TSG-RAN Working Group 4 meeting #6 **TSGR4#6(99) 361**

Queensferry, 26. – 29. July 1999

Agenda Item:

Source: SIEMENS

Title: **UE maximum output power and UE power classes (TDD)**

Document for: Discussion and Decision

---

1. Introduction

In this paper **UE maximum output power for TDD** and **power classes,** which are candidates for different environments, are discussed.

Some basic aspects to specify the output power classes for TDD-UE are identified and discussed. At the end of the paper a text proposal for document TS 25.102 is enclosed.

2. General assumptions

The following assumptions are made to discuss the attached text proposal:

- An important point of view is to achieve FDD-TDD-harmonization.
- FDD-TDD-dual-mode handheld terminals based on a common hardware-platform should be supported.
- Terminals with an output power less than 30dBm fulfill the SAR limitations, which are mandatory to handhelds.

3. Basic aspects for UE power classes

The following items give an overview of aspects which are taken into account when defining UE power classes for TDD mode:

- 2nd generation standards
- FDD-TDD-harmonization impacts
- Implementation aspects
- System scenarios

Now, lets discuss them separately and show their influence and restrictions:

3.1 2nd generation standards

3rd generation systems are designed in the way to have capabilities of 2nd generation systems like GSM, DECT, ..., too. Roaming and handover between both GSM and UMTS are very important. In the start up phase of UMTS, GSM could guarantee coverage. GSM is able to operate large cells with low traffic whereas a UMTS net consists of smaller cells with higher bandwidth. The 3rd generation system UMTS is required to serve both licenced and unlicenced operation (e.g. wireless home base stations like state-of-the-art DECT systems). So it is necessary and makes sense to have a look on them and also at the proposed power levels of other IMT2000-RTT-candidates, especially to their UE power classes. Table 1 and Table 2 give a brief and compact overview of defined 2G and 3G power classes:

Table 1: Overview 2nd generation power classes

Power class	**GSM 900** [1]	**DCS 1800**	**PCS 1900** [2]	**DECT 1800** [3]
1	(43dBm 20W) [1])	30dBm (1W)	30dBm (1W)	4dBm (0.0025W)
2	39dBm (8W)	24dBm (0.25W)	24dBm (0.25W)	24dBm (0.25W)
3	37dBm (5W)	36dBm (4W)	33dBm (2W)	
4	33dBm (2W)			
5	29dBm (0.8W)			

Notes: [1]) GSM Phase 1 only

Table 2: Overview of power classes of other RTT systems

Power class	**TIA/EIA-95-B 1.9 GHz** [4]	**ARIB W-CDMA** [5]	**Blue-Tooth 2.4 GHz** [6]
1	28 dBm < EIRP < 33dBm	Nominal value: 24dBm (8kbps voice)	20dBm 100mW
2	23 dBm < EIRP < 30dBm		4dBm 2.5mW
3	18 dBm < EIRP < 27dBm		
4	13 dBm < EIRP < 24dBm		
5	8 dBm < EIRP < 21dBm		

3.2 FDD-TDD-harmonization

An important element in the process defining power classes is to take FDD-TDD harmonization into account. From operators point of view as few as possible power classes are senseful. So only four FDD power classes have been defined. Table 3 shows FDD power classes:

Table 3: FDD power classes

Power Class (PC)	**Maximum Output Power**	**Tolerance**
1	33dBm (2W)	+1dB/-3dB
2	27dBm (0.5W)	+1dB/-3dB

3	24dBm (0.25W)	+1dB/-3dB
4	21dBm (0.125W)	+/-2dB

The maximum output power of FDD PCs 2 till 4 is smaller compared to GSM because of continuous transmission instead of non-continuous transmission of GSM. The maximum transmission power determines the cell radius.

Dual-mode FDD-TDD UE should be able to share the hardware-platform, especially the power amplifier (PA) between both modes, the FDD mode and the TDD mode, respectively. This saves money and volume. In both cases the PA is optimized by conflicting optimization criterion:

- FDD mode: continuous wave (CW) transmission
- TDD mode: peak operation (1 or more timeslots per frame)

In average, the number of timeslots per frame used per UE for transmission in TDD mode will be in general much smaller than 15. So in TDD mode the power amplifier is most of the time per frame inactive in opposite to continuous transmission of FDD mode.

Only in the seldom and unlikely case when a maximum of 13 timeslots is allocated to UL, the power amplifier is active during 87% of the frame duration what is comparable to continuous transmission in FDD mode. However, this scenario will not be very realistic for handheld terminals in TDD mode, e.g. operating on speech services.

As a compromise one could use a PA with i.e. 21 dBm continuous wave operation (FDD), which is also able to offer 24 dBm peak power (TDD).

3.3 Implementation aspects

The transmission power P_{tx} depends on the output power of the power amplifier (PA) and the losses from PA to the antenna connector:

$$P_{tx} = PA_{OutputPower} - losses$$

The demands on a TDD-PA and on a FDD-PA are nearly the same. This depends on the demands on the PA enclosing frequency spectrum, occupied bandwidth, cdma requirements, linearity necessitate, environment (handheld..., standby time, ...), accuracy of output power.

Also the unavoidable losses are nearly the same in both cases, FDD and TDD, respectively. Responsible for losses are filter, antenna switch, combiner or duplex filter (only FDD), and the antenna connector. In case of operating a dual mode FDD-TDD UE in the TDD mode, the duplex filter remains in the signal path or has to be bypassed using switches with additional signal degrading alternatively.

From the implementation point of view, handheld terminals will be able to support a maximum output power up to 30dBm. Recent state-of-the-art power amplifiers approach this power level segment with the other features (bandwidth, linearity, efficiency, size, ...) moving closer and closer to UMTS requirements.

Tolerances:

Tolerances defined in FDD are also acceptable and reachable by an TDD-UE. In GSM a tolerance of ±2 dB is defined under normal conditions. With todays possibilities and capabilities the tolerance-window of absolute 4dB is realizable and not to strict. Therefore tolerances defined in FDD are appropriate for the corresponding TDD power classes (3dB above FDD PC) too.

For power class 4 (10dBm) the tolerance is chosen by ±4dB. This value is known from implementation experience with state-of-the-art GSM hardware. In GSM specification 05.05 the absolute power control levels and their tolerances are defined separately. Under normal conditions, for power control level 10 = 10dBm a tolerance of ±4dB is defined.

3.4 System scenarios

Like in GSM, different applications and scenarios ask for proper UE power classes. The main important are:

- Handheld terminal

- Vehicle-mounted UE: power classes with higher power should be defined to cover vehicle-mounted UE similar to GSM 900 where the power class level dedicated to vehicle-mounted UE is 4 times as large as handheld power class level)
- Fixed mounted UE station
- Coexistence scenarios to FDD, DECT, GSM, ...
- Pico-cell scenarios (especially in unlicensed operation)

The proposed power classes shall be able to support all of these system scenario requirements.

4. Conclusions

Taking all the arguments into account, the following four power classes are proposed for the TDD UE output power:

- 10dBm (0.01W)

  This power class shall cover pico-cell application needs and indoor scenarios similar to bluetooth, DECT or other short-range-radio systems. Especially, this power class is very interesting for unlicensed operation.

- 24dBm (0.25W)

  According to the 3dB-gap between FDD and TDD power classes discussed above, this power class corresponds to the FDD power class 4 with 21dBm maximum output power. This power class is intended to be used by handheld dual mode FDD-TDD devices.

- 30dBm (1W)

  Also this power class level lies 3dB above the corresponding FDD power class level of 27dBm (FDD power class 2). This class will support the highest output power levels supporting handheld UEs.

- 36dBm (4W)

  This power class envisages vehicular-mounted terminals as well as fixed mounted UE. Similar to GSM specification, this power class level is chosen four times the highest power level of handhelds.

All the tolerances are proposed due to FDD harmonization and implementation aspects.

Text proposal for TS 25.102

6.2.1 User Equipment maximum output power

The following Power Classes define the maximum output power;

Power Class	Maximum output power	Tolerance	
1	~~[+33]~~ +36dBm	~~[~~+1dB /-3dB~~]~~	
2	~~[+27]~~+30 dBm	~~[~~+1dB /-3dB~~]~~	
3	~~[~~+24~~]~~ dBm	~~[~~+~~1dB~~ 2dB /-~~3dB~~2dB~~]~~	
4	~~[+21]~~+10 dBm	~~[~~+~~1dB~~ 4dB /-~~3dB~~4dB~~]~~	
~~5~~	~~[+10] dBm~~	~~[+1dB / 3dB]~~	
~~6~~	~~[0] dBm~~	~~[+1dB / 3dB]~~	

Table 1; UE power classes.

Note

1. The maximum output power refers to the measure of power when averaged over the useful part of the transmit timeslot at the maximum power control setting.

2. The maximum output power shall be specified with respect to a defined reference condition (power control status, type of timeslot {physical channel} and averaging method). The reference conditions are for further study.
3. For multi-code operation the maximum output power will be reduced by the difference of peak to average ratio between single and multi-code transmission. The error of the maximum average power is below the prescribed value even at the multi-code transmission mode <new text is required to clarify this sentence>
4. ~~.~~Power class~~es 5 and 64 are~~ is envisaged for unlicensed operation.
5. For UE using directive antennas for transmission, a class dependent limit will be placed on the maximum EIRP (Equivalent Isotropic Radiated Power).~~.~~

End of Text Proposal for 25.102

5. Definitions and abbreviations:

ACLR	Adjacent Channel Leakage Power Ratio
DL	Downlink
CW	Continuous Wave
EIRP	Equivalent Isotropic Radiated Power
EMC	ElectroMagnetic Compatibility
FDD	Frequency Division Duplex
PA	Power Amplifier
PC	Power Class
RTT	Radio Transmission Technique
RX	Receiption
SAR	Specific Absorption Rate
TDD	Time Division Duplex
TX	Transmission
UE	User Equipment
UL	Uplink
2G	second generation systems (i.e. GSM)
3G	third generation systems (i.e. UMTS)

6. References

[1] GSM 05.05 Version 5.2.0, July 1996; Digital cellular telecommunications system (Phase 2+); Radio transmission and reception

[2] J-STD-007 Air Interface: Volume 1 BALLOT VERSION, T1P1.5/97-087

Personal Communications Services PCS1900; Air Interface Specification Radio Path Physical Layer

[3] ETS 300 175-2 Radio Equipment and Systems (RES); Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 2: Physical layer (PHL), September 1996

[4] TIA/EIA-95-B: The cdma2000 ITU-R RTT Candidate Submission (0.18) V0.17 / 27-Jul-98

[5] Japan's Proposal for Candidate Radio Transmission Technology on IMT-2000 : W-CDMA June,1998

[6] Bluetooth Specification Version 0.8 21 January 1999 (intermediate draft)

[7] TS 25.101 v2.1.0 UE Radio Transmission and Reception FDD