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UTRA TDD, Physical Layer Procedures Description
(UMTS XX.13 version 1.0.0)

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Special Mobile Group (SMG).

The present document describes physical layer procedures for UTRA Physical Layer TDD mode.

The contents of the present document are subject to continuing work within SMG2 and SMG2 UMTS layer 1 expert group and may change following approval by either of these two groups.

1 Scope

This Technical Report describes physical layer procedures for UTRA Physical Layer TDD mode.

Text without revision marks has been approved in the previous SMG2 Layer 1 expert group meetings, while text with revision marks is subject to approval.

Document Status

The status of the chapters in this specification is as follows:

4.1 proposal
4.2 proposal
4.2.1 proposal
4.2.2 working assumption
4.3 working assumption
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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, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] Reference 1.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

definition 1: to be completed.

3.2 Abbreviations

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

<Editor's note: This section covers TDD relevant abbreviations only.>

BCCH	Broadcast Control Channel
BCH	Broadcast Channel
DCA	Dynamic Channel Allocation
FACH	Forward Access Channel
NRT	Non-Real Time
ODMA	Opportunity Division Multiple Access
TPC	Transmit Power Control
RACH	Random Access Channel
RT	Real Time
RU	Resource Unit
SCH	Synchronization Channel
UE	User Equipment
VBR	Variable Bit Rate

4 Physical layer procedures (TDD)

4.1 General

4.2 Synchronisation

4.2.1 Synchronisation of TDD NodeBs

It is required that nodeB supporting the TDD mode are operated in synchronised mode, if the coverage areas of the cells are overlapping, i.e. we have contiguous coverage for a certain area. The nature of the TDD operation requires nodeB frame synchronisation, to achieve good spectral efficiency. The fact that UE and nodeB are receiving and transmitting on the same frequency makes it desirable, that in the reuse cell the same TX / RX timing is used.

The lack of a frame synchronisation could cause, interference in several time slots, depending on the amount of time slip.

Frame synchronisation is used to minimise this effect. However, it will be necessary for a cost efficient solution to allow a certain amount of slip. The tolerance of the frame synchronisation shall be such, that the affected timeslots receive only a minor performance degradation. I.e. only some of the symbols shall be corrupted by the frame slip, rather than a full slot. Synchronisation on a chip level is not required.

4.2.2 Synchronisation of ODMA Relays

Due to the relatively short range of transmissions, the inclusion of ODMA does not impose any additional guard period or frame synchronisation requirements over those discussed above for standard TDD.

Any potential overlap caused by relay transmissions will be localised to a node and its neighbours by the ODMA protocol.

The inclusion of ODMA could relax the guard period requirements when relaying between nodes (not involving the BS) since neighbouring UEs are regarded as relay opportunities and any communications between neighbours (on an ODCH) could be synchronised further.

4.3 Channel Allocation

For the UTRA-TDD mode a physical channel is characterised by a combination of its carrier frequency, time slot, and spreading code as explained in the chapter on the physical channel structure.

Channel allocation covers both:

- resource allocation to cells (slow DCA);
- resource allocation to bearer services (fast DCA).

4.3.1 Resource allocation to cells (slow DCA)

Channel allocation to cells follows the rules below:

A reuse one cluster is used in the frequency domain. In terms of an interference-free DCA strategy a timeslot-to-cell assignment is performed, resulting in a time slot clustering. A reuse one cluster in frequency domain does not need frequency planning. If there is more than one carrier available for a single operator also other frequency reuse patters >1 are possible.

Any specific time slot within the TDD frame is available either for uplink or downlink transmission. UL/DL resources allocation is thus able to adapt itself to time varying asymmetric traffic.

In order to accommodate the traffic load in the various cells the assignment of the timeslots (both UL and DL) to the cells is dynamically (on a coarse time scale) rearranged (slow DCA) taking into account that strongly interfering cells use different timeslots. Thus resources allocated to adjacent cells may also overlap depending on the interference situation.

Due to idle periods between successive received and transmitted bursts, UEs can provide the network with interference measurements in time slots different from the one currently used. The availability of such information enables the operator to implement the DCA algorithm suited to the network.

For instance, the prioritized assignment of time slots based on interference measurements results in a clustering in the time domain and in parallel takes into account the demands on locally different traffic loads within the network.

4.3.2 Resource allocation to bearer services (fast DCA)

Fast channel allocation refers to the allocation of one or multiple physical channels to any bearer service Resource units (RUs) are acquired (and released) according to a cell-related preference list derived from the slow DCA scheme.

The following principles hold for fast channel allocation:

The basic RU used for channel allocation is one code / timeslot / (frequency).

Multirate services are achieved by pooling of resource units. This can be made both in the code domain (pooling of multiple codes within one timeslot = **multicode** operation) and time domain (pooling of multiple timeslots within one frame = **multislot** operation). Additionally, any combination of both is possible.

Since the maximal number of codes per time slot in UL/DL depends on several physical circumstances like, channel characteristics, environments, etc. (see description of physical layer) and whether additional techniques to further enhance capacity are applied (for example smart antennas),. the DCA algorithm has to be independent of this number. Additionally, time-hopping can be used to average inter-cell interference in case of low-medium bit rate users.

Channel allocation differentiates between RT and NRT bearer services:

RT services: Channels remain allocated for the whole duration the bearer service is established. The allocated resources may change because of a channel reallocation procedure (e.g. VBR).

NRT services: Channels are allocated for the period of the transmission of a dedicated data packet only UDD channel allocation is performed using ‘best effort strategy’, i.e. resources available for NRT services are distributed to all admitted NRT services with pending transmission requests. The number of channels allocated for any NRT service is variable and depends at least on the number of current available resources and the number of NRT services attempting for packet transmission simultaneously. Additionally, prioritisation of admitted NRT services is possible.

Channel reallocation procedures (intra-cell handover) can be triggered for many reasons:

To cope with varying interference conditions.

In case of high rate RT services (i.e. services requiring multiple resource units) a ‘channel reshuffling procedure’ is required to prevent a fragmentation of the allocated codes over to many timeslots. This is achieved by freeing the least loaded timeslots (timeslots with minimum used codes) by performing a channel reallocation procedure.

When using smart antennas, channel reallocation is useful to keep spatially separated the different users in the same timeslot.

4.3.3 Resource allocation for ODMA

<for further study>

4.4 Power Control

Power control is applied for the TDD mode to limit the interference level within the system thus reducing the intercell interference level and to reduce the power consumption in the UE.

A slow C-level based power control scheme (similar to GSM) is mandatory for both up- and downlink. Open loop power control and the reference source for power measurements are under study. Power control is made, individually for each group of resource units (codes) in each slot which have a common TFCI, with the following characteristics:

Table 1: TPC characteristics

	Uplink	**Downlink**
Dynamic range	80 dB	30 dB
Power control rate	variable; 100-800 cycles / second	variable; 100-800 cycles / second
Step size	[0.25 ... 3] dB	[0.25 ... 3] dB
Remarks	A cycle rate of 100 means that every frame the power level is controlled	within one timeslot the powers of all active codes may be balanced to within a range of [20] dB

All codes within one timeslot allocated to the same bearer service use the same transmission power.

For RT services, in UL and DL a closed loop power control is used. UL open loop power control is under study.

For NRT services, both open loop power control and closed loop power control are used according to the UE state and the operators’ needs (similar to GPRS power control in GSM 03.64).

The initial power value is based on the pathloss estimate to the serving BS.

In case of one user with simultaneous RT and NRT bearer service, the closed loop power control is used both for RT and NRT bearer service. However, depending on the current services different power levels are used.

Optional enhancements concerning power control for further study:

Introduction of quality based power control.

4.4.1 ODMA Power Control

<for further study>

4.5 Timing Advance

The timing of transmissions from the UE will be advanced with respect to the timing of signals received from the serving nodeB to compensate for round trip propagation delay. The initial value for timing advance (TA) will be determined in the serving nodeB by measurement of the timing of a specific transmission from the UE [FFS]. The required timing advance will be represented as a [7] bit number, n [(0-127)] being the multiple of [1.953 µs (= 8 chips)] which is nearest to the required timing advance. The maximum allowed value may be limited by the operator to a value lower than [127], if required or the function may be disabled. A UE cannot operate beyond the range set by the maximum value of TA.

The serving nodeB will measure the timing of a transmission from the UE and signal the necessary timing advance (TA). On receipt of the TA the UE will adjust the timing of its transmissions accordingly.

As the UE moves within the cell, the serving nodeB will signal whether to advance, retard or maintain UE timing when the error in the timing of the signal received from the UE reaches a significant value. The UE shall respond by adjusting its timing advance by [± 8] chips accordingly.

When TDD to TDD handover takes place the UE shall measure the timing difference (Δ_{TA}) between the new and old cells, double it and add it to the current timing advance value to provide the new timing advance. The new value is adopted on completion of handover.

$TA_{new} = TA_{old} + 2.\Delta_{TA}$

4.6 Cell Search

4.6.1 Initial Mode Cell Search

During the initial cell search, the UE searches for the cell with the highest receive power level. It then determines the midamble, the downlink spreading code and frame synchronisation of that cell. The initial cell search uses the synchronisation channel (SCH), shown in Figure 1 below (repeated from UMTS XX.09).

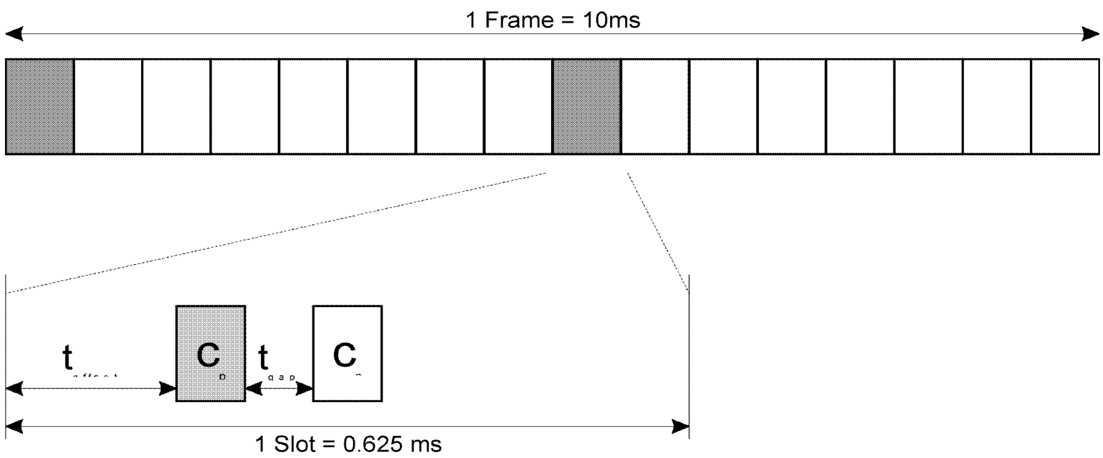

Figure 1: Structure of synchronisation channel (SCH)

This initial cell search is carried out in three steps:

Step 1: Slot synchronisation

During the first step of the initial cell search procedure the UE uses the primary synchronization code to acquire slot synchronisation to the strongest cell. Furthermore, frame synchronization with the uncertainty of 1 out of 2 is obtained in this step. A single matched filter (or any similar device) is used for this purpose, that is matched to the primary synchronisation code c_p which is common to all cells. The procedure is according to the description for the FDD mode in XX.07.

Step 2: Frame synchronisation and code-group identification

During the second step of the initial cell search procedure, the UE uses the secondary synchronization code to find frame synchronisation and identify the code and midamble group of the cell as well as the BCH structure and the time offset t_{offset}(see XX.09). This is done by correlating the received signal at the positions of the Secondary Synchronisation Code with all possible Secondary Synchronisation Codes. After four frames a sequence of eight codes is available providing all necessary informations described above. The same Secondary Synchronisation Codes as in FDD are used for this purpose.

Step 3: Spreading-code identification

During the third and last step of the initial cell-search procedure, the UE determines the exact midamble and the accompanying spreading code used by the found cell. They are identified through correlation over the BCH with all midambles of the group identified in the second step.

4.6.2 Idle Mode Cell Search

When in idle mode, the UE continuously searches for new cells on the current and other carrier frequencies. The cell search is done in basically the same way as the initial cell search. The main difference compared to the initial cell search is that an idle UE has received a priority list from the network. This priority list describes in which order to search for other cells. The priority list is continuously updated to reflect the changing neighbourhood of a moving UE.

4.6.3 Active Mode Cell Search

In the Active state, the UE periodically scans for the radio environment in order update the list of the strongest cells. The list, which contains the identity and the Received Signal Strength Intensity (RSSI) of each detected cell, is periodically forward to the serving cell (or it can be forwarded on demand) and can be used to perform intercell handovers of the allocated physical channels.

By receiving the SCH, BCH of other cells, the UE learns about its radio environment.

4.7 ODMA Relay Probing

This section describes the probe-response procedure used by ODMA nodes to detect neighbours which may be used as relays during a call.

4.7.1 Initial Mode Probing

The initial mode probing procedure is activated by a UE when it is switched on and has no information about its surroundings. In this case the UE will synchronise with the ODMA Random Access Channel (ORACH) which is used by all UEs to receive and broadcast system routing control information and data. The UE begins a probing session by periodically broadcasting a probe packet on the ORACH. The broadcast probe includes the current neighbour list for the UE which will initially be empty. If a neighbouring UE, UE*a*, receives the broadcast packet it will register the UE as a neighbour and send an addressed response probe. The response probe is transmitted at random to avoid contention with other UEs and typically one response is sent for every *n* broadcast probes received from a particular UE.

The next time the UE transmits a broadcast probe the neighbour list will have one new entry, *UEa*, and an associated quality indicator (a weighted factor based on the received signal strength of the response probe). It is through this basic mechanism that each UE builds a neighbour list.

4.7.2 Idle Mode Probing

The Idle Mode Probing procedure is activated when the UE has synchronised with the ORACH but is not transmitting data. This procedure is the same as that described above after ORACH synchronisation.

The ODMA Idle Mode Probing procedure controls the rate of probing on the ORACH to reduce interference levels and regulate power consumption. The procedure is governed by a state machine, which consists of the following states: full probing, duty maintained probing, and relay prohibited. Each state defines the number of probing opportunities within one N multiframe, and a probing activity parameter *K* which is the ratio of probe transmission time to probe monitoring time.

Full probing

Full probing is the case where probing is allowed on every ORACH timeslot within an *N* multiframe. The UE_R will probe on the ORACH at a rate defined by the probing activity parameter *K*.

Duty Maintained probing

The duty maintained probing is the case where probing is allowed on *M* slots of an *N* multiframe. The UE_R will probe on the *M* ORACH slots in an *N* multiframe at a rate defined by the probing activity parameter *K*.

Relay Prohibited

In this mode the UE_R would cease all of its ODMA probing activities and will fall into standard TDD or FDD operation.

The probing activity levels for given state machines are illustrated in Figure 2 for a system with an ORACH for M slots per N $\times$ 16 multiframe.

Note that the distribution of probing opportunities within a multiframe may not necessarily be consecutive and located at the beginning of a multiframe.

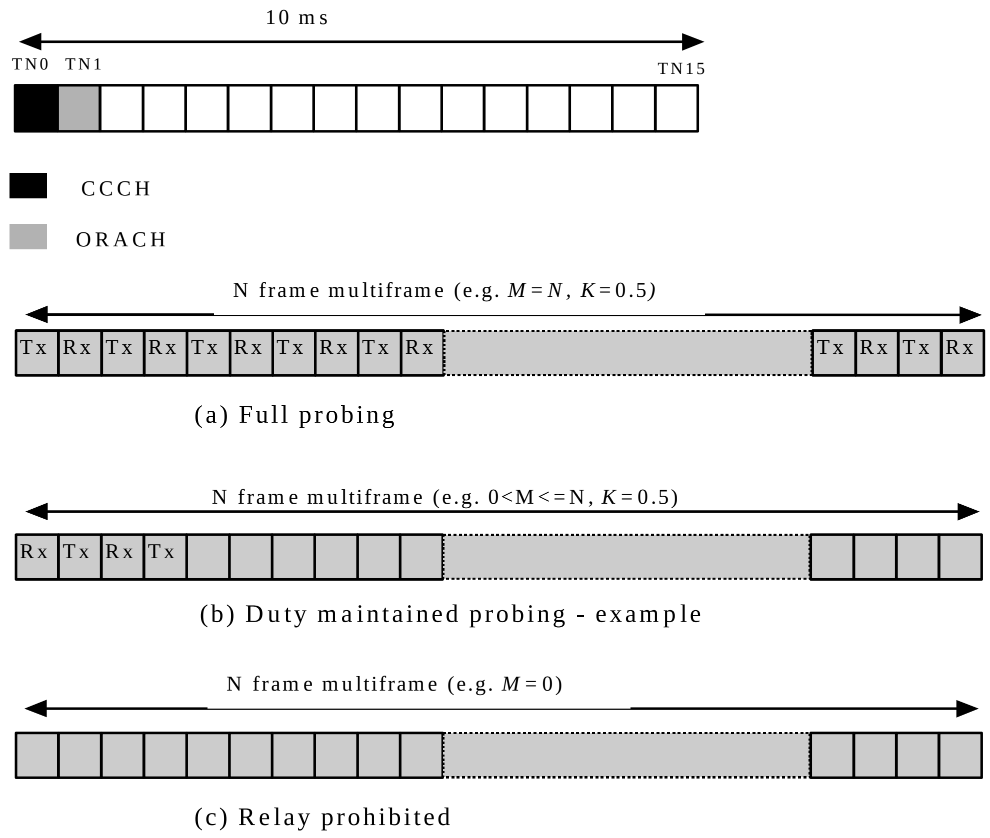

Figure 2: Probing state machines and mechanism

4.7.3 Active Mode Probing

The Active Mode Probing procedure is activated when the UE has synchronised with the ORACH and is transmitting data.

With ODMA, data may be relayed on either the ODMA Random Access Channel (ORACH) or the ODMA dedicated transport channel (ODCH), depending on the volume of data to be sent. When a UE has small amounts of data to send it may transmit an addressed probe response packet on the ORACH at an interval proportional to air interface modem rate,

R_{CCH}, and is defined by *Probe_timer_1*. This interval also defines the broadcast probe interval, *Probe_timer_2*, which is typically five times longer than *Probe_timer_1*. Every time an UE transmits a response probe containing data on the ORACH, it may be received, but not acknowledged, by third party neighbour UEs, and provides an implicit indication of activity. In this instance broadcast probes are not necessary and *Probe_timer_2* is reset after every addressed probe transmission. Only when an UE has no data to send is it necessary to transmit a broadcast probe every *Probe_timer_2* seconds to register its active status with its neighbours.

In order to avoid overlapping packet transmissions the length of the packet may not exceed the probe timer interval, *Probe_timer_1*. The relationship between the different probe timers is illustrated in Figure 3.

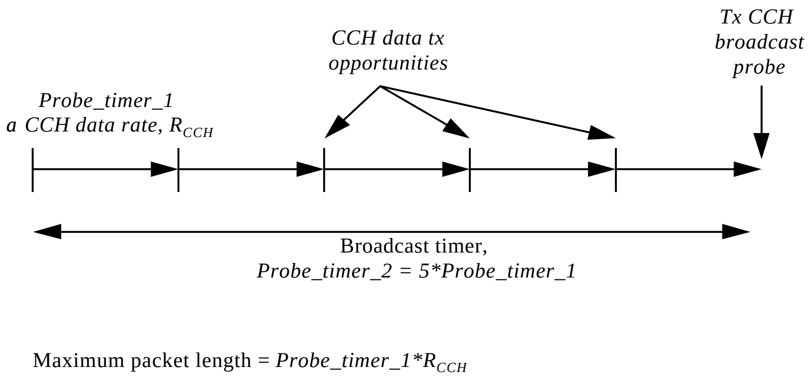

Figure 3: Probe timer relationships

History

Document history		
v0.0.1	1998-08-17	Document created based on the documents Tdoc SMG2 UMTS L1 274/98(UTRA TDD system description V 0.2.1)
v0.1.0	1998-09-15	Document approved at the SMG2 UMTS L1#6 meeting in Helsinki
v0.1.1	1998-10-19	A paragraph has been added showing the status of each chapter of the document
v0.2.0	1998-11-2	Some sections for ODMA have been included as proposal
v0.2.1	1998-11-13	Revision marks in version 0.2.0 removed after approval during L1#8, Version 0.2.1 sent to SMG2#28, Dresden, Germany
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v0.4.0	1998-01-11	changes approved at L1#9: Power Control modified, Timing Advance added, ODMA sections modified, editorial modifications
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