are made with the transmitter modulated at 16 kbit/s on traffic channels and at 1000 bit/s on the control channels.

(c) The tuning of the "receiver" shall be adjusted away from the carrier so that the "receiver" −6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency of 17 kHz.

The specified necessary bandwidth of the "receiver" is 16 kHz minimum.

(d) The "receiver" variable attenuator shall be adjusted to obtain the same meter reading as in step (b) or a known relation to it.

(e) The ratio adjacent channel power to carrier power is the difference between the attenuator settings in steps (b) and (e), corrected for any differences in the reading of the meter.

(f) The measurement shall be repeated with the "receiver" tuned to the other side of the carrier.

2.3.2.3. Power measuring receiver specification

The power measuring receiver consists of a mixer, an IF-filter, an oscillator, an amplifier, a variable attenuator and a rms value indicator. Instead of the variable attenuator with the rm value indicators it is also possible to use a dB calibrated rms voltmeter. The technical characteristics of the power measuring receiver are given below.

2.3.2.3.1. IF-filter

The IF-filter shall be within the limits of the following selectivity characteristic.

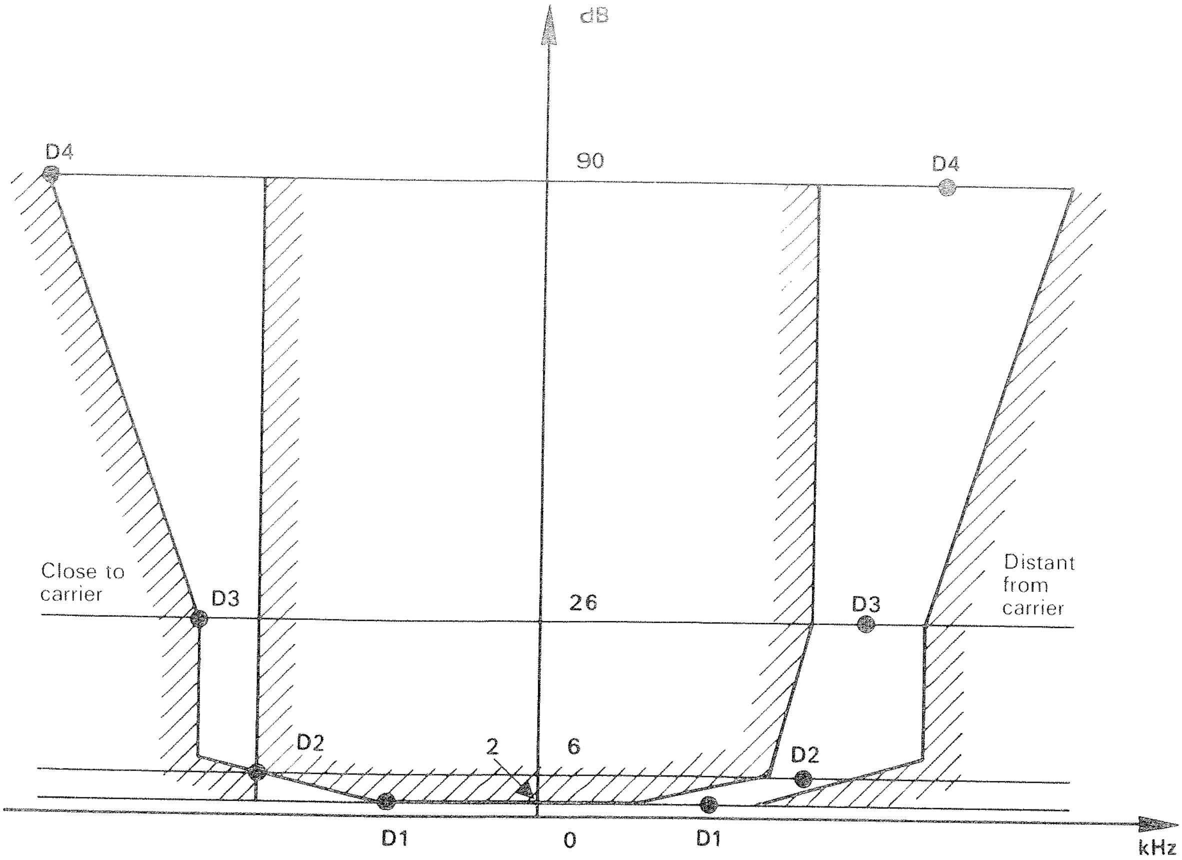


Figure 2 (T/R 24-04). Selectivity characteristic of the receiver.

The frequency separation of the filter curve from the nominal centre frequency of the adjacent channel related to the above diagram is:

D1: 5 kHz; D2: 8 kHz
D3: 9.25 kHz; D4: 13.25 kHz

The tolerances related to the attenuation points close to the carrier shall not exceed:

D1: 3.1 kHz; D2: ±0.1 kHz
D3: −1.35 kHz; D4: −5.35 kHz

The tolerances related to the attenuation points distant from the carrier shall not exceed:

D1: ±3.5 kHz; D2: ±3.5 kHz
D3: ±3.5 kHz; D4: −7.5 kHz to 3.7 kHz

The minimum attenuation of the filter outside the 90 dB attenuation points must be equal to or greater than 90 dB.

2.3.2.3.2. Attenuation indicator

The attenuation indicator shall have a minimum range of 80 dB and a reading accuracy of 1 dB. With a view to future regulations an attenuation of 90 dB or more is recommended.

2.3.2.3.3. Rms value indicator

The instrument shall accurately indicate non-sinusoidal signals in a ratio of up to 10:1 between peak value and rms value.

2.3.2.3.4. Oscillator and amplifier

The oscillator and the amplifier shall be designed in such a way that the measurement of the adjacent channel power of a low-noise unmodulated transmitter, whose self-noise has a negligible influence on the measurement results, yields a measured value of −90 dB, referred to the carrier of the transmitter.

2.3.2.4. Method of measurement using a spectrum analyser

The adjacent channel power may be measured with a spectrum analyser which conforms to Clause 2.3.2.5. The transmitter shall be operated at the carrier power determined in Clause 2.2. under normal test conditions (Clause 1.2.3.). The output of the transmitter shall be linked to the input of a spectrum analyser by a connecting device such that the impedance presented to the transmitter is 50 ohms and the level at the spectrum analyser input is appropriate.

The transmitter shall be modulated by the normal test signal (M1) according to Clause 1.3.4. The spectrum analyser shall be adjusted so that the spectrum of the transmitter output, including that part which lies within the adjacent channels, is displayed.

For the purpose of this test, the bandwidth of a receiver of the type normally used in the system shall be taken to be 16 kHz.

The centre frequency of the bandwidth within which measurements are to be made shall have a separation from the nominal carrier frequency of the transmitter equal to the channel separation for which the equipment is intended.

The adjacent channel power is the sum of the power of each of the modulation components and of the noise in the appropriate bandwidth. This sum may be calculated or an automatic power level integrating device may be used to obtain it (see Clause 2.3.2.6.).

In the latter case, the relative power level of the carrier and its sidebands are initially measured by integration in the appropriate bandwidth, centred on the nominal frequency. The integration is repeated at this bandwidth centred on the nominal frequency of the adjacent channel and the input level of the carrier signal increased until the same power level at the output of the device is obtained.

The difference in the input levels, in dB, is the ratio of the adjacent channel power to the carrier output power.

The adjacent channel power expressed as an effective radiated power is calculated by applying this ratio to the carrier output power as determined in Clause 2.2.

The measurement shall be repeated for the other adjacent channel.

2.3.2.5. Spectrum analyser*) specification

The specification shall include the following requirements:

It shall be possible, using a resolution bandwidth of 1 kHz, to measure the amplitude of a signal or noise at a level 3 dB or more above the noise level of the spectrum analyser, as displayed on the screen, to an accuracy of ±2 dB in the presence of a signal separated in frequency by 25 kHz at a level 90 dB above the level of the signal to be measured.

The reading accuracy of the frequency marker shall be within ±0.1 kHz.

The accuracy of relative amplitude measurements shall be within ±1 dB.

It shall be possible to adjust the spectrum analyser so that two components with a frequency difference of 1 kHz are displayed separately.

2.3.2.6. Integrating and power summing device

The integrating and power summing device is connected to the video output of the spectrum analyser, described in Clause 2.3.2.5.

It shall be possible to summate the effective power of all discrete components (and the spectral power density) and the noise power in the selected bandwidth and to measure this as a ratio relative to the carrier power.

The position and the width of the integration range selected can be indicated on the spectrum analyser by brightening the trace.

When power levels as low as 50 nanowatts are measured, the output of the device should exceed the internal noise level by at least 10 dB. The dynamic range shall permit measurement of the values required under Clause 2.3.3. with a margin of at least 10 dB.

*) *Note.* For statistical distributed modulation status the spectrum analyser and the integrating device must allow to determine the *real spectral power density* (energy per time and bandwidth), which has to be integrated over the bandwidth in question. (This point has to be considered very carefully.)

2.3.3. *Limits*

The adjacent channel power for the control channels shall not exceed a value of 70 dB below the carrier power of the transmitter without any need to be below 0.2 microwatt. For the traffic channels 3 to 77 the adjacent channel power shall not exceed a value of 50 dB below the carrier power without any need to be below 0.2 microwatt.

2.4. Spurious Emissions

2.4.1. *Definition*

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

The level of spurious emissions shall be measured as:

(a) their power level in a transmission line or antenna, and

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

2.4.2. *Method of measuring the 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 transmitter output through and attenuator to a spectrum analyser or selective voltmeter, or by monitoring the relative levels of the spurious signals delivered to an artificial antenna (Clause 1.3.6.)

If possible, the transmitter shall be unmodulated and the measurements made over the frequency range 9 kHz to 12.5 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels. The measurement shall be repeated with the transmitter modulated by the normal test signal (M1) (Clause 1.3.4.). If possible should be continuous modulation for the duration of the measurement.

The measurement shall be repeated with the transmitter in the standby position.

2.4.3. *Methods of measuring the effective radiated power of spurious radiations*

On a test site, fulfilling the requirements of Clause 1.4., the sample shall be placed at the specified height on the support. The transmitter shall be operated at the carrier power as specified under Clause 2.2., delivered to an artificial antenna (Clause 1.3.5.).

If possible, the transmitter shall be unmodulated and the radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency 30 MHz to 12.5 GHz, 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 determined by a substitution measurement.

The measurements shall be repeated with the transmitter modulated by the normal test signal (Clause 1.3.4.). If possible this should be continuous modulation for the duration of the measurement.

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

The measurements shall be repeated for any alternative integral antenna which can be supplied with the equipment.

The measurements shall be repeated with the transmitter in the standby position.

2.4.4. *Limit*

The power of any spurious emission shall not exceed the values given below:

	9 kHz to 30 MHz	30 MHz to 1 GHz	1 GHz to 12.5 GHz
TX Operating	Under Consideration	0.25 Microwatt	1 Microwatt
TX Standby	Under Consideration	2 Nanowatts	20 Nanowatts

2.5. Intermodulation Attenuation

2.5.1. *Definition*

This test is only applied to equipment used as a base station for two frequency operation.

For the purpose of this specification, the intermodulation attenuation is a measure of the capability of a transmitter to inhibit the generation of signals in its non-linear elements caused by the presence of the carrier and an interfering signal reaching the transmitter via its antenna.

2.5.2. *Method of measurement*

The output of the transmitter under test shall be connected to a signal source via a coupling device, presenting to the transmitter a load with an impedance of 50 ohms.

The coupling device can consist of a circulator, one port of which is to be connected by a coaxial cable to the output terminal of the transmitter, the second port is to be correctly terminated (nominal value 50 ohms). This termination is to be provided with means for connection to a selective measuring device (e.g. a spectrum analyser). The third port of the circulator is to be connected to the test signal source by means of an isolator.

Alternatively, the coupling device may consist of a resistive attenuator, which may be combined with an isolator, one end to be connected to the output terminal of the transmitter by coaxial cable and the other end to be connected to the test signal source. A selective measuring device is to be connected to the transmitter end of the attenuator by means of a sampling probe, giving the required attenuation.

The transmitter under test and the test signal source shall be physically separated in such a way that the measurement is not influenced by direct radiation.

The test signal shall be unmodulated and the frequency shall be within to 1 to 4 neighbouring channels above the frequency of the transmitter under test. The frequency shall be chosen in such a way that intermodulation components to be measured do not coincide with other spurious emissions. The test signal power level shall be adjusted to −30 dB relative to the carrier power level of the transmitter (Clause 2.2.), both levels being measured at the output of the transmitter. The power level of the test signal shall be measured at the transmitter end of the coaxial cable, when disconnected from the transmitter and then correctly matched (nominal value 50 ohms)*).

The output power of the transmitter shall be measured directly at the output terminal connected to an artificial antenna comprising a 50 ohm non-reactive non-radiating lead.

With the transmitter switched on in an unmodulated condition the levels of the transmitter carrier and the intermodulation components are compared by means of the selective measuring device.

The length of the coaxial cable between the transmitter output and the coupling device shall be varied until the maximum level of the intermodulation component considered is obtained.

This measurement shall be repeated with the test signal at a frequency within 1 to 4 neighbouring channels below the transmitter frequency. When the above measurements are performed, precautions must be taken, so that non-linearities in the selective measuring device do not influence the results appreciably. Furthermore, it should be ensured that intermodulation components, which may be generated in the test signal source, are sufficiently reduced; e.g. by means of a circulator.

The intermodulation attenuation is expressed as the ratio in dB of the output power level of the transmitter under test to the power level of an intermodulation component.

2.5.3. *Limit*

The intermodulation attenuation shall be at least 60 dB for any intermodulation component.

2.6. Transmitter Attack Time

2.6.1. *Definition*

The transmitter attack time is the time which elapses between the initiation of the "transmitter on" function and the moment that the transmitter output power has reached a level 1 dB below its steady state level.

2.6.2. *Method of measurement*

The transmitter is connected to a storage oscilloscope via a matched test load attenuator and the oscilloscope amplitude response is calibrated to display the steady state output power at a suitable level. By appropriate means, a triggering pulse to the oscilloscope is generated at the moment that the "transmitter on" function is initiated.

2.6.3. *Limit*

The transmitter attack time shall not exceed 25 ms.

*) *Note.* The impedance that the transmitter presents to the test signal being unknown, the test signal level cannot be measured or its amplitude compared with that of the intermodulation components, while the transmitter is connected.

2.7. Transmitter Release Time

2.7.1. *Definition*

The transmitter release time is the time which elapses between the initiation of the "transmitter off" function and the moment that the transmitter output power has decayed to a level 40 dB below the steady state level (1% amplitude).

2.7.2. *Methode of measurement*

The transmitter is connected to a storage oscilloscope via a matched test load attenuator and the oscilloscope amplitude response is calibrated to display the steady state output power at a suitable level. By appropriate means, a triggering pulse to the oscilloscope is generated at the moment that the "transmitter off" function is initiated.

2.7.3. *Limit*

The transmitter release time shall not exceed 20 ms.

2.8. Transmitter Transient Bbehaviour

2.8.1. *Definition*

The transient behaviour of transmitters is determined by the time-dependency of transmitter frequency and transmitter power when the transmitter is switched on and off or other switching combinations are used.

2.8.2. *Legend to the Figures 3 (T/R 24-04) and 4 (T/R 24-04)*

To ease the understanding of the Figures 3 (T/R 24-04) and 4 (T/R 24-04) the following descriptions are given:

- Tx_{on}: the time at which the final irrevocable logic decision is taken to initiate transmission
- t_d :: the time between "Tx_{on}" function and "RF power on"
- t_a: the time between the "RF power on" function and t_{on}
- t_{am}: the transmitter attack time as measured in Clause 2.6.
- t_{al}: the limit of the transmitter attack time as given in Clause 2.6.
- t_{rm}: the transmitter release time as measured in Clause 2.7.
- t_{rl}: the limit of the transmitter release time as given in Clause 2.7.
- P_o: steady state power
- Δf_0: frequency tolerance in the steady state
- Δf_1: frequency difference which is greater than half the channel separation
- Δf_2: frequency difference which is not greater than half the channel separation
- t_1, t_3: period of time during which frequency tolerance Δf_1 applies
- t_2: period of time during which frequency tolerance Δf_2 applies

According to the method of measurement described in 2.8.6., the switch-on instant (t_{on}) of a transmitter is defined by the condition when the output power, measured at the antenna terminal, exceeds $P_o - 20$ dB. The switch-off instant (t_{off}) is given when the nominal power falls below this limit.

2.8.3. *Keying criterion when the transmitter is switched on*

The transient times and frequency tolerances are shown in Figure 3 (T/R 24-04).

2.8.4. *Keying criterion when the transmitter is switched off*

The transient time is not subdivided: the frequency tolerance is shown in Figure 4 (T/R 24-04).

2.8.5. *Other switching combinations*

They include all switching processes, such as switch on/off of the ratio equipment with simultaneous activation on the transmitter key, and may include when appropriate a change of frequency of the synthesizer of the transmitter.

2.8.6. *Method of measurement*

The transient time (ON/OFF) and the frequency difference occurring during these times can be measured by means of a test discriminator which meets the requirements indicated in Clause 2.8.7.

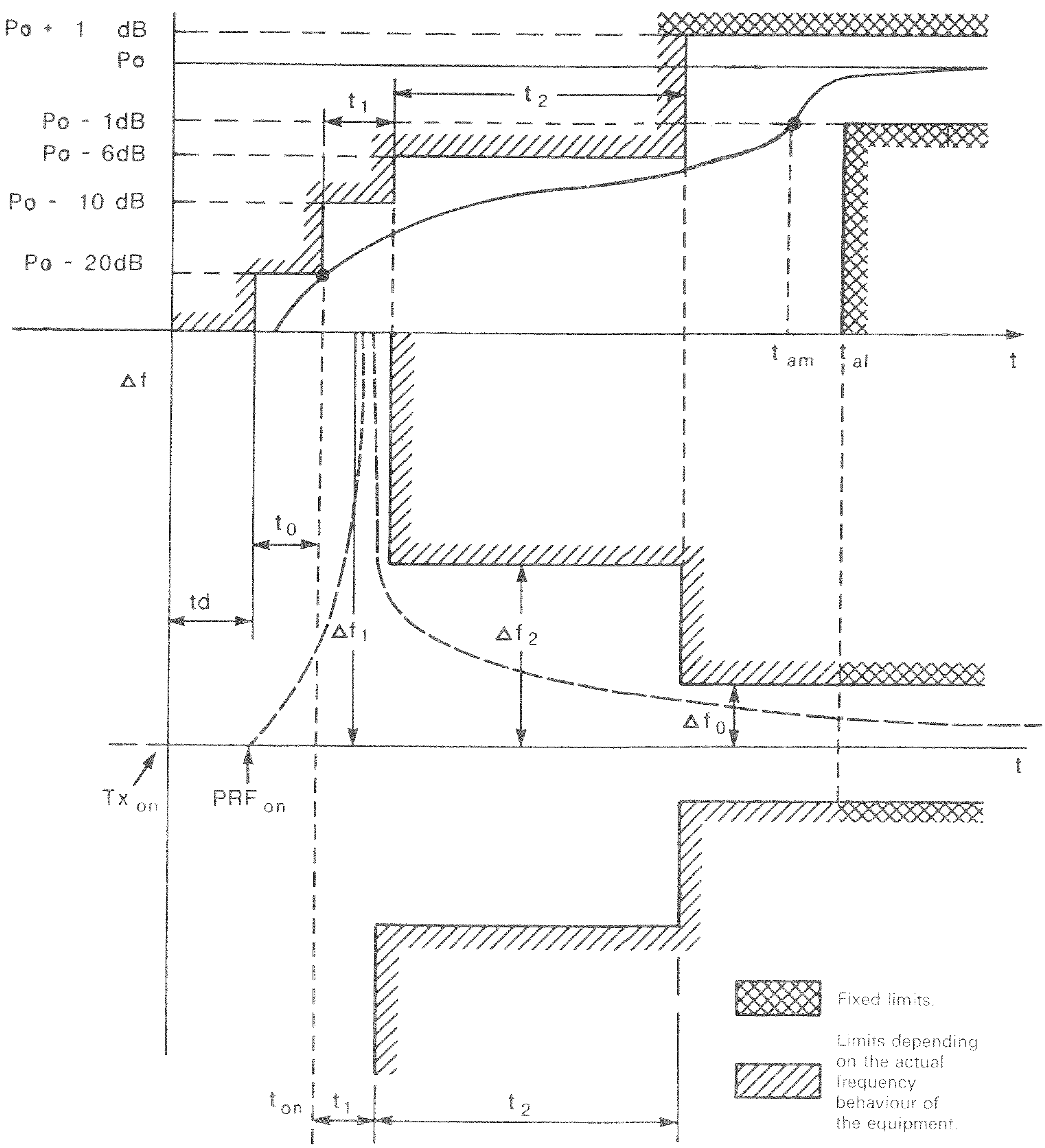


Figure 3 (T/R 24-04). Transient behaviour in the switch-on position according to Clauses 2.8.3. and 2.8.5.

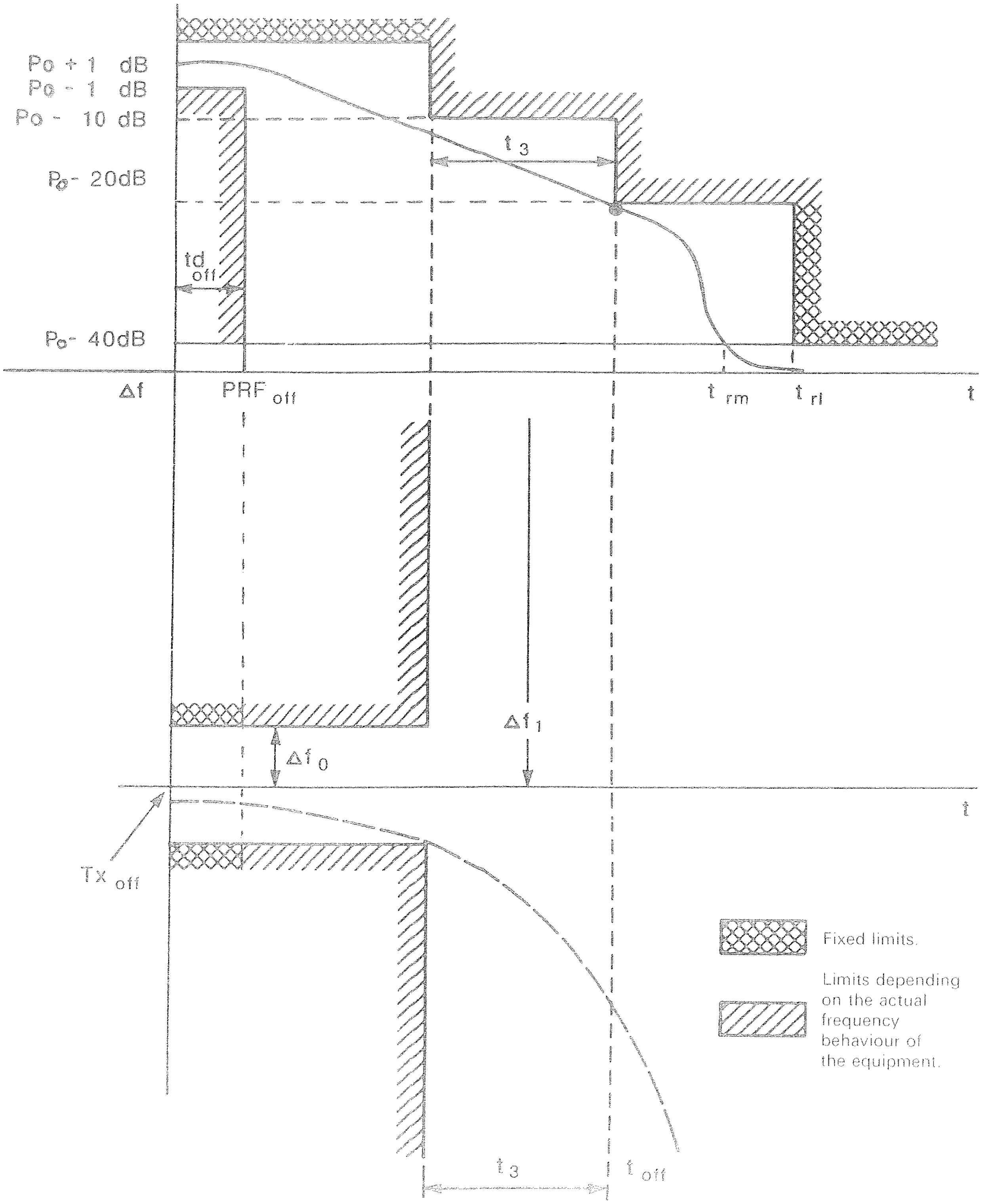


Figure 4 (T/R 24-04). Transient behaviour in switch-off position according to Clauses 2.8.4. and 2.8.5.

Connect the transmitter with the test set-up as shown in Figure 5 (T/R 24-04). The calibration of the test set-up has to be checked. Operate the transmitter unmodulated in accordance with the operating conditions indicated in Clauses 2.8.3. and 2.8.5. Connect the transmitter output to the input of the test discriminator via a matched test load attenuator. The attenuation of the test load attenuator must be dimensioned in such a way that the input of the test discriminator is protected against overload and the limiter amplifier of the test discriminator operates correctly in the limiting range when the power condition in Clause 2.8.2 is reached.

Prior to each test, the calibration of the test discriminator has to be checked by feeding in RF voltages with defined frequency differences, and the signal generator has to be properly tuned to the nominal frequency of the transmitter.

By appropriate means, generate a triggering pulse either at the instant the transmitter is switched on and off or when the power supply of the radio equipment is switched on and off the transmitter key is simultaneously pressed. The voltage occurring at the test discriminator output has to be recorded as a function of time and amplitude on a storage oscilloscope or a transient recorder. The voltage deviation is a measure of the frequency difference. The elapsed time of the frequency transient can be measured by the given time base ranges of the oscilloscope.

2.8.7. *Technical requirements of the test discriminator*

The test discriminator consists of a mixer and local oscillator (auxiliary frequency) to convert the transmitter frequency to be measured into the frequency of the (broadband) limiter amplifier and the following broadband discriminator.

- The effective bandwidth of the measuring equipment shall be so wide as to allow frequency differences in the order of 5 times the channel spacing to be resolved exactly.
- The test discriminator must be capable of displaying the frequency deviations sufficiently fast (approximately 100 kHz/100 µs).
- The test discriminator output must be dc coupled.

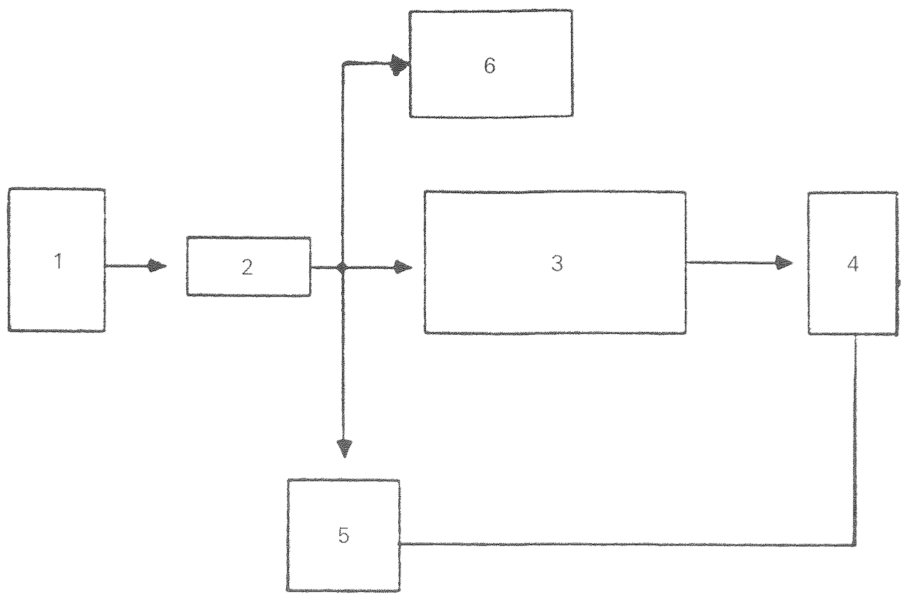


Figure 5 (T/R 24-04). Measuring arrangement for testing the frequency transient behaviour of transmitters.

Legend:

1. Transmitter under test.
2. Test load attenuator.
3. Broadband test discriminator.
4. Storage oscilloscope or transient recorder.
5. Transmitter power trigger device.
6. Power meter.

2.8.8. *Limits*

The transient times shall not exceed the values given below:

t_1: 20 msec

t_3: 20 msec

In addition, the following requirement shall be fulfilled:

$t_d + t_o + t_1 + t_2 \leq t_{al}$;

In the time periods t_1 and t_3 the power shall not exceed $P_0 - 10$ dB;

In the time period t_2 the power shall not exceed $P_0 - 6$ dB.

3. RECEIVER

3.1. Maximum Usable Sensitivity (data)

3.1.1. *Definition*

The maximum usable sensitivity (data) of the receiver is the minimum level of signal (e.m.f.) at the receiver input, at the nominal frequency of the receiver, with normal test modulation (Clause 1.3.4.), which will produce *after demodulation a data signal with a specified bit error rate.*

3.1.2. *Method of measurement*

A test signal with a frequency equal to the nominal frequency of the receiver, unmodulated, is applied to the receiver input terminals. The e.m.f. of the input signal is measured.

The input signal is then modulated by the normal coded test modulation M1 (Clause 1.3.4.) and the modulation signal is compared with the signal which is obtained from the receiver after demodulation.

The e.m.f. of the input signal of the receiver is adjusted until the bit error rate is 10^{-2}.

The maximum usable sensitivity (data) is the e.m.f. of the input signal to the receiver.

3.1.3. *Limits*

The maximum usable sensitivity (data) shall not exceed +6 dB relative to an e.m.f. of one microvolt under normal test conditions, and +12 dB relative to an e.m.f. of one microvolt under extreme test conditions.

3.2. Bit Error Rate

3.2.1. *Performance without the presence of noise*

3.2.1.1. Definition

In the absence of noise generated by the receiver, the bit error rate shall be as low as possible.

3.2.1.2. Method of mesurement

The input signal defined in 3.1.2. to the receiver is adjusted to a level of 30 dB above the level of the limit for the maximum usable sensitivity. The number of errors that occur at the data output terminal or at a special measuring terminal of the receiver, during a period of 3 minutes, is counted.

The measurements are repeated with the input signal of the receiver at a level of 100 dB above the level of the limit for the maximum usable sensitivity.

3.2.1.3. Limit

The number of errors within a period of 3 minutes shall be 0 or 1.

3.3. Co-Channel Rejection

3.3.1. *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 the presence of an unwanted modulated signal, both signals being at the nominal frequency of the receiver.

3.3.2. *Method of measurement*

(a) Two signal generators A and B shall be connected to the receiver via a combining network (see Clause 1.3.2.). Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M1 (see Clause 1.3.4.). Signal generator A provides the wanted signal.

Signal generator B shall be modulated with the normal test signal M2 (see Clause 1.3.4.). Signal generator B provides the unwanted signal.
Both signals shall be at the nominal frequency of the receiver and the measurement shall be repeated for displacements of the unwanted signal of up to ±3000 Hz.

(b) Initially the unwanted signal shall be switched off and the wanted signal shall be adjusted to establish the level of the maximum usable sensitivity (data) in this test set-up, according to Clause 3.1. The level of the wanted signal shall then be adjusted to a level which is equivalent to the level of the limit for the maximum usable sensitivity (data) plus 3 dB.

(c) The unwanted signal shall then be switched on, and the input level adjusted until a bit error rate of about 10^{-1} is obtained.

(d) The normal test signal (M1) shall be transmitted whilst observing the bit error rate. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error rate of 10^{-2} or better is obtained. The level of the unwanted signal shall then be recorded.

(e) The co-channel rejection ratio shall be expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal at the receiver input.

3.3.3. *Limit*

The co-channel rejection ratio at the signal displacements, given in the method of measurement, shall be greater than −18 dB.

3.4. Adjacent Channel Selectivity

3.4.1. *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 adjacent channel separation for which the equipment is intended.

3.4.2. *Method of measurement*

(a) Two signal generators A and B shall be connected to the receiver via a combining network (see Clause 1.3.2.). Signal Generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M1 (see Clause 1.3.4.). Signal generator A provides the wanted signal.
Signal generator B shall be modulated with the normal test signal M2 (see Clause 1.3.4.). Signal generator B provides the unwanted signal.
Signal generator B shall be adjusted to the frequency of the channel immediately above that of the wanted signal.

(b) Initially signal generator B shall be switched off and using signal generator A the maximum usable sensitivity (data) shall be established in this test set-up, according to Clause 3.1.2. The output level of generator A shall then be adjusted to a level which is equivalent to the level of the limit for the maximum usable sensitivity (data) plus 3 dB.

(c) The unwanted signal (generator B) shall then be switched on, and the input level adjusted until a bit error rate of 10^{-1} is obtained.

(d) The normal test signal (M1) shall be transmitted whils observing the bit error rate. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error rate of 10^{-2} or better is observed. The level of the unwanted signal shall then be recorded.

(e) The measurement shall be repeated with the unwanted signal at the frequency of the channel below that of the wanted signal.

(f) The adjacent channel selectivity shall be expressed as the lower value of the ratios for the upper and lower adjacent channels of the levels of the unwanted signal to the level of the wanted input signal (generator A).

(g) The measurement shall be repeated under extreme test conditions (Clauses 1.2.4.1. and 1.2.4.2. applied simultaneously), using the extreme test condition limits for the maximum usable sensitivity.

3.4.3. *Limits*

The adjacent channel selectivity shall not be less than the values given below:
Normal test conditions: 50 dB
Extreme test conditions: 45 dB.

3.5. **Spurious Respone Rejection**

3.5.1. *Definition*

The spurious response 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 signal at any other frequency, at which a response is obtained.

3.5.2. *Method of measurement*

(a) Two signal generators A and B shall be connected to the receiver via a combining network (see Clause 1.3.2.). Signal Generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M1 (see Clause 1.3.4.). Signal generator A provides the wanted signal.

Signal generator B shall be modulated with the normal test signal M2 (see Clause 1.3.4.). Signal generator B provides the unwanted signal.

Signal generator B (unwanted signal) shall be adjusted to the frequency at which it is anticipated that a spurious response could occur.

(b) Initially signal generator B shall be switched off and using signal generator A the maximum usable sensitivity (data) shall be established in this test set-up, according to Clause 3.1.2. The output level of generator A shall then be adjusted to a level which is equivalent to the level of the limit for the maximum usable sensitivity (data) plus 3 dB.

(c) The unwanted signal (signal generator B) shall then be switched on, and the input level adjusted until a bit error rate of 10^{-1} is obtained.

(d) The normal test signal (M1) from signal generator A shall be transmitted whilst observing the bit error rate. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error rate of 10^{-2} or better is observed. The level of the unwanted signal shall then be recorded.

(e) The spurious response rejection shall be expressed as the ratio in dB of the levels of the unwanted signal (generator B) to the level of the wanted signal at the receiver input (generator A).

(f) The measurement shall be repeated at each frequency within the frequency range 100 kHz to 4 GHz at which it is anticipated that a spurious response could occur.

3.5.3. *Limit*

At any frequency separated from the nominal frequency of the receiver by an amount exceeding one channel separation, the spurious response rejection shall be greater than 60 dB.

3.6. **Intermodulation Response**

3.6.1. *Definition*

The intermodulation response 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 two or more unwanted signals wich a specific frequency relationship to the wanted signal frequency.

3.6.2. *Method of measurement*

(a) Three signal generators A, B and C shall be applied to the receiver via a combining network (see also Clause 1.2.3.). Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal (M1) (Clause 1.3.4.).

Signal generator B shall be modulated and shall be adjusted to a frequency separated by four times the channel separation above (or below) the nominal frequency. Signal generator C shall be modulated by the normal test signal (M2) (Clause 1.3.4.) and shall be adjusted to a frequency separated by eight times the channel separation above (or below) the nominal frequency.

(b) Initially signal generator B and C shall be switched off and using signal generator A the maximum usable sensitivity (data) shall be established in this test set-up, according to Clause 3.1.2. The output level of generator A shall then be adjusted to a level which is equivalent to the level of the limit for the maximum usable sensitivity (data) plus 3 dB. This level is noted.

(c) Signal generator B and C (providing the unwanted signals) shall then be switched on. The output levels of the two signal generators shall be kept equal and adjusted to a value such that a bit error rate of about 10^{-1} is obtained.

(d) The wanted test signal (signal generator A) shall be transmitted whilst observing the bit error rate. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error rate of 10^{-2} is obtained. The level of the input signals shall then be recorded.

(e) The intermodulation response is expressed as the value in dB of the input levels of the two signal generators B and C obtained in paragraph d) above, to the level of the wanted signal (generator A).

(f) The measurement shall be repeated with the frequencies of the unwanted signals of the other side of the wanted input signal.

3.6.3. *Limits*

The intermodulation response shall be not less than 55 dB.

3.7. **Blocking or Desensitisation**

3.7.1. *Definition*

Blocking is a measure for the ability of the receiver to receive a modulated wanted input signal in the presence of an unwanted input signal on frequencies other than those of the spurious responses or the adjacent channels, without these unwanted input signals causing a degradation of the performance of the receiver beyond a specified limit.

3.7.2. *Method of measurement*

(a) Two signal generators A and B shall be connected to the receiver via a combining network (see Clause 1.3.2.). Signal Generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M1 (see Clause 1.3.4.). Signal generator A provides the wanted signal.
Signal generator B provides the unwanted signal.
The amplitude (e.m.f.) of the wanted signal shall be adjusted to the level corresponding to the limit for the maximum usable sensitivity (data) plus 3 dB. This level is noted.

(b) The unwanted signal shall be unmodulated and the frequency shall be varied between +1 MHz and +10 MHz, also between −1 MHz and −10 MHz relative to the nominal frequency of the receiver. At any frequency in the specified range, other than those at which a spurious response could occur (see Clause 3.6.) the level of the unwanted signal shall be to a value such that a bit error rate of about 10^{-1} is obtained.

(c) The normal test signal from generator A shall then be transmitted whilst observing the bit error rate. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error rate of 10^{-2} is obtained. The level of the input signal shall then be recorded.

(d) The blocking level is expressed as the ratio in dB of the levels of the unwanted signal to the wanted signal at the receiver input.

3.7.3. *Limit*

The blocking level response shall be not less than 80 dB except at frequencies on which spurious responses are found (Clause 3.5.).

3.8. **Spurious Emissions**

3.8.1. *Definition*

Spurious emissions from the receiver are emissions at any frequency, radiated by the equipment and its antenna.

The level of spurious emissions shall be measured by:

(a) their power level in a transmission line or antenna and,
(b) their effective radiated power when radiated by the cabinet and structure of the equipment;
(b) is also known as "cabinet radiation".

3.8.2. *Method of measuring the power level*

Spurious emissions shall be measured as the power level of any discrete signal at the input terminals of the receiver. The receiver input terminals are connected to a spectrum analyser or selective voltmeter having an input impedance of 50 ohms and the receiver is switched on.

If the detecting device is not calibrated in terms of power input, the level of any detected components shall be determined by a substitution method using a signal generator.

The measurements shall extend over a frequency range of 9 kHz to 12.5 GHz.

3.8.3. *Method of measuring the effective radiated power*

On a test site, fulfilling the requirements of Clause 1.4. the sample shall be placed at the specified height on the support. The receiver shall be operated from a power source via a radio frequency filter to avoid radiation from the power leads. Radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 30 MHz to 12.5 GHz.

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 determined by a substitution measurement.

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

3.8.4. *Limits*

The power of any spurious emission in the range 30 MHz to 1 GHz shall not exceed 2 nanowatts and in the range 1 GHz to 12.5 GHz shall not exceed 20 nanowatts.

The effective radiated power of any spurious emission, on any discrete frequency, at either plane of polarisation, shall not exceed 2 nanowatts in the 30 MHz to 1 GHz, and shall not exceed 20 nanowatts in the range 1 GHz to 12.5 GHz.

The effective radiated power limit for any spurious emissions in the range 9 kHz to 30 MHz is under consideration.

3.9. Receiver Opening Delay

3.9.1. *Definition*

The receiver opening delay is the time which elapses between the application of a test signal to the receiver and the establishment of the receiving condition when correctly decoded information is received.

3.9.2. *Method of measurement*

An unmodulated carrier with a level of 30 dB above the limit of maximum usable sensitivity is applied to the receiver. After 10 ms (−0, +5 ms) a relevant synchronising sequence at 16 kbit/s is used to modulate the carrier. This is immediately followed by a pseudo random bit sequence of 511 bits at 16 kbit/s.

3.9.3. *Limit*

Within the pseudo random bit sequence, the number of bit errors shall be 0 or 1.

4. ACCURACY OF MEASUREMENT

The tolerance for the measurement of the following parameters shall be as given below:

4.1.1.	DC voltage	±3%
4.1.2.	AC mains voltage	±3%
4.1.3.	AC mains frequency	±0.5%
4.2.1.	Audio frequency voltage, power, etc.	±0.5 dB
4.2.2.	Audio frequency	±1%
4.3.1.	Radio frequency	±100 Hz
4.3.2.	Radio frequency voltage	±2 dB
4.3.3.	Radio frequency field strength	±3 dB
4.3.4.	Radio frequency carrier power	±10%
4.3.5.	Radio frequency adjacent channel power	±3 dB
4.4.1.	Impedance of artificial loads, combining units, cables, plugs, attenuators, etc.	±5%
4.4.2.	Source impedance of generators and input impedance of measuring receivers	±10%
4.4.3.	Attenuation by attenuators	±0.5 dB
4.5.1.	Temperature	±1.0°C
4.5.2.	Humidity	±5%

Appendix 1

CALCULATION OF FIRST OPERATING CHANNEL

In order to minimize scanning time when looking for a free channel each station commences sequential scanning from a randomly selected channel. To obtain a pseudo-random distribution the first scanning channel for an individual radio is determined by taking the 7 least significant bits of the first cyclic redundancy check word and converting to a channel number between 3 and 77 according to the following algorithm.

For n = 0 to 127 (n is the value of the 7 least significant bits of 1st address word CRC), the channel number is calculated by:

Channel number = (remainder of n divided by 75) + 3

For example:

i) CRC gives decimal value of 10
10 divided by 75 gives a remainder of 10
therefore channel 13 is selected.

ii) CRC gives decimal value of 105
105 divided by 75 gives a remainder of 30
therefore channel 33 is selected.

iii) CRC gives decimal value of 0
0 divided by 75 gives a remainder of 0
therefore channel 3 is selected.

iv) CRC gives decimal value of 74
74 divided by 75 gives a remainder of 74
therefore channel 77 is selected.

v) CRC gives decimal value of 75
75 divided by 75 gives a remainder of 0
therefore channel 3 is selected.

vi) CRC gives decimal value of 123
123 divided by 75 gives a remainder of 48
therefore channel 51 is selected.

In the event of a retry of a failed call to the same station, scanning will commence at the previously chosen traffic channel plus one.

Appendix 2

ATTRIBUTION OF NUMBERS AND ABBREVIATIONS OF COUNTRIES

In this Appendix, the country numbers and the country abbreviations are given for the different CEPT countries.

The country number is the BCD coded number which is transmitted as the country code in the selective signalling code to indicate the country which has issued the licence or has authorized the use of the equipment.

The abbreviations specified below shall be used as characters in the CEPT-approval mark. The characters shall be preceded by the indication CEPT-SRR.

Country	Country Code	Symbols
Germany (Fed. Rep. of)	01	D
Austria	02	A
Belgium	03	B
Cyprus	04	CY
Denmark	05	DK
Spain	06	E
Finland	07	SF
France	08	F
Greece	09	GR
Ireland	10	IRL
Iceland	11	IS
Italy	12	I
Liechtenstein	13	FL
Luxembourg	14	L
Malta	15	M
Monaco	16	MC
Norway	17	N
Netherlands	18	NL
Portugal	19	P
United Kingdom	20	GB
San Marino	21	RSM
Sweden	22	S
Switzerland	23	CH
Turkey	24	TR
Vatican (City)	25	SCV
Yugoslavia	26	YU

Note. Sequence from French alphabetic order.

Appendix 3

CONTROL CHANNEL ACCESS AND RETRIES

The procedure for initiating an individual call is described under PRINCIPLES OF OPERATION.

If no acknowledgement code word is received from the called station within 200 ms of the end of the selective signalling code transmission, the following retry procedure is implemented automatically:

(a) The calling station randomly generates a number between 0 and 5 and retransmits at a time equivalent to the generated number multiplied by 200 ms, i.e. immediately if the number is zero or after 1 second if the number is five. However, the conditions of initial access must be adhered to in that the channel must be monitored as above. If a signal is present which would inhibit transmission at the given time then the retry shall take place, when the channel is available.

(b) If no acknowledgement is received (within 200 ms) then on the third and last try the calling station generates a random number between 0 and 10 and repeats the procedure under (a) above.

If the three attemps are unsuccessful on the first control channel then the above procedure is repeated on the second control channel. If there is still no acknowledgement then the calling station reverts to the standby mode on the first control channel.

Appendix 4

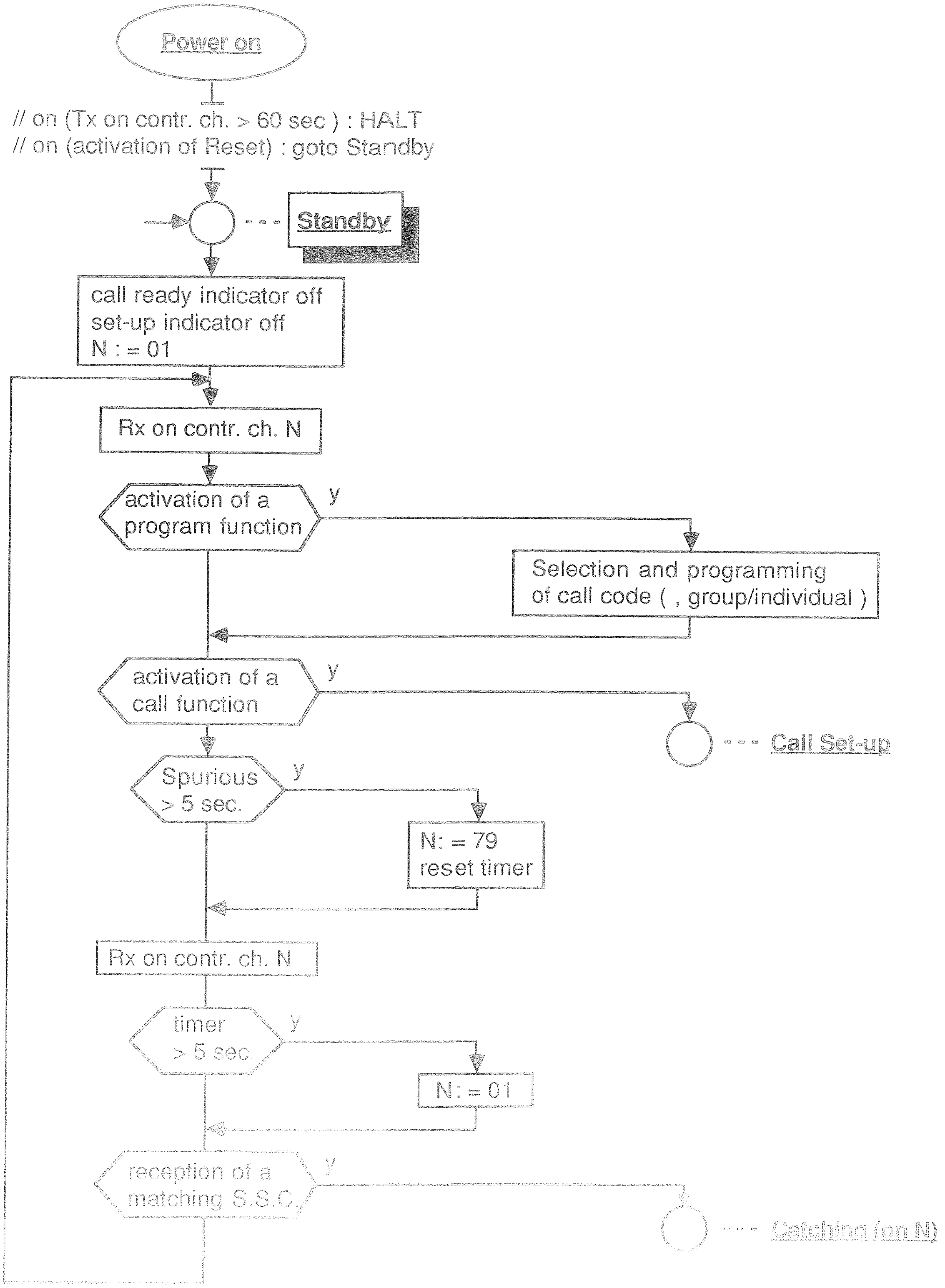
CALCULATION OF CHANNEL NUMBER

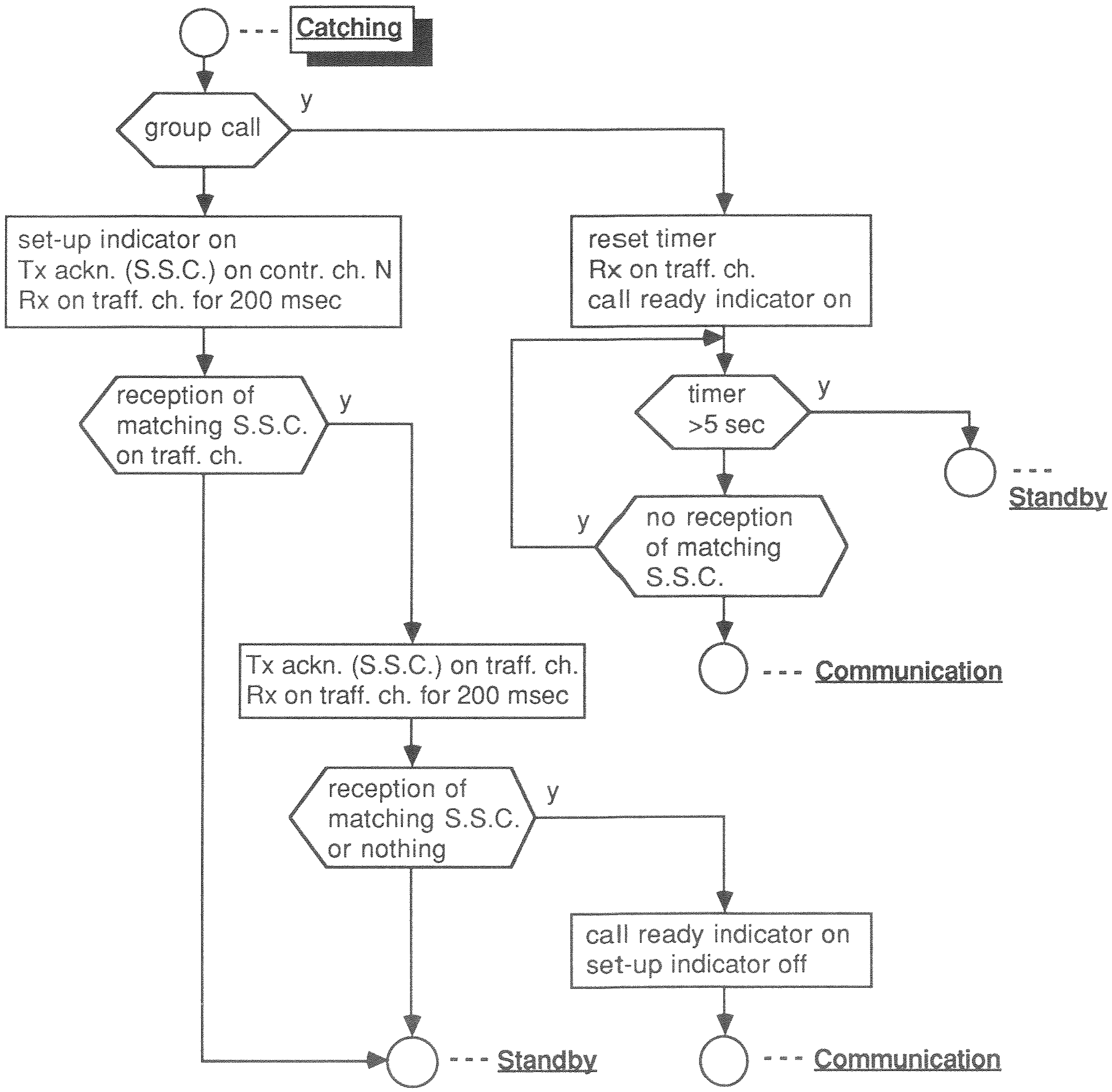
The channel code shall be the binary number converted from the number N which is calculated by the folowing equation:

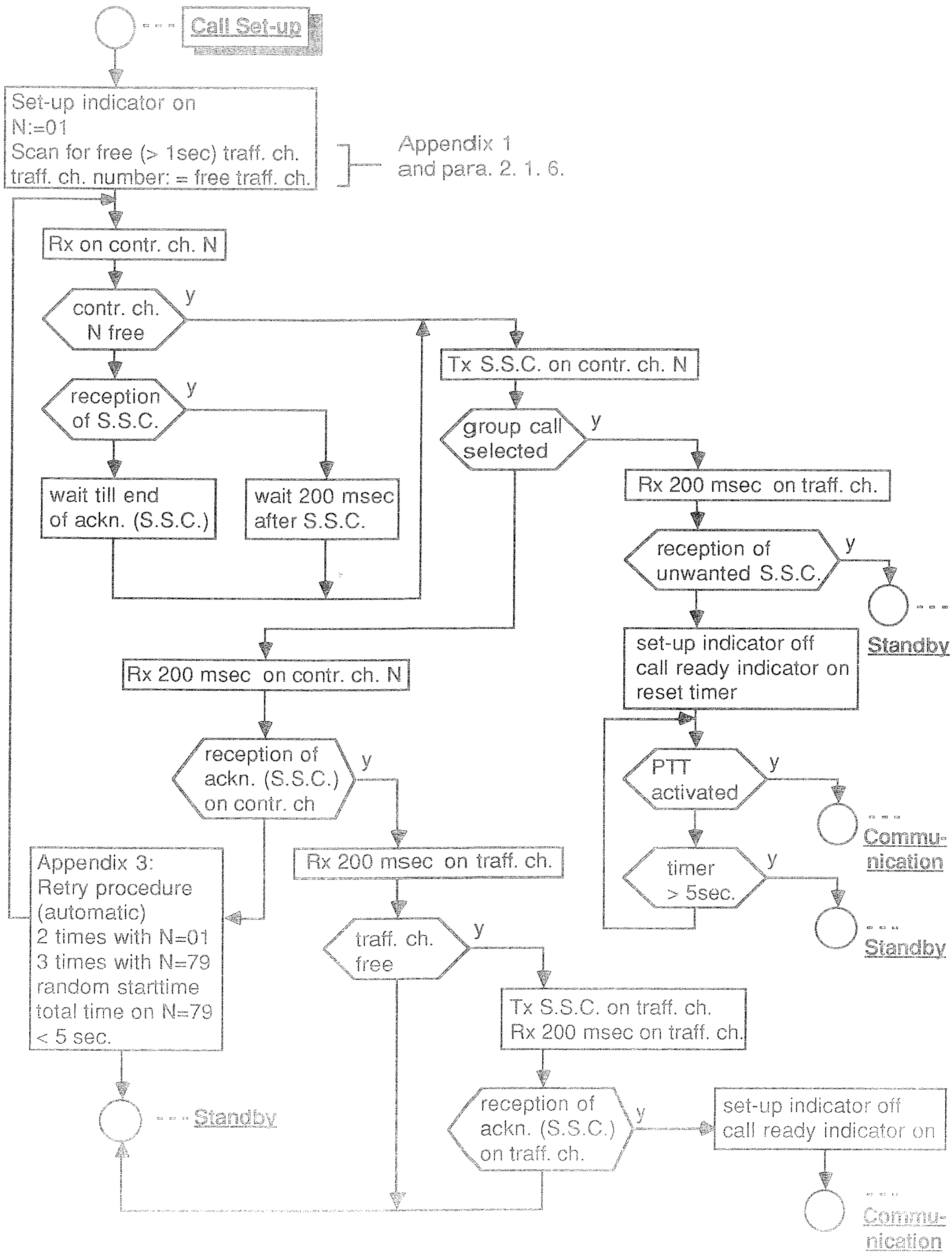
$$N = \frac{\text{Frequency of the transmitting working channel (MHz)} - 933.000}{0.025}$$

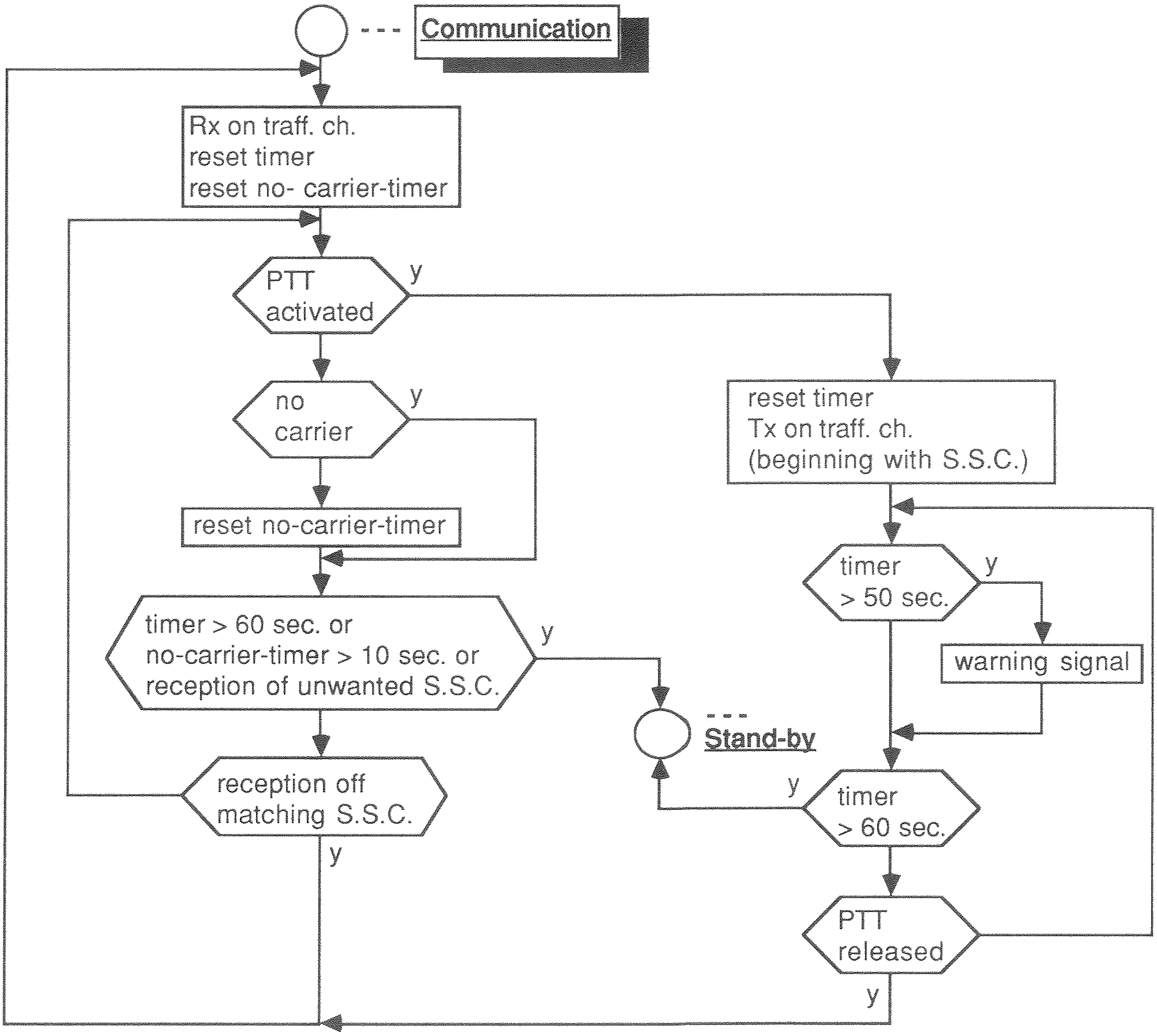
Appendix 5

FLOW DIAGRAM SINGLE FREQUENCY WORKING




Catching
group call
y
set-up indicator on
Tx ackn. (S.S.C.) on contr. ch. N
Rx on traff. ch. for 200 msec
reset timer
Rx on traff. ch.
call ready indicator on
reception of
matching S.S.C.
on traff. ch.
y
timer
>5 sec
y
Standby
y
no reception
of matching
S.S.C.
Communication
Tx ackn. (S.S.C.) on traff. ch.
Rx on traff. ch. for 200 msec
reception of
matching S.S.C.
or nothing
y
call ready indicator on
set-up indicator off
Standby
Communication


Call Set-up
Set-up indicator on
N:=01
Scan for free (> 1sec) traff. ch.
traff. ch. number: = free traff. ch.
Appendix 1
and para. 2. 1. 6.
Rx on contr. ch. N
contr. ch. N free
y
reception of S.S.C.
y
wait till end of ackn. (S.S.C.)
wait 200 msec after S.S.C.
Tx S.S.C. on contr. ch. N
group call selected
y
Rx 200 msec on traff. ch.
reception of unwanted S.S.C.
y
Standby
set-up indicator off
call ready indicator on
reset timer
PTT activated
y
Commu-nication
timer > 5sec.
y
Standby
Rx 200 msec on contr. ch. N
reception of ackn. (S.S.C.) on contr. ch
y
Appendix 3:
Retry procedure
(automatic)
2 times with N=01
3 times with N=79
random starttime
total time on N=79
< 5 sec.
Rx 200 msec on traff. ch.
traff. ch. free
y
Tx S.S.C. on traff. ch.
Rx 200 msec on traff. ch.
reception of ackn. (S.S.C.) on traff. ch.
y
set-up indicator off
call ready indicator on
Commu-nication
Standby

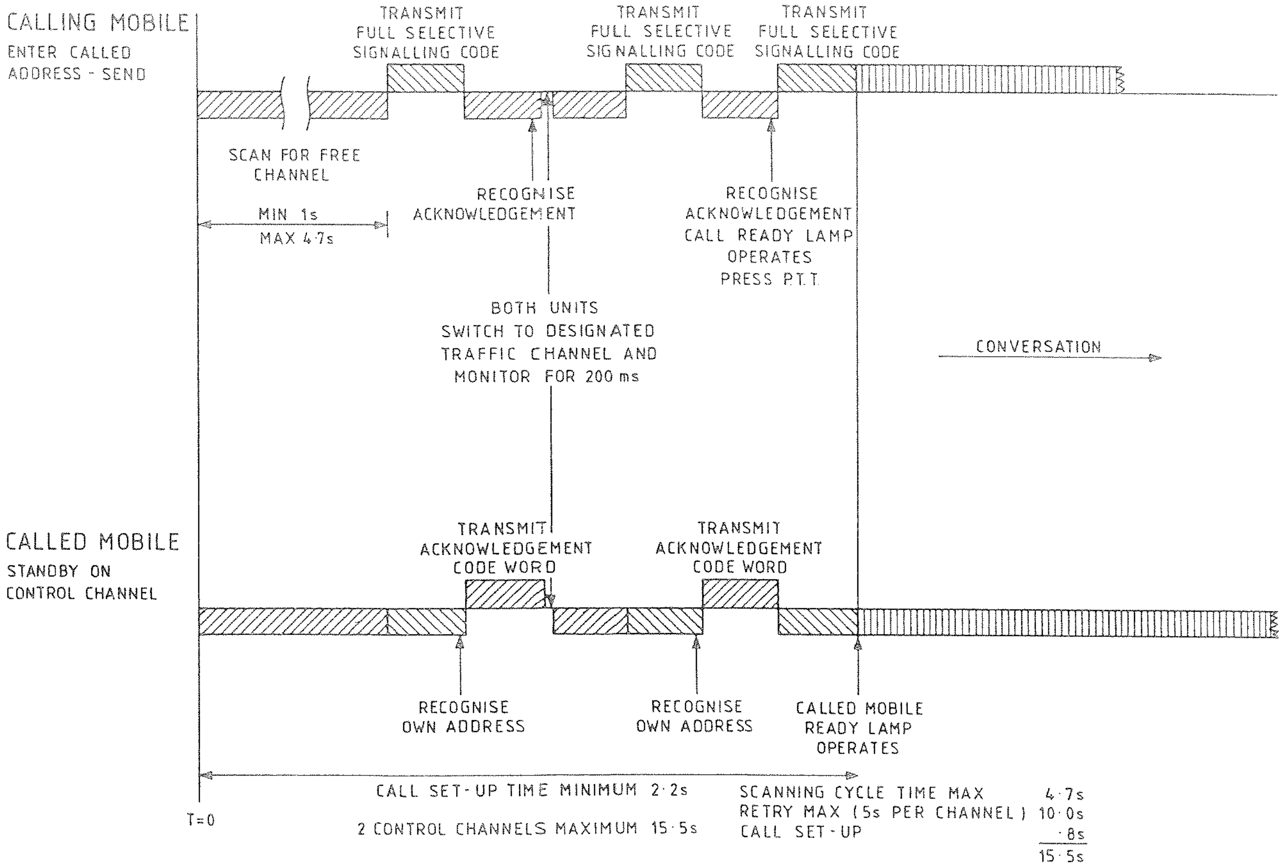


Abbr.:

Tx	transmitting
Rx	receiving
S.S.C.	selective signalling code
matching S.S.C.	S.S.C. of which the call code and the licence code and the command code correspond with programmed codes
ackn.	acknowledged
contr. ch.	control channel
traff. ch.	traffic channel
timer	ever running counter
PTT	Press-to-Transmit switch

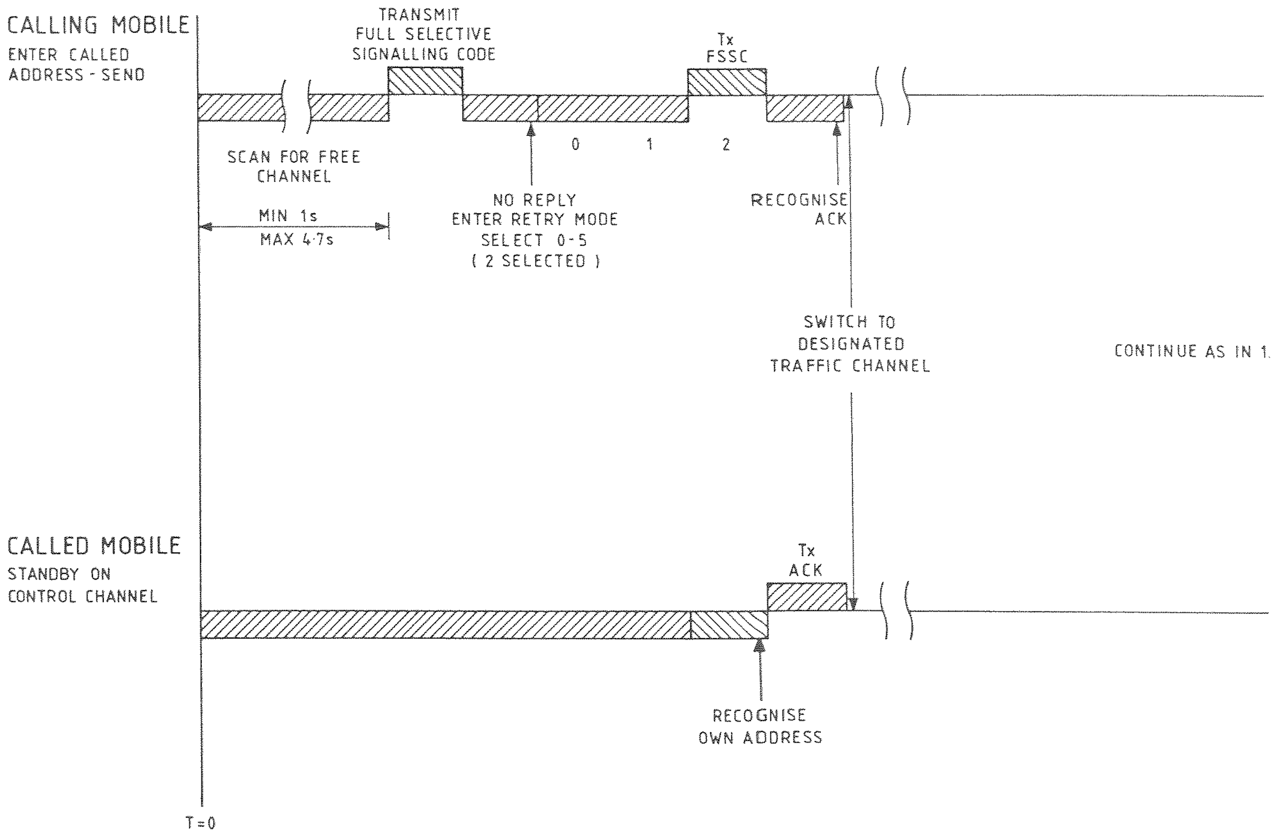
CALL SET-UP TIMING (SINGLE FREQUENCY SIMPLEX MODE)

1. NORMAL CALL—FIRST TIME ACCESS ON ONE CONTROL CHANNEL



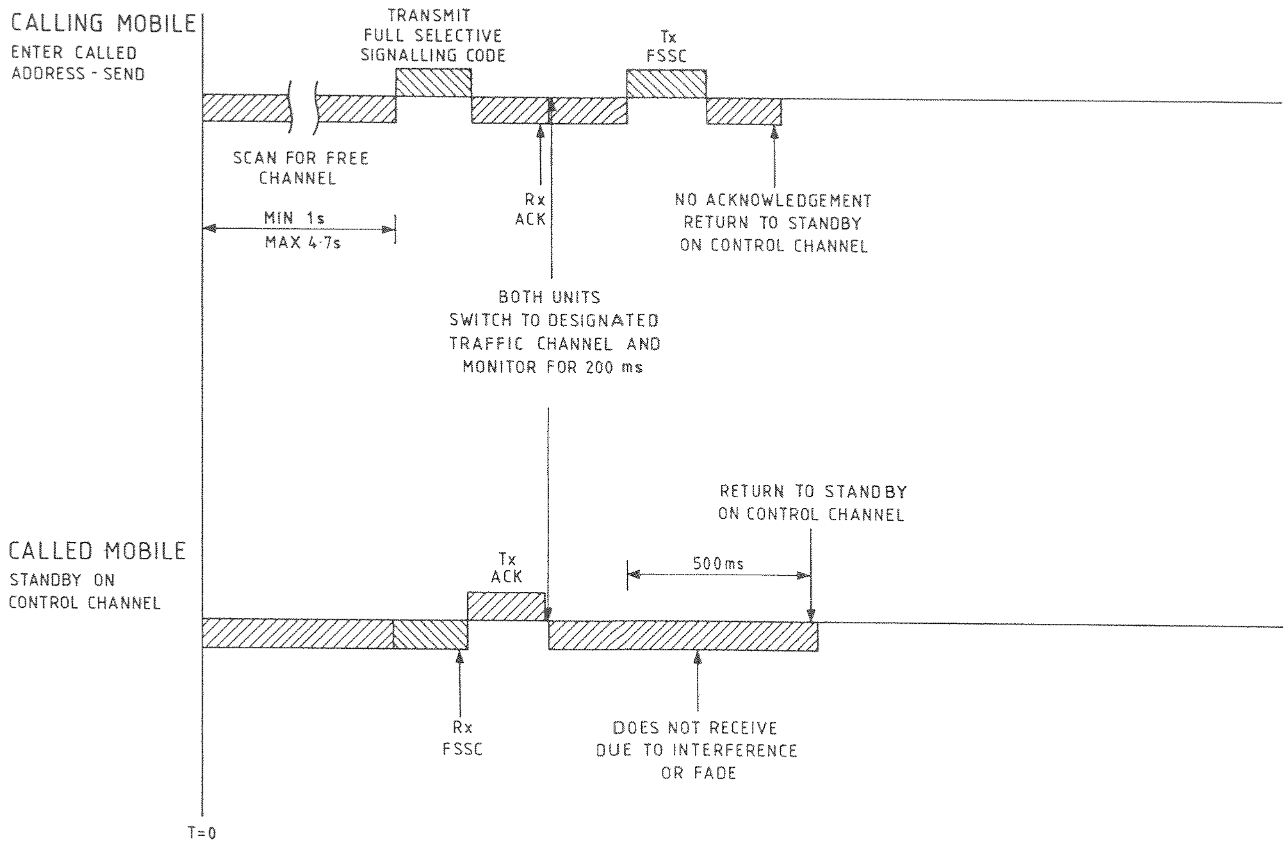
CALL SET-UP TIMING (SINGLE FREQUENCY SIMPLEX MODE)

2. NORMAL CALL—WITH ONE RETRY



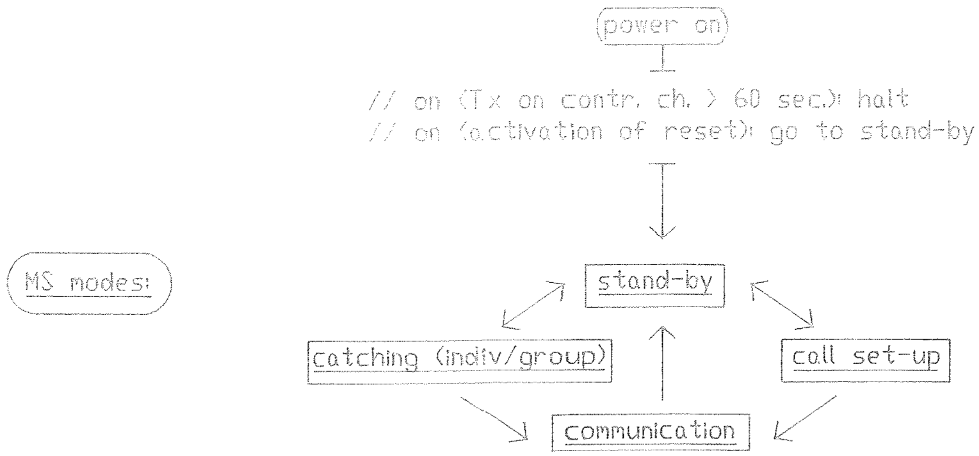
CALL SET-UP TIMING (SINGLE FREQUENCY SIMPLEX MODE)

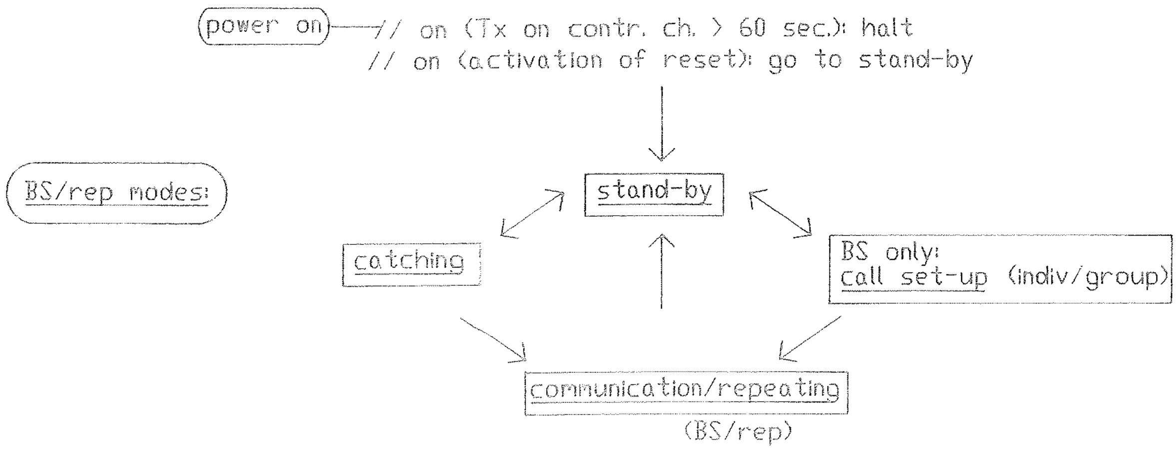
3. NORMAL CALL—FAILURE ON THE TRAFFIC CHANNEL



Appendix 6

FLOW DIAGRAMS TWO FREQUENCY WORKING

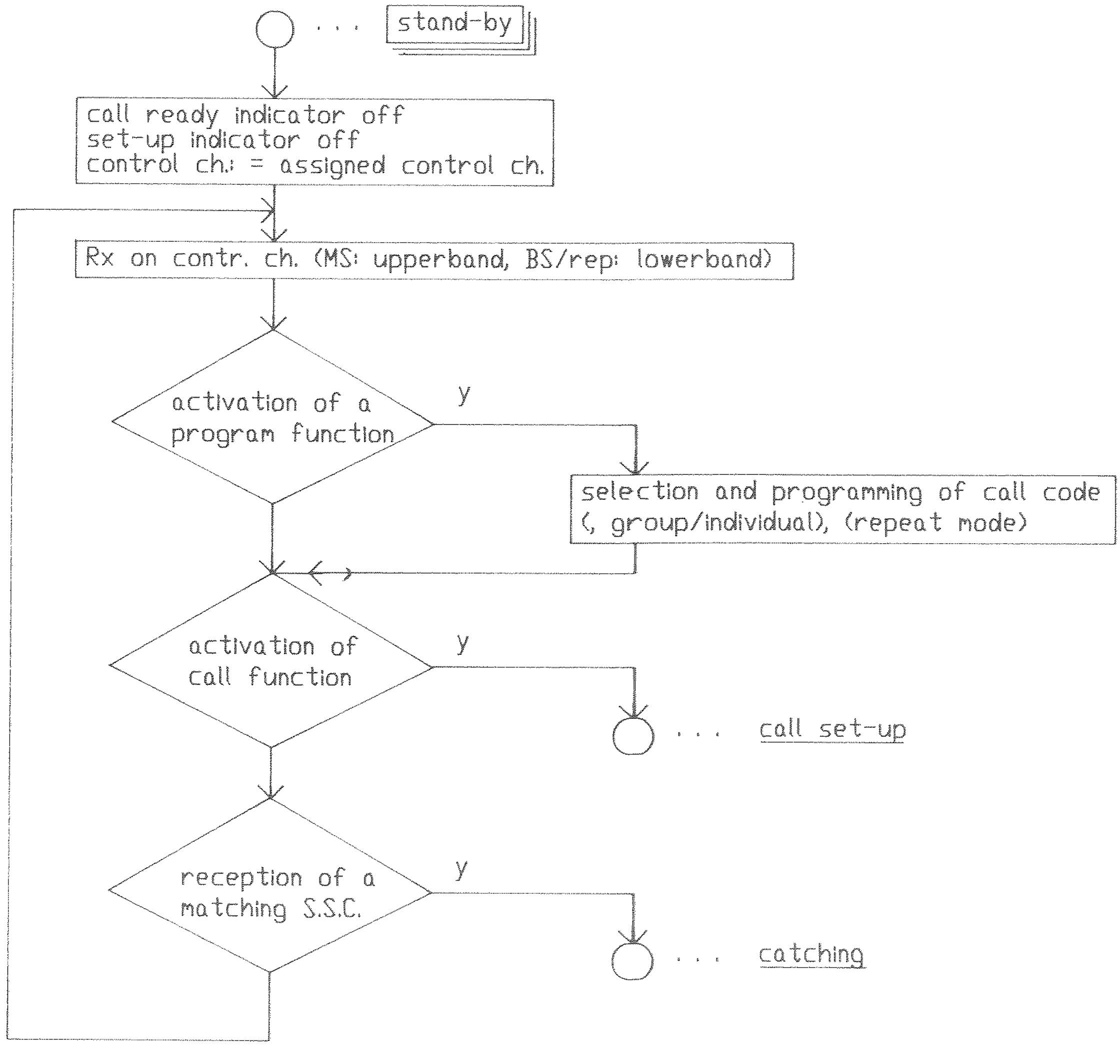


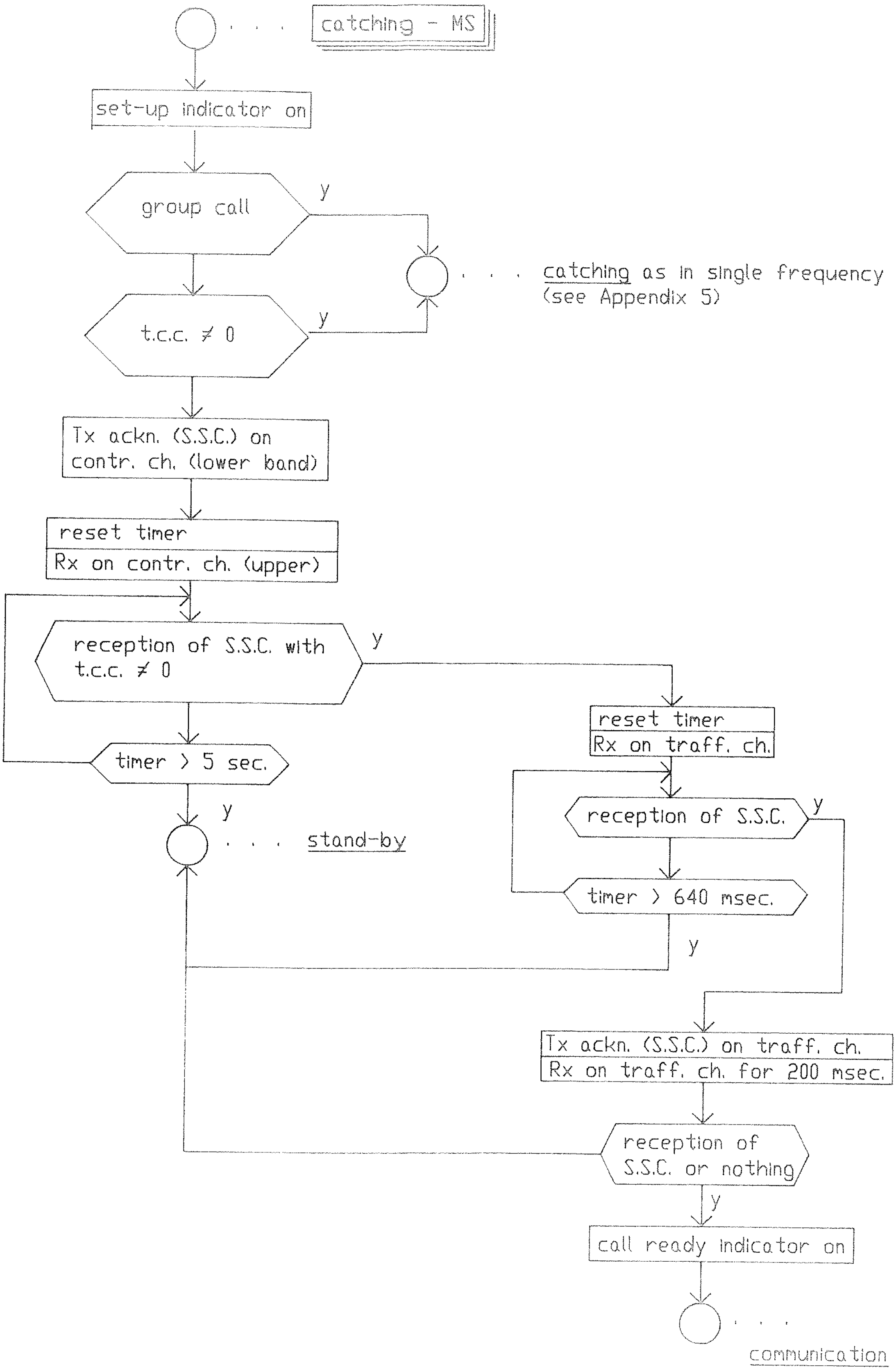


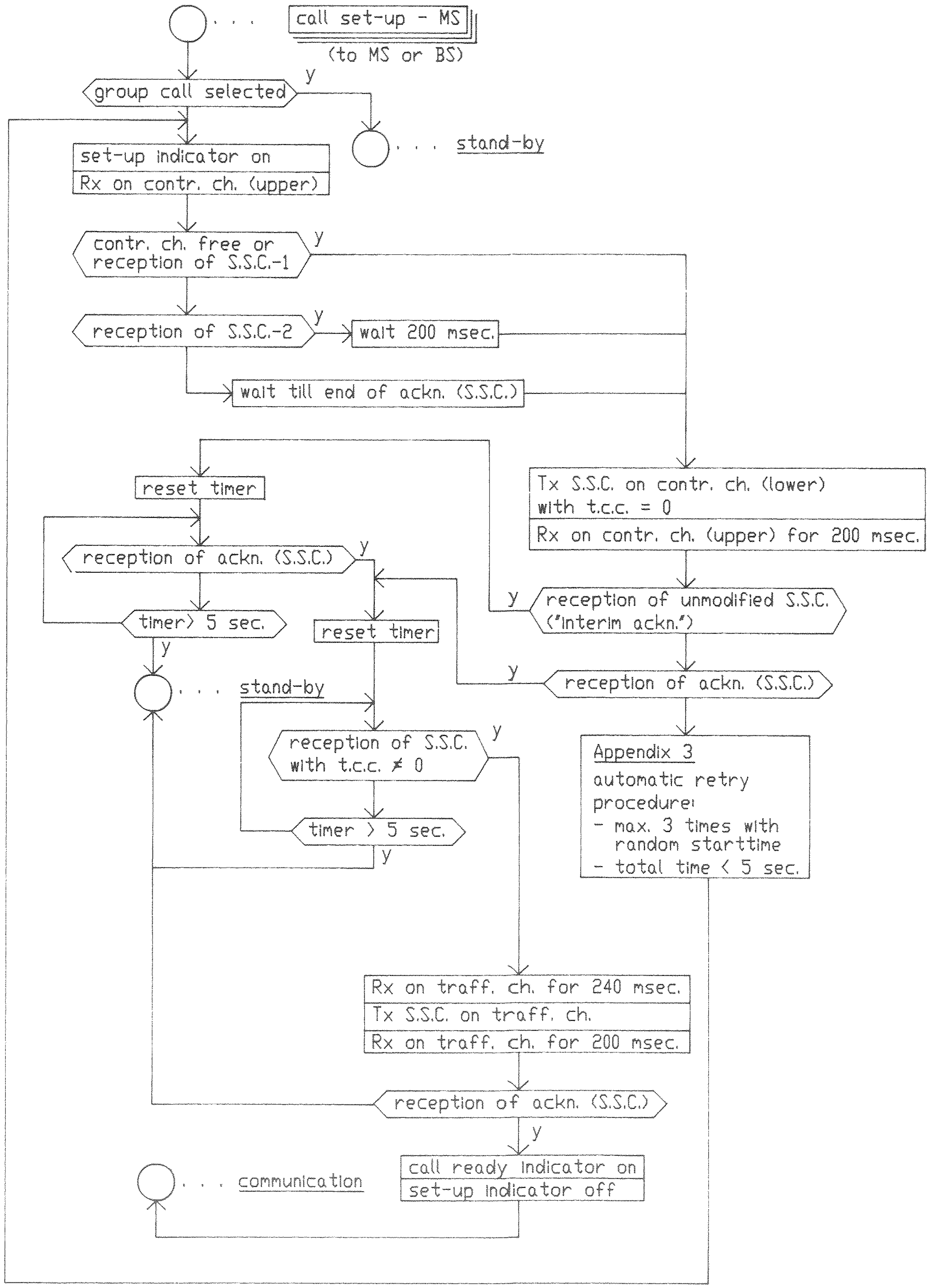
Abbr.:

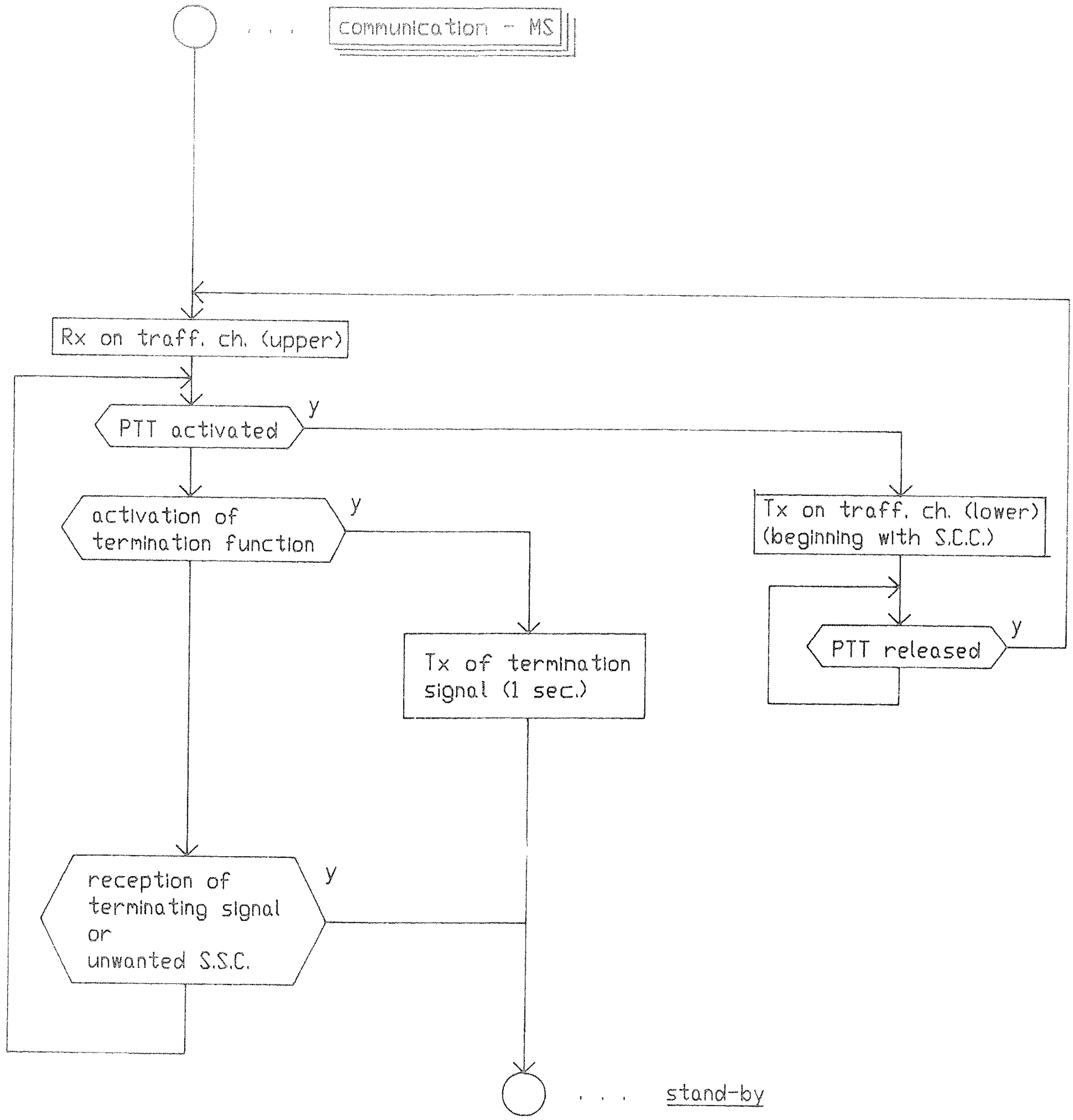
MS	mobile station
BS rep	base station repeater
Tx	transmitting
Rx	receiving
S.S.C.	selective signalling code
matching S.S.C.	S.S.C. of which the call code and the licence code and the command code correspond with programmed codes (in repeatmode only the licence code and the command code are checked)
ackn.	acknowledged
S.S.C.-f 2	S.S.C. of which the command code indicates single two frequency working
t.c.c.	traffic channel code (part of S.S.C.)
contr. ch.	control channel
traff. ch.	traffic channel
timer	ever running counter
PTT	Press-to-Transmit switch

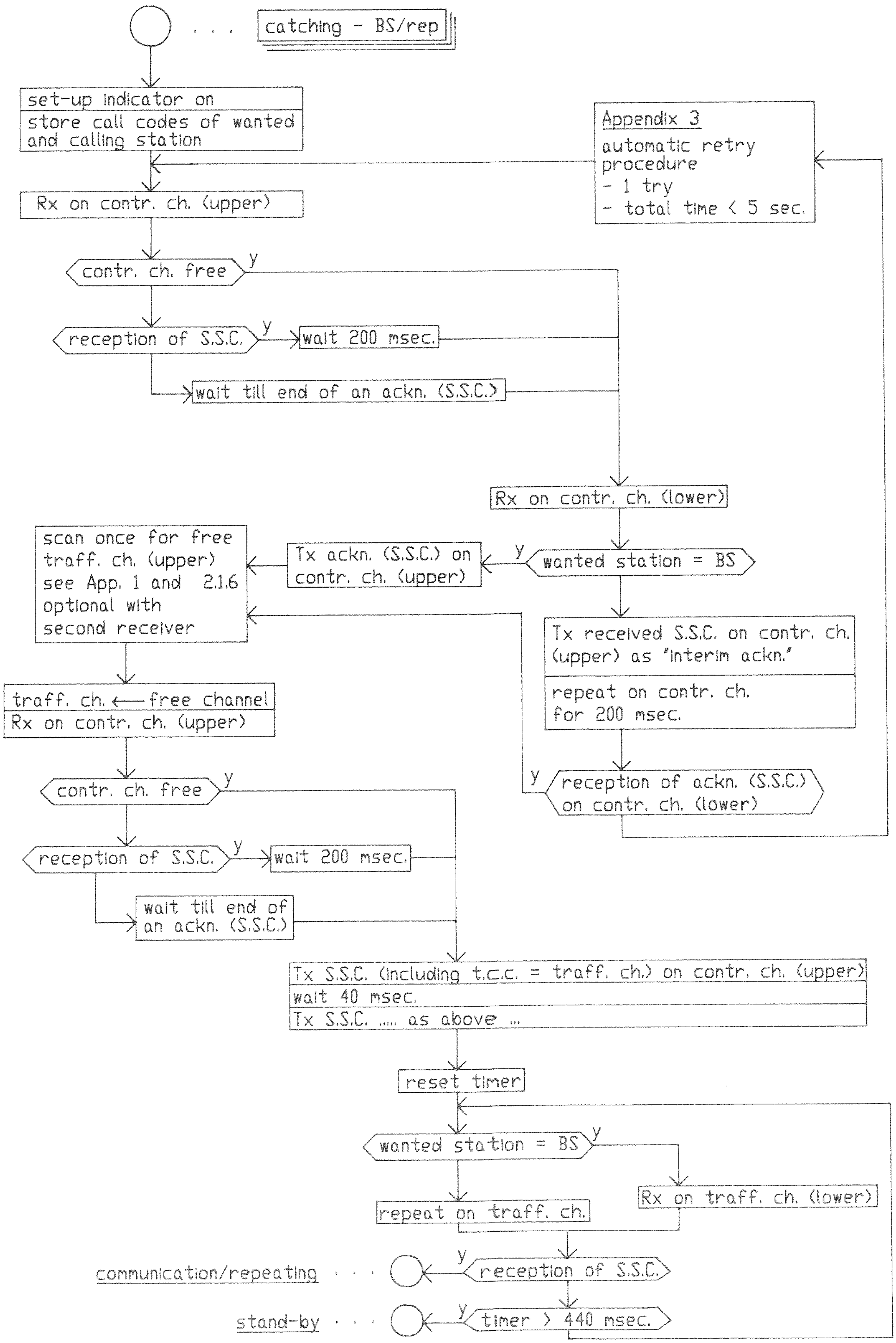
MS and BS/rep

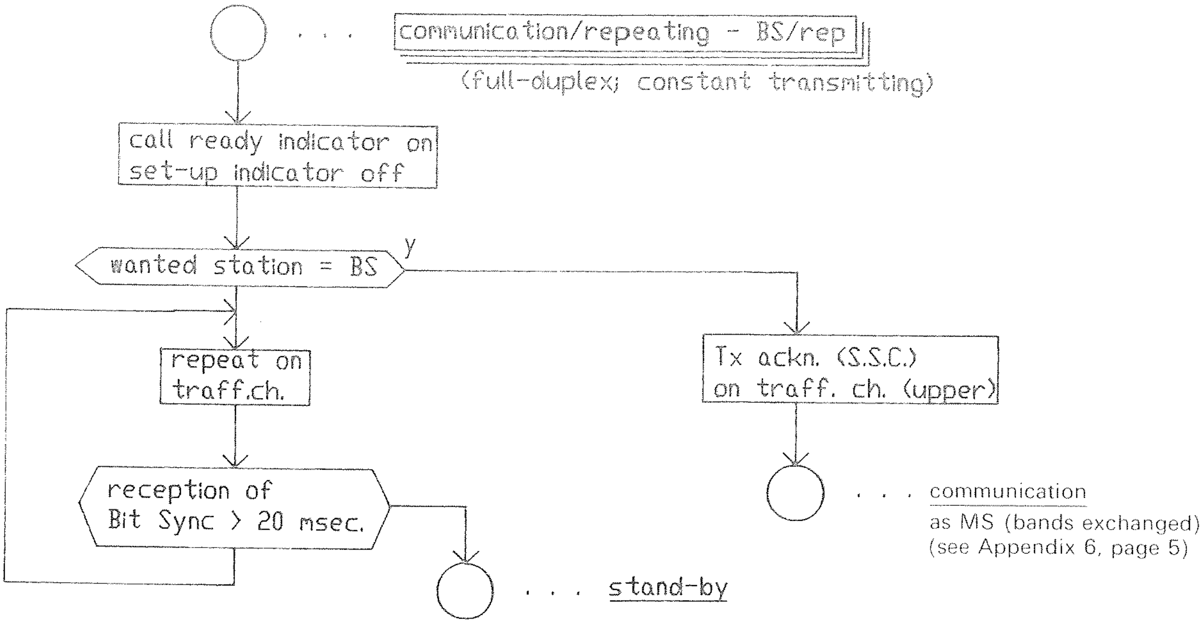

stand-by
call ready indicator off
set-up indicator off
control ch.: = assigned control ch.
Rx on contr. ch. (MS: upperband, BS/rep: lowerband)
activation of a program function
y
selection and programming of call code (, group/individual), (repeat mode)
activation of call function
y
call set-up
reception of a matching S.S.C.
y
catching

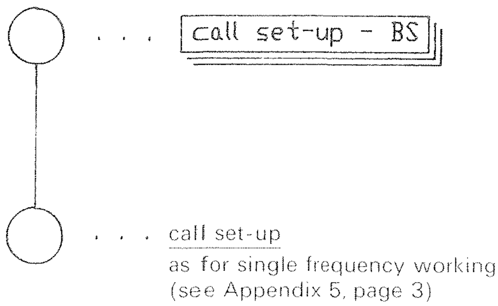

catching - MS
set-up indicator on
group call
y
catching as in single frequency
(see Appendix 5)
t.c.c. ≠ 0
y
Tx ackn. (S.S.C.) on
contr. ch. (lower band)
reset timer
Rx on contr. ch. (upper)
reception of S.S.C. with
t.c.c. ≠ 0
y
reset timer
Rx on traff. ch.
timer > 5 sec.
y
stand-by
reception of S.S.C.
y
timer > 640 msec.
y
Tx ackn. (S.S.C.) on traff. ch.
Rx on traff. ch. for 200 msec.
reception of
S.S.C. or nothing
y
call ready indicator on
communication


call set-up - MS
(to MS or BS)
group call selected
y
stand-by
set-up indicator on
Rx on contr. ch. (upper)
contr. ch. free or reception of S.S.C.-1
y
reception of S.S.C.-2
y
wait 200 msec.
wait till end of ackn. (S.S.C.)
reset timer
Tx S.S.C. on contr. ch. (lower) with t.c.c. = 0
Rx on contr. ch. (upper) for 200 msec.
reception of ackn. (S.S.C.)
y
y
reception of unmodified S.S.C. ("interim ackn.")
timer> 5 sec.
reset timer
y
y
reception of ackn. (S.S.C.)
stand-by
reception of S.S.C. with t.c.c. ≠ 0
y
Appendix 3
automatic retry procedure:
- max. 3 times with random starttime
- total time < 5 sec.
timer > 5 sec.
y
Rx on traff. ch. for 240 msec.
Tx S.S.C. on traff. ch.
Rx on traff. ch. for 200 msec.
reception of ackn. (S.S.C.)
y
call ready indicator on
set-up indicator off
communication


communication - MS
Rx on traff. ch. (upper)
PTT activated
y
activation of
termination function
y
Tx on traff. ch. (lower)
(beginning with S.C.C.)
PTT released
y
Tx of termination
signal (1 sec.)
reception of
terminating signal
or
unwanted S.S.C.
y
stand-by

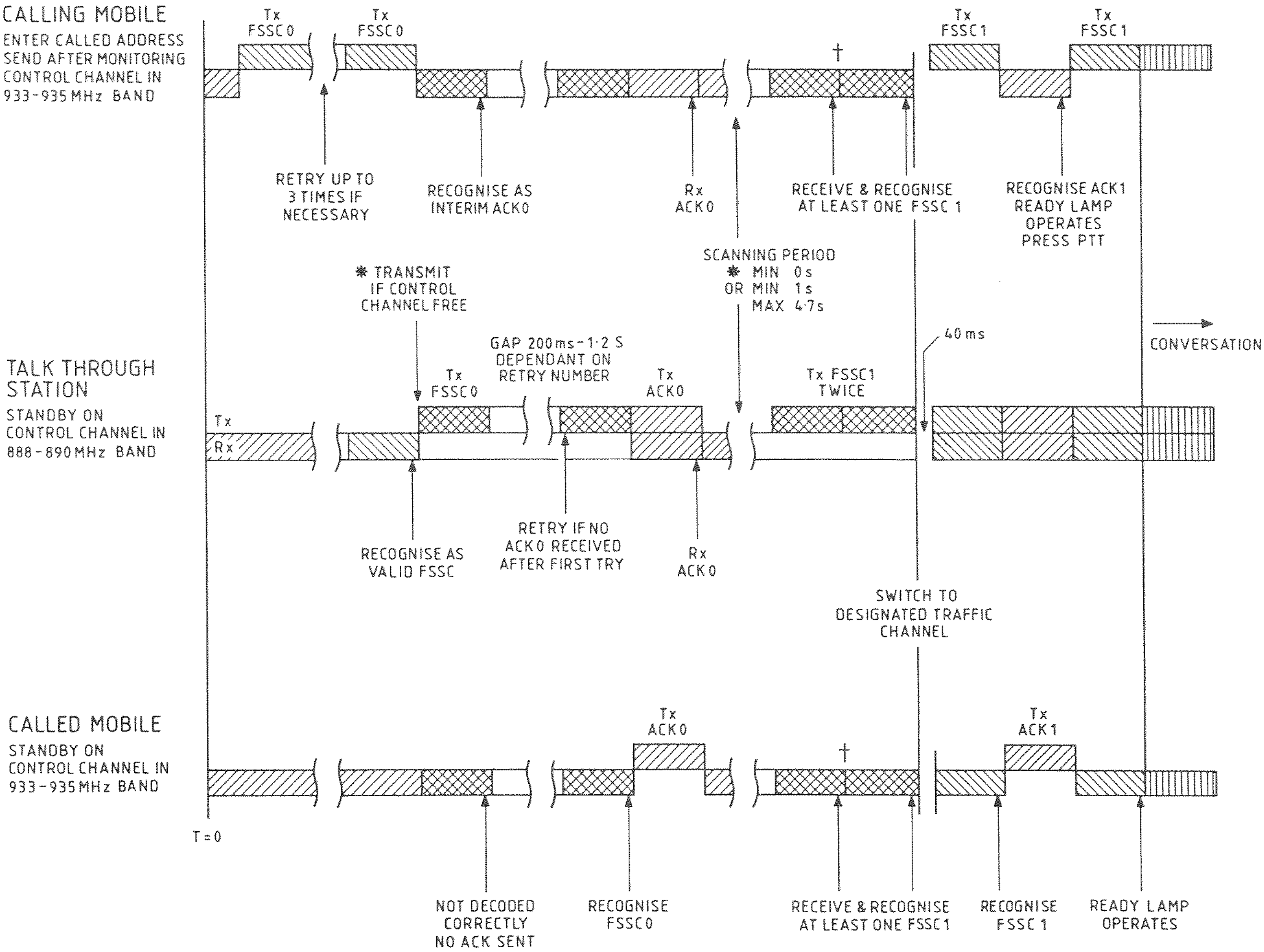

catching - BS/rep
set-up indicator on
store call codes of wanted and calling station
Appendix 3
automatic retry procedure
- 1 try
- total time < 5 sec.
Rx on contr. ch. (upper)
contr. ch. free
y
reception of S.S.C.
y
wait 200 msec.
wait till end of an ackn. (S.S.C.)
Rx on contr. ch. (lower)
scan once for free traff. ch. (upper) see App. 1 and 2.1.6 optional with second receiver
Tx ackn. (S.S.C.) on contr. ch. (upper)
y
wanted station = BS
Tx received S.S.C. on contr. ch. (upper) as "interim ackn."
repeat on contr. ch. for 200 msec.
y
reception of ackn. (S.S.C.) on contr. ch. (lower)
traff. ch. ← free channel
Rx on contr. ch. (upper)
contr. ch. free
y
reception of S.S.C.
y
wait 200 msec.
wait till end of an ackn. (S.S.C.)
Tx S.S.C. (including t.c.c. = traff. ch.) on contr. ch. (upper)
wait 40 msec.
Tx S.S.C. ..... as above ...
reset timer
wanted station = BS
y
Rx on traff. ch. (lower)
repeat on traff. ch.
communication/repeating
y
reception of S.S.C.
stand-by
y
timer > 440 msec.


communication/repeating - BS/rep
(full-duplex; constant transmitting)
call ready indicator on
set-up indicator off
wanted station = BS
y
repeat on
traff.ch.
Tx ackn. (S.S.C.)
on traff. ch. (upper)
reception of
Bit Sync > 20 msec.
communication
as MS (bands exchanged)
(see Appendix 6, page 5)
stand-by


call set-up - BS
call set-up
as for single frequency working
(see Appendix 5, page 3)

CALL SET-UP TIMING (SINGLE FREQUENCY SEMI SIMPLEX MODE)

4. MOBILE TO MOBILE THROUGH A REPEATER



FSSC0	FULL SELECTIVE SIGNALLING CODE WITH THE CHANNEL NUMBER SET TO ALL ZERO'S.
FSSC1	FULL SELECTIVE SIGNALLING CODE WITH THE CHANNEL NUMBER SET TO THE DESIGNATED CHANNEL.
ACK0	FULL SELECTIVE SIGNALLING CODE WITH THE ACKNOWLEDGEMENT BIT SET TO ZERO AND THE CHANNEL NUMBER SET TO ALL ZERO'S.
ACK1	FULL SELECTIVE SIGNALLING CODE WITH THE ACKNOWLEDGEMENT BIT SET TO ZERO AND THE CHANNEL NUMBER SET TO THE DESIGNATED CHANNEL.

✱ IF A SECOND RECEIVER IS INSTALLED AT THE REPEATER STATION WHICH MONITORS THE FREQUENCY BAND 933-935 MHz, THE CONTROL CHANNEL MAY BE CHECKED FOR OTHER TRANSMISSIONS WITHOUT THE DELAY OF CHANGING RECEIVER BANDS.

SIMILARLY A MEMORY OF CURRENTLY AVAILABLE FREE TRAFFIC CHANNELS MAY BE KEPT, REMOVING THE NEED FOR A SCANNING PERIOD.

† IF ONLY ONE OF THE GO TO CHANNEL FSSC1 IS RECEIVED BY EITHER MOBILE THEN IT SHALL ALWAYS BE REGARDED AS THE FIRST OF THE TWO FSSC'S.

THE TIMINGS IN PARAGRAPHS 2.2.3.1. AND 2.2.4.1. ALLOW FOR THIS.