A Design of Co-channel Feedback Interference Cancellation System using Analog Control

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***Abstract* — In this paper, a co-channel interference cancellation technique is suggested in order to cancel a feedback interference signal in the wireless communication repeater. And an amplitude, phase and group delay time of the correction signal can be controlled adaptively for optimum cancellation of the feedback interference signal in the proposed cancellation system. The fabricated co-channel interference cancellation system for Korean RFID frequency band (908.5~914MHz) could obtain the reduced feedback interference signal about 36.4dB.**

I. Introduction

The telecommunication and mobile communication markets are being growing up rapidly in many countries. Particularly, the rapid increase of mobile phone requires micro- or pico-cell service, so that many base station or repeater are also increased. Additionally, RFID that radiates a radio frequency (RF) signal and detects the reflected RF signal must distinguish the received signal with the transmitted signal.

In the base station, when the radiated signal from transmitter antenna is feedbacked to receiver antenna, the feedback signal operates as interference signal. This feedback interference signal is a natural common phenomenon which exists in all of the wireless communication system using the same frequency. The feedback interference signal makes possibility to oscillate the receiver system and deteriorates a performance of the receiver system.

A co-channel interference cancellation technique can reduce the unwanted feedback interference signal as small as possible. Therefore, the technique prevents the oscillation of the receiver system and makes the maximum output power of the amplifier in repeater system. It is very important in modern communication system.

In previous, many co-channel interference cancellation systems have conducted, but the most of research have assumed a fixed environment factor. [1]-[3] But an air interface environment of wireless communication and wireless channel are time-varying condition due to weather, temperature, fading condition, etc [4].

In this paper, we proposed the new co-channel interference cancellation systems that amplitude, phase and group delay time of the correction signal can be adaptively controlled to optimum cancellation of interference signal. This adaptive correction signal can reduce the feedback interference signal effectively than previous.

II. Cancellation Theory of Interference Signal

Fig.1 shows the each signal in confirmation of cancellation theory of interference signal . The received signal, interference signal and correction signal can be named as below $S_R(t)$, $I_F(t)$ and $S_C(t)$, respectively.

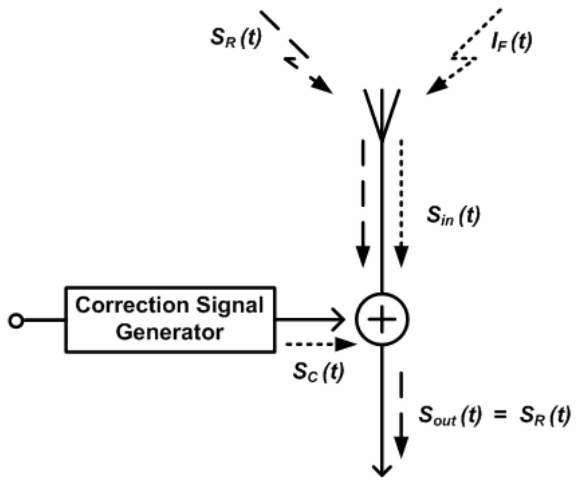

Fig. 1. Block diagram of interference signal cancellation theory.

Each signal can be expressed as Eq. (1).

$$\begin{aligned} S_{in}(t) &= S_R(t) + I_F(t) \\ S_R(t) &= A\cos(\omega t) \\ I_F(t) &= B\cos(\omega t + \phi) \\ S_C(t) &= C\cos(\omega t + \theta) \end{aligned} \quad (1)$$

When $S_C(t)$ is combined with input signals $S_{in}(t)$, the output signal can be expressed as Eq. (2).

$$\begin{aligned} S_{out}(t) &= S_R(t) + I_F(t) + S_C(t) \\ &= A\cos(\omega t) + B\cos(\omega t + \phi) + C\cos(\omega t + \theta) \end{aligned} \quad (2)$$

If the amplitude of correction signal is same and the phase is out-of-phased with that of the feedback signal, the output signal can be extracted as pure received signal.

$$S_{out}(t) = A\cos(\omega t) \quad (3)$$

However, if communication signal is band-limited signal, not continuous wave(CW), there must be considered group delay time matching as well as amplitude and out-of-phase matching for optimum cancellation of the interference signal [5][6]. According to consider group delay time, the interference signal and correction signal can be modified as Eq. (4) and (5), respectively

$$I_F = B\cos(\omega t + \phi) \qquad (4)$$

$$S_C(t) = (B + \Delta B)\cos[\omega(t + \Delta\tau) + \phi + \pi + \Delta\phi] \qquad (5)$$

Where ΔB, $\Delta\phi$, and $\Delta\tau$ are amplitude, phase, and group delay time difference, respectively. The combined error signal, $S_{err}(t)$, that is difference between the feedback and the correction signal. It is expressed as Eq. (6).

$$S_{err}(t) = B\cos(\omega t + \phi) + (B + \Delta B)\cos(\omega t + \omega\Delta\tau + \phi + \pi + \Delta\phi) \qquad (6)$$

The general form of error signal can expressed as Eq. (7) and the amplitude of this signal is the same as Eq. (8).

$$S_{err}(t) = E\cos(\omega t + \phi) \qquad (7)$$

$$E = \sqrt{\Delta B^2 + 2(1 + \Delta B)[1 - \cos(\omega\Delta\tau + \Delta\phi)]} \qquad (8)$$

As a result, the amplitude of error signal is comprised of amplitude mismatch, phase mismatch and group delay time mismatch. Therefore, group delay time matching as well as magnitude and out-of-phase matching must be obtained like linearizing system for optimum cancellation.

III. Design of Group Delay time Adjuster.

In this paper, the group delay time adjuster (GDTA) is designed for the optimum matching of group delay time between the correction and the feedback signal [7]. The designed single GDTA unit using a variable capacitance and a variable inductor is shown in Fig. 2.

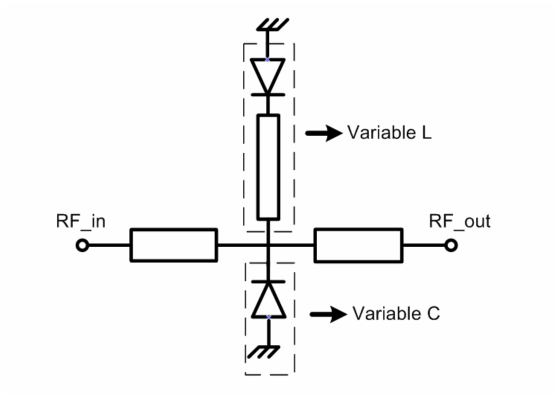

Fig. 2. The group delay time adjuster (GDTA) unit.

The variable capacitor and inductor are realized with a varactor diode and a transmission line terminated with varactor diode, respectively. If a resonance frequency is maintained constantly and a capacitance is changed, transmission group delay time will be changed. Additionally, we designed balanced GDTA to improve variation characteristic of group delay time. Fig. 3 shows the balanced group delay time adjuster with two group delay unit.

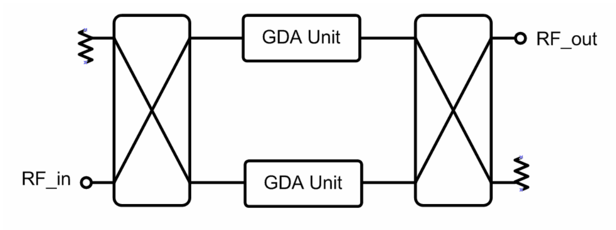

Fig. 3. The designed GDA adjuaster

Measurement results of group delay time according to control voltage are summarized in Table I. A variation of group delay time is about 6ns. A reflection coefficient of the GDTA unit is under -20dB over all variation range.

TABLE. I
Measurement of Group Delay Time Adjuster.

Group Delay [ns]			Insertion loss [dB]			S11 [dB]
908.5 [MHz]	911 [MHz]	914 [MHz]	908.5 [MHz]	911 [MHz]	914 [MHz]	max.
1.04	0.98	1.04	-0.22	-0.24	-0.24	-20.70
2.19	2.11	2.06	-1.11	-1.19	-1.24	-20.56
3.13	3.12	2.89	-2.11	-2.29	-2.19	-20.50
3.99	3.94	3.98	-2.17	-2.17	-2.18	-20.50
5.05	5.08	4.76	-3.17	-2.95	-2.79	-20.50
5.19	6.13	5.95	-4.90	-4.47	-4.03	-20.21

IV. Design of Co-channel Interference Cancellation System.

The block diagram of proposed co-channel interference cancellation system is shown in Fig. 4.

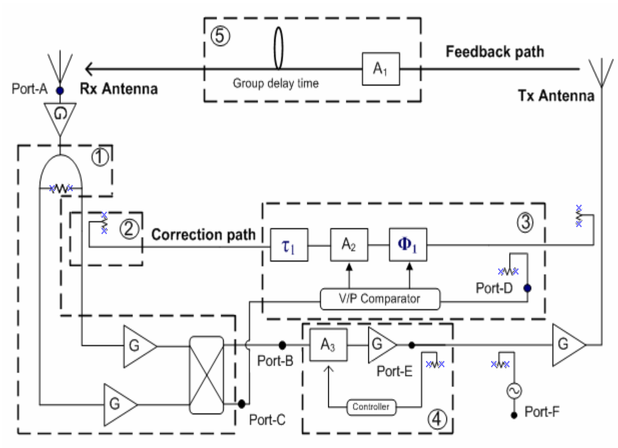

Fig. 4. Block diagram of the proposed co-channel interference cancellation system..

In the Fig 4, block 1 is an error signal detector, block 2 is a signal combiner, block 3 is a correction signal generator, block 4 is an automatic level controller (ALC) that maintains constant output power level, and block 5 is a feedback signal adjuster. Particularly, block 1 is the main block of this system. In case of the perfect cancellation condition, it will be extract the correction signal that satisfy the cancellation condition from port C to compare with the output signal from port D. The error signal detector is using balanced amplifier as shown in Fig. 5.

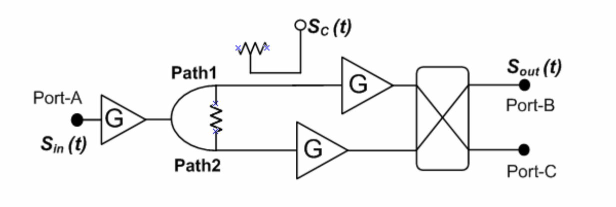

Fig. 5. The block diagram of error signal detector.

There has 90° phase difference between path 1 and path 2 by directional coupler to combine the correction signal. Therefore, when optimum cancellation was occurred, the output signal will become the pure received signal at port B and the correction signal will be obtained from port C [9]. And the perfect cancellation state can be maintained by comparison the signal between at port D and port C.

Block 3 is consisted of amplitude/phase comparator, analog controller using op-amp, group delay time adjuster, attenuator and phase shifter. These circuits are used to analog control the correction signal according to the variation of feedback interference signal.

To maintain the cancellation condition, the proposed system has the feedback path and the correction path. The correction signal that satisfy perfect cancellation can be obtained from port C and the output signal can be obtained from port D. The comparator is compare the extracted signal of port C with the extracted signal of port D in block 3, and this compared signal can be controlling low phase variable attenuator, variable phase shifter. As a result, it will generate the correction signal that corresponds with the feedback signal. This signal will perform to cancel the feedback signal in block 2, and the optimum cancellation condition will be constantly maintained by operation of analog feedback control

The fabricated co-channel interference cancellation system is designed for Korean RFIC frequency band (908.5~911MHz). And we confirmed the validity at operating band. The used low noise amplifier is RF2347 of Micro devices. An amplitude/phase comparator is used AD8302 of Analog devices and an analog controller is designed with op-amp. And at transmitted system, the used power amplifier is MHL9236 of Motorola that the maximum output power is 34dBm.

V. Measurement of Co-channel Interference Cancellation System.

Measurement results of the proposed system are shown at Fig. 6 to 8. Fig. 6 shows that the output signal with the received signal and the feedback interference signal at port B, when the correction signal generator was not operated. The 1-tone signal is used as the received signal to distinguish the feedback interference signal. The power level of received signal is -40dBm for center frequency 911.25MHz that is injected into port A. On the other hand, IS-95 CDMA-4FA signal is used as the feedback interference signal that is injected into port F.

Fig. 7 shows the measurement result at port B, when the correction signal generator was operated. We could obtain cancellation effect of the feedback interference signal about 24.92dB

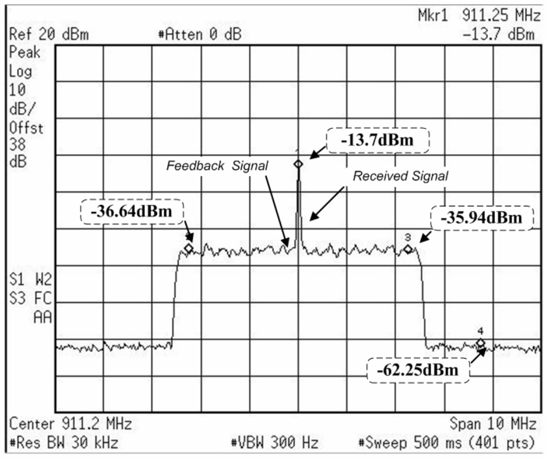

Fig. 6. Received and feedback interference signal at port B.

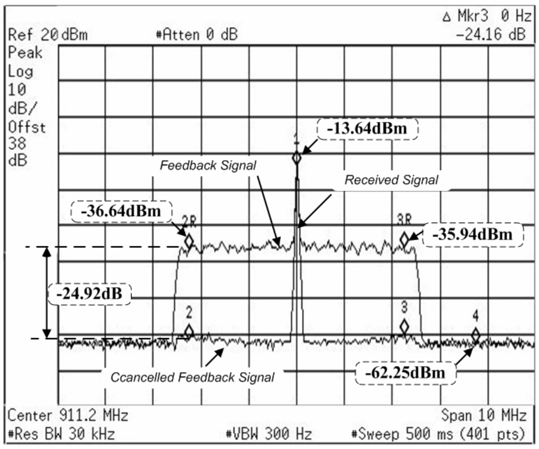

Fig. 7. Received signal and cancelled feedback interference signal at port B.

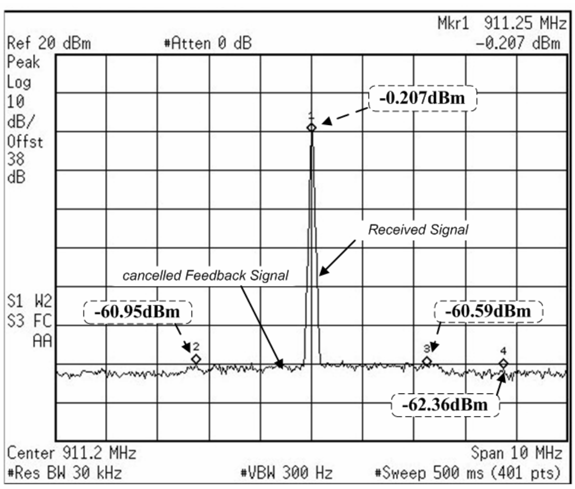

Fig. 8. Received and cancelled feedback interference signal at port E.

Fig. 8 shows measurement results at port E, when the correction signal generator was operated.

At this time, the output power level of ALC is maintained about 0dBm. According to this operation, received signal is amplified with ALC circuit by 0dBm. But the power level of feedback interference signal is almost similar. Consequently, Fig. 8 shows signal cancellation effect about 36.41dB.

Table. II summarizes the measurement results of the proposed co-channel interference cancellation system.

TABLE. II
SUMMARY OF MEASUREMENT RESULTS

Correction signal generator is not operating.		
Measurement port	Port B	
Received Signal [dBm]	-13.64	
Feedback Interference [dBm]	-36.64	
Correction signal generator is operating.		
Measurement port	Port B	Port E
Received Signal [dBm]	-13.64	-0.207
Feedback Interference [dBm]	-61.56	-60.95
Cancellation [dB]	24.92	**36.41**

VI. CONCLUSION.

In this paper, we designed circuits to cancel the feedback interference signal, when the radiated signal at Tx antenna had been return to Rx antenna from in wireless communication. Additionally, we designed circuits that could be analog control for optimum cancellation of interference signal.

As a result, we could be obtained a maximum improved cancellation about 36.41dB in respect to the feedback interference signal. The proposed co-channel interference cancellation system can not only improve in quality of repeater system, but also used to several wireless communication system.

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