WCDMA 시스템에서 단말기 RF 송신 성능 분석

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Performance Analysis of UE RF Transmitting for WCDMA System

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Abstract

This paper evaluates the RF transmitting parameters of User Equipment(UE) for W-CDMA system based on 3GPP specifications. The parameters of transmitter are derived from the aspect of RF. In order to keep UE in high performance, the transmitter requirements such as ACLR, EVM, Peak Code Domain Error, spectrum emission mask are considered. The UE transceiver is implemented on the basis of performance requirements and then tested for the analysis of RF transmitter characteristics through test scenarios.

I. INTRODUCTION

The wideband-code division multiple access (W-CDMA) system offering voice, packet and image simultaneously has different data rate on the basis of required service. In this paper, 12.2 kbps of data rate is used as a signal source to verify the performance of User Equipment (UE) for W-CDMA system [1].

The W-CDMA based on third generation partnership project (3GPP) begins with a signal at a data rate of 12.2 kbps and it is variable up to 2 Mbps[1]. After processing of coding and interleaving, the symbol rate becomes 30 kbps. This symbol spreads with the special code to the chip rate of 3.84 Mcps. The uplink frequency band is from 1920 MHz to 1980 MHz and the down link frequency band is from 2110 MHz to 2170 MHz. The nominal frequency spacing is 5 MHz. In the downlink, quadrature phase-shift keying (QPSK) modulation is employed and root raised cosine (RRC) filtering is applied to shape spectrum. The uplink uses a more complicated hybrid QPSK modulation method to minimize amplitude variations of transmitted signal.

In this work, main RF transmitting factors of UE for W-CDMA are defined on the basis of 3GPP specifications. Several major RF parameters such as Adjacent Channel Leakage Ratio (ACLR), Error Vector Magnitude (EVM) and Peak Code Domain Error are reviewed [2]. For the verification of performance requirements, the transceiver was implemented with commercial components. With the test equipment, W-CDMA signal generator and signal analyzer, the transmitting characteristics of the implemented transceiver are measured. The test scenarios showed that how the RF transmitting parameters are relate to UE performance for W-CDMA system.

II. Review on RF Transmitting Requirements of UE for 3G W-CDMA

The structure and peak to average ratio (PAR) of power for uplink is shown as in figure 1. The desired uplink channel comprises the dedicated physical channel (DPCH) carrying

user data channel and control channel. As data channels are increased, the PAR is increased. In order to reduce amplitude variation of transmitting signal, hybrid QPSK modulation method is used.
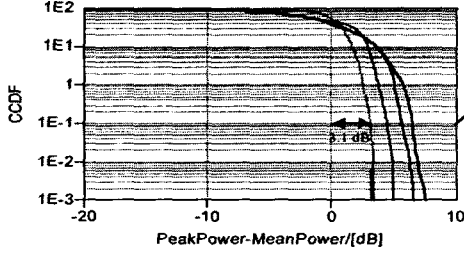

Figure 1. Uplink structure and PAR

Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the transmitted power to the power measured in an adjacent channel. Both the transmitted power and the adjacent channel power are measured with a filter that has a Root Raised Cosine (RRC) filter response with roll-off = 0.22 and a bandwidth equal to chip rate.   The ACLR test sets requirements to inter-modulation products, phase noise, and DACs. With TOIMD being the equivalent temperature of the inter-modulation noise at the output, the equivalent noise temperature for adjacent channel is found from

$$T_{OT} = T_{OIMD} + T_{OPH} + T_{ODAC} \quad [k] \quad (1)$$

The minimum requirement of ACLR is 33 dB at adjacent channel of 5 MHz from center frequency. At that time the maximum output power of +21 dBm is defined for conformance test.

The chip impulse response of RRC filter is represented in equation (2).

$$RC_0(t) = \frac{\sin\left[\pi \frac{t}{T_c}(1-\alpha)\right] + 4\alpha \frac{t}{T_c} \cos\left[\pi \frac{t}{T_c}(1+\alpha)\right]}{\pi \frac{t}{T_c}\left[1 - \left(4\alpha \frac{t}{T_c}\right)^2\right]} \quad (2)$$

Where Tc = 1/ chip rate.

The spectrum characteristic of RRC filter is shown in figure 2. Where 81 sampling with 1/8 Tc step, beta=1.5 of kaiser window and 8 bit quantization are used.
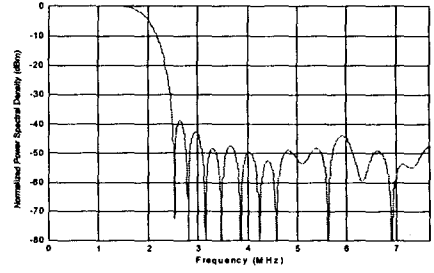

Figure 2. The spectrum characteristic of RRC filter

The Error Vector magnitude (EVM) is a measure of the difference between the measured waveform and the theoretical modulated waveform (the error vector). It is the square root of the ratio of the mean error vector power to the mean reference signal power expressed a percentage. The EVM of the output signal of the transmitter is a result of many factors that cause signal degradation [3]. The significant contributing factors are in-band ripple, I / Q amplitude imbalance, I / Q phase imbalance, phase noise and LO leakage. In-band ripple is specified for the desired channel only. It includes in-band magnitude ripple compared to RMS magnitude, and RMS phase ripple compared to the linearized in-band phase that causes minimum RMS error. Amplitude ripple of 0.4 dB results in an EVM of 4.7 %, while phase ripple of 4 degree results in an EVM 7 % [4]. An I/Q amplitude imbalance of 1.4 dB generates an EVM of 8.0 %, while a phase offset between the I and the Q signal of 5 degree generates EVM of 4.4 % [5]. The degradation due to LO leakage is expressed as LO to signal ratio (LSR). LSR is defined as the ratio between the average power of the LO signal, measured at the output of up-converter, and the average power of the desired signal, measured at the same place. LSR can be transferred directly to the output of the transmitter, which makes it suitable for specification of LSR induced EVM, EVMLO, found by

$$EVM_{LO} = (LSR)1/2 \ 100 \ \% \quad (3)$$

For specification purposes, the required LSR is expressed in dB. For example, an LSR of 27 dB is found to generate an EVM of 4.5 %. The 3GPP specification of UE requires that the EVM at the output of transmitter shall not exceed 17.5 %.

The spectrum emission mask of the UE applies to frequencies, which are between 2.5 MHz and 12.5 MHz away from the UE center carrier frequency. The out of channel

emission is specified relative to the UE output power measured in a 3.84 MHz bandwidth. The spectrum emission mask requirement is summarized in table 1.

Table 1: Spectrum emission mask requirement
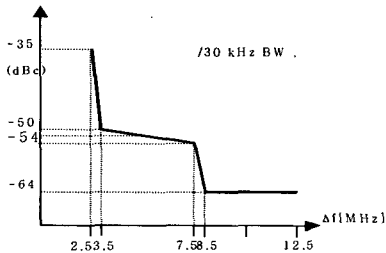
The peak code domain error is computed by projecting power of the error vector onto the code domain at a specific spreading factor. The code domain error for every code in the domain is defined as the ratio of the mean power of the projection onto that code, to the mean power of the composite reference waveform. The peak code domain error is defined as the maximum value for the code domain error for all codes. The requirement for peak code domain error is only applicable for multi-code transmission and it shall not exceed 15 dB.

III. The design of RF Transmitter

To verify the performance requirements, the RF transceiver was designed. The transceiver block diagram is shown in figure 3. In transmitting path, analog base-band I/Q signal is modulated with IF carrier frequency. The channel filtered IF signal is up-converted to RF frequency and then is amplified. Transmitting gain control signal comes from digital demodulator to adjust transmitting power level and the dynamic range should be 70 db and above.
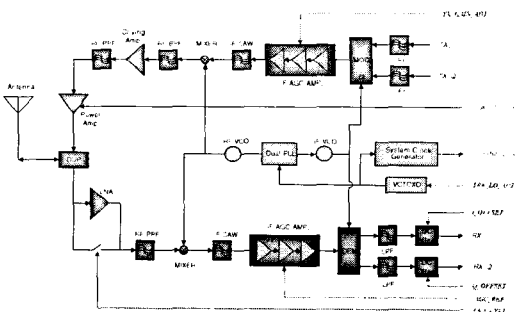

Figure 3. Block diagram of RF transceiver

The calculated cascaded level diagram of transmitting block is shown in figure 4. The level variation of transmitting path due to control signal is shown in figure 5.

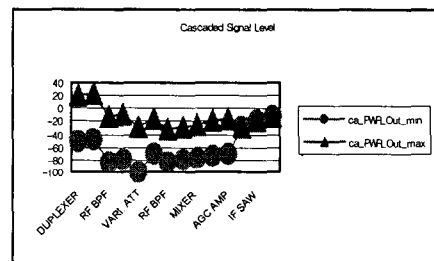Figure 4. Cascaded level diagram of transmitting block

Figure 5. Level variation of transmitting block

Basically, the control signals for power control and frequency correction are coming from digital demodulator. However, for the verification of transceiver itself, the control signals are generated in the RF transceiver. Figure 6 shows the implemented RF transceiver for performance test.
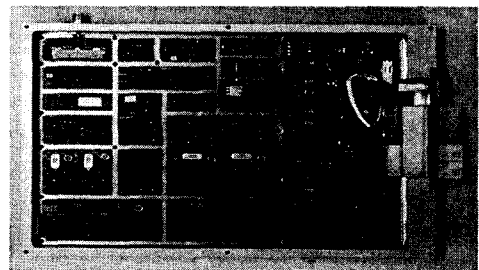

Figure 6. Implemented RF transceiver

IV. Analysis of RF transmitting parameters

W-CDMA signal generator and analyzer are used to evaluate RF performance parameters. The data rate of 12.2 kbps is used as signal source. The Dedicated Physical Control Channel (DPCCH) is assigned to ch1 and the Dedicated PhysicalData Channel (DPDCH) is assigned to ch4. The test condition is configured in figure 7 [5].

Figure 7. Test configuration of UE transmitter

Spectrum mask characteristic at 2.5 MHz offset is 39.77 dBc as shown in figure 8.
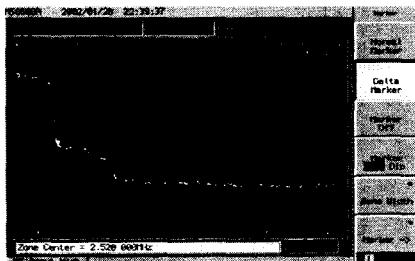

Figure 8. Spectrum mask characteristic at 2.5 MHz offset

Figure 9 shows that + 24.03 dBm of maximum output power and ACLR of 43.77 dB at 5 MHz offset.
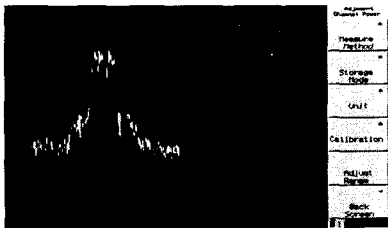

Figure 9. Measurement result of ACLR

The peak code domain error at maximum power output is 19.23 dB as in figure 10.

Figure 10. Test result of peak code domain error

The EVM of 4.76 % is obtained through signal analysis process and is shown in figure 11.

Figure 11. The measured EVM value

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