Experimental Measurement for EVM Performance Enhancement of Wireless Repeater System

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Abstract. This paper suggests the adaptive multi-feedback filter system which, among a number of adaptive feedback filters in the wireless repeater system, applies the most appropriate feedback system according to the channel environment to enhance the performance of removing interference. The experiment result shows that the ITU 3GPP (3rd Generation Partnership Project) recommended specifications are met on both down-link and up-link. The cancellation was 25dBm, the window size was 500ns/1us, and the max. power was +10dBm. By using algorithms selectively according to the change of environment, the system reduced unnecessary use of hardware resources, and enhanced the convergence rate.

Keywords: Wireless Repeater System, Adaptive Feedback, Normal Least Mean Square, Error Vector Magnitude.

1 Introduction

A repeater is used to enhance quality of signal for wireless communication in a shadow area or in an area with low signal strength. There are different types of repeater in use. Among those, wired repeaters are most widely used. Wired repeaters can meet the situation or environment under which installation can become complicated or difficult. Installing this type of repeater requires wiring, and it takes much cost for installation and maintenance. Wireless repeaters are easier and cheaper to install than other types of repeater. This type of repeater, however, has a disadvantage that part of the output signal from the Tx antenna feeds back to the Rx antenna. [1,2,3]

This paper suggests the adaptive multi-feedback filter system which, among a number of adaptive feedback filters in the wireless repeater system, applies the most appropriate feedback system according to the channel environment to enhance the performance of removing interference. The suggested system can enhance the convergence rate and the hardware structure of the wireless repeater system as it selects the adaptive feedback filter according to the channel environment.[4,5]

In this study, the adaptive multi-feedback filter is designed, the multi-feedback filter is implemented with FPGA and DSP, and the EVM and interference cancellation performance was measured on the home wireless repeater system of less than 10mW.

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2 Hardware Structure of Multi-feedback Filter for Cancellation of Interface of Wireless Repeater

There are various feedback filters with various structures. The most widely used feedback filter model is the adaptive digital feedback filter. The performance of the adaptive digital feedback filter is measured with the algorithm that finds the optimum coefficient to be applied to the filter. The typically used algorithm to find the optimum coefficient is the LMS algorithm with superior stability and simple structure [6][7].

The suggested multi-feedback system is composed of a feedback signal generator which sums up power from numbers of adaptive sub-filters and generates the feedback signal; an original signal detector which deduces the feedback signal from the input signal and detects the service signal only; an input channel filter which removes unnecessary signal from the input signal; a feedback signal channel filter which generates only the signal in the same band with the input channel filter; and an output signal control which controls the delay of feedback signal caused due to device and environment coefficients. The input channel filter is located at the leading edge of the original signal detector, and the adaptive filter calculates the optimum weight for the selected band. Because the same channel filter is used at the output of the feedback signal, the system suppresses the signal of the band which is generated unnecessarily during the weight update process. Channel filters are applied to the output unit for the system using the existing channel filter, while they are applied to the input unit and the feedback signal for the proposed. This structure removes unnecessary signal from the input signal used in the adaptive filter algorithm, and corrects errors which may occur due to out-of-band signal.

Figure 1 illustrates the hardware structure of the suggested system. In order to efficiently handle the entered signal, the A/D converter must be selected in consideration of the frequency band, strength of signal and noise to be handled when converting the received analog signal into the digital signal.

In this research, Altera's EP3C55F484 was used as FPGA. Most of the adaptive feedback filter algorithm was processed by FPGA with VHDL [8]. For controlling, monitoring and signal processing, 32-bit DSC (Digital Signal Controller) is used. In this research TI's TMS320F2812 was used [9]. A D/A converter is used to output the result calculated with DSC and FPGA algorithms. The D/A convert used in this research was Analog Device's AD9775. In this research, the under sampling method was used for AD sampling. In this research, sampling was made with 64.11MHz, and for the sampling image area, the system is designed to cover 15.36MHz-7.5MHz and 15.36MHz+7.5MHz as the in-band where no aliasing occurs.

In order to remove the quantizing noise, a digital filter is installed in FPGA. The signal received from RF and entered into FPGA through the down converter is divided into In-Phase and Quad-Phase signal. NCO (Numerically Controlled Oscillator) is installed in FPGA to take the frequency of this signal to the baseband by FA. To handle the received signal, a decimation filter using a channel filter and a half-band filter is installed in FPGA. Using the decimation filter, FPGA extracts the

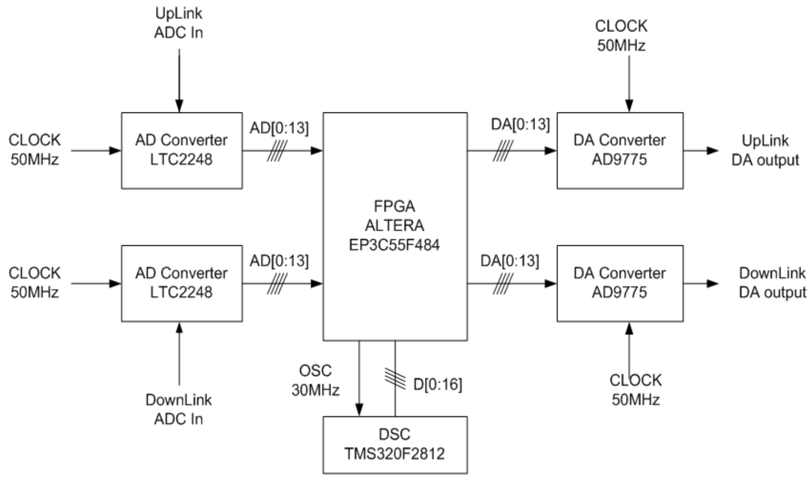

Fig. 1. The proposed system digital system block

feedback signal, and restores the original signal. The restored signal is sent to DAC through the interpolation block. The entire digital system is synchronized with FPGA, and ADC and DAC are sampled.

The system generates the feedback signal for each assigned sub-block by multiplying the filter coefficient updated by the adaptive filter sub-block update unit by the reference signal from the output signal delay unit. The system adds up the feedback signals of each sub-block, generates the final feedback signal, deducts the output signal of A/D converter, and detects the original signal.

3 Experiment and Result

To verify the LMS algorithm to be applied to the interference cancellation device of the wireless repeater system using multi-feedback filter, simulation was performed on the convergence time of weight according to isolation. Figure 2 shows the change of weight by isolation under the NLMS algorithm when the received power is -35dBm. The figure shows that, in the most cases, the weight becomes stabilized after 1800-sample (32us) time is passed (1 sample = 20ns). In this figure, I-40 indicates that the isolation is 40dB, the values on the y-axis are weights, and those on the x-axis are times.

To verify the performance of ICR made based on the suggested algorithm, a 10mW miniature ICR hardware was developed. FPGA and DSP programs were developed to implement the functions of interference cancellation device of ICR.

Test environment was deployed and the equipment performance was verified to assess the hardware structure and the system performance. The operating frequency of ICR was Down-Link 3FA (2112.5~2122.5) and Up-Link 3FA (1922.5~1932.5) in the WCDMA frequency domain, and has 5MHz per FA.

In order to verify performance of the wireless repeater using multi-feedback filter, EVM was measured.

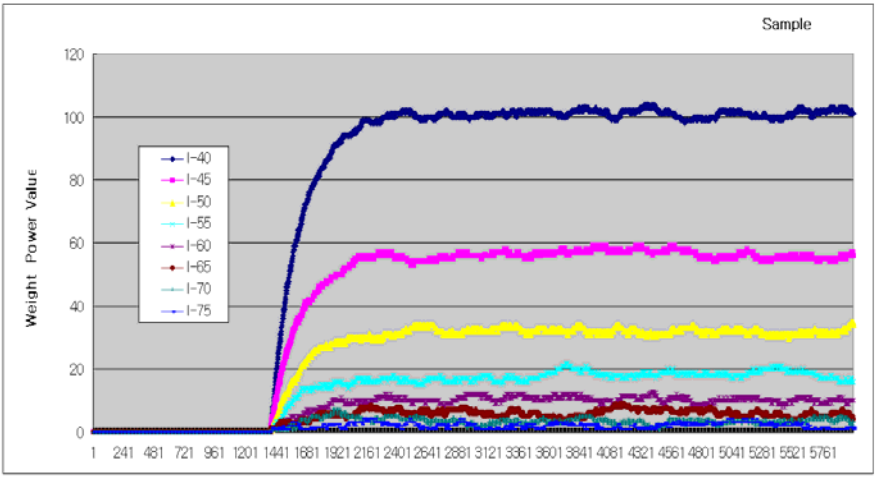

Fig. 2. Weight Value in Isolation to the Case of Received Power of -35dBm

Figure 3 shows the experimental system used to measure EVM performance of the wireless repeater. Feedback characteristics were experimented for differential isolation by measuring EVM performance with variable center frequency for each FA.

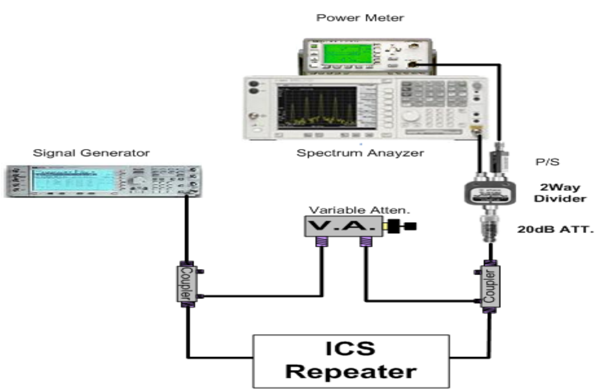

Fig. 3. Experimental System

To verify stability of the system, EVM characteristics were compared on the two conditions: when the feedback signal is entered into ICR interference cancellation device, and when it is not. The interference cancellation device of the produced wireless repeater was equipped with the suggested multi-feedback filter.

Figure 4 and 5 show the EVM characteristics on both down-link and up-link with or without feedback signal.

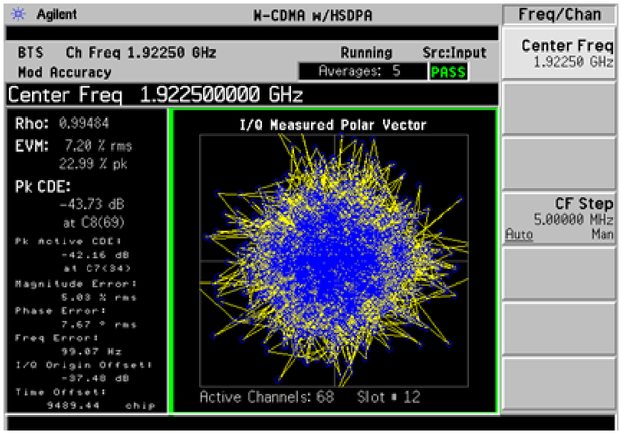

Fig. 4. EVM Characteristic by uplink FA without Feedback Signal

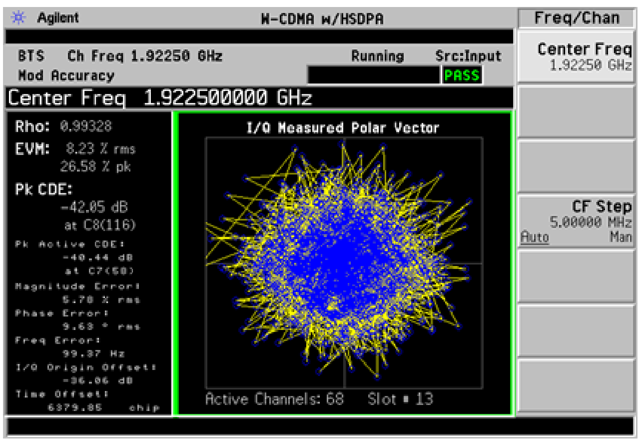

Fig. 5. EVM Characteristic by uplink FA wit Feedback Interference Signal

The improved LMS algorithm was added to each sub feedback filter algorithm. Under a normal condition when no feedback signal is entered, EVA in 1FA was 7.2%. Under the center frequency 1922.5MHz, input power -65dBm, isolation 60dB and system gain 70dB, EVM of FA1 on the Up-Link channel was 8.2%.

The above tables show that in order to meet the specifications, the EVM on the entire FA on both down-link and up-link must be lower than 12%, which is the value recommended by ITU 3 GPP (3rd Generation Partnership Project) [10][11]. Any feedback signal entered was removed in a stable manner. To determine the performance of the wireless repeater, the cancellation performance, the window size and the max. power were measured.

For the suggested ICR, the cancellation was 25dBm, the window size was 500ns/1us, and the max. power was +10dBm.

4 Conclusion

This paper suggests the adaptive multi-feedback filter system which, among a number of adaptive feedback filters in the wireless repeater system, applies the most appropriate feedback system according to the channel environment to enhance the performance of removing interference.

In proposed system, the size of isolation and the environmental change rate are added as the coefficients that determine the size of μ. In this way, the adaptive LMS algorithm is changed to enhance performance of the system by enhancing the adaptation rate according to the change of the environment. This paper also suggests the enhanced LMS algorithm having multi-feedback filters by applying n sub-blocks.

The experiment result shows that the ITU 3GPP (3rd Generation Partnership Project) recommended specifications are met on both down-link and up-link. The cancellation was 25dBm, the window size was 500ns/1us, and the max. power was +10dBm. By using algorithms selectively according to the change of environment, the system reduced unnecessary use of hardware resources, and enhanced the convergence rate.

References

1. Lattice Semiconductor Corporation, LMS Adaptive Filter, Reference Design RD1031 (December 2006)
2. Kim, I.: The Improved 8-PSK Space-Time Trellis Codes on Fast Fading Channels for High Data Rate Transmission. Korea Institute of Information Technology 7(6), 93–98 (2010)
3. Song, Y.J., Kang, I.: New Rapid Synchronization Method for Indoor Wireless Channel Environment. Korea Institute of Information Technology 9(4), 105–112 (2011)
4. Dasgupta, S., et al.: Sign-Sign LMS convergence with Independent Stochastic Inputs. IEEE Trans. on Information Theory 36(1), 197–201 (1990)
5. Kwong, R.H., Johnston, E.W.: A variable step size LMS algorithm. IEEE Trans. Signal Processing 40(7), 1633–1642 (1992)
6. Rani, S., Subbaiah, P.V., Chennakesava Reddy, K.: LMS and RLS Algorithms for Antennas in a CDMA Mobile Communication Environment. International Journal of The Computer, the Internet and Management 16(3), 12–21 (2008)
7. http://www.altera.com
8. http://www.ti.com
9. Lee, M., Keum, B., Son, Y., Joo-Wan, K., Lee, H.S.: A New Low-Complex Interference Cancellation Scheme for WCDMA Indoor Repeater. In: IEEE Region 8 International Conference on Computational Technologies in Electrical and Electronics Engineering, SIBIRCON, pp. 457–462 (July 2008)
10. Kwong, R.H., Johnston, E.W.: A variable step size LMS algorithm. IEEE Trans. Signal Processing 40(7), 1633–1642 (1992)
11. Lan, T., Zhang, J.: FPGA Implementation of an Adaptive Noise Canceller. In: International Symposiums on Information Processing, pp. 553–558 (2008)