Understanding Downlink Power Allocation in LTE

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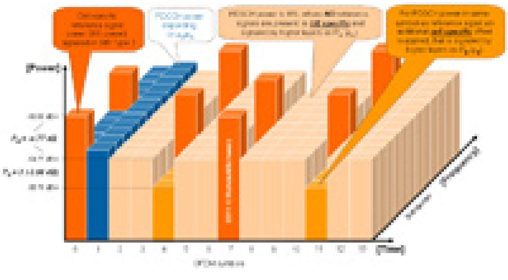
UMTS Long Term Evolution, short LTE, is the technology of choice for the majority of network operators worldwide, providing mobile broadband data and high-speed internet access to their subscriber base. Due to the high commitment LTE is understood as the innovation platform for the wireless industry for the next decade. That’s the reason why I link the abbreviation LTE more to the term LONG TERM EMPLOYMENT. The technology itself is high complex, utilizing advanced procedures on top of what we know from existing standards such as WCDMA or HSPA. This blog picks interesting aspects of LTE and takes a closer look while providing some explanations around it. A basic understanding of the concepts used for LTE and standardized by the 3rd Generation Partnership Project (3GPP) is assumed while reading.

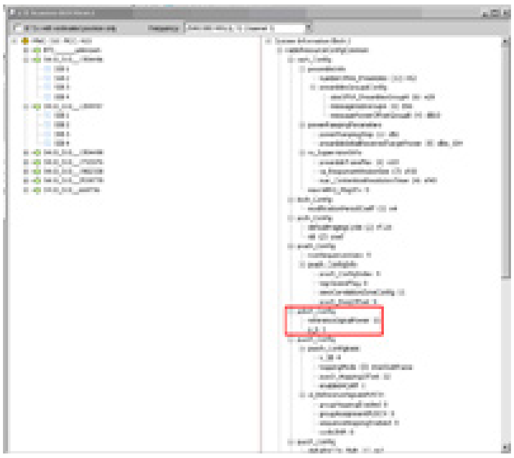
You may ask why power allocation in the downlink is an aspect? It actually is ? and therefore I thought it is interesting to shed some light on it. Well, downlink power allocation can vary from cell to cell and furthermore it can be device specific. These settings – beside many others – will have an impact on the performance of an LTE-capable device. And data throughput is, of course, a performance criteria that not only network operators are judging, but also affect the user experience. But let’s start with the fundamentals first.



[1]

As you know, cell-specific reference signals (RS) are embedded into the overall signal bandwidth at certain resource elements (RE). In the frequency domain every 6th subcarrier (= RE) carries a RS. The RS pattern is a pseudo-random sequence, whose generation depends on the cell's identity and used cyclic prefix. Further a frequency shift is applied that is based on a modulo-6 operation. The mapping of the pattern is therefore cell-specific, but the scattering is always six subcarriers.

In the time domain every 4th OFDM symbol carries reference symbols. Due to their importance, reference signals are the highest powered components within the downlink signal. The power level for the reference signals is signaled within system information to the device, is cell-specific, and is in the range of -60 to +50 dBm per 15 kHz. It is a requirement that the LTE base station transmits all reference signals with constant power over the entire bandwidth. The power of all other signal components (synchronization signals, PBCH, PCFICH, PDCCH, PDSCH and PHICH) is set relative to this value. As mentioned above, there are OFDM symbols that do contain RE carrying reference symbols and there are OFDM symbols that do not. The relative PDSCH power for these symbols is given by two different parameters: p_A and p_B (see Figure 1).



[2]

For the majority of cases p_A corresponds to the parameter P_A, that is signaled via higher layers. Only for some special cases, like transmit diversity with four antennas or Multi-user MIMO, p_A is computed differently. P_A is device specific, comes as part of the RRCConnectionSetup message, and can take one out of eight different values Figure 1 assumes P_A to be -4.77 dB.

P_B is related to the cell-specific RS power and can not be changed dynamically. It can take one out of four integer values. Depending on the number of used transmit antennas (1, 2 or 4) each value corresponds to a certain ratio and thus power offset. The LTE networks that are currently deployed worldwide are supporting 2x2 MIMO. Let's assume P_B = 3. In that case the RE carrying data in that OFDM symbol where RS are present, are transmitted with an additional offset of 3 dB compared to symbols without RS [Ref.3]. For only one transmit antenna (SISO) P_B = 3 translates to -3.98 dB. This is shown in Figure 1.

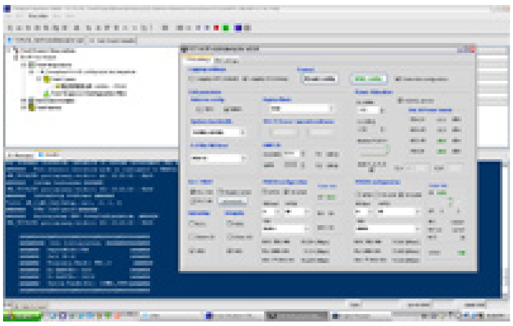
Now the question is, why all this is necessary?

The overall goal is to have a constant power for all OFDM symbols to avoid power variations at the receiver (UE). With less PDSCH power given by P_B the boost of reference signals is compensated, compared to OFDM symbols that do not contain reference signals. The PDSCH power depends always on the allocation, i.e. the number of allocated Resource Blocks (RB). Allocation can change from subframe to subframe, thus P_A can also change on a 1 millisecond basis. While incorporating P_A and P_B it is ensured that the overall OFDM symbol power remains constant, even when the PDSCH allocation is changed.

What are values for P_A and P_B in a real LTE network?

The later can be easily derived with Rohde&Schwarz drive test solution based on the TSMW network scanner and ROMES drive test software as it is a common network parameter. The integrated BCH demodulator decodes all system information, so P_B and reference signal power can be easily found while decoding SIB Type 2 (see Figure 2).

Now what is the impact of P_B, P_A on device performance in terms of high data rates?



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These types of investigation can be carried out with the R&S®CMW500 Wideband Radio Communication Tester. With the software Throughput Configuration Tool for LTE (TCT4LTE), that comes at no costs, the instrument can be easily configured for example for maximum throughput testing. Beside P_A, P_B and other essential cell parameters, ciphering and authentication modes, resource allocation for downlink and uplink with modulation and coding schemes can be changed on the fly (see Figure 3).

This type of testing helps design engineers to develop a good understanding on how the device performs at different network settings in terms of downlink power allocation to optimize the protocol stack, algorithms and hardware to deliver best results. Rohde & Schwarz helps to achieve these goals with its test solutions and tools.

References

[1] 3GPP TS 36.211 V8.9.0 Physical channels and modulation (Release 8), 2009-12

[2] 3GPP TS 36.212 V8.8.0 Multiplexing and channel coding (Release 8), 2009-12

[3] 3GPP TS 36.213 V8.8.0 Physical layer procedures (Release 8), 2009-09