New Products & Technologies

Digital Filter LSI Chip Set for Ghost Canceller*

Junichi Orihara** Norimitsu Sako*** Ken Tahara****

1 Introduction

In August 1989, major television stations in Japan successively started practical "clear vision" broadcasting. Clear vision, a TV broadcasting system intended to improve picture quality while maintaining compatibility with the NTSC (National Television System Committee) system, is also referred to as EDTV (enhanced definition TV). The clear vision technology includes a technique for correcting the deterioration of picture quality which occurs in the process of modulating video signals first into NTSC signals, then demodulating them back into the original signals, as well as a technique for canceling ghost images resulting from broadcast signals reflected from obstacles. Since GCR (ghost cancel reference) signals, which are added to NTSC signals to cancel ghosts, present fewer problems with the introduction of broadcasting equipment than other picture quality improvement techniques, many TV stations across the country began transmitting GCR signals first. At the same time, manufacturers of household electric appliances have started marketing ghost cancellers.

A ghost canceller requires digital filters having a clock frequency of 14.32 MHz and about 640 taps. The authors, in cooperation with Zoran Corporation, a U.S. company with an excellent track record in the field of digital filters, developed two types of digital filter chip sets, "ZR33072" and "ZR33288," which were marketed in September 1993. Described in the following are the architecture of the chip sets and their application to ghost cancellers.

2 Cause of Ghosts and Ghost Cancellation Principle

A ghost is generated when a TV signal transmitted through a broadcasting antenna is reflected from obstacles such as buildings and mountains before reaching a household TV antenna, as illustrated in **Fig. 1**, and is then added to the directly arriving TV signal. Since a TV receiver scans the screen from left to right, the reflected signal arriving after the original is duplicated on the screen as a ghost image on the right-hand side of the true picture. The position and strength of the ghost image depend on the delay time, phase shift, and strength of the reflected signal. In many cases, plural ghosts are observed.

While a ghost can be cancelled by superimposing the

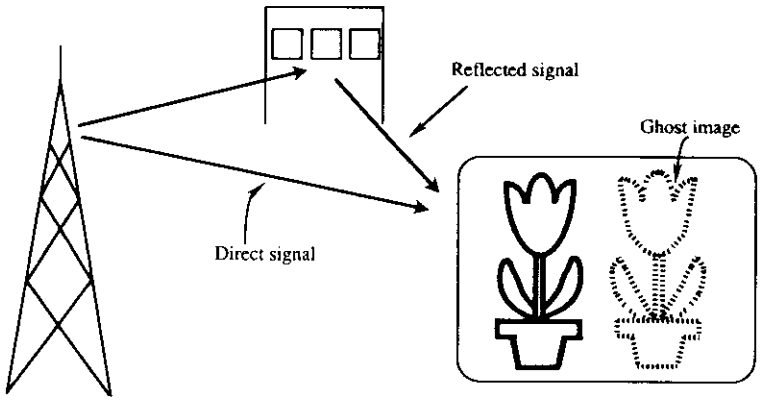

Fig. 1 Reflection of the TV signal

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** Staff Deputy Manager, Products Development Sec., Products Development & Design Dept., LSI Div.
*** Staff Manager, Products Development Sec., Products Development & Design Dept., LSI Div.
**** Products Development Sec., Products Development & Design Dept., LSI Div.

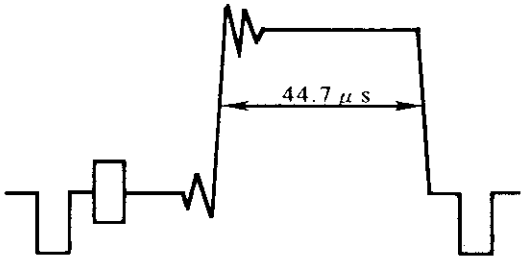

Fig. 2 Japanese GCR signal

negative equivalent of the reflected components on the incoming TV signal, it is not easy to distinguish between direct and reflected signals. To solve this problem, a method was conceived whereby a standardized signal (GCR signal) is added at a position which offers no possibility of affecting the images created by direct TV signals. Shown in **Fig. 2** are waveforms of the GCR signal used in Japan. The level and delay time of a ghost can be determined from the state of deformation of an incoming GCR signal. The width of the GCR signal, 44.7 μs, is the range within which a ghost can be detected.

Once the level and delay time of a ghost are determined, the ghost can be cancelled by digital filters through reverse operation of the determined spectrum from the point at which the ghost was added. Two types of digital filters are available: the finite impulse response (FIR) type, with no signal feedback loop, and the infinite impulse response (IIR) type, which is an FIR type with a signal feedback loop included. In general, in structuring a ghost canceller, an FIR digital filter with fewer taps is used for waveform equalization and removal of near-by ghosts, followed by ghost cancellation by an IIR digital filter covering the whole remaining range.

3 Architecture and Function of Chip Sets

Table 1 shows the main specifications of the newly developed chip sets.

(1) The ZR33072 is an FIR digital filter with 72 taps for use in the FIR filter section of a ghost canceller for waveform equalization and removal of near-by ghosts.

(2) The ZR33288 is an FIR digital filter with 288 taps, two of which are cascaded to provide 576 taps for use in the IIR filter section of the ghost canceller for removing the remaining ghosts.

Both types are provided with 14.32 MHz of clock frequency, 8 bits of data, and 10 bits of coefficients.

Figure 3 is a block diagram of the chip sets.[1] The ZR33288 performs 288 tap FIR filter operation on data input from DIN and outputs the result from CASOUT. DOUT is a delayed output from the DIN. However, an 8 clock delay resulting from the pipeline structure is added to DOUT and CASOUT. Cascade connection can be realized by connecting DIN and DOUT, and CASIN and CASOUT, to further increase the number of taps.

The ZR33072 performs 72 tap FIR filter operation on data input from VIDIN and outputs the result from RESOUT and VIDOUT. The difference between the outputs of the two systems is the bit width or accuracy. A reference tap, output shift, and input for IIR connection are provided as additional functions.

By turning on the reference tap switch of the ZR33072, data input from VIDIN can be added to the 37th tap of a 72 tap FIR filter to make it a reference tap. As a result, the FIR filter can be used exclusively for correction. In other words, if a range that can be expressed by 10 bit 2's complement number is set to from -1 to $+(1-2^{-9})$, a coefficient of up to

Table 1 Specifications of the digital filter chip set

	ZR33072	ZR33288
Tap #	72 Tap	288 Tap
Clock frequency	14.32 MHz	14.32 MHz
Filter structure	FIR	FIR
Data input	8 bit	8 bit
Coefficient input	10 bit	10 bit
Data output	8 bit and 10/11/12/18 bit	18 bit
Accumulator	24 bit	26 bit
Coefficient bank	2 Stage	2 Stage
Optional function	Reference tap Output shift IIR structure	Cascade connection
Package	Plastic QFP 100 Pin	Plastic QFP 128 Pin

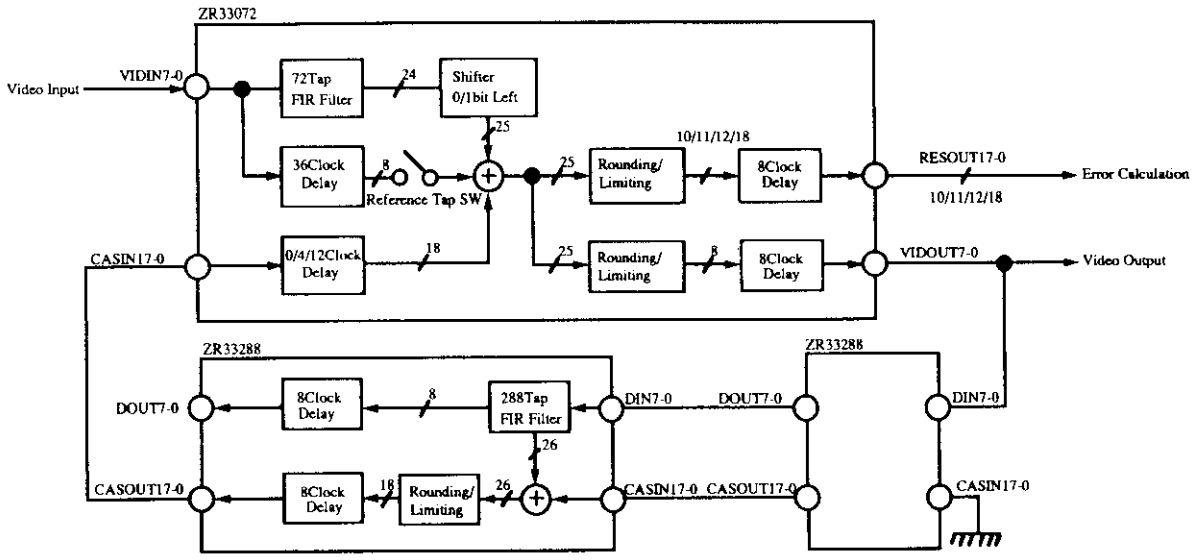

Fig. 3 Block diagram of the chip set

$+(2-2^{-9})$ can be provided to the reference tap position.

The output shift function, which is arranged to provide coefficients between -2 and $+(2-2^{-8})$ for all 72 taps by shifting the FIR filter output 1 bit to the left, can set a reference tap to any position. However, the accuracy of the coefficients in this case equals 9 bits.

The CASIN input of the ZR33072 is an input for use of the ZR33288 as an IIR filter, into which a 12 clock delay is inserted when the 37th tap of the ZR33072 is set as a reference tap. As a result, the loop delay of the IIR section becomes 36 clocks in total and, as shown in **Fig. 4**, taps after the 36th tap following a reference tap may be assigned to an IIR filter without their overlapping an FIR filter. The ghost range covered by the first 36 taps and the second 611 taps is $-2.5\,\mu$s to $+42.7\,\mu$s, which is capable of cancelling all ghosts in the range of up to $44.7\,\mu$s detectable by GCR signals. One tap is equivalent to 69.8 ns (= 1/14.32 MHz).

As the accumulator bit width, 24 bits (ZR33072) and 26 bits (ZR33288) are secured to eliminate overflow and rounding error in the accumulator section. Since, however, the input to configure the cascade input/output and IIR is limited to 18 bits (7 bits above and 11 bits below the decimal point), rounding error occurs only in this section.

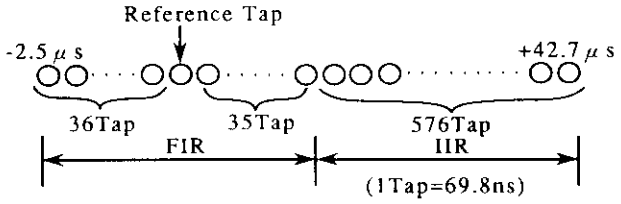

Fig. 4 Ghost cover range

As described above, the characteristics of these chip sets provide the ideal architecture for application to ghost cancellers.

4 Concluding Remarks

In cooperation with Zoran Corporation in the United States, the authors developed and Kawasaki Steel Corp. has started marketing of two types of digital filter chip sets suited for application to TV ghost cancellers. The ability to cover 648 taps without gaps using only three chips (ZR33072 × 1 and ZR33288 × 2) and an additional circuit included to realize an FIR-plus-IIR configuration can substantially reduce the number of required parts and thus contribute to cost reduction and wider application of ghost canceller systems.

Reference

1) C. Erskine, S. Kusevitzky, J. Orihara, and H. Watanabe: "A VLSI Chip Set for Ghost Cancellation and Waveform Equalization of Analog Television Signals," IEEE ICASSP, (USA), March (1992)

For Further Information, Please Contact:
LSI Div., Kawasaki Steel Corp.
2-3 Uchisaiwaicho 2-chome, Chiyoda-ku, Tokyo 100, Japan
Fax: 03 (3597) 3634 Phone: 03 (3597) 4619