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Technical Specification

Satellite Component of UMTS-IMT 2000;
A-family;
Part 4: Physical layer procedures
(S-UMTS-A 25.214)

Reference

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

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- the third digit (n) is incremented when editorial only changes have been incorporated in the specification;
- the second digit (m) is incremented for all other types of changes, i.e. technical enhancements, corrections, updates, etc.

The present document is part 4 of a multi-part deliverable covering the Satellite Component of UMTS/IMT 2000; A-family, as identified below:

Part 1: "Physical channels and mapping of transport channels into physical channels";

Part 2: "Multiplexing and channel coding";

Part 3: "Spreading and modulation";

Part 4: "Physical layer procedures".

Introduction

S-UMTS stands for the Satellite component of the Universal Mobile Telecommunication System. S-UMTS systems will complement the terrestrial UMTS (T-UMTS) and inter-work with other IMT-2000 family members through the UMTS core network. S-UMTS will be used to deliver 3rd generation mobile satellite services (MSS) utilizing either low (LEO) or medium (MEO) earth orbiting, or geostationary (GEO) satellite(s). S-UMTS systems are based on terrestrial 3GPP specifications and will support access to GSM/UMTS core networks.

NOTE 1: The term T-UMTS will be used in the present document to further differentiate the Terrestrial UMTS component.

Due to the differences between terrestrial and satellite channel characteristics, some modifications to the terrestrial UMTS (T-UMTS) standards are necessary. Some specifications are directly applicable, whereas others are applicable with modifications. Similarly, some T-UMTS specifications do not apply, whilst some S-UMTS specifications have no corresponding T-UMTS specification.

Since S-UMTS is derived from T-UMTS, the organization of the S-UMTS specifications closely follows the original 3rd Generation Partnership Project (3GPP) structure. The S-UMTS numbers have been designed to correspond to the 3GPP terrestrial UMTS numbering system. All S-UMTS specifications are allocated a unique S-UMTS number as follows:

S-UMTS-n xx.yyy

Where :

- The numbers xx and yyy correspond to the 3GPP-numbering scheme.
- **n** (n=A, B, C, …) denotes the family of S-UMTS specifications.

An S-UMTS system is defined by the combination of a family of S-UMTS specifications and 3GPP specifications, as follows:

- If an S-UMTS specification exists it takes precedence over the corresponding 3GPP specification (if any). This precedence rule applies to any references in the corresponding 3GPP specifications.

NOTE 2: Any references to 3GPP specifications within the S-UMTS specifications are not subject to this precedence rule. For example, an S-UMTS specification may contain specific references to the corresponding 3GPP specification.

- If an S-UMTS specification does not exist, the corresponding 3GPP specification may or may not apply. The exact applicability of the complete list of 3GPP specifications shall be defined at a later stage.

1 Scope

The present document specifies the characteristics of the physical layer procedures used for family A of the satellite component of UMTS (S-UMTS-A).

It is based on the FDD mode of UTRA defined by 3GPP [2], [3], [4], [5] and adapted for operation over satellite transponders.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] ETSI TS 101 851-1: "Satellite Component of UMTS/IMT 2000; A-family; Part 1: Physical channels and mapping of transport channels into physical channels (S-UMTS-A 25.211)".

[2] ETSI TS 125 211: "Universal Mobile Telecommunication System (UMTS); Physical channels and mapping of transport channels onto physical channels (FDD) (3G TS 25.211 version 3.3.0 Release 1999)".

[3] ETSI TS 125 212: "Universal Mobile Telecommunication System (UMTS); Multiplexing and channel coding (FDD) (3G TS 25.212 version 3.3.0 Release 1999)".

[4] ETSI TS 125 213: "Universal Mobile Telecommunication System (UMTS); Spreading and modulation (FDD) (3G TS 25.213 version 3.3.0 Release 1999)".

[5] ETSI TS 125 214: "Universal Mobile Telecommunication System (UMTS); Physical layer procedures (FDD) (3G TS 25.214 version 3.3.0 Release 1999)".

[6] ETSI TS 125 331: "Universal Mobile Telecommunications System (UMTS); RRC Protocol Specification (3G TS 25.331 version 3.3.0 Release 1999)".

[7] ETSI TS 125 101: "Universal Mobile Telecommunication System (UMTS); UE Radio transmission and Reception (FDD) 3G TS 25.101 version 3.3.0 Release 1999".

3 Abbreviations

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

BCH	Broadcast Channel
CCPCH	Common Control Physical Channel
DCH	Dedicated Channel
DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel
DPDCH	Dedicated Physical Data Channel
FACH	Forward Access Channel
FSW	Frame Synchronization Word
PCH	Paging Channel
PI	Paging Indication
PRACH	Physical Random Access Channel
RACH	Random Access Channel

SCH	Synchronization Channel
SIR	Signal-to-Interference Ratio
TPC	Transmit Power Control
UE	User Equipment

4 Synchronization procedures

4.1 Initial satellite search

During cell search, the UE searches for a satellite and determines the downlink scrambling code and common channel frame synchronization of that satellite beam. A typical initial satellite beam search is described in annex A.

4.2 Common physical channel synchronization

The radio frame timing of all common physical channels can be determined after cell search. The P-CCPCH radio timing is found during cell search and the radio frame timings of all common physical channels are related to that timing as described in [1].

4.3 DPCCH/DPDCH synchronization

4.3.1 Synchronization primitives

4.3.1.1 General

For the dedicated channels, synchronization primitives are used to indicate the synchronization status of radio links, both in uplink and downlink. The definition of the primitives is given in the following clauses.

4.3.1.2 Downlink synchronization primitives

Layer 1 in the UE shall every radio frame check synchronization status of the downlink-dedicated channels. Synchronization status is indicated to higher layers using the CPHY-Sync-IND and CPHY-Out-of-Sync-IND primitives.

Out-of-sync shall be reported using the CPHY-Out-of-Sync-IND primitive if either of the following criteria is fulfilled:

- the UE estimates the DPCCH quality over the last 200 ms period to be worse than a threshold Q_{out}. This criterion shall never be fulfilled during the first 200 ms of the dedicated channel's existence. Q_{out} is defined implicitly by the relevant tests in [7];

- the last 20 transport blocks, as observed on all TrCHs using CRC, are received with incorrect CRC. In addition, over the last 200 ms, no transport block has been received with correct CRC.

In-sync shall be reported using the CPHY-Sync-IND primitive if both of the following criteria are fulfilled:

- the UE estimates the DPCCH quality over the last 200 ms period to be better than a threshold Q_{in}. This criterion shall always be fulfilled during the first 200 ms of the dedicated channel's existence. Q_{in} is defined implicitly by the relevant tests in [7];

- at least one transport block, as observed on all TrCHs using CRC, is received with correct CRC. If there is no TrCH using CRC, this criterion is always fulfilled.

How the primitives are used by higher layers is described in [6].

4.3.1.3 Uplink synchronization primitives

Layer 1 in the Node B shall every radio frame check synchronization status of all radio link sets. Synchronization status is indicated to the RL Failure/Restored triggering function using either the CPHY-Sync-IND or CPHY-Out-of-Sync-IND primitive. Hence, only one synchronization status indication shall be given per radio link set.

The exact criteria for indicating in-sync/out-of-sync is not subject to specification, but could e.g. be based on received DPCCH quality or CRC checks. One example would be to have the same criteria as for the downlink synchronization status primitives.

4.3.2 Radio link establishment

The synchronization of the dedicated physical channels can be divided into two cases:

- when a downlink dedicated physical channel and uplink dedicated physical channel shall be set up at the same time;
- or when a downlink dedicated physical channel shall be set up and there already exist an uplink dedicated physical channel.

The two cases are described in clauses 4.3.2.1 and 4.3.2.2 respectively.

4.3.2.1 No existing uplink dedicated channel: initial synchronization

The assumption for this case is that a DPCCH/DPDCH pair shall be set up in both uplink and downlink, and that there exist no uplink DPCCH/DPDCH already. This corresponds to the case when a dedicated physical channel is initially set up on a frequency.

The outline of synchronization establishment procedures of the dedicated physical channel is described below.

a) The network starts the transmission of downlink DCH channels. The TPC commands transmitted by the network are set alternatively to the value Increase Power Small Step/Decrease Power Small Step. The DPDCH is transmitted only when there is data to be transmitted to the UE.

b) The UE establishes downlink DCH chip synchronization and frame synchronization based on the Primary CCPCH synchronization timing.

c) If necessary, the nominal up-link Tx frequency is pre-corrected following Doppler estimate based on the down link current estimated and nominal Rx carrier frequency and the Doppler pre-compensation information included in the BCH associated to each primary CCPCH. If more than a downlink carrier is received, the Tx frequency is the average of the individual pre-corrected Tx frequency estimates based on all received downlink primary CCPCH.

d) The uplink initial power setting is based on the open-loop estimation procedure described in clause 5.1.1.

e) The UE starts the transmission of uplink channels. To help initial uplink demodulator synchronization, the transmission starts with a preamble having the same format as the RACH preamble. $N_{preambles}$ repetition of the RACH preamble shall be used with $N_{preambles}$ being a system parameter. After $N_{preambles}$ preambles, the DPDCH/DPCH is transmitted. The DPDCH is actually transmitted only when there is data to be transmitted to the network. The transmission power of uplink channels follows the TPC commands transmitted by the network. TPC commands transmitted by the UE are based on downlink SIR measurements.

f) The network establishes uplink channel chip synchronization and frequency synchronization based on the received preamble. Once preamble acquisition is performed the uplink demodulator will simultaneously search for another preamble (if the detected preamble is not the last in the set of transmitted preambles) or for the transmission of the DPDCH/DPCCH. If a DPDCH/DPCCH is being transmitted, frame synchronization can be confirmed by exploiting the reference symbols transmitted on the DPCCH which are modulated according to a known pattern. The success of the frame synchronization confirmation is determined when the successive S_R frame synchronization is confirmed. Otherwise, frame synchronization failure is determined. Then this synchronization status information is reported to the upper layer. The transmission power of the downlink channels follows the TPC commands transmitted by the UE.

4.3.2.2 DPCCH/DPDCH diversity path synchronization

During an established DCH link the uplink demodulator is continuously searching for useful signal replicas coming from different beams of same/different satellites in simultaneous view of the same user. The reverse link signal search is simplified by the fact that the randomization code is common to all beams of all satellites but is complicated by the fact that normally the spreading sequence code length is much larger than the forward link SCH. The searcher task can be largely simplified by the approximate user location knowledge that can significantly help in reducing the search range both in time and frequency. Note that because of the DPDCH frame activation only in presence of traffic, the diversity searcher shall be able to operate on the DPCCH that is continuously transmitted typically at lower power than the DPDCH.

5 Power control

5.1 Uplink power control

5.1.1 PRACH

5.1.1.1 General

The transmitter power of UE shall be calculated by following equation:

$PRACH = L_{Perch} + I_{SAT} + \text{Constant value}$
where,
PRACH: transmitter power level in dBm,
L_{Pearch}: measured path loss in dB; it can be estimated from the *SNIR* and *N* + *I* power measured on the SCH and the P-CCPCH,
I_{SAT}: interference signal power level at the satellite receiver input in dBm, which is broadcast on BCH,
Constant value: This value shall be designated via Layer 3 message (operator matter).

5.1.1.2 Setting of PRACH control and data part power difference

The message part of the uplink PRACH channel shall employ gain factors to control the control/data part relative power similar to the uplink dedicated physical channels. Hence, clause 5.1.2.4 applies also for the RACH message part, with the differences that:

- β_c is the gain factor for the control part (similar to DPCCH);
- β_d is the gain factor for the data part (similar to DPDCH);
- no inner loop power control is performed.

5.1.2 DPCCH/DPDCH

5.1.2.1 General

'The uplink transmit power control procedure controls simultaneously the power of a DPCCH and its corresponding DPDCHs. The power control loop adjusts the power of the DPCCH and DPDCHs with the same amount. The relative transmit power offset between DPCCH and DPDCHs is determined by the network and signalled to the UE using higher layer signalling.

The uplink closed-loop power control adjusts the UE transmit power in order to keep the received uplink signal-to-noise plus interference ratio (SNIR) at a given SNIR target, $SNIR_{target}$. A higher layer outer loop adjusts the $SNIR_{target}$.

5.1.2.1.1 Outer power control loop

The outer loop updates the target SNIR in a way similar to that of terrestrial systems, according to the following algorithm:

- If the received frame is correct, decrease the $SNIR_{target}$ by the quantity $G_{dw;}$
- If the received frame is wrong, increase the $SNIR_{target}$ by the quantity G_{up}.

5.1.2.1.2 Inner power control loop

The receiving demodulator should estimate the uplink DPCCH SNIR after RAKE combining ($SNIR_{meas}$) of the connection to be power controlled (see note). The serving satellite/Gateway then generates a TPC command and transmits it once per frame according to the following procedure.

NOTE: The DPDCH may as well be used for SNIR measurement provided that variability of power in the DPDCH with Transport Format is taken into consideration.

Define $\varepsilon_0 = SNIR_{meas} - SNIR_{target}$ (all parameters in dB), Δ_1^{PC} , Δ_2^{PC} the small and large power control steps and N_1^{UP} , N_1^{DW} and N_2^{UP} , N_2^{DW} , the numbers of small and large up and down PCs sent in a period equal to N_d frames (N_d being the loop delay expressed in frames). Then calling ε_1 (dB) the error threshold for sending a large power control step Δ_2^{PC} :

- compute $\varepsilon_c = \varepsilon_0 + (N_1^{UP} - N_1^{DW})\Delta_1^{PC} + (N_2^{UP} - N_2^{DW})\Delta_2^{PC}$
- if $|\varepsilon_c| < \varepsilon_1$ send an up correction Δ_1^{PC} if $\varepsilon_c < 0$ and a down correction if $\varepsilon_c > 0$
- if $|\varepsilon_c| > \varepsilon_1$ send an up correction Δ_2^{PC} if $\varepsilon_c < 0$ and a down correction if $\varepsilon_c > 0$

For the case of a three-level PC strategy, simply set Δ_1^{PC} =0. The two levels PC corresponds to ε_1=∞.

The UE then adjusts the transmit power of the uplink dedicated physical channels with a step of $\pm\Delta_1^{PC}$ or $\pm\Delta_2^{PC}$ dB according to the TPC command. The change of transmitter power shall apply at the beginning of a new frame.

The relationship between the TPC symbol and the transmitter power control command is presented in table 1.

Table 1: TPC Bit Pattern

TPC Bit Pattern	Transmitter power control command
00	Reduce large power step
01	Reduce small power step
10	Increase small power step
11	Increase large power step

The initial uplink transmit power to use is decided using an open-loop power estimate, similar to the random access procedure.

If the TPC commands cannot be received due to a downlink DPCCH temporary loss-of-synchronization, the transmitter power shall be kept constant. When SNIR measurements cannot be performed due to uplink demodulator loss-of-synchronization, the TPC command transmitted shall be set as Increase Power Large Step during the period of loss-of-synchronization.

The maximum transmitter power value of the closed-loop TPC is set by the network using higher layer signalling.

5.2 Downlink power control

5.2.1 Primary CCPCH

The Primary CCPCH transmit power can vary on a slow basis, i.e. the power is kept constant over many frames. The transmitter power is determined by the network and signalled on the BCH.

5.2.2 Secondary CCPCH

'The Secondary CCPCH transmit power is set by the network, and may vary according to system requirements.

5.2.3 DPCCH/DPDCH

The downlink transmitter power control procedure controls simultaneously the power of a DPCCH and its corresponding DPDCHs. The power control loop adjusts the power of the DPCCH and DPDCHs with the same amount, i.e. the relative power difference between the DPCCH and DPDCHs is not changed.

The relative transmitter power offset between DPCCH fields and DPDCHs is determined by the network and signalled to the UE using higher layer signalling. The TFCI/TPC and pilot fields of the DPCCH are offset relative to the DPDCHs power by PO_1 and PO_2 (dB) respectively.

The downlink closed-loop power control adjusts the network transmit power in order to keep the received downlink SNIR at a given SNIR target, $SNIR_{target}$. A higher layer outer loop adjusts $SNIR_{target}$ independently for each connection (see clause 5.1.2.1.1).

The UE should estimate the received downlink DPCCH/DPDCH SNIR after RAKE combining. The obtained SNIR estimate SIR_{meas} is then used by the UE to generate TPC commands according to the same rule described as for up-link DPDCH/DPCH (see clause 5.1.2.1.2).

The TPC command generated is transmitted in the first available TPC field in the uplink DPCCH.

When SNIR measurements cannot be performed due to downlink out-of-synchronization, the TPC command transmitted shall be set as Increase Power Large Step during the period of out-of-synchronization.

5.2.4 Power Control with DSCH

The DSCH Power Control is based on the power control commands sent by the UE on the uplink DPCCH.

6 Random Access (RACH) Procedure

Before the random-access procedure is executed, the UE should acquire the following information from the BCH:

- The preamble spreading code(s)/message scrambling code(s) used;
- The available spreading factors for the message part (P_{BCCH});
- The satellite receiver noise plus interference level (N_{SAT});
- The primary CCPCH current transmit power level;
- The power ramp-up increment (ΔP_0 power step when no acquisition indicator is received);
- The nominal down-link centre of beam carrier frequency (f_{BCCH});
- The applied down-link centre of beam frequency correction (Δf_{BCCH}).

The above information may be different for the differently received BCH channels.

The random-access procedure is:

a) The UE randomly selects a preamble spreading code among the set of available spreading codes. The randomization function is TBD;

b) The nominal up-link Tx frequency is pre-corrected according to the Doppler estimate based on the down link current estimated and nominal Rx carrier frequency and the Doppler pre-compensation information included in the BCH associated to each primary CCPCH. If more than a downlink carrier is received, the Tx frequency is the average of the individual pre-corrected Tx frequency estimates based on all received downlink primary CCPCH.

c) The UE sets the preamble transmit power to the value *PRACH* given in clause 5.1.1.

d) The UE implements the dynamic persistence algorithm by:

   1) Reading the current dynamic persistence value from the BCH;

   2) Performing a random draw using the current dynamic persistence value. The randomization function is TBD;

   3) Deferring transmission for one frame and repeat step 3.2 if the result of the random draw is negative, otherwise proceed to step 5.

a) The UE sets the Retransmission Counter to a maximum value (TBD).

b) The UE transmits its RACH using the pre-computed transmission power.

c) After a predefined interval (greater than the estimated round trip time), if the UE does not detect an acquisition indication on the FACH channel with the selected UE ID, it:

   1) Increases the preamble transmission power with the specified ramp-up increment ΔP_0;

   2) Decrease the Retransmission Counter by one;

   3) If the Retransmission Counter > 0, the UE repeats from step 3 otherwise an error indication is passed to the higher layers and the random-access procedure is exited.

Dynamic persistence is provided for managing interference and minimizing delay by controlling access to the RACH channel. The system will publish a dynamic persistence value on the BCH, the value of which is dependent on the estimated backlog of users in the system.

Annex A (Informative): Cell (satellite) search procedure

A.1 Initial acquisition

During the initial satellite search, the UE searches for a satellite and determines the downlink scrambling code and common channel frame synchronization of that satellite.

Step 1: Initial satellite search and Scrambling code identification

In case of UE cold start, the UE can use its internal constellation model, time reference and rough location knowledge to locally generate a list of candidate SCH scrambling sequences. If the UE has some more accurate knowledge of its position and satellite ephemeris (warm start), the number of scrambling codes to be searched can be further reduced, together with the search time.

The initial acquisition procedure exploits the SCH.

During the first step of the satellite search procedure the UE uses the SCH to acquire satellite slot synchronization. This is typically done with a single matched filter (or any similar device) matched to the satellite SCH (scrambling) code. The slot timing of the cell can be obtained by detecting peaks in the SCH scrambling code matched filter output.

Multiple correlation peaks may be detected at the output of the SCH code matched filter corresponding to different beams of the same satellite. The timing corresponding to the best peak is assigned to the CCPCH primary demodulator.

In case of non-GEO satellite constellation, a parallel coarse frequency search is also typically required due to the large Doppler carrier frequency error present, as well as the possible inaccuracy of the frequency reference in the UE.

Step 2: Frame synchronization

During the second step of the search procedure, the UE exploits the FSW on the primary CCPCH to perform frame synchronization. The FSW is divided over each slot of a frame, 4 symbols per slot which are differentially encoded using the preceding SCH pilot symbol as the initial phase reference for differential encoding.

Soft differential integration of the FSW instead of hard UW detection may be exploited in case the frequency error resulting from the initial coarse frequency acquisition is too large and fast frame synchronization (without waiting for a finer frequency error estimation and correction) is required. The soft differential integration approach also allows estimating the frequency error simultaneously with the frame synchronization.

The radio frame timing of all common physical channels can be determined now, as the radio frame timing of all common physical channel are related to the timing of P-CCPCH, as described in [1].

A.2 Satellite/beam diversity path acquisition

Once the primary and secondary CCPCH acquisition has been completed, the UE can start searching other candidate beams and/or satellite using the candidate SCH list contained in the BCH broadcast by the CCPCH. The UE will typically report to the satellite/gateway estimated SNIR for the best N_{PIL} (system parameter) SCH and primary CCPCH measured at the UE. Pilot reports take place through the DPDCH in-band signalling. Note that as stated above, the CCPCH of the different beams can be simultaneously estimated looking at the SCH code matched filter output. Other satellites measurement requires switching the SCH matched filter code stored. The SCH quality reports will be elaborated at the gateway that will consequently update forward link diversity resources allocation according to current system strategy. In case the gateway decides to add a forward link diversity path, the UE is informed trough in-band DPDCH signalling and extra UE demodulator resources (CCPCH/DCH fingers) are allocated accordingly. In case one path CCPCH SNIR report is not satisfactory the Gateway may decide to drop this path by informing the UE to remove the finger.

Annex B (informative): Bibliography

- ETSI TS 101 851-2: "Satellite Component of UMTS/IMT 2000; A-family; Part 2: Multiplexing and channel coding (S-UMTS-A 25.212)".
- ETSI TS 101 851-3: "Satellite Component of UMTS/IMT 2000; A-family; Part 3: Spreading and modulation (S-UMTS-A 25.213)".

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