ELECTRONICALLY CONTROLLABLE TIME DELAY

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Abstract

An electronically controllable, time delay implementation is described for composite TV video signals using quartz substrate, surface acoustic-wave delay lines with CHIRP coded interdigital transducers. Potential applications to radar, data links, and CATV systems are indicated.

Introduction

The capability of providing electronically controllable time delay is described, using an intermediate frequency (IF) signal processor suitable for use with composite wideband television signals. The technique, originally studied in 1971, is significant in providing wide bandwidth and large time delay control at modest cost. This capability is obtainable through the use of linear frequency (CHIRP) coded surface acoustic-wave delay lines (SAWDDL). These CHIRP coded lines provide a frequency sensitive dispersive time delay within a given IF passband. The basis of the time delay control is the selective frequency control of the input signal spectrum between two identical slope SAWDDLs, with spectrum inversion employed to convert dispersive delay transmission to constant time delay transmission. Spurious signals in time, produced in this process by large signal frequency deviations, are suppressed by operation of the decoding line with apodization (frequency weighting) at a fixed transmission frequency. The performance obtainable with this implementation is superior to that reported for the popular charge-coupled devices.[1]

Comparable time delay control techniques in the past have been generally deficient in bandwidth and/or magnitude of time delay control. Implementation has frequently involved bridge tee IF networks with varactor control, tapped glass delay lines, meander delay lines,[2] or charge-coupled devices. These approaches, although acceptable for some applications, suffer from the limitations in the magnitude of time delay control, linearity, bandwidth, and operating frequency. These limitations have prompted the consideration of the alternative approach described in this paper.

The description and application of time delay control of TV transmission is indicated using SAWDDLs providing >1000/1 dispersion with time delays greater than 100 µs and bandwidths exceeding 10 MHz. Composite TV video is used to observe delay-dispersed and delay-compressed signal imaging. Results have confirmed the basic system time delay control concepts and provide encouragement for a variety of system applications in radar, data links, and CATV systems.

Details

The implementation of an electronically variable time delay system, using multiple SAWDDLs is illustrated in Figure 1. The functional operation is described, using a composite input TV signal consisting of a synchronizing pulse and TV video, with an input frequency, f_{in}, of less than 10 MHz. Initial dispersive coding for frequency sensitive time control is accomplished initially, by frequency translation into the passband of the input SAWDDL. Placement in the passband for a specific time delay is accomplished by adjustment of the voltage-controlled oscillator frequency, f_{VCO}, supplying the carrier drive voltage to the input frequency translator, namely $(f_o \pm \Delta)$. The SAWDDL, with its indicated linear dispersion characteristic, receives the frequency-coded carrier input signal and produces the frequency sensitive time delay dispersion. Spectral inversion, required when the SAWDDLs have identical slopes, must also include a frequency deviation cancellation factor, if the second SAWDDL is to be operated at a fixed frequency. Otherwise the input time-frequency delay code would result in fold-over in the spectral inversion process at other than the fixed bandpass frequency desired. Fixed frequency operation is desirable for providing direct generation of the very high frequency (VHF) vestigal single sideband TV transmission, in addition to providing frequency weighting for suppression of spurious coding signals. The spectral inversion and frequency stabilization are accomplished by the subsidiary generation of the carrier drive for the spectrum inverter: $(f_{VCO} \pm f_o)$ or $(2f_o \pm \Delta f)$. This coded carrier, when mixed with the dispersively coded SAWDDL output signal $(f_{VCO} \pm f_{in})$, produces the desired spectral inversion result $(f_o \pm f_{in})$ with the frequency deviation factor Δf removed. The subsidiary factor $(f_{VCO} \pm f_o)$ is also generated as indicated in Figure 1, by the addition of a crystal oscillator operating at f_o with the VCO operating at $f_{VCO} = (f_o \pm \Delta)$.

Conversion of the dispersive coded time delay at the output of the first SAWDDL to constant time delay transmission with a fixed delay offset is now accomplished in driving the second SAWDDL. This result occurs, since the original spectrum has been inverted and the SAWDDL now produces the inverse process so that all elements now are reassembled in time phase. In addition, the frequency weighting insures that those spurious signals generated due to large frequency deviations will be suppressed. Subsequent transmission as a VHF TV signal may be accomplished with a coded time delay modulation, or directly detected and the resultant TV video time-corrected for jitter-free line placement in a TV frame. The time delay correction is required if the original data possess line-to-line jitter.

The surface acoustic-wave technology provides the capability of electronically controllable time delay for a variety of operating frequencies and time-delay-bandwidth factors.[3] Large time dispersion with low bandwidth or the inverse may be accomplished. In either case, adequate linearity and dynamic range can be provided using low or high coupling crystal substrates. Signals may be controlled in time, scrambled, or unscrambled for a variety of system applications.

Performance data are provided using multiple circulative lines with a variable frequency translator to demonstrate variable time delay control (40 µs for a 4-MHz frequency change) in Figure 2. No frequency correction was provided to these data. Lines were operated in cascade with conjugate slopes, using an input variable frequency-controlled oscillator and a frequency translator between lines. Time delay was accomplished by changing the translator oscillator frequency.

Performance data are also provided, demonstrating the ability to dispersively time-delay code a composite TV camera video signal, using this same pair of conjugate SAWDDLs. Figure 3 illustrates the demodulated frame scan video before dispersion and after dispersion and subsequent compression. Figure 4 illustrates a similar sequence for the line scan video as observed on a TV monitor. This display illustrates the ability to defocus or provide electronic scrambling of a TV picture. This technique can be of use to CATV, radar, or data link transmission systems. Time division multiplexing and time ordered transmission with the need for accurate time synchronization are candidate applicants of this time delay control technique. Previous experiments[4] with the digital encoding of SAWDDLs using CHIRP coding have provided encouragement for this time delay control application in satellite retransmission systems.

References

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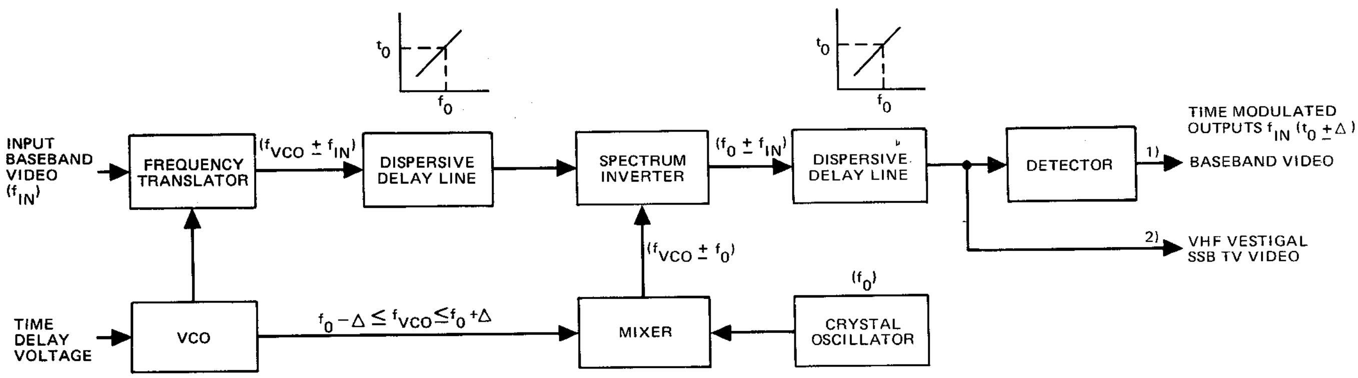

FIG. 1. FREQUENCY CONTROLLED VARIABLE TIME DELAY SYSTEM USING SAWDDLS

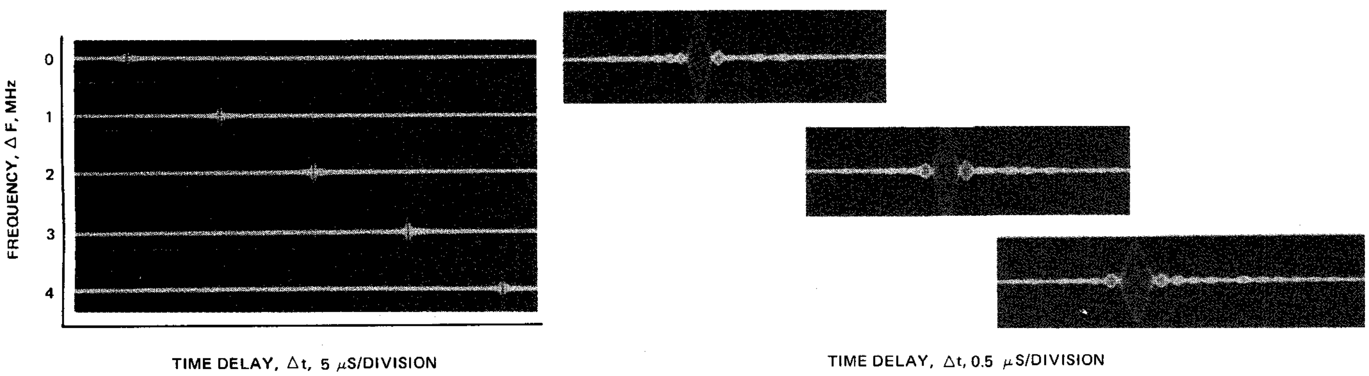

FIG. 2. FREQUENCY-CONTROLLED TIME DELAY "SYNCH" PULSE USING CONJUGATE MATCHED SAWDDLS (TB > 1000, ΔT > 100 μs, ΔF > 10 MHz)

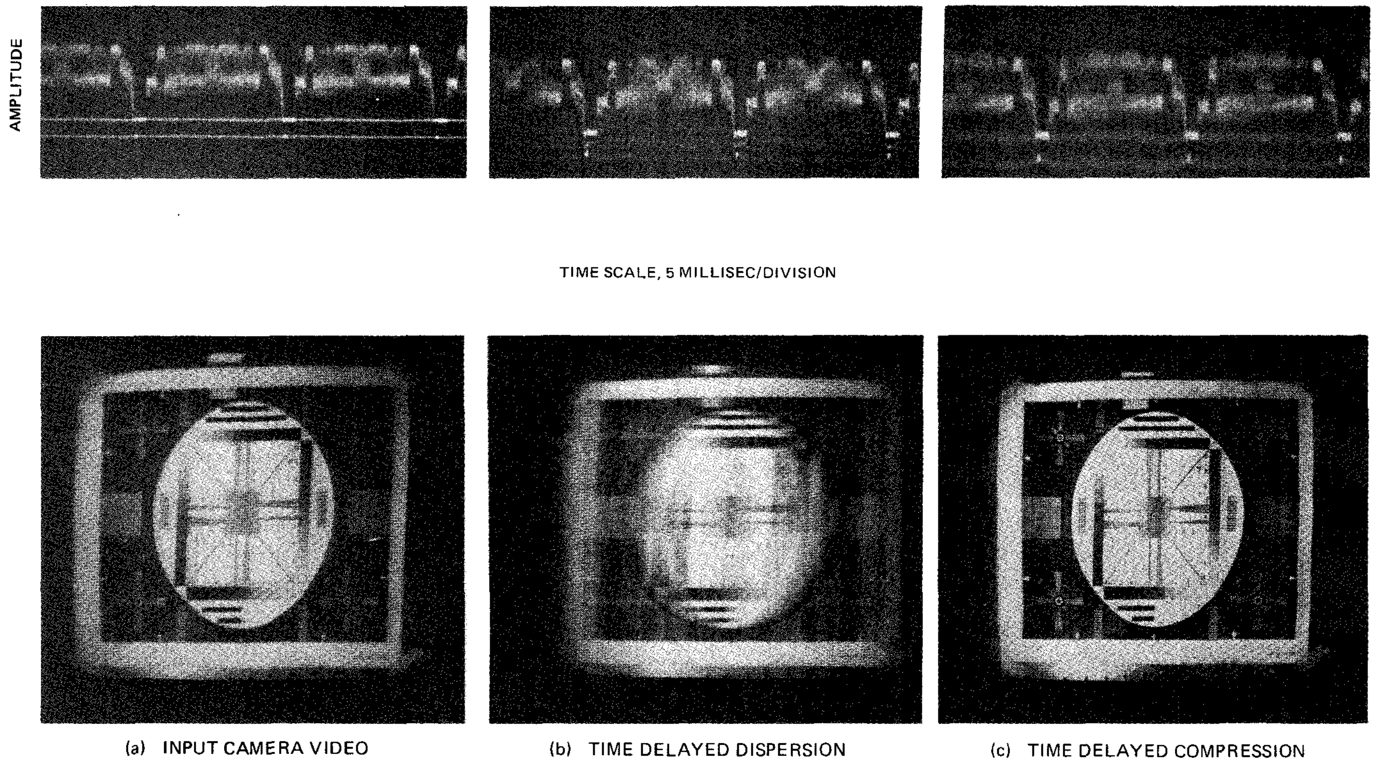

FIG. 3. TIME DELAY CONTROLLED TV VIDEO FIELDS AND MONITOR DISPLAYS ILLUSTRATING DISPERSION AND COMPRESSION PROCESSING