Adaptive Feedback Interference Cancellation System (AF-ICS)

S.J. Kim, J.Y. Lee, J.C. Lee, J.H. Kim, B. Lee, and N.Y. Kim

Kwangwoon University, 447-1 Wolgye-dong, Nowon-ku, Seoul 139-701, Korea
RFIC Center, Mission Technology Research Center
E-mail : nykim@daisy.kwangwoon.ac.kr

Abstract - In this paper, the adaptive feedback interference cancellation system(AF-ICS) is suggested in order to cancel the feedback signal in the wireless communication system with the same frequency. AF-ICS prevents the oscillation of the receiver system and maintain the maximum output power of the power amplifier by the reduction of time-varying feedback signal. The cancellation ratio and the error ratio of the adaptive detector are achieved as simulation result of 40~44 dB and the performance index(cancellation ratio and error ratio) of the adaptive detector is 13~15 dB in the system implementation. AF-ICS improves total channel power about 4.11 dBm under CDMA-3FA and 90 dB feedback loss.

I. INTRODUCTION

The feedback signal from Tx antenna comes back to the Rx antenna and this feedback signal becomes the source of an interference. The performance of the receiver system is decreased by the feedback signal. Therefore, this feedback signal should be cancelled before it returns as the input signal. Feedback interference or feedback signal is a natural common phenomenon which exists in all of the wireless communication system using the same frequency [1]-[3]. Therefore, the interference cancellation scheme is very important technique to be cancelled or suppressed the feedback signal to reduce the effect of interference on the receiver system [4]. In this paper, an adaptive feedback interference cancellation system is adapted to the time-varying wireless channel and circumstance of the same frequency system [5]-[6]. Adaptive feedback method prevents the oscillation of the receiver system and maintains maximum output power of the power amplifier.

II. WIRELESS REPEATER SYSTEM WITH THE INTERFERENCE CANCELLER

Wireless repeater system block diagram with the general interference canceller is shown as Fig. 1.

Interference canceller generates the counterpart signal to cancel the feedback signal and the counterpart signal has the same amplitude and anti-phase as the feedback signal. However, the variable factors are fixed in one value by the primary setting in this system. This system can not control all the feedback signal with time-varying factors under time varying environment. So, only one feedback signal which is the same variable factors as the primary setting is cancelled out.

Therefore, counterpart signal is requires to adapt the time varying amplitude, phase, and time delay under time varying environment. Adaptive counterpart signal is generated by the adaptive detector and the method of adaptive counterpart signal generator and the adaptive feedback algorithm in the AF-ICS.

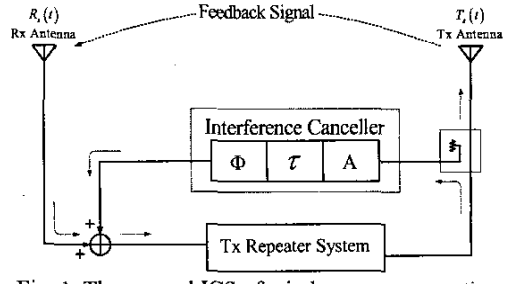

Fig. 1. The general ICS of wireless repeater system

III. AF-ICS SYSTEM SIMULATION

The block diagram of the AF-ICS is shown as Fig. 2. AF-ICS consists of four blocks, such as signal divider, cancellation signal generator, adaptive detector, and adaptive status monitoring control system.

The cancellation signal generator makes the counterpart signal(cancellation signal or removal signal) to cancel the feedback signal. This counterpart signal has the same amplitude, anti-phase and the same time delay as the feedback interference for the feedback signal cancellation. The cancellation signal generator consists of attenuator, phase shifter, and delay line.

Adaptive detector consists of error signal detector

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part and cancellation signal detector part. Cancellation signal detector part acts as a signal coupler and the feedback signal is cancelled by the cancellation signal in this part. The function of error signal detector is a sampler that generates only the necessary error signal. In the adaptive detector block, if the feedback signal perfectly cancelled out by the cancellation(counterpart) signal in the cancellation signal detector part. The error signal which is generated in error detector part is equal to the feedback signal.

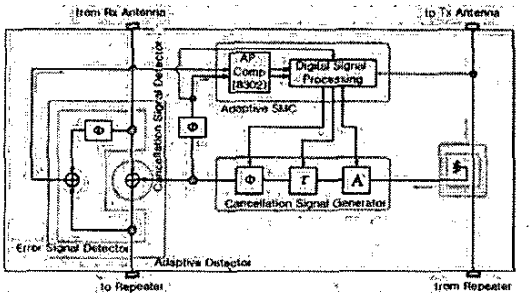

Fig. 2. Block diagram of the AF-ICS

The concept of the adaptive detector as the key elements of the AF-ICS is shown as Fig.3 and the functions of adaptive detector are above descriptions. The error signal detector and the cancellation signal detector are verified in this simulation. The powers of CW(continuous wave) signal source are -45 dBm at 1.760 GHz and 1.770 GHz, respectively. The simulation results are shown in Table I.

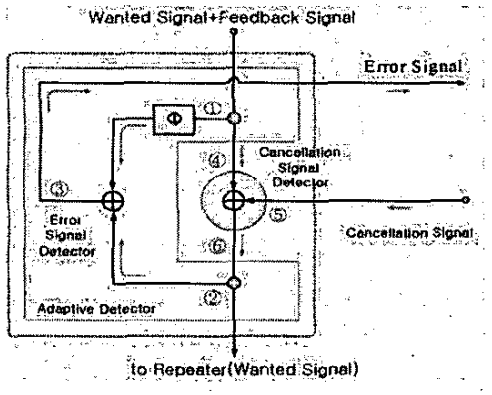

Fig. 3. Concept diagram of the adaptive detector

TABLE I. SIMULATION RESULTS OF THE ADAPTIVE DETECTOR

Frequency(GHz)	CF(dB)	EF(dB)
1.750	40	-
1.760	40	44
1.770	40	44
1.780	40	-

The error signal detector generates only the error signal ③ by the input signal ① and input signal ②. The input signal ① is mixed signal with wanted signal and the feedback signal. The input signal ② is the output signal of the cancellation signal detector.

The CF is the performance estimation index in the cancellation signal detector and EF is the performance estimation index in the error signal detector [7]. Therefore, EF means that the detection ratio of the feedback signal in the error signal detector by the mixing of the input signal ① and the input signal ②. CF also means that the cancellation ratio of the feedback signal in the cancellation signal detector by the mixing of the input signal ④ and the input signal ⑤.

The simulation results of the output channel power without and with AF-ICS are shown in Table II. The main output power variation at 1.760 GHz and 1.770 GHz and a variation of IM signal power generated by the applied CW-2 tones are shown as Fig. 4 and Fig. 5, respectively. Figure 4 and 5 have an inflection point on the about 80 dB feedback loss(FBL) and those are the compression point of the power amplifier from linear region to saturation region.

TABLE II. SIMULATION RESULTS OF THE OUTPUT CHANNEL POWER WITHOUT AND WITH AF-ICS

AF-ICS	without		with	
FBL(dB)	1.760	1.770	1.760	1.770
100 dB	41.05	41.05	40.04	40.04
90 dB	43.93	44.03	40.14	40.14
80 dB	44.25	44.70	40.22	40.23
70 dB	28.38	28.41	40.26	40.29
65 dB	22.49	22.51	40.58	40.68

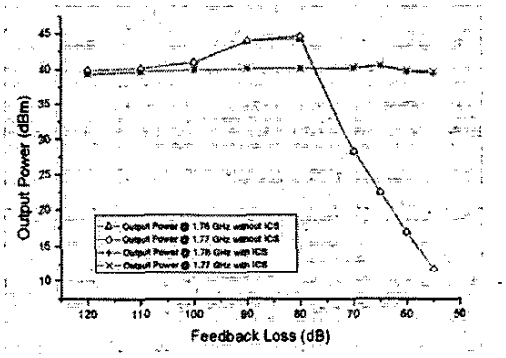

Fig. 4. Main output power simulation results with and without AF-ICS

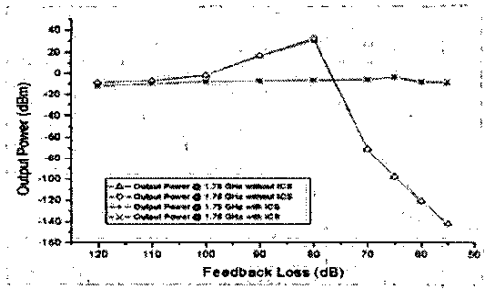

Fig. 5. IM output power simulation results with and without AF-ICS

The results of time delay mismatching between the feedback path and the cancellation signal path are shown as Fig. 6. The variation of the output power signal has a period, which is about 0.6 nsec and also the peak-to-peak amplitude is about 6~7 dBm. Therefore, the time delay mismatching should be smaller than ±0.15 nsec to satisfy the excellent cancellation ratio.

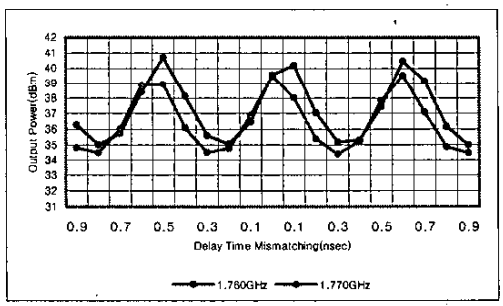

Fig. 6. Output power simulation results according to the time delay mismatching

IV. Broadband Signal Cancellation Factors

The cancelled signal characteristics of the CDMA-7FA(frequency allocation) signal model is shown as Fig. 7. However, there are some problems in the cancelled signal, that is, the cancelled signal has too large deviation of the amplitude and negative/positive slope characteristics from the center frequency.

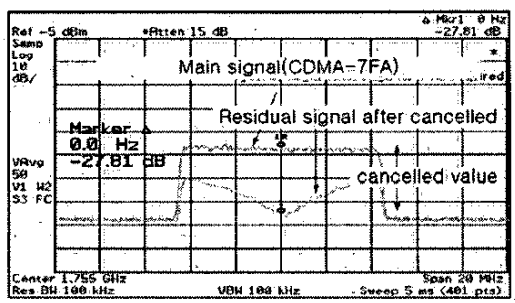

Fig. 7. Broadband CDMA signal cancellation(7FA) for the variable factor

The characteristics of Fig. 7 are caused by in accurate control signal of the amplitude, un-flatness of phase shifter(broadband linearity of the phase shifter) and time delay mismatching. In order to minimize the deviation of amplitude and the slope characteristics, the attenuator and phase shifter in the cancellation signal generator should be controlled by the precise step and must have the broadband linearity, and also time delay mismatching should be minimized.

Figure 8 shows the test result graph using the precise controlled attenuator and phase shifter and control cable to minimize the time delay mismatching of the path of the feedback and cancellation signal. The oscillation signal in Fig. 8 is generated when the feedback signal is the same FBL(feedback loss) as the repeater gain. In this case the magnitude of the feedback signal is equal to the receive signal. However, the reconstructed signal after cancelled the feedback signal by the precise control, prevents the oscillation as shown in Fig. 8.

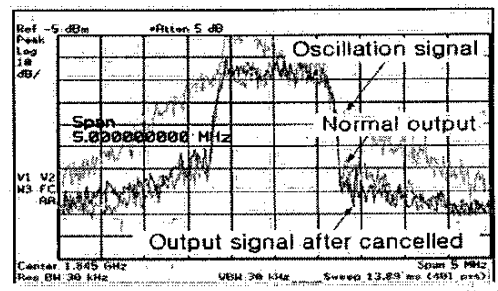

Fig. 8. CDMA-1FA signal cancellation test detailed factor control

V. Adaptive And System Integration Test

The variation of output power level after adaptation of the AF-ICS using multi-FA CDMA signal is shown in Table 4. The measured data requires the specification as listed in Table 3. The gain of the OFR is 95 dB and output power of power amplifier is 20 watts. According to the Table III, the total output power satisfies the requirement of the OFR at feedback loss 95dB in all FA's signal source but there is one data(39.90 dBm) more than the requirement of the OFR(39.66 dBm) at FBL 90 dB in the test of CDMA-4FA signal source.

TABLE III. MULTI-FA CDMA OUTPUT POWER LEVEL WITH AND WITHOUT AF-ICS

Test Unit		dBm/10MHz		Spec.
AF-ICS Connection		without	with	
1FA	95dB	42.69	41.03	41.76
	90dB	43.94	41.17	
3FA	95dB	42.91	40.13	40.98
	90dB	44.30	40.19	
7FA	95dB	44.07	39.43	39.63
	90dB	45.28	39.35	

Therefore, it is not too much to say that this is nearly satisfaction at the result but it is not perfect satisfaction at feedback loss which is less 10 dB than OFR gain.

The effects of the feedback signal in 90 dB gain OFR system is tested as below. When the input signal of the receiver antenna consists of -58 dBm wanted signal and -58 dBm feedback signal, the oscillation output signal occurs such as Fig. 9. However, as the feedback signal is cancelled by the AF-ICS connection, the oscillation disappeared from the output signal and reconstructed signal is show as Fig 10. The normal output signal of the only OFR without feedback signal is shown in Fig. 11 and the output spectrum of the OFR is very similar to that of Fig. 10. Therefore, adaptive characteristics of the AF-ICS is certified by reconstruction capacity as shown in Fig 10 and 11.

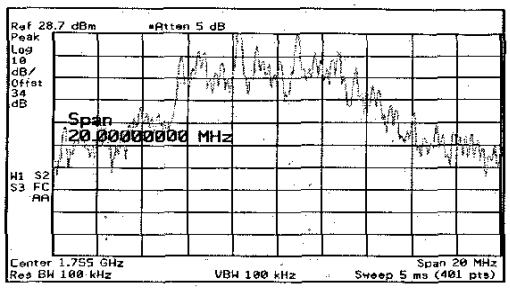

Fig. 9. Oscillated output signal by the wanted signal and feedback signal of the same amplitude

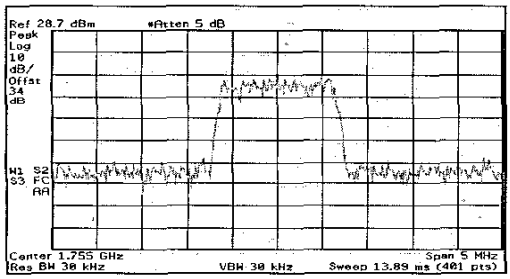

Fig. 10. Output signal after cancelled the feedback signal by the AF-ICS

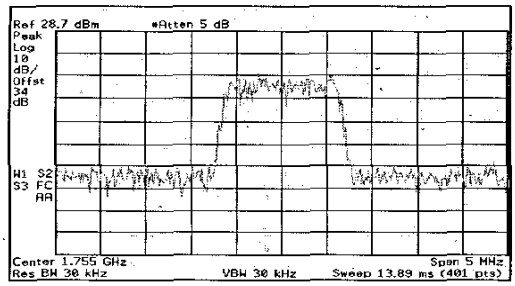

Fig. 11. Normal output signal of OFR

VI. Conclusion

In this paper, the cancellation ratio and error ratio of the adaptive detector are achieved as simulation result of 40~44 dB. The AF-ICS performs an excellent interference cancellation even with very high level feedback signal in this simulation. However, the system implementation test results are not under ideal case as simulation results, because the performance index(cancellation ratio and error ratio) of the adaptive detector is 13~15 dB. The adaptive detector is the key factor for the performance of the AF-ICS and the performance of the AF-ICS is decided by the performance index of the adaptive detector. The test results show that the key factor for the broadband signal cancellation consists of amplitude, phase, and time delay. The attenuator and phase shifter is required for the broadband linearity. The total channel power of the system without and with AF-ICS are measured as 44.3 dBm and 40.19 dBm under CDMA-3FA sources and 90 dB feedback loss. The 10 MHz bandwidth total channel power of 4.19 dBm is improved by AF-ICS.

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