Agenda item:	**AdHoc #24 HSDPA**
Source:	**Motorola**
Title:	**Peak to Average Impact at Node-B due to HSDPA**
Document for:	**Approval**

Introduction:

Let $s(t)$ denote the complex base band equivalent model of the Node-B transmitted signal. Thus, the power in $s(t)$ is given by

$$z(t) = s(t)s^*(t) \qquad (1)$$

Define the peak-to-average power ratio (*PAP*) as

$$PAP(Z) = 10 \times \log10\left(\frac{z_p}{E\{z(t)\}}\right) \qquad (2)$$

where *Z* represents a random variable taken from the *z(t)* random process and the peak value of Z, denoted by z_p, is defined as the α percent value that Z takes such that

$$P\{Z \le z_p\} = \int_0^{z_p} p(z)dz = \alpha \qquad (3)$$

where $p(z)$ is probability density function of *Z*.

The *PAP* is an important design metric since when the signal passes through a non-linear device, such as a power amplifier, the signal may suffer significant spectral spreading and in band distortion. Typical approaches to remedy this problem are to use a linear amplifier or to backoff the operating point of a non-linear amplifier. Both of these approaches result in significant power efficiency degradation.
Before evaluating the *PAP* of a Node-B using HS-DSCH it is important to assess the *PAP* of existing Rel-99 system.

Rel-99 W-CDMA System:

The W-CDMA Rel-99 forward link uses QPSK modulation and spreading which can be modeled as shown in Figure 1, and can be represented by

$$s(t) = s_I(t) + js_Q(t) \qquad (7)$$

where $s_I(t)$ and $s_Q(t)$ are the inphase and quadrature components.
The power in $s(t)$ is given by

$$z(t) = s(t)s^*(t) = s_I(t)^2 + s_Q(t)^2 \qquad (8)$$

Again invoking the Central-Limit theorem, it can be easily shown that $s_I(t)$ and $s_Q(t)$ are independent zero-mean Gaussian distributed with identical variance σ^2. Thus, $z(t)$ becomes Exponentially distributed, i.e.

$$P\{Z \le z\} = \int_0^{z_p} e^{-z/2\sigma^2} dz = 1 - e^{-z/2\sigma^2}, \; z \ge 0 \qquad (9)$$

The mean of Z is given by

$$E\{z(t)\} = E\{s_I(t)^2\} + E\{s_Q(t)^2\} = 2\sigma^2 \qquad (10)$$

and z_p is easily computed from (9) as

$$z_p = 8\sigma^2 \ln(10) \qquad (11)$$

Therefore, the *PAP* is given by

$$PAP_{Rel-99} = 10 \cdot \log 10(4 \cdot \ln(10)) = 9.64dB \qquad (12)$$

W-CDMA using HS-DSCH

The HSDPA system uses a combination of QPSK, 16-QAM and 64-QAM and QPSK spreading and can be modeled as shown in Figure 2. The *PAP* for HSDPA system is also given by Equation (12).
The *PAP* is evaluated using simulation using transmit filter that is two times up-sampled for both the systems. Figure 3 shows the complementary CDF for the PAP for the above systems. It may be observed from the figure that the *PAP* performance of the HSDPA system is approximately 0.1dB worse than the value shown in Equation 12 (at 1e-04 point). Note that the Rel-99 simulation assumes 20 users utilizing Walsh of size 32 and HSDPA simulation assumes an equiprobable mix of QPSK, 16 QAM and 64 QAM.

Conclusions: It can be concluded that the PAP is not affected for a W-CDMA system using HS-DSCH with higher order modulation.

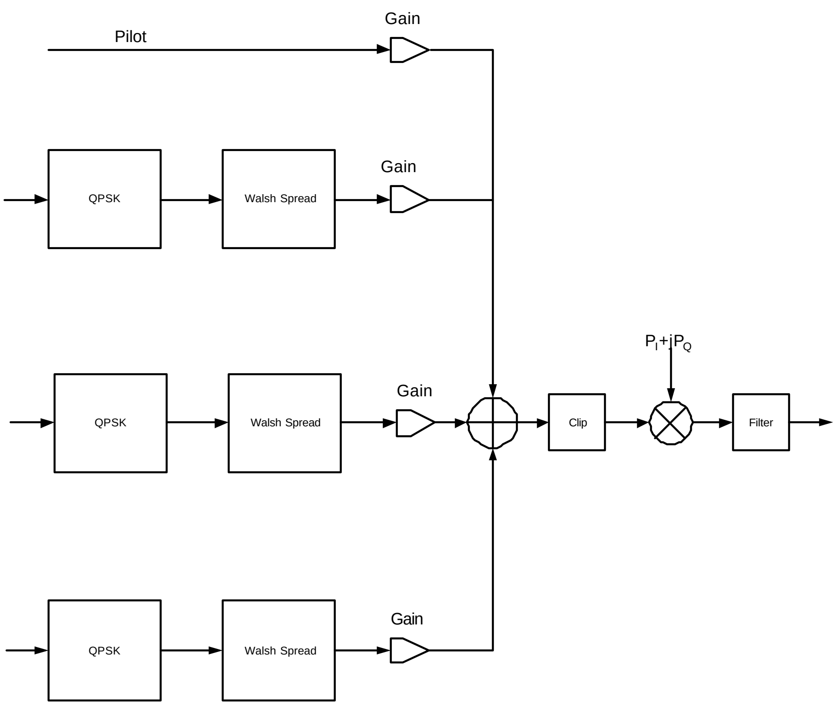

Figure 1. Release-99 BTS Transmitter Model

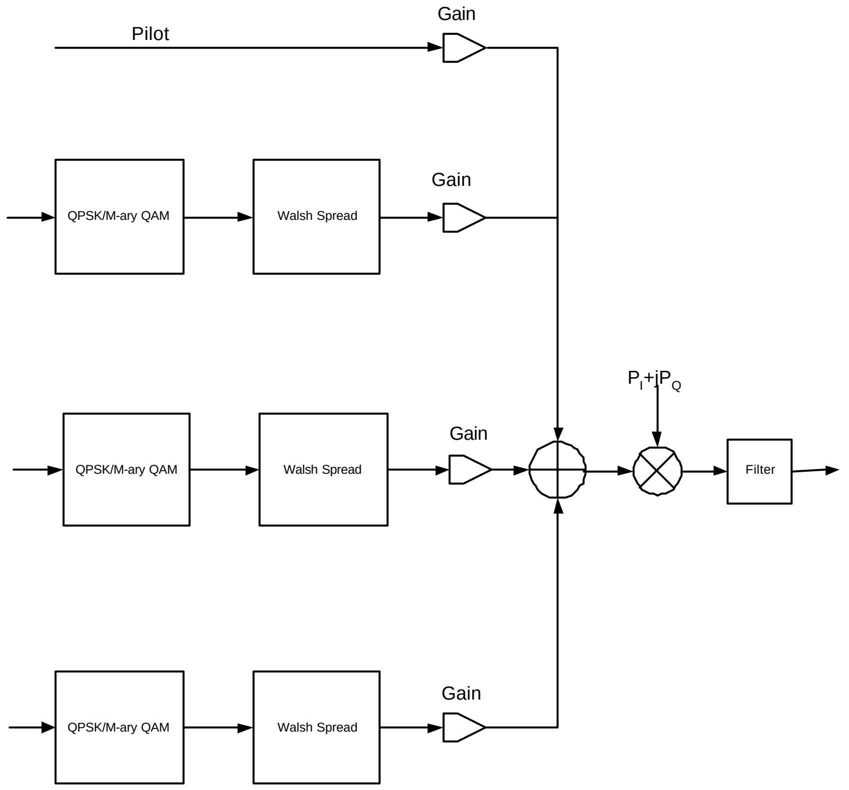

Figure 2 HS-DSCH BTS Transmitter Model

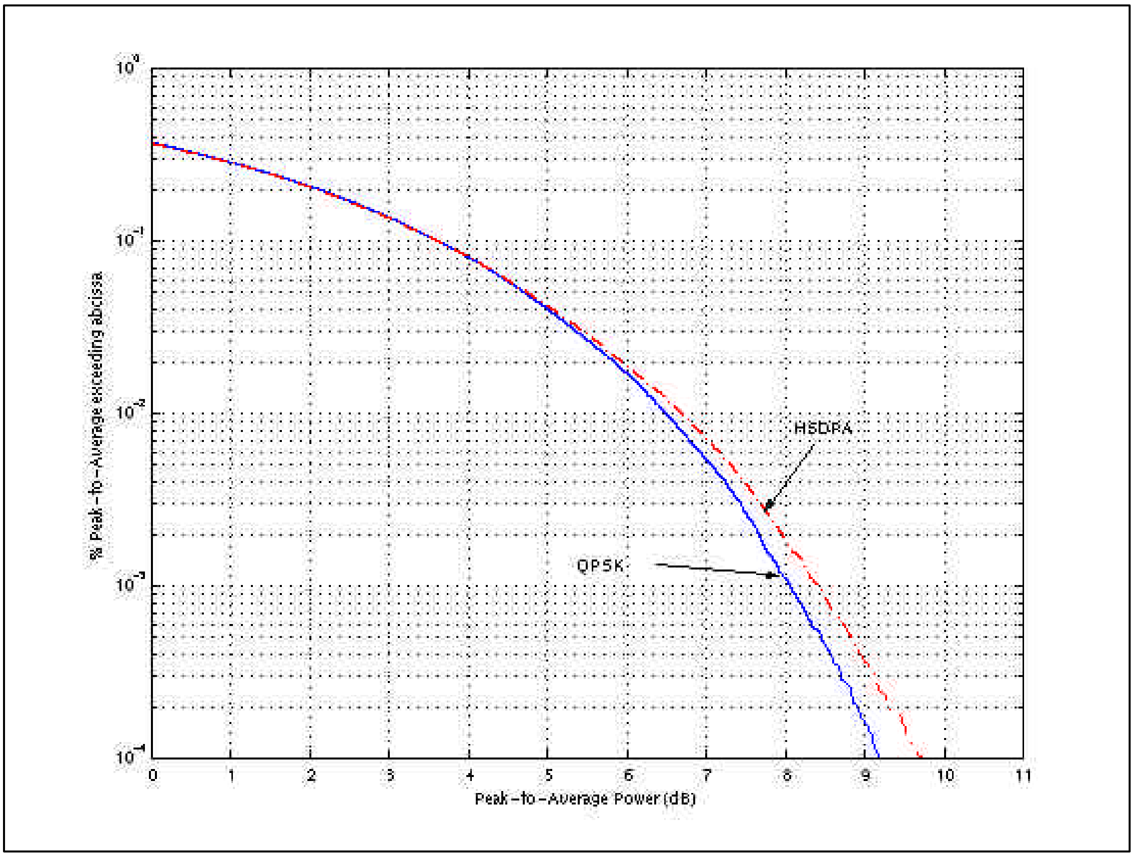

Figure 3. CCDF of the Peak-to-Average Power Ratio for Rel-99 and W-CDMA system using HS-DSCH