3GPP (S1.24) V0.1.0 1999-02

# TDD, Physical Layer Procedures Description

# Contents

# 1 Intellectual Property Rights

<Editors note: ETSI text has been deleted. Text applicable to 3GPP has to be inserted>

# 2 Foreword

This document has been produced by 3 GPP organisation.
It describes physical layer procedures for Physical Layer TDD mode.
<Editors note: Text applicable to 3GPP has to be inserted>

# 3 Document Status

<Editors note: This has to be adapted to current 3GPP status>

# 4 References

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply;
b) publications without mention of a specific version, in which case the latest version applies.

# 5 Definitions and abbreviations

<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 | Synchronisation Channel |
| UE | User Equipment |
| VBR | Variable Bit Rate |

# 6 Physical layer procedures (TDD)

## 6.1 General

## 6.2 Synchronisation of NodeBs and ODMA Relays

### 6.2.1 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.

#### 6.2.1.1 Inter-system-synchronisation

<Editors Note: to be determined>

### 6.2.2 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

## 6.3 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)

<Editors Note: Especially the measurements need to be standardised which are the inputs for the DCA algorithm; details are FFS.
It was decided to draft a liaison statement to the WG2,WG4 and architecture group concerning the TDD specific protocol functions, location of DCA etc. The number of this liaison statement is TDoc R1(99) 107.>

### 6.3.1 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.

### 6.3.2 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.

1. The following principles hold for fast channel allocation: The basic RU used for channel allocation is one code / timeslot / (frequency).
2. 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.
3. 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.

4. 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.
5. 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.

### 6.3.3 Resource allocation for ODMA

<for further study>

## [6.4 Power Control (ETSI)

*<editor's note: the basic characteristics are the same for ETSI and ARIB. The description, however, is different and some section of ARIB TDD are for further study for ETSI TDD, like diversity handover.>*

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 -**Error! Unknown switch argument.**: 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

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## 6.4.1 ODMA Power Control

<for further study>

# [6.4 Transmitter Power Control (ARIB 3.3.6.7)

*<The text in the ARIB FDD section, which is referred to, is based on the specific physical structure and timing. It might not be applicable for other channel structures. Also the figures in this chapter should be adapted in the future.>*

## 6.4.1 Reverse link Control (ARIB 3.3.6.7.1)

### 6.4.1.1 Common Physical Channel

Transmission power of perch channel and reverse link interference power are transmitted using BCCH. Mobile station decides transmission power of RACH by open loop power control based on the information and the signal power level of the Perch channel.

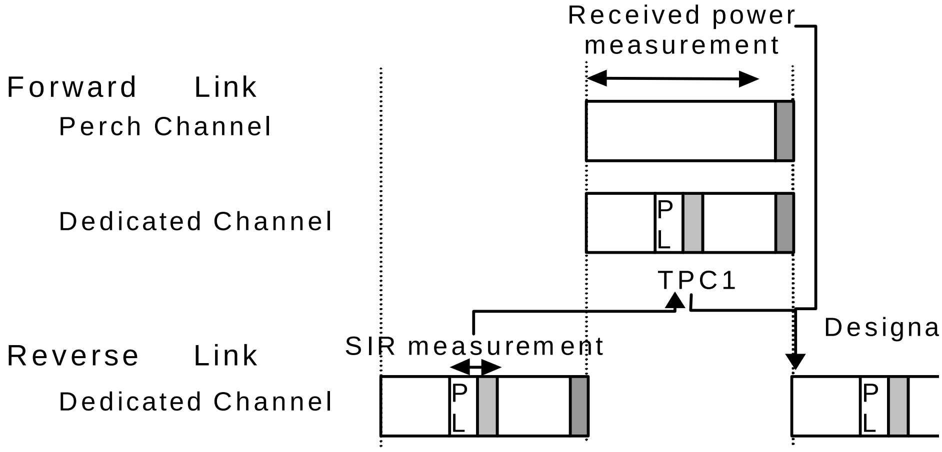
### 6.4.1.2 Dedicated Physical Channel

The initial transmission power is decided in a similar manner as RACH. After the synchronization between BTS and MS is established, MS transits into a combination scheme of open-loop and fast closed-loop transmitter power control (TPC). Fast closed-loop TPC is based on SIR, and the TPC processing procedures are the same as the FDD mode. During this power control process, the BTS periodically makes a comparison between the received SIR measurement value and the target SIR value. 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“. The TPC bits shall be transmitted continuously to the MS. At the MS, soft decision on the TPC bits is performed, and when it is judged as „0“, the target received power at the BTS ($P_{BTS}$) shall be reduced by $P_{TPC2}$dB, whereas if it is judged as „1“, $P_{BTS}$ shall be raised by $P_{TPC2}$dB. The MS measures the received signal power of the perch channel, which is code multiplexed with the dedicated channel, at the previous forward link time slot. After this, the transmitter power is decided by the combination of open-loop and closed-loop transmitter power control based on the equation below:

$T_{MS} = (P_{BTS} + P_{TPC2}) + (T_{BTS} - R_{MS})$
$T_{MS}$: Transmission power of MS
$T_{BTS}$: Transmitted signal power level of perch channel on BTS, which is broadcasted on BCH
$P_{BTS}$: Target received power on BTS
$R_{MS}$: Received power of Perch channel on MS

When the TPC bit cannot be received due to out-of-synchronisation, $T_{MS}$ shall be kept at a constant value. When SIR measurement cannot be performed for being out-of-synchronisation, the TPC bit shall always be = „1“ during the period of being out-of-synchronisation.
Fig.3.3.6-3 shows reverse link transmitter power control timing. The combination power control of open loop with 1-slot control delay and closed loop with 2-slots control delay can be realised.

Fig.3.3.6-3 Reverse link transmitter power control timing



##### 6.4.1.2.1Outer Loop
This is the same as FDD mode.

##### 6.4.1.2.2 Transmitter power control upon Inter-sector Diversity Handover
This is the same as FDD mode.

#### 6.4.1.3 Transmitter power control upon Inter-cell Diversity Handover

(a)BTS operations

This is the same as FDD mode.

(b)MS operations

Receives the TPC bits independently in BTS units(inter-sector handover is performed). At the same time, measures the reliability of the TPC bits(received SIR) for each BTS. If there is even one „0“ among the soft decision majority result of TPC bits that satisfy the required reliability, the target received power on BTS($P_{BTS}$) shall be reduced by $P_{TPC}$dB. If the TPC bits are all „1“, $P_{BTS}$ shall be raised by $P_{TPC}$dB.

### 6.4.2 Forward link Control (ARIB 3.3.6.7.2)

#### 6.4.2.1 Perch Channel
This is the same as FDD mode.

#### 6.4.2.2 Common Physical Channel
This is the same as FDD mode.

#### 6.4.2.3 Dedicated Physical Channel
In principle, there is no restrictions on the initial transmission power of the forward link Dedicated Physical Channel. After the initial transmission, the BTS transits into SIR-based fast closed-loop TPC as similar to the FDD mode.
The measurement of received SIR shall be carried out periodically at the MS. 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“. 2bits are transmitted continuously to the BTS. At the BTS, soft decision on the TPC bits is performed, and when it is judged as „0“, the transmission power shall be reduced by $P_{TPC1}$dB, whereas if it is judged as „1“, the transmission power shall be raised by $P_{TPC1}$dB.
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.
Fig.3.3.6-4 shows forward link transmitter power control timing. The transmitter power control of closed loop with 2-slots control delay can be realised.

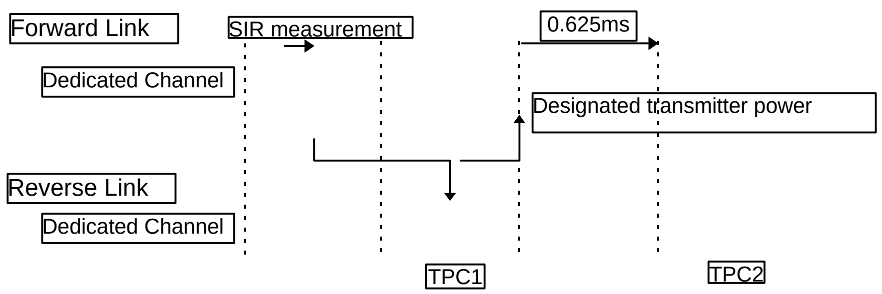



Fig.3.3.6-4 Forward link transmitter power control timing

### 6.4.3 Transmitter power control for Packet Data Transmission

Packet data transmission using the dedicated physical channels is always handled as a pair of reverse link and forward link as similar to the FDD mode.

Uplink common physical channel (RACH):
Open-loop transmitter power control is adopted.
Downlink common physical channel (FACH):
Transmission power is determined by the information transmitted on RACH, or fixed power.
Uplink dedicated physical channel (DCH):
Open-loop transmitter power control is applied basically. Fast closed-loop transmitter power control is combined with open loop control. TPC bits in downlink dedicated physical channel are used for power control.
Downlink dedicated physical channel (DCH):
Fast closed-loop transmitter power control is adopted. TPC bits in the uplink dedicated physical channel are used.
]

## 6.5 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 ($\Delta_{TA}$) 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.

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

## 6.6 Synchronisation and Cell Search Procedures

### 6.6.1 Cell Search

<Editors Note: It is approved according to TDoc TSGR1-(99)075 to have the following basic parameters:

- Length 256 chips primary and secondary synchronisation sequences
- SF of CCCH <=16
- Usage of $t_{off}$ and $t_{gap}$
- CCCH pointing is for further study (cf. TDoc R1#2(99) 74)

>

During the initial cell search, the UE searches for a cell. It then determines the midamble, the downlink spreading code and frame synchronisation of that cell. The initial cell search uses the synchronisation channel (SCH) described in S1.21.

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 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 $c_p$ which is common to all cells. The procedure is according to the description for the FDD mode in S1.14.

**Step 2: Frame synchronisation and code-group identification**

During the second step of the initial cell search procedure, the UE uses the secondary synchronisation 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 S1.21). 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 information 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.

## 6.7 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.

### 6.7.1 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.

### 6.7.2 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 × 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.

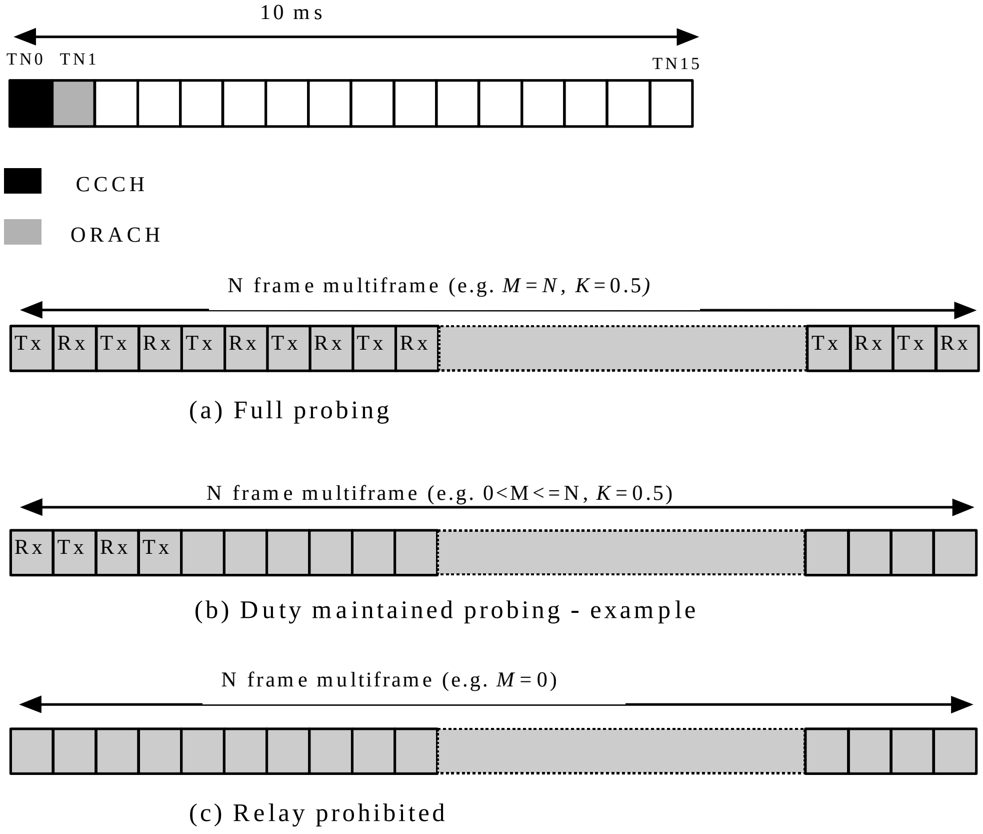



**Figure 3: Probing state machines and mechanism.**

## 6.7.3 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.

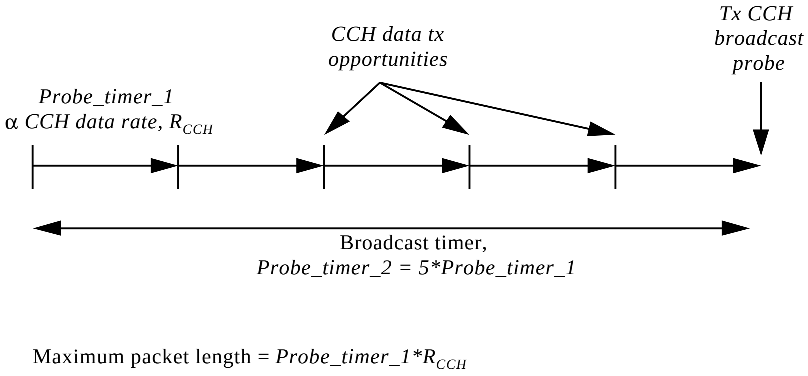



**Figure 3: Probe timer relationships.**

## 6.8 Idling Operation

<Editors Note: A text exists in ARIB 3.3.6.3 which is removed now since not applicable. This should be taken into consideration when new text is to be produced.>

## 6.9 Handover

<Editors Note: A text exists in ARIB 3.3.6.6 which is removed now since not applicable. This should be taken into consideration when new text is to be produced. It should be also considered that TDD handover measurements are covered in S1.25. Slotted mode for inter-frequency handover is described in S1.22. According to TDoc TSGR1-#2(99)074 the following items have been identified:

- Intra-frequency HHO: required
- Intra-frequency SHO: FFS
- Inter-frequency HHO: required

>

## 6.10 Discontinuous transmission (DTX) of Radio Frames

<Editors Note: A text exists in ARIB 3.3.6.9 which is removed now since not applicable. This should be taken into consideration when new text is to be produced.>

## 6.11 Forward Link Transmit Diversity

Transmit diversity in the forward link provides means to achieve similar performance gains as the mobile-station receiver diversity without the complexity of a second mobile-station receiver. Furthermore, transmit diversity improves the SIR and increases the system capacity. Depending on the mobile station's distance to the base station, its speed, and the asymmetry ratio, selective transmit diversity (STD) can be employed.

With STD, the received signal power of reverse link is measured for each of the antennas at the BTS over every single reverse link interval (1 slot). The antenna with the highest signal level is used to transmit the forward link information for that link during the next interval over which the carrier is used for the forward link (1 or more slots). The basis for the gains from this type of diversity is the availability of information on the channel due to the use of the same frequency for reverse link and forward link. STD is applied only to dedicated physical channels. STD can be applied if the distance between the different transmit antennas is small enough so that the delay profile from each antenna is almost the same.

<Editors Note: Other TX diversity schemes such as schemes for common channels and TXAA are for further study>

# 7 History

| Document history | | |
|---|---|---|
| v0.0.1 | 1998-02-09 | Document is a merged version of documents XX.13 V 0.5.0 of ETSI and Vol.3 V1.0 of ARIB. The merging is editorial and based on XX.13. Some sections of the corresponding ARIB text in chapter 3.3.6 of Vol 3 have been moved partly or completely to other specifications. |
| v0.0.2 | 1999-02-24 | This version was edited according to the recommendations from TDoc TSGR1-#2(99)75 which was agreed by the TSG RAN WG1 Meeting #2 in Yokohama on February the 23rd of 99.<br>The usage of ODMA is still under study.> |
| V0.1.0 | 1999-02-25 | The version number was increased due to approval on TSG RAN WG1 Meeting #2 in Yokohama. |
| Temporary editor for UMTS physical layer procedures, TDD parts, is:<br><br>Stefan Oestreich, Siemens AG<br>Tel: +49 89 722 21480, Fax: + 49 89 722 24450, Email: stefan oestreich@icn.siemens.de<br><br>This document is written in Microsoft Word 7.0. | | |