Review on Performance Requirements, Design and Implementation of RF Transceiver for Mobile Communications

Il-Kyoo Lee* | Seong-Ryeol Ryu** | Seung-Hyeub Oh** | Heon-Jin Hong***
Kongju National Univ.*, Chung-Nam National Univ.**, ETRI(Radio Resource Management Team)***

ABSTRACT

This paper describes the RF performance issues of UE RF Transceiver for W-CDMA system based on 3GPP 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, linearity, AGC dynamic range for receiver are considered. On the basis of the required parameters, the UE RF transceiver is designed and then implemented. The evaluation of RF performance is accomplished through practical test scenarios.

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 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, linearity, 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 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. Performance requirements of RF Transceiver for UE W-CDMA

2-1 RF Transmitter Requirements

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 α = 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. The maximum output power of +21 dBm is defined for conformance test. After spreading & scrambling operations, base- band 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 α= 0.22. The ideal impulse response of RRC filter $RC_0(t)$ at chip level is

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

Where Tc = 1/ chip rate.

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 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 and depicted in figure 1.

Table 1. Spectrum emission mask requirement.

Freq.offset from carrier (Δf)	Minimum requirement	Meas. BW
2.5~3.5 MHz	−35−15×(Δf−2.5) dBC	30 kHz
3.5~7.5 MHz	−35−1×(Δf−3.5) dBc	1 MHz
7.5~8.5 MHz	−39−10×(Δf−7.5) dBc	1 MHz
8.5~12.5 MHz	−49 dBc	1 MHz

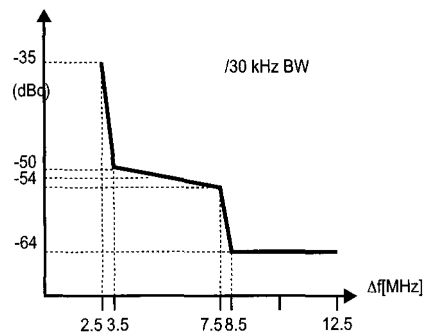

Fig.1.Characteristic of spectrum emission mask

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 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_{LO}, found by

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

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 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 RF Receiver Requirements

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.

$$G_P = 10\log_{10}(3.84\ Mcps/12.2kbps) = 25\ dB \qquad (4)$$

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 Eb/Nt 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 (E_c/I) is −117 dBm. Using $(E_b/N_t)eff$, user data processing gain, the maxim acceptable level (P_N) after de-spreading within the channel bandwidth result in[8]:

$$P_N(acceptable) = E_c/I - (E_b/N_t)_{eff} + G_P \qquad (5)$$

The value of P_N(acceptable) is −99 dBm.

When the noise figure (NF) and the bandwidth (B) are known, the actual noise power is determined using

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

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

$$NF \leq P_N(acceptable) + 108\ dBm = 9\ dB \quad (7)$$

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, PI, 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:

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

The adjacent channel selectivity is shown in Figure 2.

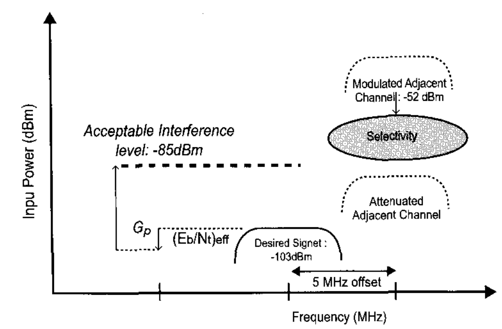

Fig. 2. Adjacent Channel Selectivity

Low even-order distortion, especially second-order distortion, is crucial to the receiver' s performance because of the presence of strong modulated signals with time varying envelopes. When a second-order non-linearity is exposed to such signals as unwanted channel in the receive band and the transmitted leakage signal, which disturb the reception of the desired signal. The spectral shape of these signals is the same as for the wanted signal but the second-order product is different as shown in Figure 3.

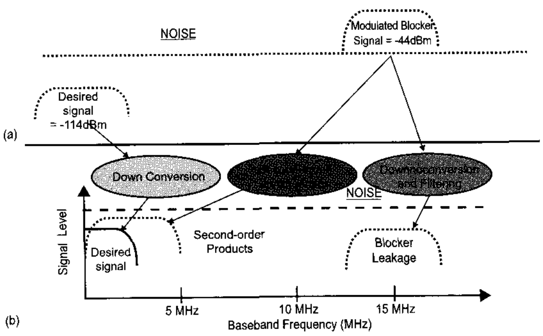

Fig.3. In-Band Modulated Blocking
(a) RF spectrum with desired signal and offset modulated blocker
(b) Baseband spectrum with desired and disturbing signal

Second-order input intercept point(IIP_2) is determined by the in-band blocker test. The desired signal has a power of $P_{R,DPCH}$ = -114*dBm*. The modulated blocker has a power of P_{BLOCK} = -114*dBm* and is offset in frequency by a minimum of 15 MHz. Since the power of the desired signal is 3 dB higher than that for the sensitivity, it is assumed that noise constitutes 50 percent of the total disturbing power. The remaining power is divided equally(25 percent, 6 dB) between the second-order products and the blocker leakage. The acceptable noise plus interference level measured at the antenna input is expressed as

$$P_{N+I} = P_{R,DPCH} - (E_b/N_t) + G_p = -114dBm - 4dB + 25dB = -96dBm \quad (9)$$

and the acceptable levels are

$$P_{N+I} = P_{N+I} - 3dBm = -99dBm \quad (10)$$

and the power of leakage blocker(P_{BLeak}) which is equal to the power of effective distributed second- order distortion ($P_{2DISeff}$) is

$$P_{BLeak} = P_{2DISeff} = P_{N+I} - 6dB = -102dBm \quad (11)$$

The necessary selectivity for a channel at 15 MHz offset is found to be

$$\text{Selectivity} \geqq P_{BLOCK} - P_{BLeak} = -44dBm - (-102)dBm = 58dB \quad (12)$$

The third - order intercept point(IP_3) of the receiver is determined using the inter-modulation characteristics. The test process is shown as in figure 4. The desired signal is at $P_{R,DPCH}$ = -114dBm, 3 dB above the minimum sensitivity level. Two interfering signals are 10 MHz and 20 MHz from the desired signal. The first interferer is a CW signal with a power of -46 dBm and the second interferer is a modulated signal with a power of -46 dBm. Assuming that the third order inter-modulation product of the two interferers may be treated as noise, the maximum level of noise and interference is found to be

$$P_{N+I} = P_{R,DPCH} - (E_b/N_t) + G_p = -114dBm - 7dB + 25dB = -96dBm \quad (13)$$

where P_{N+I} is referred to the antenna input.

In this case, several interfering products are created, thus the allowable noise and interference power must be distributed. The assumed power distribution of inter-modulation and CW interferer' s blocking effect is 15 percent of power(- 8 dB), respectively. Therefore the power level corresponding to each of interfering or blocking products is P_{N+I} -8 dB = -104dBm.

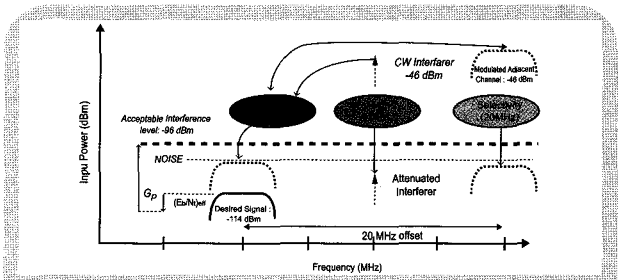

Fig.4. Description of inter-modulation process

The relationship between inter-modulation power level (P_{INT} = -46 dBm) and input intercept point gives

$$IIP_3\,(10/20MHz) \geqq P_{INT} + \frac{1}{2}[P_{INT} - (P_{N+I} - 8dB)] = -17dBm \quad (14)$$

III. 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 figure 5. 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

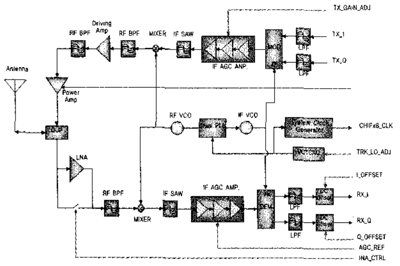

Fig. 5. Block diagram of RF transceiver.

performance requirements. The calculated cascaded level diagram of receiving block and transmitting block is shown as in figure 6 and figure 7, 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 transmitter is shown in figure 8 and figure 9, respectively.

	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 IMD=-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 IMD=-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.6. 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)	50.0	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	50.0
P1dB_In (dBm)	25.0	8.0	25.0	25.0	-2.0	25.0	12.0	25.0	-10.0	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	-82.0	-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.7.Cascaded level diagram of transmitting block

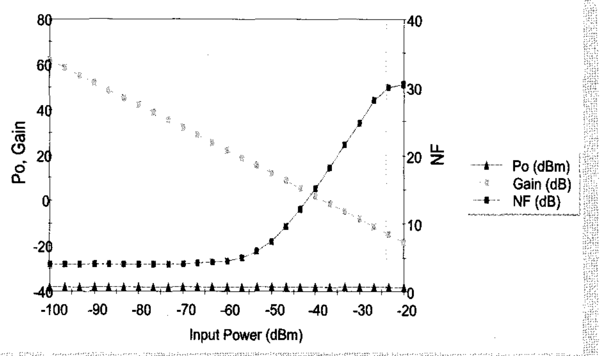

Fig. 8. Simulation result of receiver

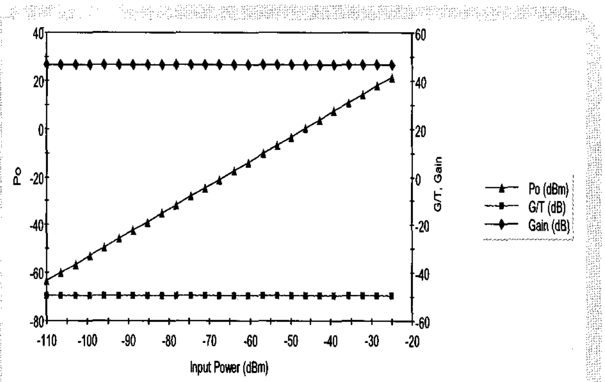

Fig. 9. Simulation result of transmitter

The power amplifier and front end have several main functions such as amplifying of transmitting signal, power amp on/off, tx/rx duplexing, and low noise amplifying of receiving signal. Sub-functions for the test of RF performance include power amplifier on/off and switching of low noise amplifier(LNA). There are also sub-functions in RF transceiver to generate all control signals such as I path DC control (I_OFFSET), Q path DC control (Q_OFFSET), LNA control (LNA_CTRL), AGC control (AGC_REF), frequency control (TRK_LO_ADJ) and transmitting power control (TX_GAIN_ADJ which are supposed to be produced by digital demodulator. The main signals interfaced between RF transceiver and digital Modem are analog base-band signal (TX_I, TX_Q, RX_I, RX_Q).

The implemented RF transceiver on the basis of simulation results is shown as in figure10.

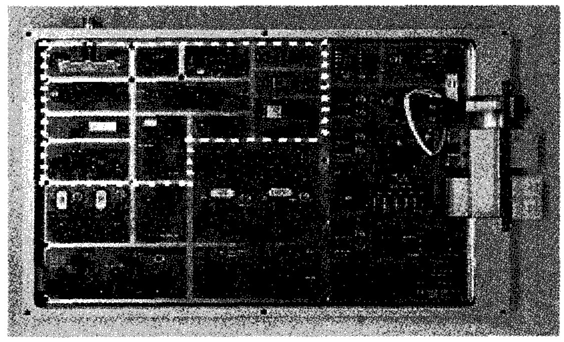

Fig. 10. Implemented RF Transceiver

Ⅳ. Evaluation of RF Transceiver

Test-bed of UE system is configured as in figure 11.

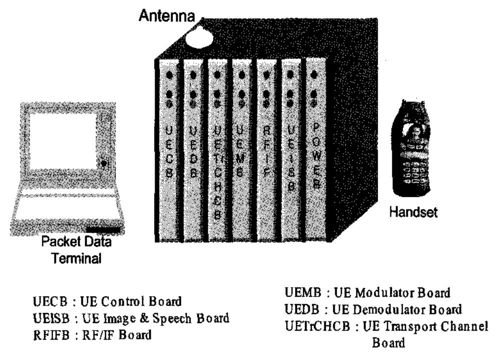

Fig. 11. Test-bed of UE system

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 figure 12. 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 number is 0.

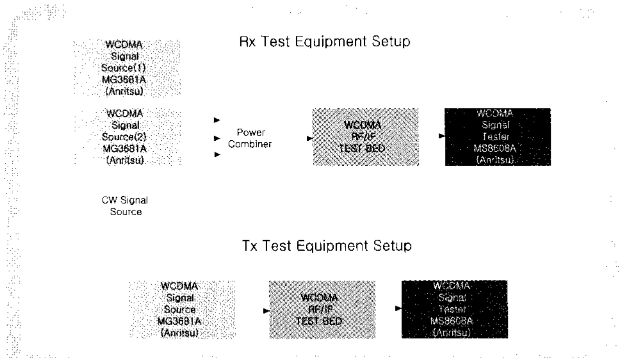

Fig. 12. Test configuration of RF performance

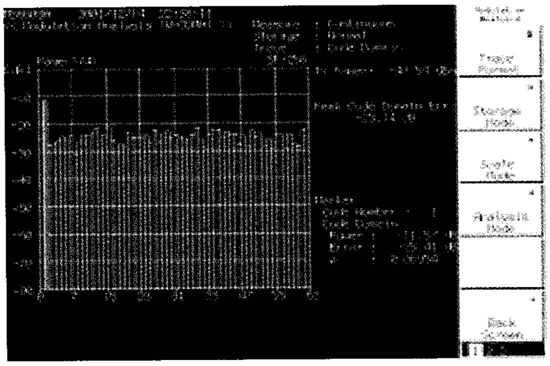
Fig. 13. Measurement result of sensitivity level

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 figure 13. 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 figure 14, 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 in figure 15. 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 figure 16.

The required peak code domain error at maximum output power is −15 dB below and the measured value was −19.23 dB as in figure 17.

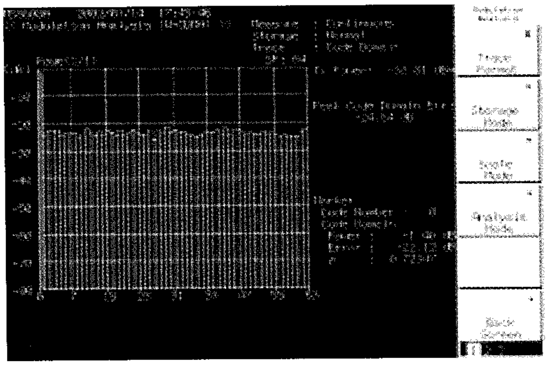
Fig. 14. Measurement result of ACS

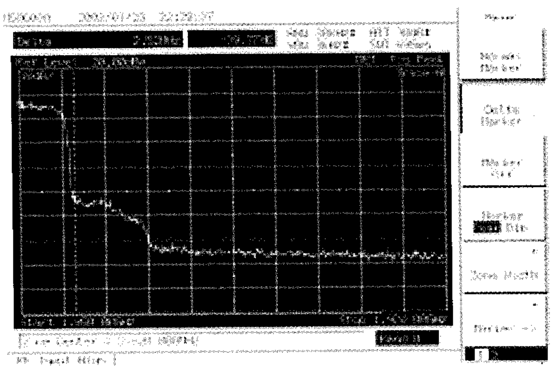
Fig. 15. Spectrum emission mask characteristic

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

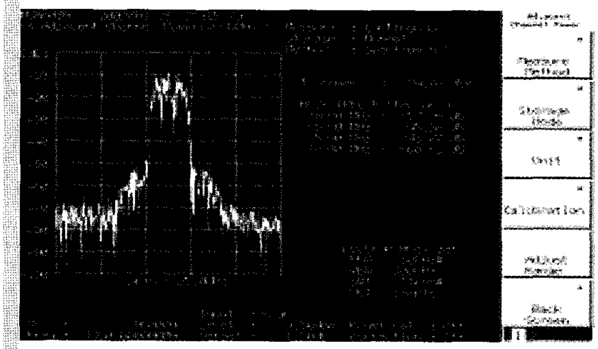

Fig. 16. Maximum output power & ACLR

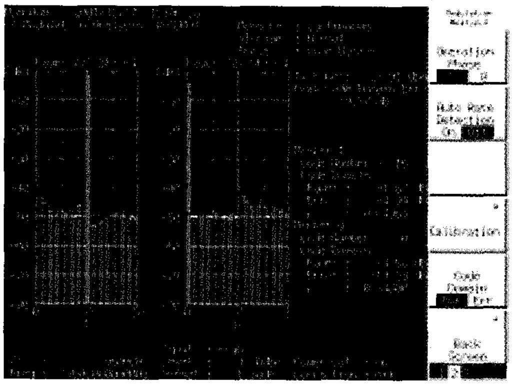

Fig. 17. Test result of peak code domain error

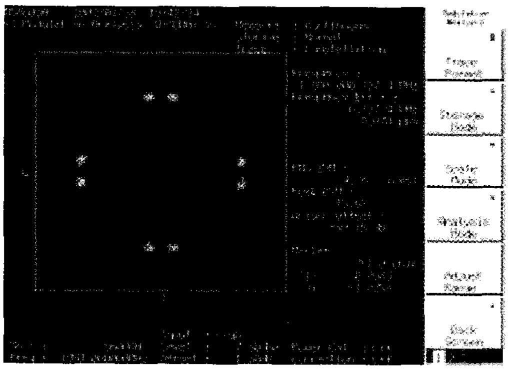

Fig.18.The measured EVM value and frequency error.

working. The frequency error of 0.07 ppm was obtained through practical test. The test results of EVM and frequency error are shown in figure 18.

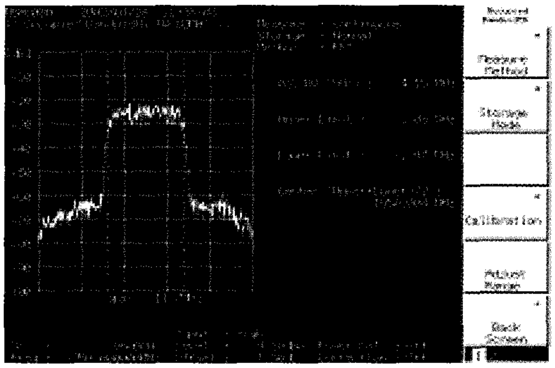

Fig. 19. The measured occupied bandwidth

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 figure 19.

The receiving dynamic range of 85 dB and above (from −110 dBm to −25 dBm) is required for the 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 figure 20.

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 figure 21.

V. Conclusions

This paper reviewed performance requirements, design approach, implementation and test evaluation of RF transceiver which is available to the application of W-CDMA

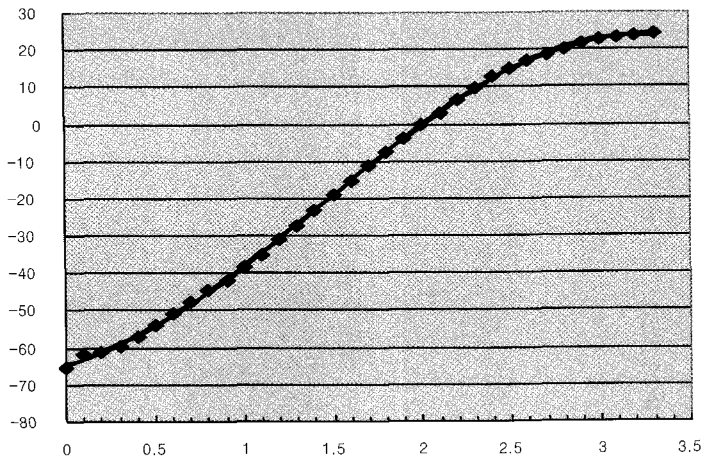

Fig. 20. The measured receiving dynamic range

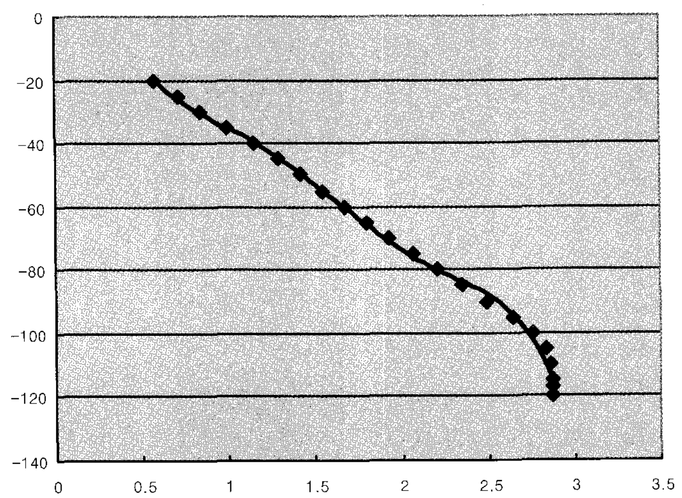

Fig. 21. The measured transmitting dynamic range.

mobile communication system.

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, linearities, 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 were obtained. The all measured values are good enough to meet conformance test requirements of UE RF performance in W-CDMA system.

Acknowledgement

This research was supported by University IT Research Center Project (INHA UWB-ITRC), Korea.

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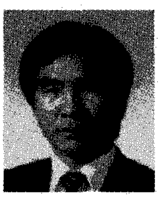
약 력

이 일 규

1992년 충남대학교 전자공학과 (공학사)
1994년 충남대학교 대학원 전자공학과 (공학석사)
2000년 충남대학교 대학원 전자공학과 (공학박사)
1994년 ~ 2004년 한국전자통신연구원 선임연구원
2004년 ~ 현재 공주대학교 정보통신공학부 조교수
관심분야 : 이동통신 RF 시스템, 초고주파 회로설계, 근거리 무선통신 시스템 등

류 성 렬

2005년 공주대학교 전자공학과 (공학사)
2006년 ~ 현재 충남대학교 대학원 전자공학과 (공학석사 과정)
관심분야 : RF 시스템 및 초고주파 회로설계



오 승 엽

1971년 연세대학교 전기공학과 (공학사)
1973년 연세대학교 전기공학과 (공학석사)
1982년 연세대학교 전기공학과 (공학박사)
1981년 ~ 1982년 일본 Tohku 대학 교환교수
1985년 ~ 1986년 미국 Pennsylvania 주립대학 교환교수
1994년 ~ 현재 충남대학교 전자공학과 교수
관심분야 : RF 시스템 및 소자, 안테나, 전파전파 등

홍 헌 진

1986년 충남대학교 전자공학과 (공학사)
1990년 충남대학교 대학원 전자공학과 (공학석사), 충남대학교 대학원 전파공학과 (공학박사 과정)
1990년 ~ 현재 한국전자통신연구원 책임연구원, 전파자원 연구팀 팀장
관심분야 : RF 시스템 및 부품 설계, 전파간섭, 전파전파, 전파자원 등