RF Transceiver Implementation to Evaluate the Requirements of 3G W-CDMA User Equipment

3G W-CDMA UE 요구사항 평가를 위한 RF 트랜시버 구현

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Abstract

This paper describes the RF performance issues of UE for W-CDMA system based on 3 GPP specifications. The parameters of transmitter and receiver are derived from the viewpoint of RF performance. In order for UE to achieve high performance, the transceiver performance requirements such as ACLR, EVM, Peak Code Domain Error, spectrum emission mask, frequency error stability and TX power control dynamic range for transmitter and reference sensitivity level, blocking characteristics, noise figure, ACS, AGC dynamic range for receiver are considered. On the basis of the required parameters, the UE RF transceiver is implemented and then the evaluation of RF performance is accomplished through practical test scenarios.

요 약

본 논문은 3 GPP 규격을 바탕으로 한 W-CDMA UE 시스템의 RF 성능관련 내용을 다루고 있으며 송수신 파라미터를 RF 성능관점에서 유출하였다. 최적의 UE성능을 얻기 위해 송신기에 대해서는 ACLR, EVM, 피크코드영역 에러, 스펙트럼 방사 마스크, 주파수 오차 안정도, 송신전력제어 범위와 같은 성능 요구사항을 고찰하였고 수신기에 대해서는 수신 감도, 블록킹 특성, 잡음지수, 인접채널 선택도, 수신 AGC 범위 등이 고려되었다. 요구된 파라미터 들을 근거로 UE RF 트랜시버를 구현하였고 실제 측정 시나리오에 따라서 RF 성능평가를 수행하였다.

Key words : W-CDMA, 3GPP Specifications, RF Transceiver

Ⅰ. Introduction

The user equipment (UE) standard of wideband-code division multiple access (W-CDMA) system delivers improved services for wireless communications including voice, data, image and multimedia as compared to second generation (2G) cellular systems[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[2]. 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. In the general characteristics of W-CDMA, the uplink frequency band is from 1920 MHz to 1980 MHz and down link frequency band is from 2110 MHz to 2170 MHz. The nominal frequency spacing is 5 MHz. In the downlink, quadrature

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phase-shift keying (QPSK) modulation is employed and root raised cosine (RRC) filtering is applied to shape transmitting spectrum. The uplink uses a more complicated hybrid QPSK modulation method to minimize amplitude variations of transmitted signal.

Major RF parameters such as ACLR, EVM, spectrum emission mask, frequency error stability for transmitter and reference sensitivity level, blocking characteristics, noise figure, ACS, AGC dynamic range for receiver are reviewed to design transceiver [3]. For the verification of performance requirements, the transceiver was implemented with commercial components. Several factors such as I/Q phase imbalance, I/Q amplitude imbalance, and LO leakage are taken into consideration to design and implement RF transceiver. Thereby it is realized that how much RF design parameters have effect on performance requirements of UE W-CDMA system. For the practical test, W-CDMA signal generator and vector signal analyzer are used. The characteristics of transmitting and receiving of the implemented RF transceiver are measured and then compared with the performance requirements. The test results show that how the RF design factors are related to system performance and how well the implemented RF transceiver meet UE W-CDMA requirements.

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

2-1 Analysis on UE Transmitting Characteristics

The peak to average ratio (PAR) of power for uplink is shown as in Fig. 1. It reveals the relationship between complementary cumulative distribution function (CCDF) and PAR. The desired uplink channel comprises the dedicated physical channel (DPCH) carrying user data channel and control channel. As data channels are increased, the PAR grows up. In order to reduce amplitude variation of transmitting signal, hybrid QPSK modulation method

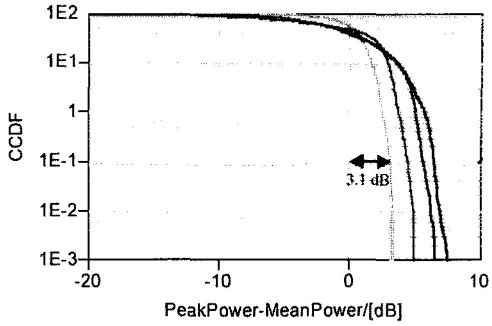

Fig. 1. PAR characteristic for uplink.

is used.

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 $\alpha = 0.22$ and a bandwidth equal to chip rate. The ACLR test sets requirements to inter-modulation products, phase noise, and DAC. With T_{OIMD} being the equivalent temperature of the inter-modulation noise at the output, the equivalent noise temperature for adjacent channel is found from

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

Where T_{OT} is the total equivalent noise temperature at the output for adjacent channel. T_{OIMD}, T_{OPH} and T_{ODAC} are the equivalent temperature of the inter-modulation noise, phase noise and DAC noise at the output, respectively. 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.

After spreading & scrambling operations, baseband I/Q data are applied to the inputs of transmit base-band pulse shaping filters. The transmitting base-band pulse shaping filter is RRC filter with roll-off factor $\alpha = 0.22$. The ideal impulse response of RRC filter $RC_0(t)$ at chip level is

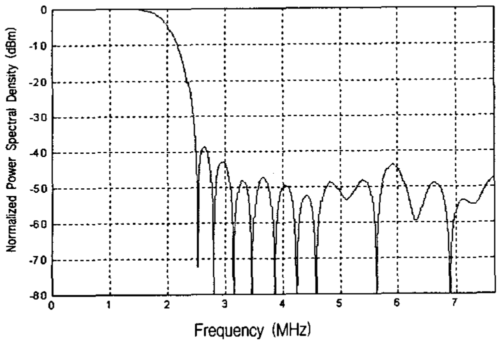

Fig. 2. The magnitude response of RRC filter.

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

Where Tc = 1/ chip rate.

The designed RRC filter for the UE transmitter has a magnitude response as shown in Fig. 2.

Specifically, Nyquist bandwidth is 1.92 MHz and the bandwidth including 99 % of energy is 2.082 MHz. The power level difference between signal and 2.5 MHz offset frequency is supposed to be −40 dBc and above in order to meet spectrum emission mask requirement at RF output.

The values of the discrete coefficients h(k) for $K<40$ and $h(k) = h(39-k)=0$ for $K \geq 40$ are given in Table 1.

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. 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

Table 1. Coefficients of h(k).

K	h(k)
0, 39	−0.0076
1, 38	0
2, 37	0.0152
3, 36	0.0227
4, 35	0.0152
5, 34	−0.0076
6, 33	−0.0379
7, 32	−0.0379
8, 31	−0.0076
9, 30	0.0455
10, 29	0.0909
11, 28	0.0833
12, 27	0
13, 26	−0.1136
14, 25	−0.1894
15, 24	−0.1364
16, 23	0.0758
17, 22	0.4242
18, 21	0.7727
19, 20	1.0000

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 of 7 %[4]. An I/Q amplitude imbalance of 1.4 dB generates an EVM of 8.0 %, while 5 degree of phase offset between the I and the Q signal 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, EVM_{LO}, found by

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

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 3 GPP specification of UE requires that the EVM at the

Table 2. Spectrum emission mask requirement.

Freq. offset from carrier (Δf)	Minimum requirement	Meas. BW
2.5 ~ 3.5 MHz	$-35-15\times(\Delta f-2.5)$ dBC	30 kHz
3.5 ~ 7.5 MHz	$-35-1\times(\Delta f-3.5)$ dBc	1 MHz
7.5 ~ 8.5 MHz	$-39-10\times(\Delta f-7.5)$ dBc	1 MHz
8.5 ~ 12.5 MHz	-49 dBc	1 MHz

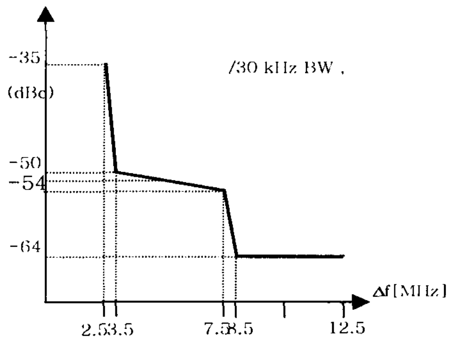

Fig. 3. Characteristic of spectrum emission mask.

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 2 and depicted in Fig. 3.

The peak code domain error is calculated 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.

2-2 Analysis on UE Receiving Characteristics

The standard uses the user bit rate of 12.2 kbps and the bit error rate (BER) should be below 10^{-3}. The downlink channel has two or more orthogonal channels, which include the dedicated physical channel (DPCH) carrying user data, a synchronization channel and other user's data channel[6]. In de-spreading and decoding process of the receiver, the processing gain is represented as follows.

$$G_p = 10\ \log_{10}(3.84\ \text{Mcps} / 12.2\ \text{kbps}) = 25\ \text{dB} \quad (4)$$

To meet a BER of 10^{-3}, a (E_b/N_t) of 5.2 dB is needed. It is suggested that base-band implementation margin must be accounted. The required effective E_b/N_t is then supposed to be $(E_b/N_t)_{eff}$ = 7 dB[7].

The reference sensitivity level is the minimum receiver input power at the antenna port, which does not degrade the specified BER performance. The total incoming signal power is -106.7 dBm and the wanted signal level prior to de-spreading (Ec/I) is -117 dBm. Using (E_b/N_t)eff, user data processing gain, the maxim acceptable level after de-spreading (P_N) within the channel bandwidth result in[8]:

$$P_N(\text{acceptable}) = Ec/I - (E_b/N_t)_{eff} + G_p \quad (5)$$

The value of P_N(acceptable) is -99 dBm. When the noise figure (NF) and the bandwidth (BW) are known, the actual noise power is determined using

$$P_N(\text{actual}) = NF + 10\ \log_{10}(kTB) \quad (6)$$

Where k is Boltzmann's constant and T is standard noise temperature (300 K). The value of P_N (actual) is NF -108 dBm. Since the actual noise power must be lower or equal to the acceptable noise power, the tolerable noise figure becomes as

$$NF \le P_N(\text{acceptable}) + 108\ \text{dBm} = 9\ \text{dB} \quad (7)$$

Adjacent channel selectivity (ACS) is a measure of receiver's ability to receive a W-CDMA signal at its assigned channel frequency in the presence of an adjacent channel signal at a given frequency offset from the center frequency of the assigned channel.

Adjacent channel selectivity is the ratio of the receive filter attenuation on the assigned channel frequency to the receive filter attenuation on the adjacent channel(s). The requirement of ACS shall be better than 33 dB where the BER shall not exceed 10^{-3}. Received power of the wanted signal at antenna input is -92.7 dBm. The desired signal power before de-spreading Ec/I is -103 dBm. The first adjacent channel, P_{ACI}, has a power of -52 dBm centered at 5 MHz offset from center frequency. By treating the adjacent channel signal as noise, the required first adjacent channel selectivity can be derived. The acceptable interference level, P_I, is determined in the same way as equation (5). Therefore an acceptable interference level, P_A, is -85 dBm. If the adjacent channel interference signal is treated as Gaussian noise like interference, the required adjacent channel selectivity is derived:

$$ACS = P_I - P_A = -52 \text{ dBm} + 85 \text{ dBm} = 33 \text{ dB} \quad (8)$$

Ⅲ. The Design and Implementation of UE RF Transceiver

On the basis of performance requirements mentioned previously, the RF transceiver was designed. The block diagram of RF transceiver is shown as in Fig. 4. In receiving path, incoming RF signal is translated to intermediate frequency (IF), which is usually much lower than the received frequency band. Channel select filtering is done at this IF. Automatic gain control is operated by a control signal from digital demodulator. The receiving dynamic range must be 80 dB and above. Analog base-band I/Q signal is retrieved through I/Q demodulation process. 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.

The super-heterodyne architecture is used in implementing RF transceiver instead of homodyne structure since the work is more focused on performance evaluation than integration point of view. The discrete commercial components are selected in each block and then integrated to meet the performance requirements. The calculated cascaded level diagram of receiving block and transmitting block is shown as in Fig. 5 and Fig. 6, respectively. 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.

The basic simulation for receiving and transmitting path is achieved using system calculator (SysCal 4). The simulation result of receiver and

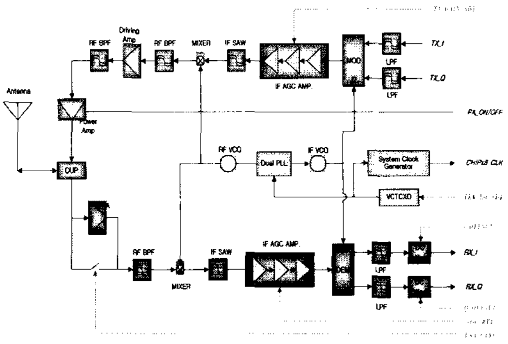

Fig. 4. Block diagram of RF transceiver.

	RF INPUT	DUPLEXER	LNA	PAD	LNA	RF BPF	PAD	RF MIXER	PAD	IF SAW	PAD	IF AGC AMP	IF AMP	PAD	DEMOD
Gain (dB)		-3.0	12.0	-2.0	12.0	-3.0	-5.0	15.5	-2.0	-14.0	-2.0	45 TO -30	16.0	0.0	
NF (dB)		3.0	1.3	2.0	1.4	3.0	5.0	5.5	2.0	14.0	2.0	5 TO 50	3.0	0.0	
IP3_In (dBm)		50.0	-2.0	50.0	5.5	50.0	50.0	-0.5	50.0	50.0	50.0	-47 TO -2	-16.0	50.0	
P1dB_In (dBm)		25.0	-12.0	25.0	-12.0	25.0	25.0		25.0	25.0	25.0	-58 TO -15	-26.0	25.0	
1. Input RF Power (-100 dBm)															
ca_Gain (dB)		-3.0	9.0	7.0	19.0	16.0	11.0	26.5	24.5	10.5	8.5	53.5	69.5	69.5	
ca_NF (dB)		3.0	4.3	4.4	4.5	4.6	4.6	4.9	4.9	5.0	5.1	5.5	5.5	5.5	
ca_PWR_Out (dBm)	-100.0	-103.0	-91.0	-93.0	-81.0	-84.0	-89.0	-73.5	-75.5	-89.5	-91.5	-46.5	-30.5	-30.5	500 mVpp
ca_IM_PWR (dBm)		-403.0	-293.0	-295.0	-276.8	-279.8	-284.8	-250.4	-252.4	-266.4	-268.4	-135.5	-91.5	-91.5	
URr (dB)		300.0	202.0	202.0	195.8	195.8	195.8	176.9	176.9	176.9	176.9	89.0	61.0	61.0	
1.1 If input IM3=-30dBc															
ca_IM_PWR (dBm)		-133.0	-121.0	-123.0	-111.0	-114.0	-119.0	-103.5	-105.5	-119.5	-121.5	-76.5	-60.5	-60.5	
URr (dB)		30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	
2. Input RF Power (-25 dBm)															
ca_Gain (dB)		-3.0	9.0	7.0	19.0	16.0	11.0	26.5	24.5	10.5	8.5	-21.5	-5.5	-5.5	
ca_NF (dB)		3.0	4.3	4.4	4.5	4.6	4.6	4.9	4.9	5.0	5.1	41.5	41.5	41.5	
ca_PWR_Out (dBm)	-25.0	-28.0	-16.0	-18.0	-6.0	-9.0	-14.0	1.5	-0.5	-14.5	-16.5	-46.5	-30.5	-30.5	500 mVpp
ca_IM_PWR (dBm)		-178.0	-68.0	-70.0	-51.8	-54.8	-59.8	-25.4	-27.4	-41.4	-43.4	-71.3	-55.3	-55.3	
URr (dB)		150.0	52.0	52.0	45.8	45.8	45.8	26.9	26.9	26.9	26.9	24.8	24.8	24.8	
2.1 If input IM3=-30dBc															
ca_IM_PWR (dBm)		-58.0	-46.0	-48.0	-35.9	-38.9	-43.9	-23.7	-25.7	-39.7	-41.7	-70.2	-54.2	-54.2	
URr (dB)		30.0	30.0	30.0	29.9	29.9	29.9	25.2	25.2	25.2	25.2	23.7	23.7	23.7	
3. Intermodulation Spurious Response Attenuation															
ca_IP3_In_ISRA (dBm)		50.0	1.0	1.0	-3.4	-3.4	-3.4	-12.1	-12.1						

Fig. 5. Cascaded level diagram of receiving block.

	DUPLEXER	POWER AMP	RF BPF	PAD	PRE AMP	PAD	VARI. ATT	PAD	RF AMP	RF BPF	MIXER	PAD	AGC AMP	ATT	IF SAW	ATT
Gain (dB)	-3.0	24.0	0.0	0.0	19.0	-1.0	-30 TO -3	-1.0	14.0	-3.0	-2.0	-2.0	-20 TO 30	-8.0	-20.0	7.0
NF (dB)	3.0		0.0	0.0	2.2	1.0	30 TO -3	1.0	9.0	3.0		4.0	30 TO 13	5.0	20.0	5.0
IP3 In (dBm)	60.0	20.0	50.0	50.0	8.0	50.0	22.0	50.0	0.0	50.0	0.0	100.0	12 TO -25	50.0	50.0	60.0
P1dB In (dBm)	25.0	8.0	25.0	25.0	-2.0	25.0	12.0	25.0	-10.8	25.0	-10.5	50.0	22 TO -35	25.0	25.0	25.0
1. Min. RF Power																
ca Gain (dB)	-40.0	-37.0	-61.0	-61.0	-61.0	-80.0	-79.0	-49.0	-48.0	-62.0	-59.0	-57.0	-55.0	-35.0	-27.0	-7.0
ca NF (dB)																
ca PWR Out (dBm)	-55.0	-52.0	-76.0	-76.0	-76.0	-95.0	-94.0	-64.0	-63.0	-77.0	-74.0	-72.0	-70.0	-50.0	-42.0	-22.0
ca IM PWR (dBm)	-131.0	-128.0	-152.0	-152.0	-152.0	-171.0	-170.0	-140.0	-139.0	-153.0	-150.0	-148.0	-146.0	-179.8	-171.8	-152.0
URr (dB)	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	129.8	129.8	130.0
2. Max. RF Power																
ca Gain (dB)	37.0	40.0	16.0	16.0	16.0	-3.0	-2.0	1.0	2.0	-12.0	-9.0	-7.0	-5.0	-35.0	-27.0	-7.0
ca NF (dB)																
ca PWR Out (dBm)	22.0	25.0	1.0	1.0	1.0	-18.0	-17.0	-14.0	-13.0	-27.0	-24.0	-22.0	-20.0	-50.0	-42.0	-22.0
ca IM PWR (dBm)	-14.4	-11.6	-41.2	-41.2	-41.2	-60.7	-59.7	-56.7	-55.7	-70.0	-67.0	-72.0	-70.0	-179.8	-171.8	-152.0
URr (dB)	36.4	36.6	42.2	42.2	42.2	42.7	42.7	42.7	42.7	43.0	43.0	50.0	50.0	129.8	129.8	130.0
2.1 IF Input IMD=-40dBc																
ca IM PWR (dBm)	-12.8	-10.0	-37.0	-37.0	-37.0	-56.1	-55.1	-52.1	-51.1	-65.2	-62.2	-61.6	-59.6	-90.0	-62.0	-62.0
URr (dB)	34.8	35.0	38.0	38.0	38.0	38.1	38.1	38.1	38.1	38.2	38.2	39.6	39.6	40.0	40.0	40.0

Fig. 6. Cascaded level diagram of transmitting block.

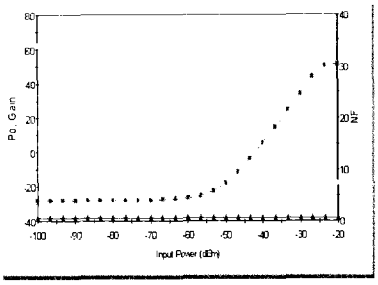

Fig. 7. Simulation result of receiver.

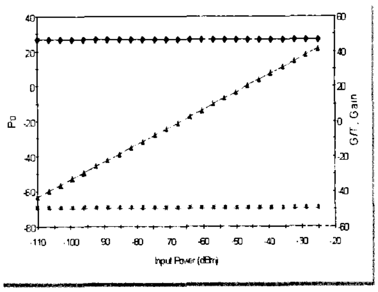

Fig. 8. Simulation result of transmitter.

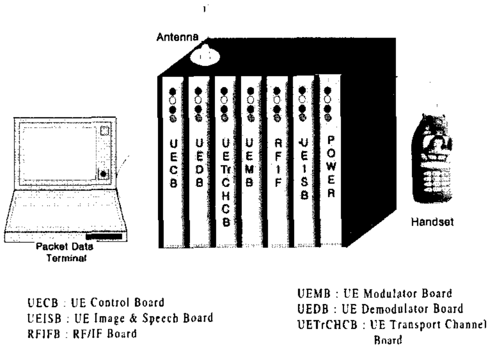

Fig. 9. UE test-bed configuration.

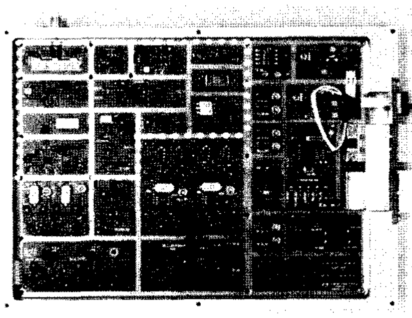

Fig. 10. Implemented RF transceiver.

transmitter is shown in Fig. 7 and Fig. 8, respectively.

Test-bed of UE system is configured as in Fig. 9 and the implemented RF transceiver on the basis of simulation results is shown as in Fig. 10.

Ⅳ. Evaluation of RF Performance Parameters

W-CDMA signal generator (MG 3681A, Anritsu) and signal analyzer (MS 8608A, Anritsu) are used to evaluate RF performance parameters. The test configuration is shown as in Fig. 11. The data rate of 12.2 kbps is used as signal source. The Primary Common Control Physical Channel (P-CC PCH) and Synch Channel (SCH) are assigned to channel 1 and then applied to antenna input at 2140 MHz of carrier frequency to measure receiving characteristics[9]. Spreading factor is 128 and channelization code

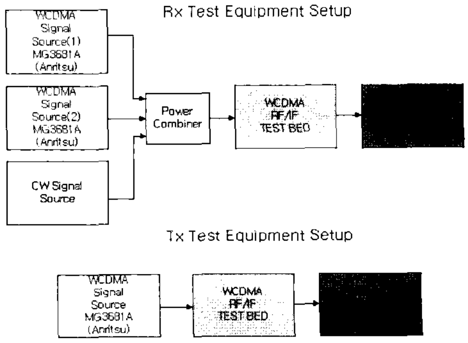

Fig. 11. Test configuration of RF performance.

number is 0.

The Dedicated Physical Control Channel (DPCCH) is assigned to ch1 and the Dedicated Primary Data Channel (DPDCH) is assigned to ch4 for transmitting performance test. The spreading factor for DPCCH is 256 and the spreading factor for DPDCH is 64. The channelization code number is 0 and the carrier frequency is 1950 MHz for transmitting test.

When the sensitivity level of −106.7 dBm is applied to antenna input, 10 dB and above of code domain error was obtained as in Fig. 12. The required value is 7 dB and above.

For ACS test, desired signal of −92.7 dBm and interference signal of −52 dBm at 5 MHz offset frequency are combined and then are used as an input signal. 20 dB of code domain error was measured as in Fig. 13, which meets 7 dB and above of standard requirement.

The spectrum mask characteristic at 2.5 MHz offset frequency was measured with −39.77 dBc as shown

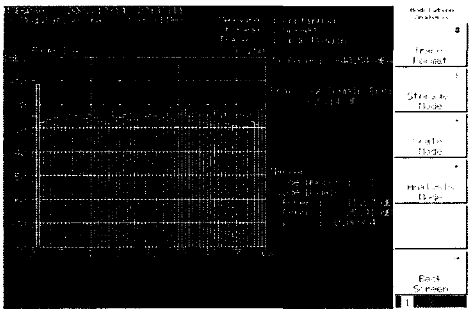

Fig. 12. Measurement result of sensitivity level.

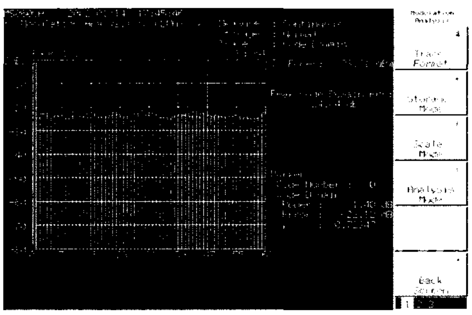

Fig. 13. Measurement result of ACS.

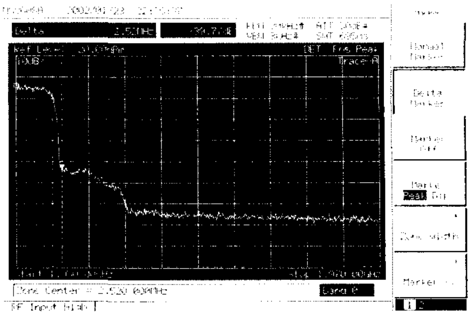

Fig. 14. Spectrum emission mask characteristic.

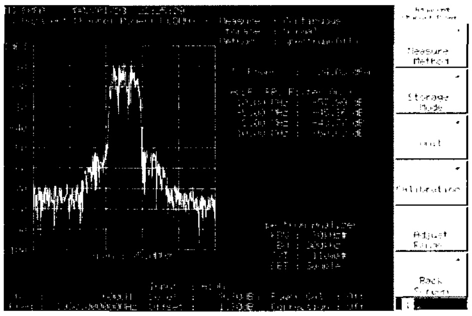

Fig. 15. Maximum output power & ACLR.

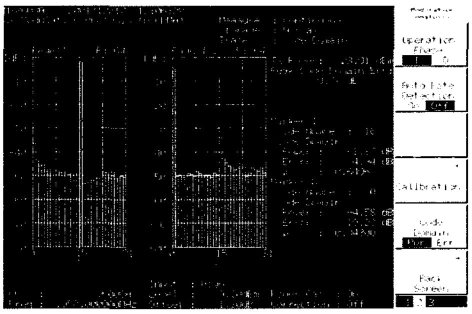

Fig. 16. Test result of peak code domain error.

in Fig. 14. The required value is −35 dBc below.

The requirement of maximum output level at antenna is +21 dBm and above. The measured value was +24.03 dBm. At that time the ACLR at 5 MHz offset is required with −33 dB below. The measured value was −43.77 dB as in Fig. 15.

The required peak code domain error at maximum output power is −15 dB below and the measured value was −19.23 dB as in Fig. 16.

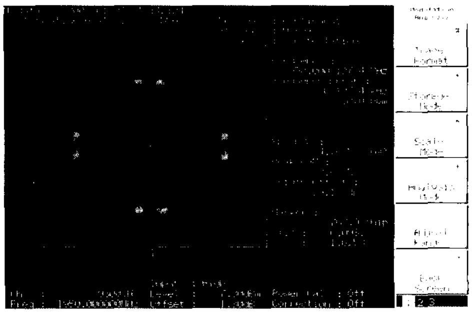

Fig. 17. The measured EVM value and frequency error.

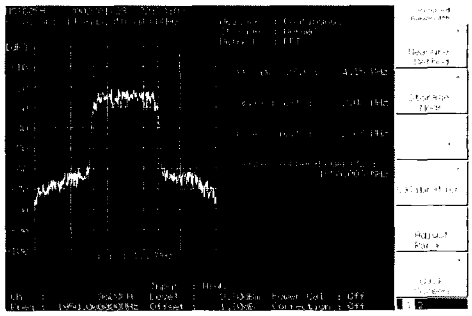

Fig. 18. The measured occupied bandwidth.

The standard requires 17.5 % below of EVM and the test result showed 4.76 %. The frequency error stability requires ±0.1 ppm when automatic frequency error correction is working. The frequency error of 0.07 ppm was obtained through practical test. The test results of EVM and frequency error are shown in Fig. 17.

Occupied bandwidth is a measure of the bandwidth containing 99 % of the total integrated power of the transmitted spectrum, centered on the assigned channel frequency. The occupied channel bandwidth shall be less than 5 MHz based on a chip rate of 3.84 Mcps. The test result of 4.15 MHz is obtained as in Fig. 18.

The amount of carrier leakage should be below -56 dBm in the minimum output level at antenna port. The measured value was −72 dBm.

The receiving dynamic range of 85 dB and above (from −110 dBm to −25 dBm) is required for the

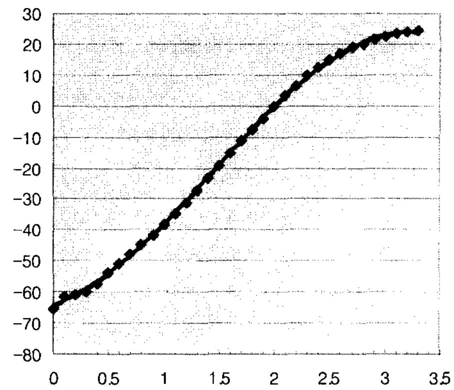

Fig. 19. The measured receiving dynamic range.

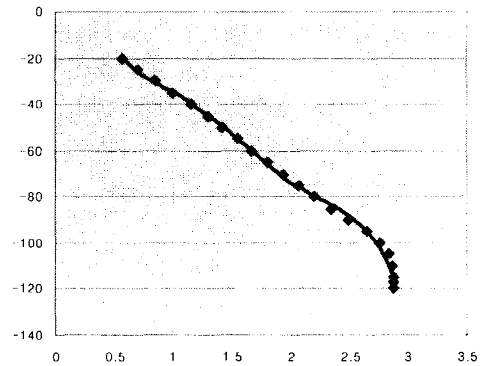

Fig. 20. The measured transmitting dynamic range.

power control operation. The variation of RF input power level versus control voltage of variable gain amplifier is measured. The receiving dynamic range of 85 dB and above was obtained as in Fig. 19.

The transmitting dynamic range for power control operation should be 71 dB and above (+21 dBm ~ −50 dBm). The control signal is supposed to be come from digital demodulator, however, the analog control signal is generated in RF transceiver for practical test. The 80 dB and above of transmitting dynamic range is obtained as in Fig. 20.

V. Conclusions

The RF related parameters for the performance of UE in W-CDMA system such as ACLR, EVM, Peak

Code Domain Error, spectrum emission mask and frequency stability error for transmitter and reference sensitivity level, blocking characteristics, noise figure, ACS, AGC dynamic range for receiver are reviewed. After considering of several factors having effect on the RF performance, the RF transceiver was designed and implemented using commercial discrete components. Using test equipment of signal source and signal analyzer instead of digital modulator and demodulator, performance items are evaluated. −43.77 dB of ACLR, 4.76 % of EVM, −19.23 dB of peak code domain error, −39.77 dBc of spectrum mask at 5 MHz offset, 80 dB of transmitting dynamic range, −106.7 dBm of receiving sensitivity level, 85 dB of receiving dynamic range, −72 dBm of carrier leakage were obtained. The all measured values are good enough to meet conformance test requirements of UE performance in W-CDMA system.

References

[1] T. S. G. Terminals, "Radio transmission and reception (FDD)", *Tech. Rep. TS 34.121 V3.3.0, 3rd Generation Partnership Project*, Dec. 2000.

[2] O. K. Jensen, T. E. Kolding, C. R. Iversen, S. Laursen, R. V. Reynisson, J. H. Mikkelsen, E. Pedersen, M. B. Jenner and T. Larsen, "RF receiver requirements for 3G WCDMA mobile equipments", *Microwave Journal*, vol. 43, no. 2, pp. 22-46, February 2000.

[3] P. Madsen, "Simulating Overall Performance Requirements for Transmitters in IMT2000 FDD User Equipment", *To appear at ECWT01*, September 2001.

[4] Hewlett Packard, "Using Error Vector Magnitude Measurements to Analyze and Troubleshoot Vector Modulated Signals", *Product Note HP 89400-8.*

[5] J. D. Kim, D. W. Weiche, "Trends and Requirements of SAW Filters for Cellular System Applications", *Proc. of IEEE Ultrasonics Symposium*, pp. 293-301, 1997.

[6] B. N. Vejlgaard, P. Mogensen and J. B. Knudsen, "Performance Analysis for UMTS Downlink Receiver with Practical Aspects", *Proceedings of IEEE Vehicular Technology Conference* (*VTC*), Amsterdam, Netherlands, pp. 998-1002, Sep. 1999.

[7] TSG-RAN Working Group 4, Nokia Mobile Phones, "MS Receiver sensitivity in UTRA FDD Mode", *Document TSGW4 #1(99)005*, January 1999.

[8] A. J. Viterbi, *CDMA: Principles of Spread Spectrum Communication*, Addision-Wesley Publishing Co., 1995.

[9] 3G TS 34.121 v3.0.1 (2000-03) 3rd Generation Partnership Project: Terminal Conformance Specification.

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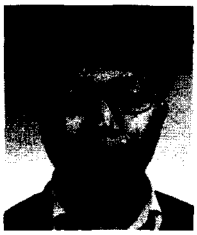

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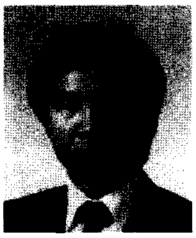

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