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Design of a Module for Oscillation Detection in an Integrated PCS and W-CDMA Receiver

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Abstract

In this paper, a circuit for detecting a fine oscillation in an integrated PCS and W-CDMA receiver is presented. The advantages for this design are small size and flexible compatibility for system operation compared with the conventional method. The fine oscillation level can be detected by dB unit through selecting the receiver mode as PCS of 1.8 GHz range or W CDMA of 1.9 GHz range by a RF switch and monitoring the corresponding frequency band. Also, the circuit is designed to be flexible for other communication systems with the consideration of the required dynamic range of 75 dB.

Key Words : Oscillation detector, PCS, W-CDMA, Wireless communication system

1. Introduction

Development of mobile communication leads to the second generation of digital systems such as PCS (Personal Communication Services) through the first generation of FDMA (Frequency Division Multiplexing/ Multiple Access), and then the third generation mobile communication, IMT-2000 (International Mobile Telecommunication 2000), in which high-speed image data transfer, mobility between individuals and terminals, and Global Roaming are possible [1].

With the consideration of cost and time for installing the new network, the transition to the third mobile generation communication systems is attempted gradually while the existing second-generation systems are utilized. For example, the compatibility between different kinds of BTS devices and relays of the 2nd and 3rd generation is positively considered and partially adopted.

Fig. 1 represents the block diagram of a transceiver for a wireless communication system. For PCS and W-CDMA (IMT2000) systems based on GSM network in which high gain of RF transceiver is needed, it can cause service interruption by system damage or system shut-down due to the insufficient isolation between Link Antenna and Coverage Antenna [2].

In this paper, fine oscillation due to insufficient isolation in Fig. 1 is considered and the circuit for oscillation detection is designed and adopted to the wi

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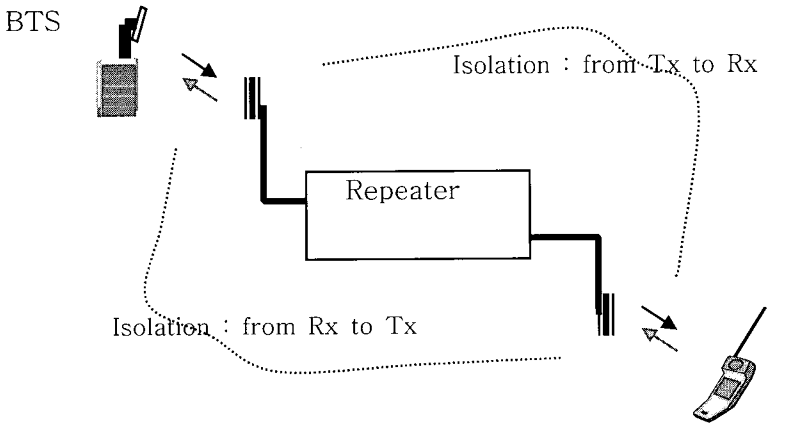


<Fig. 1> Block diagram of a transceiver for a wireless communication system

reless dual mode transceiver system so that it can be used all the time with the advantage of preventing the oscillation without extra circuit change. Besides, for optimizing the module consisting of each unit, it is designed with consideration of each unit's input and output condition within system budget.

II. Structure and Design

For a transceiver in a wireless communication system, the path loss between the Donor and the Remote, which connect the intensity and mutual relation of receiving signal among BTS, relay, and terminal, is an important element for calculating isolation that antenna should secure for the gain of relay.

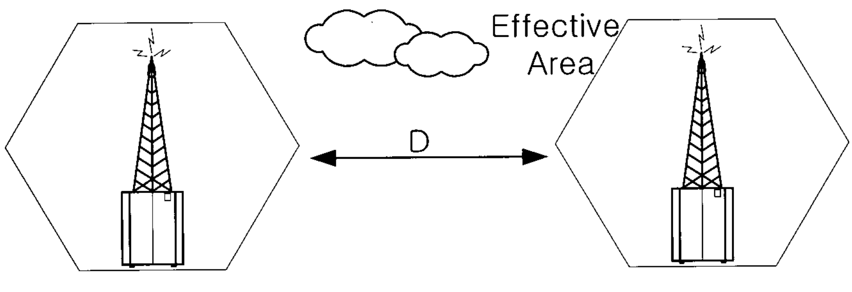
Fig. 2 shows the dissipated power in free space. When an antenna transmits the power of P_t, at a distance D, the power of the signal, P_r which is received at another antenna with the effective dimension of A is defined as following Eq. (1).

$$P_r = \frac{G_t G_r \lambda^2}{(4\pi d)^2} P_t \tag{1}$$

Here, G_t and G_r are transmitter and receiver antenna gains, is the wave length of carrier (m), and d is the distance between the transmitter and receiver. Therefore, the pass loss, L in dB can be calculated by Eq. (2).

$$\begin{aligned} L &= P_t\big|_{dB} - P_r\big|_{dB} \\ &= -10\log G_t - 10\log G_r - 20\log\lambda \\ &\quad + 20\log d + 21.98 \end{aligned} \tag{2}$$

If it uses the isotropic type of antenna ($G_t = G_r = 1$) and the units of frequency (f) and distance (d) are



<Fig. 2> The dissipated power in free space

MHz and *km*, respectively, L becomes as follows.

$$L = 20\log f + 20\log d + 32.44 \quad dB \tag{3}$$

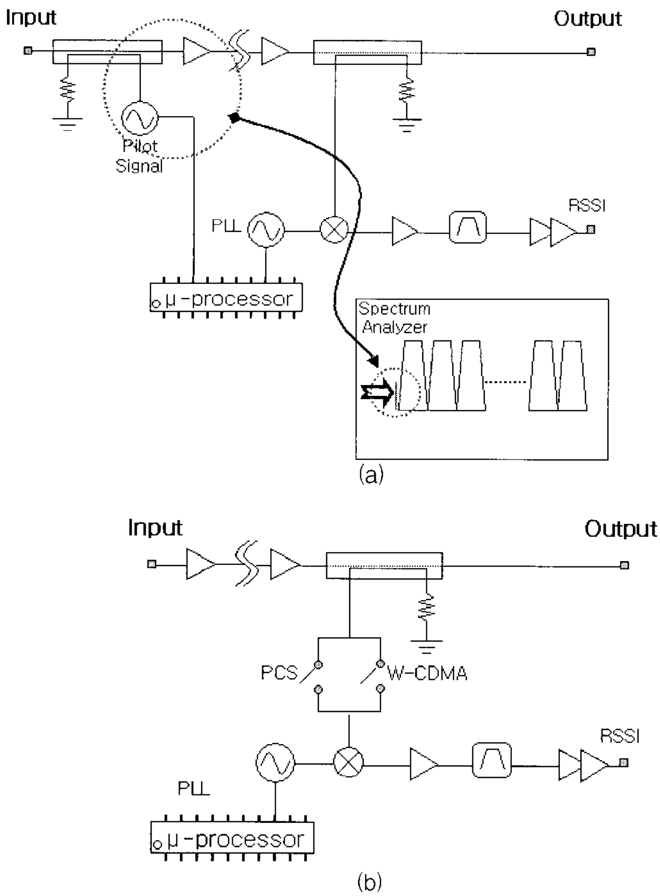
The stability factor (K) that could grasp the circuit stability on the stage of designing circuit and system is given as below equations (4) and (5),

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} \tag{4}$$

$$\Delta = S_{11}S_{22} - S_{12}S_{21} \tag{5}$$

In these equations, if $K > 1$, the circuit is unconditionally stable and if $K < 1$, it is conditionally st able. That is, if K is smaller than 1, it can be stable or unstable depending on stability circle. If $K < 1$ in element or system, stability circle should be drawn for each frequency and the stable impedance sphere be determined [3,4].

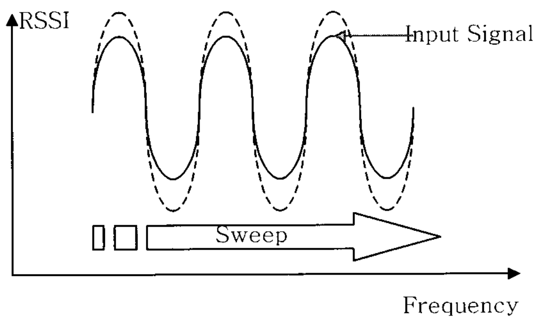
Fig. 3 shows the schematic diagram of oscillation detection module for a conventional method and a new method which is suggested in this paper for the PCS and W-CDMA. In Fig. 3(a), a conventional oscillation detection module within a transceiver consists of a part of the pilot signal generation, a mixer, and a coupler in input, and a coupler and a detection module which measures the modulation of signal in output. This structure includes complexity of system, po



<Fig. 3> Schematic diagram for oscillation detection module for (a) a conventional method and (b) the proposed method

ssibility of generation of unwanted signals within the transmission band, and only a part detection of oscillation. In a new module, these disadvantages are considered and solved by a compact and simple design as shown in Fig. 3 (b). For setting up the oscillation detective function or impressing electricity, PCS or W-CDMA path is selected by the switch. Then, the coupled input signal is converted into IF (Intermediate Frequency) signal through mixing process with Freq. Sweep Tone by micro-processor. Converted IF frequency is filtered by SAW Filter with narrowband, and finally the value of RSSI (Received Signal Intensity Indicator) is determined.

The RSSI value detected from each band (PCS or W-CDMA) is written by the peak-to-peak value using table after calculating the average values between the



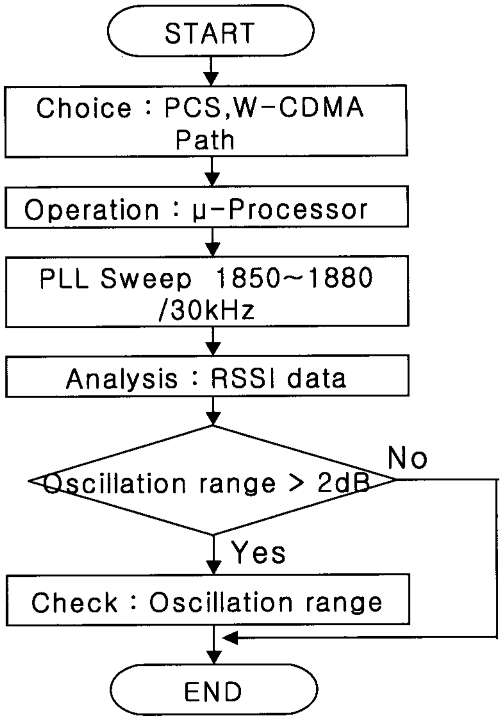
<Fig. 4> Topology of oscillation detection

average of maximum value group and of minimum value group that sampled as 30 kHz per corresponding fine oscillation level as shown in Fig. 4.

The process for determining the fine oscillation level is shown in Fig. 5. The range for the detection level of oscillation is 2 ~ 15 dB.

III. Measurements

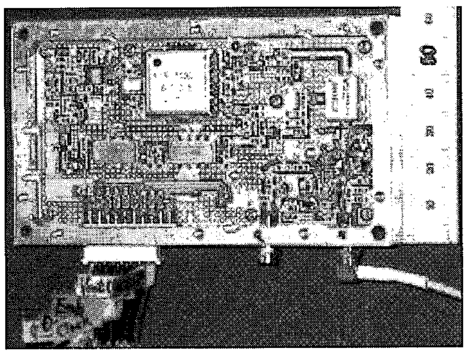
Fig. 6 shows the module for the oscillation detection. The module consists of RF receiver, PLL, and



<Fig. 5> Flowchart of oscillation detection

IF circuits. Active devices such as AM-1 by W&J and ERA-5SM by Mini-Circuit are mainly used and substrate with the dielectric constant of 4.7 and the height of 0.765 mm is used.

Supply voltage of 5 Vdc is applied and PCS or W-CDMA path is chosen by RF switch. PLL output frequency is controlled so that IF frequency becomes 100 MHz.



<Fig. 6> Photograph of the module

The reason of IF frequency to be 100 MHz is that one PLL can detect two bands by using limited PLL output frequency range. This PLL output signal of PCS or W-CDMA by RF switch is mixed with coupled input signal at the mixer, and is sampled finely by 2 SAW filters with 30 kHz narrowband.

The sampled RF signal is obtained after being converted into analog voltage by the degree of intensity.

In Fig. 6, a small repeater with the gain of 80 dB and the variable attenuator of 90 dB for securing isolation to make the same experiment condition as real field are used in measurement. Isolation detection is tested with the measurement after setting the situation that the antenna doesn't secure isolation by decreasing variable attenuator gradually and it caused to make small width through big width of oscillation.

Fig. 7 shows the test set-up for the oscillation detection of the module.

Fig. 8 represents one example of measuring fine oscillation for the cases of fine oscillation of 2 dB, 3 dB, 4 dB, and 5 dB among 2 ~ 15 dB with the condition of the power of 80 dBm at the monitoring port. When the width of fine oscillation is 2 dB, the maximum RSSI is 0.893 Vdc on an average, and the minimum RSSI is 0.914 Vdc, and the peak-to-peak value is 0.069 Vdc.

Similarly, when the widths are 3 dB, 4 dB, and 5 dB, peak-to-peak values are 0.130 Vdc, 0.154 Vdc, and 0.182 Vdc, respectively. From the figure, as the oscillation width increases, the gap of voltagein-creases, too.

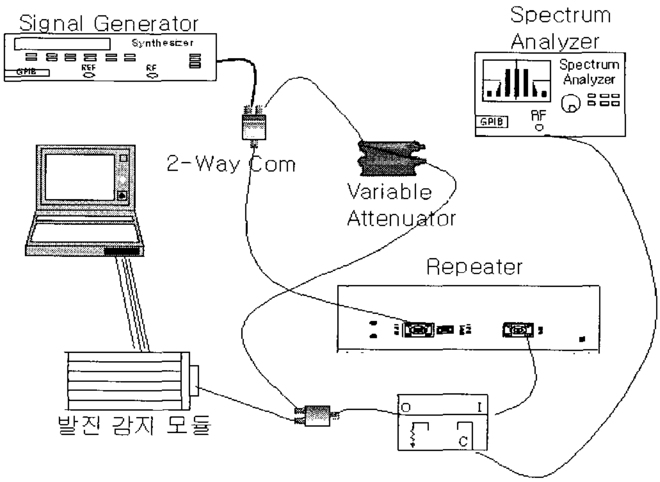
When the biggest input condition of -5 dBm is applied, the maximum RSSI in 15 dB oscillation is 3.137 Vdc on an average, the minimum RSSI is 2.677 Vdc on an average, and peak-to-peak value is 0.460 Vdc that is the biggest value.

IV. Efficiency and Analysis

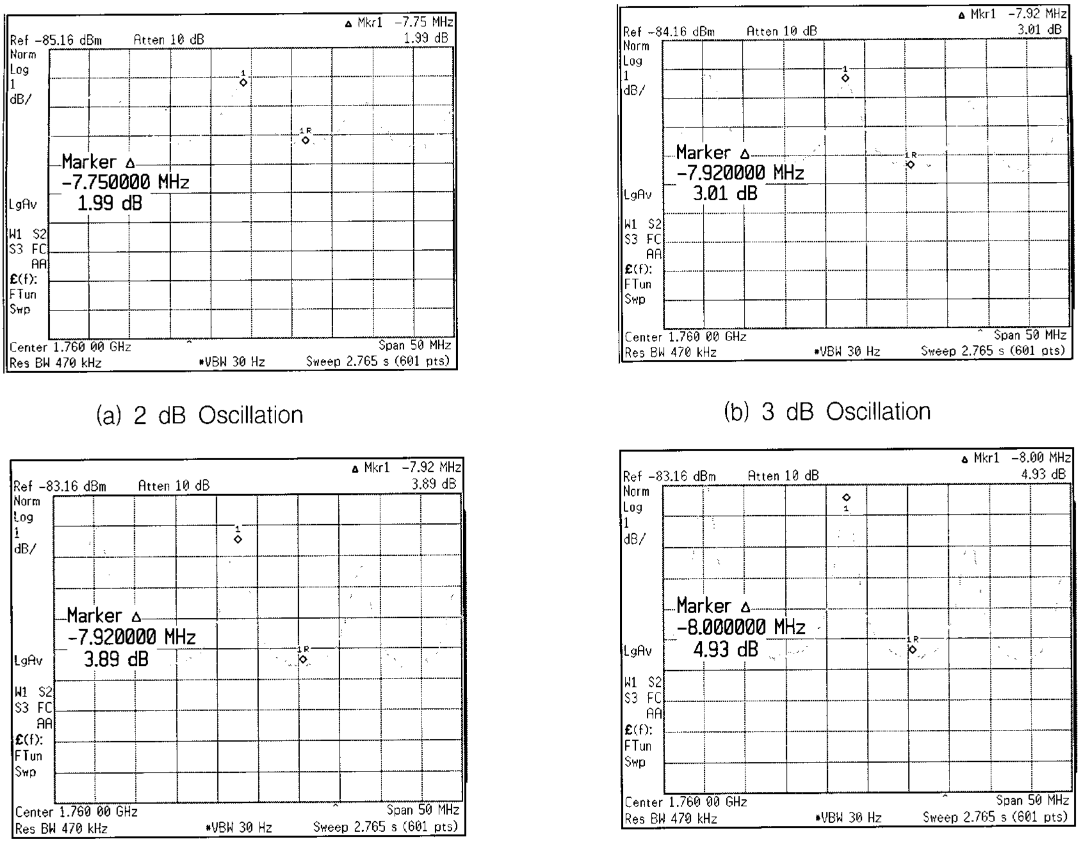
The fine oscillation for the case of input power of -80 dBm, -40 dBm, and -5 dBm in the different kinds of receiving bands of PCS, W-CDMA, and in the monitoring port is analyzed.

Fig. 9 represents the maximum group of 50 and the minimum group of 50 of sampled RSSI at inter vals of 200 kHz per oscillation dB for the 20 MHz PCS receiving band. Also, from the figure, discrim ination of oscillation has nothing to do with receiving intensity due to high linearity.

In real operation, the number of sampling, and



<Fig. 7> Test set up for the oscillation detection



(a) 2 dB Oscillation

(b) 3 dB Oscillation

(c) 4 dB Oscillation

(d) 5 dB Oscillation

<Fig. 8> Measurement results of the module for oscillation detection

maximum and minimum groups of RSSI is increased, the precision in the measurement gets higher.

V. Conclusion

In this paper, the module for oscillation detection in the integrated PCS and W-CDMA receiver has been successfully demonstrated. It is possible to monitor the corresponding whole band by choosing the PCS 1.8 GHz band or the W-CDMA 1.9 GHz band, and the module can be composed of a common IF for both PCS and W-CDMA bands with one PLL. At the same time, fine oscillation level from 2 dB to 15 dB can be detected. The module structure which is composed of RF receiver, PLL unit, IF, and oscillation detective part, is very simple compared with existing method, and it has also advantage for checking the oscillation in whole pass band.

Also, it can be applied to other tele- communication systems due to wide dynamic range of 75 dB (-80 dBm~ -5 dBm). Because this module detects CDMA signal intensity by applying wideband direct detective method, the intelligent system, which can monitor and distinguish oscillation at a transceiver can be easily constructed. This module can be applied to the existing system without extra circuit change.

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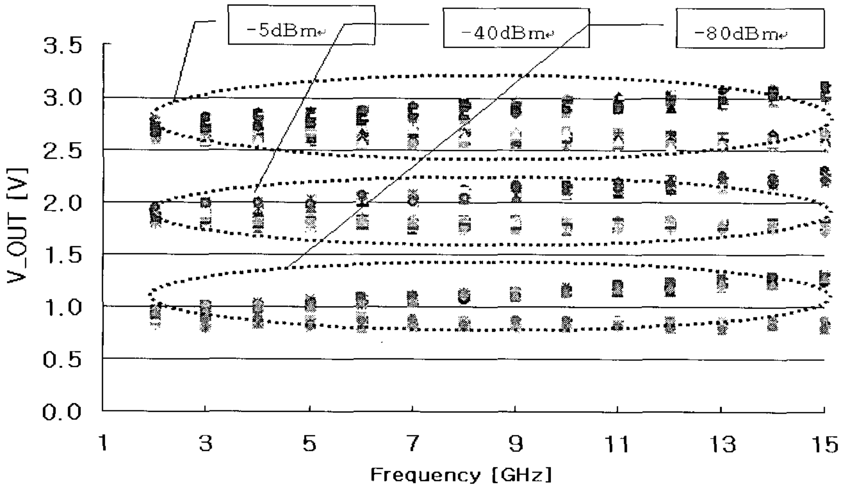

<Fig. 9> Oscillation patterns of maximum and minimum group values

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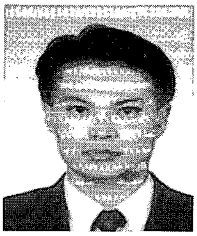

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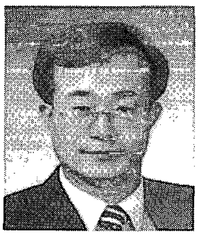

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