Title: Private Personal Handy-Phone System : Personal Handy-Phone Systems (PHS) and Global System for Mobile Communications (GSM) Dual Mode Terminal

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<td>July 31, 1998</td>
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Private Personal Handy-Phone System:
Personal Handy-Phone System (PHS) and Global System for Mobile communications (GSM)
Dual Mode Terminal

- Minimum Set Specification -

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Foreword

The purpose of this document is to specify the minimum common technical requirements of the dual mode terminal (combined Personal Handy-phone System/Global System for Mobile communications (PHS/GSM) ) and to consider the related engineering requirements and issues to implement the PHS/GSM dual mode services.

This document is also prepared intending that the combined PHS and GSM dual mode terminals which will be used in integrated service environment for fixed network and mobile network such as PHS home/office cordless services and GSM mobile services with one combined terminal. For an example, a dual mode terminal can be used as a GSM in an outdoor environment and as a home-cordless telephone in home. The automatic connection of calls on the GSM number to the home/office-cordless telephone will be implemented through the additional function (follow-me service) in the PLMN.

1 Scope

This document focuses on possible early implementations and will open the first edition of the technical specification in the sense how dual mode terminals (DMTs) can be type approved using existing documents and new additional specifications. It is also covered to investigate radio and network aspects and to clarify the problems related to dual-mode terminal.

For Personal Handy-Phone System (PHS), only Private Application is considered in this specifications and Public Application will be considered in the future.

For Global System for Mobile communications (GSM), both phase 1 and phase 2 specifications shall be considered.

2 Terminal configurations

2.1 General

A DMT for PHS and GSM is a terminal with one PHS part and one GSM part that is controlled by a common Interworking part which controls one common Human Machine Interface(keypad, display and menu functions). A reference configuration for the DMT is shown in Figure 1.

Antenna installation method is not specified here ; separate antennas for PHS and GSM shall be suitable for testing purpose and country regulations but an integrated antenna installation for common use will be also suitable for user operation.
2.2 Terminal Types

Dual mode terminals are categorized basically three types of configurations denoted as types 1-3. The essential differences between these terminal types are summarized in Table 1. These terminals can only transmit on one of the air interface at the time.

Table 1 Summary of terminal types

<table>
<thead>
<tr>
<th>Terminal Types</th>
<th>Air interface Selection</th>
<th>Simultaneous Receiving *1</th>
<th>Simultaneous Dual-Mode Receiving *2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Manual</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Type 2</td>
<td>Automatic</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Type 3</td>
<td>Automatic</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*1 Simultaneous receiving: paging is available only at the active air interface, but background scanning is performed at the non-active air interface.

*2 Simultaneous dual-mode receiving: paging is available at both air interfaces.

2.2.1 Terminal Type 1

This type is the simplest type that is just combined of two terminals into single housing case.

a. Mode selection from one air interface to the other is performed by manual.

b. This type terminal operates only active communication either air interface at the same time, the other air interface is non-active communication.(It means this type does not allow to operate over PHS and GSM air interfaces at the same time.)

2.2.2 Terminal Type 2

a. The type 2 terminal monitors both air interface to determine which will give the best operation.

b. Mode selection from one air interface to the other is performed automatically by RSSI measurements.

c. For automatic mode switching, the terminal may be pre-assigned a priority air interface by the user or terminal itself.

d. If the terminal is in active communication status, any paging is not allowed at other non-active air interface.
2.2.3 Terminal Type 3

a. The type 3 terminal monitors both air interfaces simultaneously for RSSI measurements and for paging.
b. Mode selection from one air interface to the other is performed automatically.
c. Once the terminal enters into active communication at one air interface, the terminal cannot respond to paging on the other air interface.

3 Mode Selection

3.1 General

A DMT is a terminal comprising both PHS and GSM parts. The DMT is in either PHS or GSM mode. When in either mode, the DMT operates as the corresponding single mode terminal (except that it may perform background scanning) and shall fully comply with the relevant specifications for that single mode terminal (ETS 300 607 [6] for GSM, ARIB Standard RCR STD-28 [1] for PHS), unless specified in the present document.

When one mode is entered the DMT operates like a single mode terminal that is switched on. When one mode is left the DMT operates like a single mode terminal that is switched off. When the DMT switches mode, it leaves the first before entering the second, and operates as two single mode terminal where the first is switched off before the second is switched on.

Switching between the two modes is done manually by the user or automatically by the terminal. The DMT shall not switch mode when in active communication. Automatic mode switching can be executed based on background scanning or loss of coverage.

3.2 Mode selection

3.2.1 General requirements

3.2.1.1 Communication mode

A DMT equips at least the following two communication modes against both air interfaces;
a. PHS communication mode which is active status on PHS air interface
b. GSM communication mode which is active status on GSM air interface

3.2.1.2 Mode indication

A DMT indicates to the user the current mode of status which air interface is in active.

3.2.1.3 Mode selection

The DMT supports the following two mechanisms for mode selection:
a. Manual selection mechanism (applied to Type 1, Type 2 and Type 3)
b. Automatic selection mechanism (applied to Type 2 and Type 3)

Basic concept of mode selection mechanism is illustrated in Figure 2.
3.2.1.4 Manual mode selection mechanism

Manual selection mechanism support to user an opportunity to change the present mode to other mode by manual at any time when the DMT is not in active communication status.

3.2.1.5 Automatic mode selection mechanism

a. This mechanism gives a certain decision capability to switch between both air interfaces by supporting automatic monitoring function to listen for broadcasting channels and or paging channels against both air interfaces periodically or simultaneously.
b. Mode selection of Type 2 terminal from one air interface to the other is performed automatically by the result of RSSI measurements.
c. Mode selection of Type 3 terminal is performed automatically to the mode in which paging processing is activated.

3.2.1.6 Last selection mechanism at switch-on

At every switch-on, the DMT may use the last selection mechanism, as the default selection mechanism.
If the DMT had manual mode selection activated when switched-off, it will go active in the same mode when switched-on.

3.2.1.7 SIM control

a. If the DMT with no or invalid SIM inserted had automatic mode selection activated when switched-off it may go active (at switch-on) in PHS mode.
b. In PHS mode SIM access is not allowed.

3.2.1.8 Manual resurrection of mode

a. A DMT can be changed forcibly the present mode to the other mode by a user at any time as long as the DMT is not in active communication status.
b. The manual mode selection mechanism supports the mode change to switch directly to non-active mode whether the other air interface is identified or not.

3.2.1.9 Automatic change of network

For automatic switching between networks there are two different behaviors of the DMT.
a. it stays locked to the selected system until it leaves the coverage area and then starts selecting the available network with the highest priority; or
b. it could continuously scan for available networks and initiate a change of network when it finds one with higher priority than the one presently attached to.
3.2.2 Additional requirements

3.2.2.1 Automatic mode selection procedure

a. A DMT(type 2 and type 3) selects automatically GSM or PHS mode with respect to the priority air interface which has been pre-assigned by the user.

b. [For Type 2 DMT]: Three cycles are given in the automatic mode selection procedure.
   One cycle for loss of coverage, one for background scan where a priority air interface is not found, and one for change of mode by the result of the background scanning. These switching cycles between priority and non-priority modes are shown in Figure 3.
   When the automatic mode selection mechanism is activated, the DMT behaves like a single PHS or GSM phone terminal.

c. [For Type 3 DMT]: Type 3 DMT supports simultaneous dual-mode receiving. In case of originating call, Type 3 DMT selects the priority mode first, and then non-priority mode automatically.

Figure 2 Basic concept of mode selection mechanism

Figure 3 Automatic mode selection cycles in Type 2 terminal
3.2.2.2 Priority mode, non-priority mode

a. In the case of a loss of the coverage the DMT may switch to another air interface based on predetermined time control rules.

b. If a priority air interface is detected, the Type 2 DMT may switch to the priority air interface in active. The Type 2 DMT needs not execute any background scan for non-priority air interface as long as it is in the priority mode and normal service is available.

While the Type 2 DMT is in non-priority mode and normal or limited service is available, the Type 2 DMT may execute background scanning for priority air interface periodically. If the priority air interface is detected again, it may return to the mode again based on predetermined time control rules.

c. Type 3 DMT is enable to receive the paging channel of non-priority mode also while the priority air interface is set.

Note: While the DMT is in priority mode and normal or limited service is available, the DMT can be forcibly switched to non-priority mode by manual at any time if user wants to change the mode.

3.2.2.3 Background scanning

a. The purpose of the background scanning procedure is to inform the DMT about the possibility to switch to the other mode if the currently selected mode would be non-priority mode.

b. General procedures of background scanning may be considered as following steps;
   1) searching for coverage of the air interface in the non-active mode
   2) checking the stability of coverage and the switching conditions if the coverage is identified.
   3) inform checking result to the automatic mode selection mechanism.

Note 1: The background scanning is performed without leaving the current active mode.
Note 2: The function of mode changing is not part of the background scanning. Mode changing may be activated if necessary switching conditions would be satisfied at the automatic mode selection mechanism.
Note 3: A criteria of a coverage stability could be the field strength by periodic RSSI measurement of the DMT in order to save battery power. The other criteria may be given by a certain protection mechanism to prevent frequent switching operation between the two modes.

3.3 Engineering considerations

Followings are identified issues to be taken in to account for a complete DMT specification:

3.3.1 Excessive mode switching

For automatic mode switching, there is a need to prevent excessive mode switching between the two air interfaces.
This frequent switching may cause followings when moving on the border between PHS and GSM coverage.
a. degradation of serviceability of the terminal (service interruption during the mode switching)
b. excessive battery drain
c. network overload by excessive attach/detach signaling (GSM only)

Note: The excessive mode switching is occurred by background scanning due to the principle of the usage for priority coverage when possible.

To avoid the frequent mode switching, a certain control mechanism may be given into the background scan processing by manufactures.

3.3.2 Missed paging

Paging may be missed by a type 2 DMT when it is scanning the other air interface. Paging being missed by the DMT will force the networks to take actions as if the terminal is not reachable even if it is present in the coverage.

3.3.3 Handover between air interfaces

For earlier implementation of DMT, any handover function between PHS part and GSM part in a DMT is not considered in dual mode operation.

3.3.4 Call Forwarding

If a DMT is not reachable for incoming calls in one mode, call forwarding supplementary services can be activated to the other mode by the network. But this capability may be out of scope of the DMT specification.
4. Principles for type approval for DMTs

4.1 Telephony requirements

For DMTs the technical specifications related to PHS and GSM telephony requirements can always be applied independently, therefore the type approval testings are also assumed to be performed independently in the respective parts of the DMT.

The basic testing principle is as follows:

a. when operating in PHS mode, the Adaptive Differential Pulse Code Modulation (ADPCM) codec is used and the requirements of RCR TR-T2 [2] applies.
b. when operating in GSM mode TBR 9 [7] (phase 1) or TBR 20 [8] (phase 2) applies.

4.2 Spectrum protection requirements

The coexistence criteria for DMTs are presumed to be no more strict than those of PHS and GSM single mode terminal, which are already conformed by existing GSM and PHS specifications.
In this section, potential spectrum protection problems and testing issues regarding DMTs are considered.

4.2.1 Testing philosophy

It is the basic testing philosophy that each physical layer of air interface shall be tested separately according to each specifications. Some additional tests will be considered corresponding to characteristics and behavior of different types of terminals;

a. Type 1 DMT
   There is no additional spectrum protection problem over those of a single mode PHS or GSM terminal because this terminal activates only one transmitter or receiver at a time.
b. Type 2 DMT and type 3 DMT
   - As the relating configurations is the same as a type 1 terminal, the same test philosophy will apply to type 2 and type 3 terminals.
   - If the background scanning is supported in the terminal, there may be a potential of loss of spectrum efficiency in the modes. The additional testing requirements will be studied further.

4.2.2 Testing requirements

The following items are typical spurious emissions to be taken into account and detailed requirements are summarized in Table 2;

a. Emission due to modulation
b. Emission due to transmitter transient
c. Emission due to inter-modulation
d. Spurious emission when allocated a transmit channel
e. Spurious emission when not allocated a transmit channel

For type 1 DMT the relevant technical specifications can always be applied independently.
For type 2 and type 3 DMT the relevant technical specifications can be applied independently but for some modes of operation, degradation in fulfilling existing requirements have to be considered as well as new requirements for new behaviors.
<table>
<thead>
<tr>
<th>Parameters</th>
<th>PHS reference</th>
<th>GSM Phase 2 reference</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission due to modulation</td>
<td>RCR STD-28 [1], subclause 3.4.2.3</td>
<td>ETS 300 577 [5] (GSM 05.05), subclause 4.2.1.</td>
<td>The measurements are done only in the PHS frequency band, or in the GSM bands.</td>
</tr>
<tr>
<td>Emission due to transmitter transient</td>
<td>RCR STD-28[1], subclause 3.4.2.5 Carrier off leakage power (There is no properly part in PHS reference. To be check provable part.)</td>
<td>ETS 300 577 [5] (GSM 05.05), subclause 4.2.2.</td>
<td>The measurements are done only in the PHS frequency band, or in the GSM band, as in the previous requirement.</td>
</tr>
<tr>
<td>Spurious emission when allocated a transmit channel</td>
<td>RCR STD-28[1], subclause 3.4.2.6 Transmission spurious</td>
<td>ETS 300 577 [5] (GSM 05.05), subclause 4.3.3.</td>
<td></td>
</tr>
<tr>
<td>Spurious emission when not allocated a transmit channel</td>
<td>RCR STD-28[1], subclause 3.4.2.6 Conducted spurious component</td>
<td>ETS 300 577 [5] (GSM 05.05), subclause 4.3.3.</td>
<td></td>
</tr>
</tbody>
</table>
5. References

[1] ARIB Standard RCR STD-28 Personal Handy-Phone System
[4] ETS300 535: “Digital cellular telecommunications system (Phase 2); Functions related to Mobile Station (MS) in idle mode (GSM 03.22)”.
[5] ETS300 577: “Digital cellular telecommunications system (Phase 2): Radio transmission and reception (GSM 05.05)”.
[6] ETS300 607: “Digital cellular telecommunication system (Phase 2): Mobile Station (MS) conformance specification; (GSM 11.10)”.
[7] TBR 9: “European digital cellular telecommunications system; Attachment requirements for Global System for Mobile communications (GSM) mobile stations; Telephony”.
[8] TBR 20: “European digital cellular telecommunications system (Phase 2); Attachment requirements for Global System for Mobile communications (GSM) mobile stations; Telephony”.
[9] ETR 100: “European digital cellular telecommunications system (Phase 2): Abbreviations and acronyms (GSM 01.04)”.

6. Abbreviations and Terminology

6.1 Abbreviations

Glossary and specific PHS abbreviations can be found in A-GN-1.00-TS [3]
Definition and specific GSM abbreviations may be found in ETR 100 [9].

For the purposes of this document, the following abbreviations apply:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADPCM</td>
<td>Adaptive Differential Pulse Code Modulation</td>
</tr>
<tr>
<td>BS</td>
<td>Base Station</td>
</tr>
<tr>
<td>CS</td>
<td>Cell Station</td>
</tr>
<tr>
<td>DMT</td>
<td>Dual Mode Terminal</td>
</tr>
<tr>
<td>GSM</td>
<td>Global System for Mobile communications</td>
</tr>
<tr>
<td>ISDN</td>
<td>Integrated Services Digital Network</td>
</tr>
<tr>
<td>MS</td>
<td>Mobile Station</td>
</tr>
<tr>
<td>PHS</td>
<td>Personal Handy-phone System</td>
</tr>
<tr>
<td>PLMN</td>
<td>Public Land Mobile Network</td>
</tr>
<tr>
<td>RSSI</td>
<td>Received Signal Strength Indicator</td>
</tr>
<tr>
<td>SIM</td>
<td>Subscriber Identity Module</td>
</tr>
</tbody>
</table>

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6.2 Terminology

PHS and GSM specifications often use different terminology for equivalent functions. Therefore, this section clarify some of the vocabulary used in this document. Similar PHS and GSM definitions are not necessarily strictly equivalent to use as general formulations sometimes. If dual mode standards are to be produced in this document, a common terminology needs to be defined as shown in Table 3.

Strict GSM terminology can be found in GSM 03.22 (ETS 300 535 [4]).

The PHS terminology can be found in A-GN-1.00-TS [3].

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>active communication</td>
<td>A state, where a communication link has been established between the DMT and a fixed part in either GSM or PHS mode.</td>
</tr>
<tr>
<td>active mode</td>
<td>GSM or PHS mode after being selected and switch on procedures for that mode being performed.</td>
</tr>
<tr>
<td>background scanning</td>
<td>The process whereby the DMT attempts to identify the existence of available networks in the other mode than the one it is in.</td>
</tr>
<tr>
<td>Dual Mode Terminal (DMT)</td>
<td>A terminal comprising both PHS and GSM parts.</td>
</tr>
<tr>
<td>GSM</td>
<td>In the present document, the GSM part of a DMT can be GSM 900.</td>
</tr>
<tr>
<td>GSM coverage</td>
<td>The sum of all GSM Public Land Mobile Network (PLMN) coverage where the DMT has at least limited service.</td>
</tr>
<tr>
<td>mode selection</td>
<td>A DMT based procedure, whereby operating mode, PHS or GSM, is chosen.</td>
</tr>
<tr>
<td>mode</td>
<td>A basic DMT is in either of the two modes PHS and GSM. In GSM mode the DMT behaves as a GSM Mobile Station (MS) and in PHS mode the DMT behaves as a PHS Personal Station (PS).</td>
</tr>
</tbody>
</table>

Note: The word **PHS** is used to refer to the PHS air interface or the access network related to the PHS air interface.

The word **GSM** is used to refer to the GSM air interface and the related access network.
<table>
<thead>
<tr>
<th>PHS term</th>
<th>GSM term</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal station (PS)</td>
<td>Mobile station (MS)</td>
<td>The combination of mobile termination equipment, subscription identity equipment and any required terminal equipment. Often through this document the word &quot;terminal&quot; is used for those terms.</td>
</tr>
<tr>
<td>Cell station (CS)</td>
<td>Base station (BS)</td>
<td>The physical equipment providing the elementary part of coverage. The word &quot;cell&quot; is often used through this document for the coverage area of a cell/base station.</td>
</tr>
<tr>
<td>Paging area</td>
<td>Location area</td>
<td>A group of cells all of whose broadcast location identities are the same.</td>
</tr>
</tbody>
</table>