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Foreword

This Technical Specification has been produced by the 3GPP.

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of this TS, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
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 - y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
 - z the third digit is incremented when editorial only changes have been incorporated in the specification;
-

1 Scope

The present document describes the Physical Layer Procedures in the TDD mode of UTRA.

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] TS 25.201: "Physical layer - general description"

[2] TS 25.102: "UE physical layer capabilities"

[3] TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)"

[4] TS 25.212: "Multiplexing and channel coding (FDD)"

[5] TS 25.213: "Spreading and modulation (FDD)"

[6] TS 25.214: "Physical layer procedures (FDD)"

[7] TS 25.215: "Physical Layer - Measurements (FDD)"

[8] TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)"

[9] TS 25.222: "Multiplexing and channel coding (TDD)"

[10] TS 25.223: "Spreading and modulation (TDD)"

[11] TS 25.215: "Physical Layer - Measurements (TDD)"

[12] TS 25.301: "Radio Interface Protocol Architecture"

[13] TS 25.302: "Services Provided by the Physical Layer"

[14] TS 25.401: "UTRAN Overall Description"

3 Definitions, Symbols and Abbreviations

3.1 Definitions

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

<defined term>: <definition>.

3.2 Symbols

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

<symbol> <Explanation>

3.3 Abbreviations

BCCH	Broadcast Control Channel
BCH	Broadcast Channel
DCA	Dynamic Channel Allocation
DPCH	Dedicated Physical Channel
DTX	Discontinuous Transmission
FACH	Forward Access Channel
NRT	Non-Real Time
ODMA	Opportunity Division Multiple Access
ORACH	ODMA Random Access Channel
PCCPCH	Primary Common Control Physical Channel
PRACH	Physical Random Access Channel
PSCH	Primary Synchronisation Channel
RACH	Random Access Channel
RT	Real Time
RU	Resource Unit
SCH	Synchronisation Channel
SSCH	Secondary Synchronisation Channel
STD	Selective Transmit Diversity
TA	Timing Advance
TPC	Transmit Power Control
TSTD	Time Switched Transmit Diversity
TxAA	Transmit Adaptive Antennas
UE	User Equipment
VBR	Variable Bit Rate

4 Physical layer procedures (TDD)

4.1 General

4.2 Transmitter Power Control

4.2.1 General Parameters

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.

Table 1: TPC characteristics

	Uplink	Downlink
Power control rate	Variable 1-7 slots delay (2 slot SCH) 1-14 slots delay (1 slot SCH)	Variable, with rate depending on the slot allocation.
Step size		1, 2, 3 dB
Remarks	All figures are without received power measurements.	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.
- In case of one user with simultaneous RT and NRT bearer service, the inner loop power control is used both for RT and NRT bearer service. However, depending on the current services different power levels are used.

4.2.2 Uplink Control

4.2.2.1 Common Physical Channel

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

$$P_{\text{PRACH}} = L_{\text{PCCPCH}} + I_{\text{BTS}} + \text{Constant value}$$

where

- P_{PRACH} : Transmitter power level in dBm,
 L_{PCCPCH} : Measure representing path loss in dB (reference transmit power is broadcast on BCH),
 I_{BTS} : Interference signal power level at cell's receiver in dBm, which is broadcast on BCH,
 Constant value: This value shall be set by higher Layer (operator matter).

4.2.2.2 Dedicated Physical Channel

The initial transmission power is decided in a similar manner as PRACH. After the synchronisation between UTRAN and UE is established, the UE transits into open-loop transmitter power control (TPC).

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

$$P_{\text{UE}} = \alpha L_{\text{PCCPCH}} + (1 - \alpha)L_0 + I_{\text{BTS}} + \text{SIR}_{\text{TARGET}} + \text{Constant value}$$

where

- P_{UE} : Transmitter power level in dBm,
 L_{PCCPCH} : Measure representing path loss in dB (reference transmit power is broadcast on BCH),
 L_0 : Long term average of path loss in dB
 I_{BTS} : Interference signal power level at cell's receiver in dBm, which is broadcasted on BCH
 α : α is a weighting parameter which represents the quality of path loss measurements. α may be a function of the time delay between the uplink time slot and the most recent down link PCCPCH time slot. α is calculated at the UE. An example for calculating α as a function of the time delay is given in Annex 1.
 $\text{SIR}_{\text{TARGET}}$: Target SNR in dB. A higher layer outer loop adjusts the target SIR.
 Constant value: This value shall be set by higher Layer (operator matter).

4.2.3 Downlink Control

4.2.3.1 Common Physical Channel

The Primary CCPCH transmit power can be changed based on network determination on a slow basis. The exact power of PCCPCH is signaled on the BCH on a periodic basis.

4.2.3.2 Dedicated Physical Channel

The initial transmission power of the downlink Dedicated Physical Channel is set by the network. After the initial transmission, the UTRAN transits into SIR-based inner loop TPC as similar to the FDD mode.

The measurement of received SIR shall be carried out periodically at the UE. When the measured value is higher than the target SIR value, TPC bit = „0,,. When this is lower than the target SIR value, TPC bit = „1,,. At the UTRAN, soft decision on the TPC bits is performed, and when it is judged as „0,, the transmission power may be reduced by one step, whereas if judged as „1,, the transmission power may be raised by one step.

When the TPC bit cannot be received due to out-of-synchronisation, the transmission power value shall be kept at a constant value. When SIR measurement cannot be performed due to out-of-synchronisation, the TPC bit shall always be = „1,, during the period of being out-of-synchronisation.

A higher layer outer loop adjusts the target SIR.

4.3 Timing Advance

4.3.1 Without UL Synchronization

The timing of transmissions from the UE is adjusted according to timing advance values received from the UTRAN. The initial value for timing advance will be determined in the UTRAN by measurement of the timing of the PRACH. The required timing advance will be represented as a 8 bit number (0-255) being the multiple of 4 chips which is nearest to the required timing advance. The maximum allowed value may be limited by the operator to a value lower than 255, if required or the function may be disabled. A UE cannot operate beyond the range set by the maximum value of timing advance.

The UTRAN will continuously measure the timing of a transmission from the UE and send the necessary timing advance value. On receipt of this value the UE will adjust the timing of its transmissions accordingly in steps of ± 4 chips. The transmission of TA values is done by means of higher layer messages.

When TDD to TDD handover takes place the UE shall transmit in the new cell with timing advance TA adjusted by the relative timing difference Δt between the new and the old cell:

$$TA_{\text{new}} = TA_{\text{old}} + 2 \cdot \Delta t$$

4.3.2 With UL Synchronization

With UL Synchronization, the timing advance is sub-chip granular and with high accuracy in order to enable synchronous CDMA in the UL. The required timing advance will be represented as a multiple of 1/8 chips.

The UTRAN will continuously measure the timing of a transmission from the UE and send the necessary timing advance value. On receipt of this value the UE will adjust the timing of its transmissions accordingly in steps of $\pm 1/8$ chips. The transmission of TA values is ffs.

4.4 Synchronisation and Cell Search Procedures

4.4.1 Cell Search

During the initial cell search, the UE searches for a cell. It then determines the midamble, the downlink scrambling code and frame synchronisation of that cell. The initial cell search uses the Physical Synchronisation Channel (PSCH) described in [8]. The generation of synchronisation codes is described in [10].

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 synchronisation code c_p to acquire slot synchronisation to the strongest cell. Furthermore, frame synchronisation 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 which is common to all cells.

Step 2: Frame synchronisation and code-group identification

The Step 2 is described for the case where PSCH and PCCPCH are in timeslot k and $k+8$ with $k=0..6$.

During the second step of the initial cell search procedure, the UE uses the modulated Secondary Synchronisation Codes to find frame synchronisation and identify one of 32 code groups. Each code group is linked to a specific t_{Offset} , thus to a specific frame timing, and is containing 4 specific scrambling codes. Each scrambling code is associated with a specific short and long basic midamble code.

In Cases 2 and 3 it is required to detect the position of the next synchronization slots. To detect the position of the next synchronization slots, the primary synchronization code is correlated with the received signal at offsets of 7 and 8 time slots from the position of the primary code that was detected in Step 1.

Then, the received signal at the positions of the synchronization codes is correlated with the primary synchronization Code C_p and the secondary synchronization codes $\{C_0, \dots, C_{15}\}$. Note that the correlations are performed coherently over M time slots, where at each slot a phase correction is provided by the correlation with the primary code. The minimal number of time slots is $M=1$, and the performance improves with increasing M .

Step 3: Scrambling code identification

During the third and last step of the initial cell-search procedure, the UE determines the exact basic midamble code and the accompanying scrambling code used by the found cell. They are identified through correlation over the PCCPCH with all four midambles of the code group identified in the second step. Thus the third step is a one out of four decision. This step is taking into account that the PCCPCH containing the BCH is transmitted using the first spreading code ($a_{Q=16}^{(h=1)}$ in figure 2 of [10] section '6.2 Spreading Codes') and using the first midamble $\mathbf{m}^{(1)}$ (derived from basic midamble code \mathbf{m}_p , cf. [8] section '5.2.3 Training sequences for spread bursts'). Thus PCCPCH code and midamble can be immediately derived when knowing scrambling code and basic midamble code.

4.5 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.

4.5.1 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, UE_a , 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.

4.5.2 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 1 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.

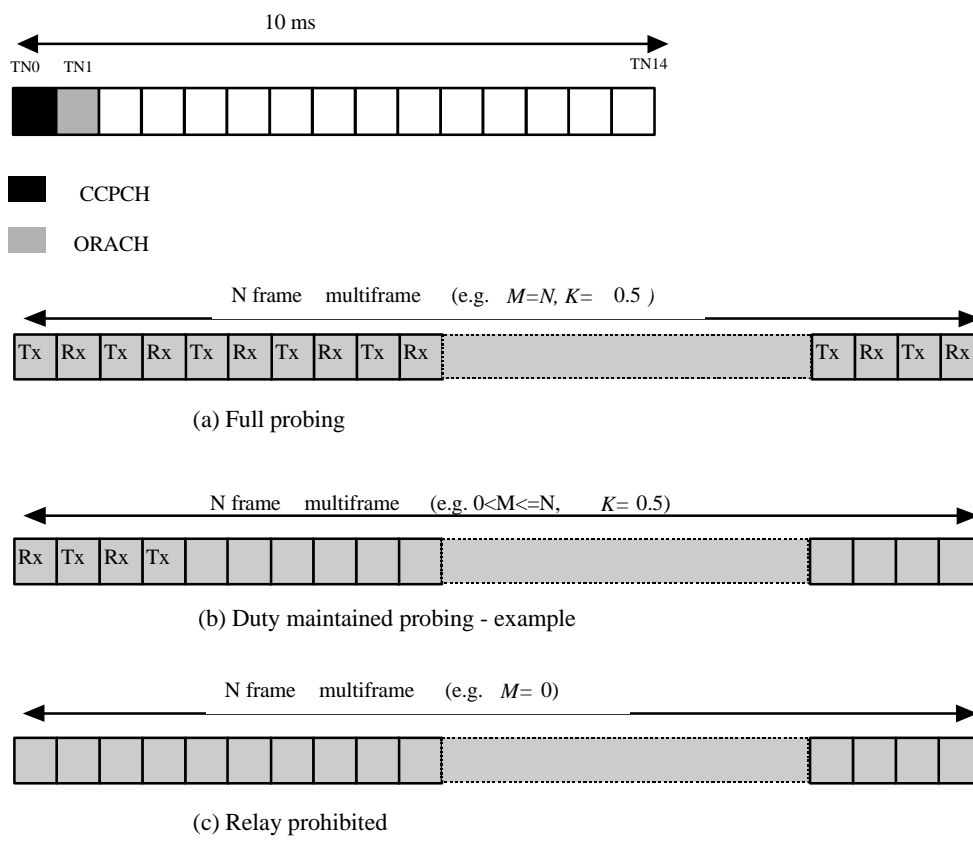


Figure 1: Probing state machines and mechanism

4.5.3 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 2.

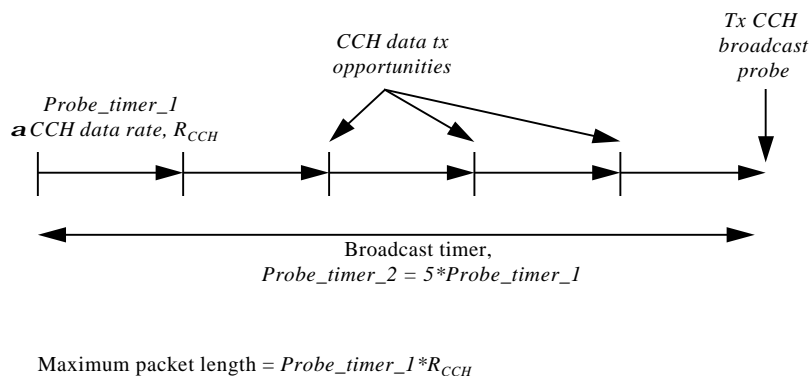


Figure 2: Probe timer relationships

4.6 Discontinuous transmission (DTX) of Radio Frames

Discontinuous transmission (DTX) is applied in up- and downlink when the total bit rate after transport channel multiplexing differs from the total channel bit rate of the allocated dedicated physical channels.

Rate matching is used in order to fill resource units completely, that are only partially filled with data. In the case that after rate matching and multiplexing no data at all is to be transmitted in a resource unit the complete resource unit is discarded from transmission. This applies also to the case where only one resource unit is allocated and no data has to be transmitted.

4.7 Downlink Transmit Diversity

4.7.1 Transmit Diversity for DPCH

The transmitter structure to support transmit diversity for DPCH transmission is shown in Figure 3. Channel coding, interleaving and spreading are done as in non-diversity mode. The spread complex valued signal is fed to both TX antenna branches, and weighted with antenna specific weight factors w_1 and w_2 . The weight factors are complex valued signals (i.e., $w_i = a_i + jb_i$), in general. These weight factors are calculated on a per slot and per user basis. The weight factors are determined by the UTRAN.

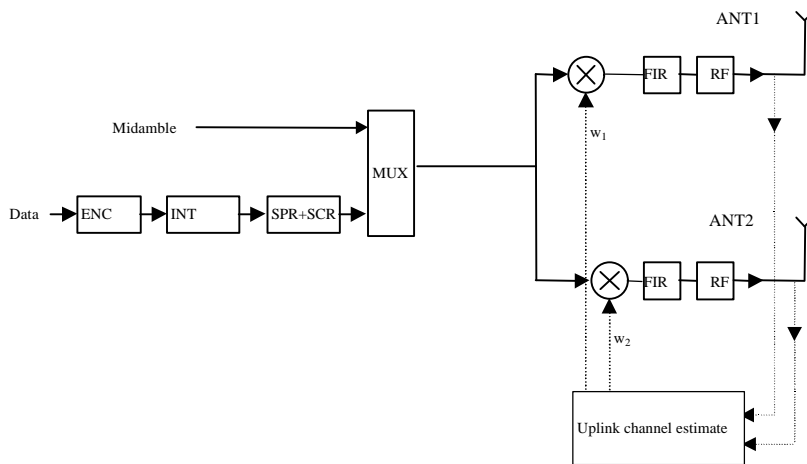


Figure 3. Downlink transmitter structure to support Transmit Diversity for DPCH transmission (UTRAN Access Point)

4.7.1.1 Determination of Weight Information

Selective Transmit Diversity (STD) and Transmit Adaptive Antennas (TxAA) are examples of transmit diversity schemes for dedicated physical channels.

4.7.1.1.1 STD Weights

The weight vector will take only two values depending on the signal strength received by each antenna in the uplink slot. For each user, the antenna receiving the highest power will be selected (i.e. the corresponding weight will be set to 1).

Table 2: STD weights for two TX antennas

	W_1	W_2
Antenna 1 receiving highest power	1	0
Antenna 2 receiving highest power	0	1

4.7.1.1.2 TxAA Weights

In a generic sense, the weight vector to be applied at the transmitter is the \underline{w} that maximises:

$$P = \underline{w}^H H^H H \underline{w} \tag{1}$$

where

$$H = [\underline{h}_1 \ \underline{h}_2 \ \dots]$$

and where the column vector \underline{h}_i represents the estimated uplink channel impulse response for the i 'th transmission antenna, of length equal to the length of the channel impulse response.

4.7.2 Transmit Diversity for SCH

Time Switched Transmit Diversity (TSTD) can be employed as transmit diversity schemes for synchronisation channel.

4.7.2.1 SCH Transmission Scheme

The transmitter structure to support transmit diversity for SCH transmission is shown in Figure 4. P-SCH and S-SCH are transmitted from antenna 1 and antenna 2 alternatively. Example for antenna switching pattern is shown in Figure 5.

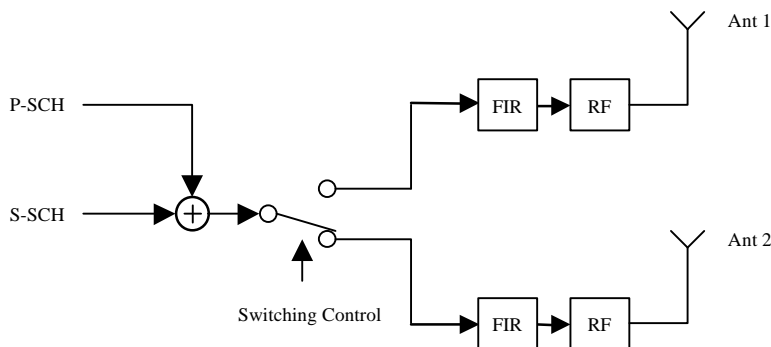


Figure 4. Downlink transmitter structure to support Transmit Diversity for SCH transmission (UTRAN Access Point)

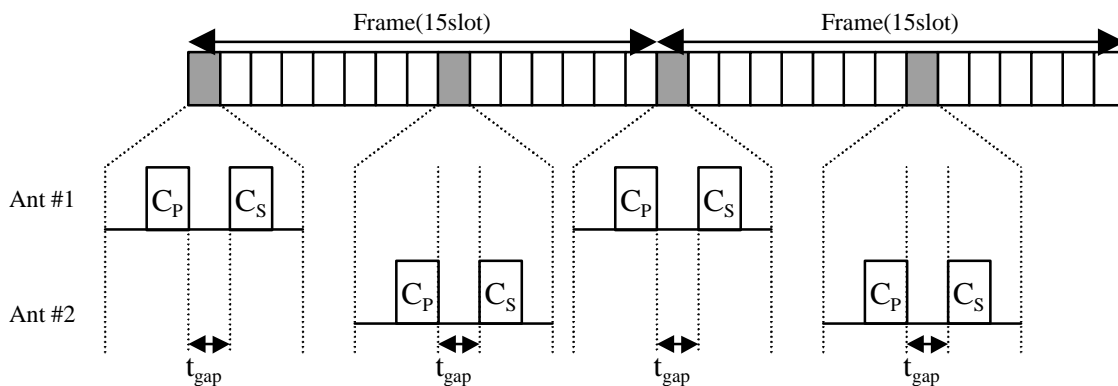


Figure 5. Antenna Switching Pattern (Case 2)

Annex 1 – an Example for Calculating α

This annex presents an example for calculating the path loss weighting parameter for open loop power control α .

α can be calculated as $\alpha = 1-(D-1)/6$ where D is the delay, expressed in number of slots, between the uplink slot and the most recent downlink slot. Note that $\alpha=1$ for a delay of one slot (minimal delay), and $\alpha=0$ for a delay of 7 slots (maximal delay).

5 History

Document history		
V1.0.0	22.04.1999	First version created based on S1.24 version 2.0.0 at TSG-RAN#3 to reflect the new specification numbering scheme and the status of the document.
V1.0.1	24.07.1999	Modifications due to OHG decision (#853), text proposals at WG1#6: timing advance (#860), UL synchronisation (#941), power control (#A08, modified)
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