CHANNEL ANALYSIS SYSTEM FOR DTV RECEPTION SIGNAL

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ABSTRACT

In general, channel information of received DTV signal analyzed based on symbol timing clock with only In-phase information in DTV receiver.
This paper presents technical requirements of channel analysis system for DTV reception signal. In order to meet such requirements and measure more accurate magnitude and phase of channel information, compensation method for the quadrature information from measured in-phase data is proposed.
The proposed channel analysis system is implemented with a commercial DTV chipset and provides fast data analysis with good connectivity with field test vehicles. Computer simulation and laboratory test results are provided to figure out the performance of the proposed channel analysis system for DTV signal.

Keywords: ATSC, DTV, CIR, DSP, receiver

1. INTRODUCTION

In the reception environments like multi-path fading channel, it is very challenging for the ATSC receivers which synchronize and recover their frequency and timing with the information of pilot carrier and segment sync as shown in Fig. 1 [1]. Usually ATSC receivers have various equalization performance and most of them show bad performance in the strong and long ghost environments. Hence it is very important to gather the multi-path fading or channel information and signal quality for the target service area. ATSC A/74 presents recommended equalization performance of commercial receivers as shown in Fig. 2 [2].

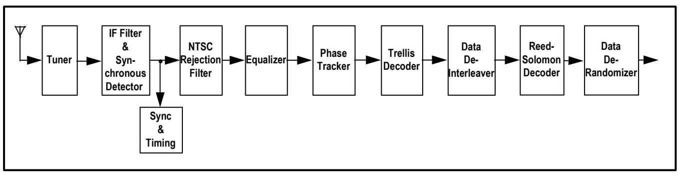


Fig. 1: Typical VSB receiver structure.

The modulation method for ATSC DTV system is 8-VSB (Vestigial Side Band). VSB modulation uses narrower bandwidth than DSB (Double Side Band). Every information of VSB transmitted data is included in the in-phase signal in general. So DTV receivers usually produce in-phase information which is demodulated and recovered as MPEG transport streams. But to measure more accurate SNR (Signal to Noise Ratio) and multi-path fading, it is recommended to get the quadrature information from measured RF data signals.

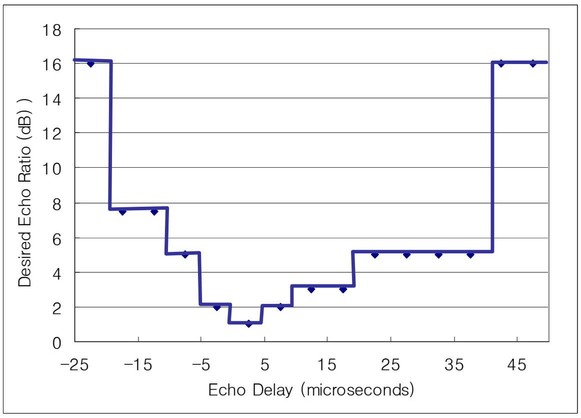


Fig. 2: Equalization performance of DTV receivers.

In this paper, we propose a CIR (Channel Impulse Response) analysis system for DTV reception signal. It acquires demodulated in-phase signal and calculates quadrature information from acquired data with the proposed Hilbert transform method. With those measured results, we can calculate more accurate SNR and CIR.
The rest of paper is organized as follows. Section II presents the basic structure and proposed conversion method. In Section III, simulation results are discussed. Hardware implementation and field trial results are introduced in Section IV. Finally, conclusions are made in Section V.

2. PROPOSED SYSTEM

2.1 Overview

The proposed CIR system includes 'VSB demodulation', 'Data acquisition' and 'Analysis' system as shown in Fig. 3.

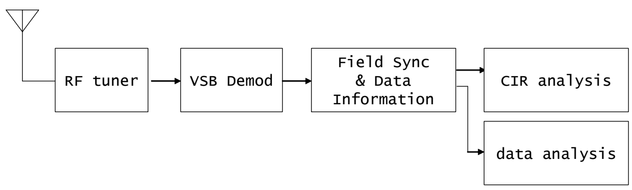


Fig. 3: Block diagram of the proposed .system

2.2 Modified Hilbert Transform

In general, to get the conjugate information from specific signal, Hilbert transform is used. Hilbert transform is a basic tool in Fourier analysis and originally defined for periodic functions. (1) and Fig. 4 show typical frequency response of Hilbert transform [3].

$$\sigma_H(\omega) = \begin{cases} j, & \omega < 0 \\ 0, & \omega = 0 \\ -j, & \omega > 0 \end{cases} \qquad (1)$$

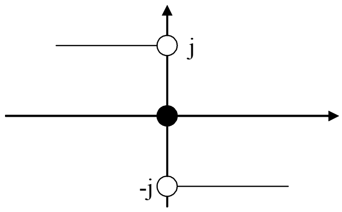


Fig. 4: Conventional frequency response of Hilbert Transform.

A base-band signal of 8-VSB can be explained as quadrature combination as in Fig. 5, while every information is included in the in-phase signal.

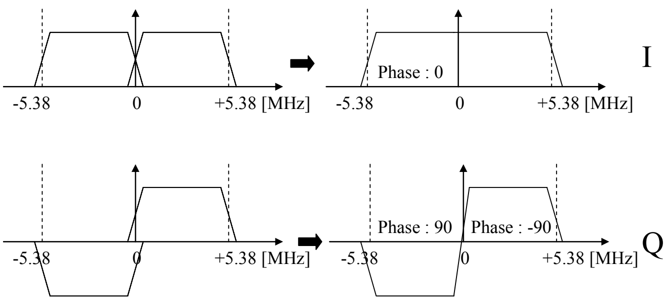


Fig. 5: Base band VSB signals.

If there is only in-phase (I) signal, it is typical to apply Hilbert transform to get quadrature (Q) signal. If we apply (1) to a base band VSB I signal, then we get frequency response as shown in Fig. 6 which is different from Q signal of Fig. 5 near zero frequency area.

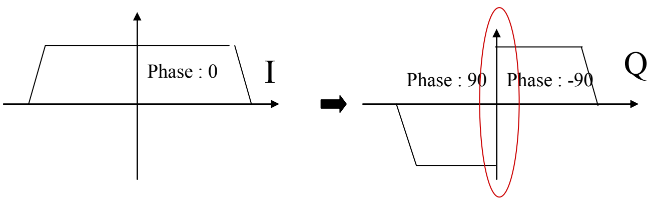


Fig. 6: Application of a conventional Hilbert transform to VSB I signal.

To solve that problem, we propose modified Hilbert transform which has raised cosine pulse shaping as in 8-VSB system.

In the 8-VSB system, VSB filter has raised cosine pulse shaping as in (2).

$$|H(j\omega)| = \begin{cases} 1, & 0 \le \omega \le \frac{\pi}{T_S}(1-\alpha) \\ \cos^2\left\{\frac{T_S}{4\alpha}\left[\omega - \frac{\pi(1-\alpha)}{T_S}\right]\right\}, & \frac{\pi}{T_S}(1-\alpha) \le \omega \le \frac{\pi}{T_S}(1+\alpha) \\ 0, & \frac{\pi}{T_S}(1+\alpha) \le \omega \end{cases} \qquad (2)$$

where $\omega = 2\pi f, \alpha = 0.1152$ (roll-off factor).

The proposed modified Hilbert transform is calculated from the composition of raised cosine filters which have an opposite phase each other. (3) shows the proposed pulse shaping .

$$|H(j\omega)| = \begin{cases} 1 \\ \cos^2\left\{\frac{T_S}{4\alpha}\left[\omega - \frac{\pi(1-\alpha)}{T_S}\right]\right\} - \cos^2\left\{\frac{T_S}{4\alpha}\left[\omega - \frac{\pi(1+\alpha)}{T_S}\right]\right\} \\ 1 \end{cases} \qquad (3)$$

where each interval is the same as (2).

Fig. 7 shows the frequency response of proposed Hilbert transform and Fig. 8 shows the applied result of it to a base band VSB I signal.

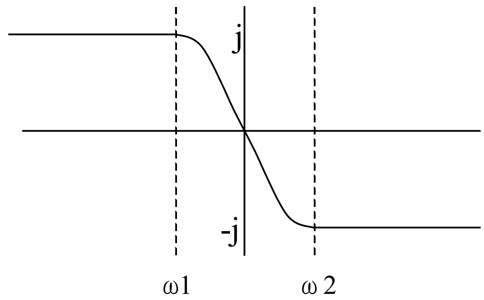


Fig. 7: Proposed Hilbert Transform.

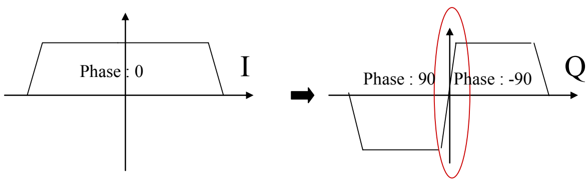


Fig. 8: Application of the proposed Hilbert transform to VSB I signal.

2.3 Data Conversion and CIR calculation

By applying the proposed Hilbert transform to an acquired I signal, Q signal can be calculated. With those signals, MER (Modulus Error Ratio) and SNR can be calculated.
To get the channel impulse response, correlation of field sync data and received sync information is usually applied. As such CIR information has only in-phase information of multi-path signals, another Hilbert transform can be applied to the measured CIR information.
Fig. 9 shows simplified measurement process of the proposed system.

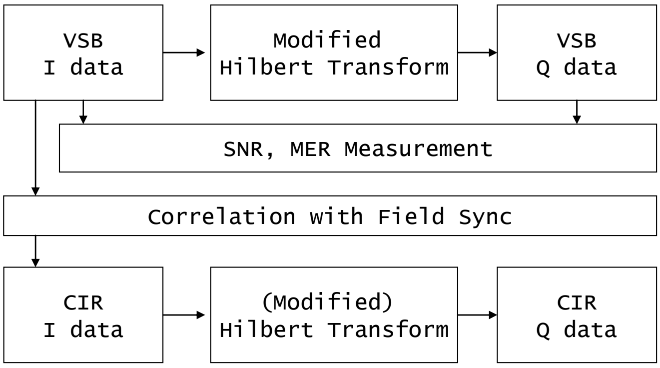


Fig. 9: Measurement process of the proposed system.

3. SIMULATION RESULTS

3.1 Data Conversion

To prove proposed data conversion process, measured I and Q signal from a vector signal analyzer was used as reference signals as shown in Fig. 10.

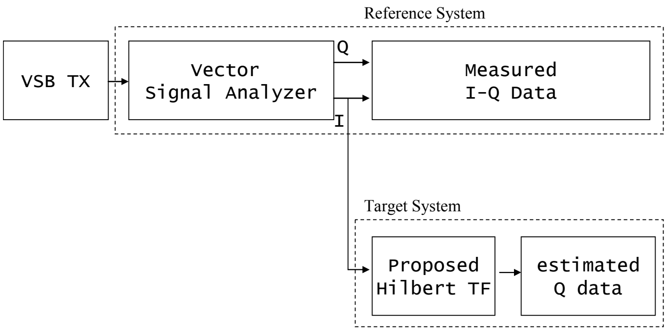


Fig. 10: Simulation system for I-Q data conversion.

Test compares the result of conventional Hilbert transform and that of proposed modified Hilbert Transform. Fig. 11 and 12 show the reference I, Q signal and converted results.

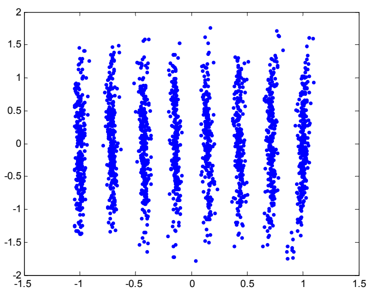
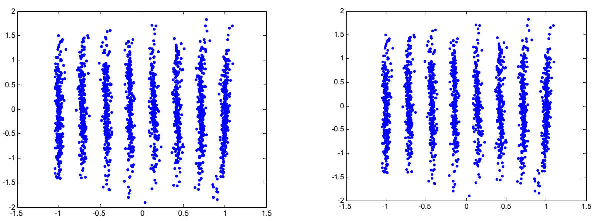


Fig.11: reference I- Q signal.



(a) Conventional transform (b) Proposed transform

Fig. 12: Reference I- Q signal.

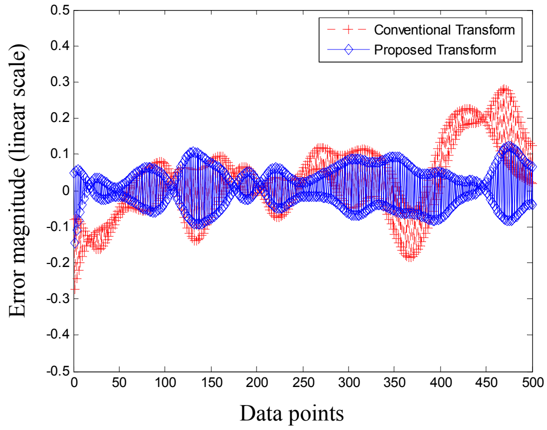


Fig. 13: Error magnitude comparison at each point

Fig 13 shows error magnitude between each trial. Average error power of conventional transform case is -19.0dB and that of proposed transform is -22.5dB, so proposed method has an advantage about 3.5dB

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3.2 CIR Conversion

To see the performance of CIR measurement, measured CIR information by a conventional system is compared with the result of the proposed system as shown in Fig. 14.

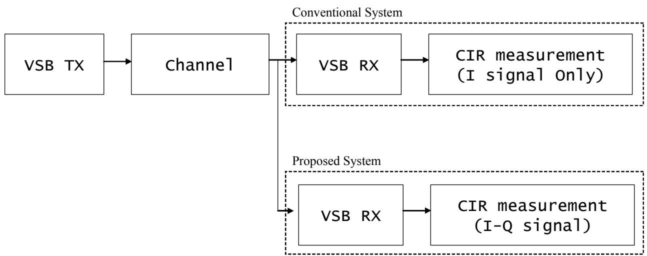

Fig. 14: Simulation system for CIR data conversion.

As a VSB Tx and Channel generator, SFQ (R&S) was used. Test channel was Brazil E (three strong ghosts of equal level) of which parameters are shown in Table 1.

Table 1: Channel Parameter

Ensemble	Parameter	Path 1	Path 2	Path 3
Brazil E	Delay(us)	0	1	2
	Attenuation(dB)	0	0	0
	Phase(degree)	0	0	0

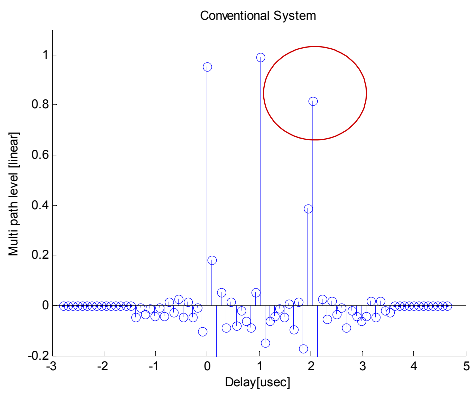

Fig. 15: Simulation result of a conventional system.

Fig. 15 and 16 show the measured results. The conventional system shows different level for three major multi-path components, but the proposed system shows almost the same level as the original channel parameters.

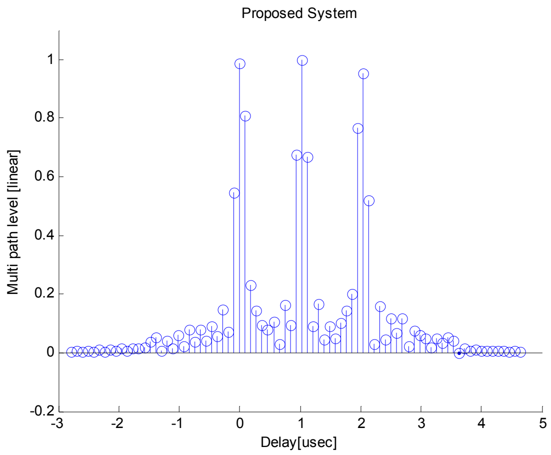

Fig. 16: Simulation result of the proposed system.

4. APPLICATION

The hardware was implemented with a commercial DTV chipset as a stand-alone measurement device as shown in Fig. 17. Data acquired from this system and transferred to another PC through a fast USB interface.

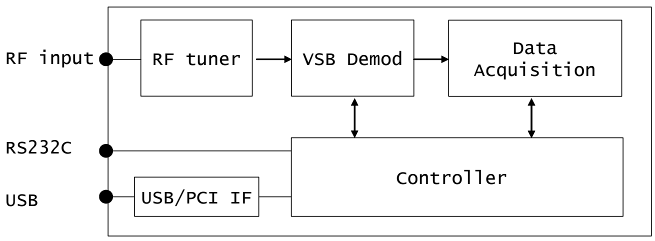

Fig. 17: Structure of Hardware implementation.

We applied this system to the field test of distributed translator network[4][5]. The proposed system connected to the measurement system (IMAS [6]) of field test vehicle. Fig. 18 shows the connection between two system.

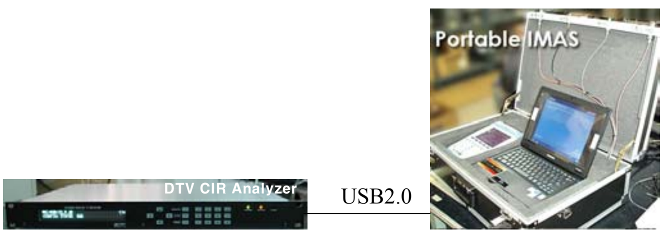

Fig. 18: Connection of the proposed system to IMAS.

The field test was successfully finished and test results including CIR measurements were analyzed for the target network [7]. Fig. 19 shows an example of CIR measurement results of the proposed system.

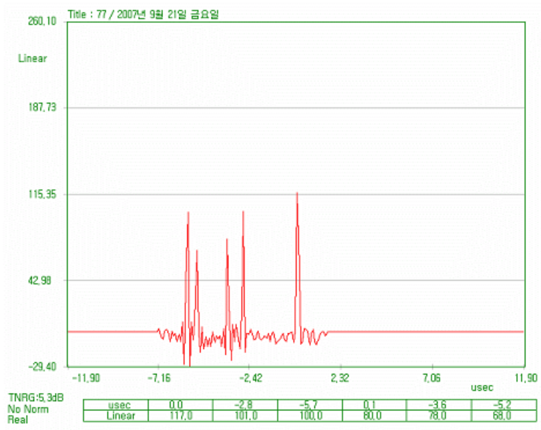

Fig. 19: Example of CIR measurement.

5. CONCLUSIONS

This paper presented technical requirements of a channel analysis system for ATSC DTV reception signal. In order to meet such requirements and measure more accurate magnitude and phase of channel information, calculation method of the quadrature information from measured in-phase signal based on a modified Hilbert transform is proposed.

The proposed channel analysis system is implemented with a commercial DTV chipset and provides fast data analysis. Computer simulation and laboratory test results showed more than 3dB improvement in normal data processing with modified Hilbert transform and more accurate level measurement for the measurement of channel impulse response.

The proposed channel analysis system was applied to the filed test for DTV distributed translation and contributed for the measurement of multi-path fading environments.

6. REFERENCES

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