Application Note

Implementing the Z86129 and Z86229 Line 21 Decoders to Minimize On-Screen Jitter

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Abstract

This Application Note describes the inherent jitter associated with ZiLOG's Z86129 and Z86229 Line 21 decoders. It offers guidelines as to how to determine the optimal bandwidth to use in the parts' loop filters for minimizing the amount of jitter that can occur in the application.

ZiLOG Television Solutions

The Z86129 and Z86229 Line 21 decoders are stand-alone integrated circuits capable of processing Vertical Blanking Interval (VBI) data from both fields of the video frame in data conforming to the transmission format defined in the Television Decoder Circuits Act of 1990 and in accordance with the Electronics Industry Association specification 608 (EIA–608). The Z86129/229 devices process data signals in accordance with the NTSC, PAL, PAL-M, and SECAM standards.

The Line 21 data stream can consist of data from several data channels multiplexed together. Field 1 offers four data channels: two Captions and two Text. Field 2 provides five additional data channels: two Captions, two Text, and Extended Data Services (XDS). XDS data structure is defined in EIA–608. The Z86129 and Z86229 Line 21 decoders can recover and display data transmitted on any of these nine data channels.

Discussion

Jitter is defined as the difference in timing between where a data transmission should occur and where it actually does occur. Imperfections in the generation and transmission of the data stream can result in displacement of the transition points to either before or after their proper locations. With respect to the closed captioning display, the data stream that is under scrutiny is that which is output on pin 17 (Box pin) of the Z86129/229 parts.

In an ideal environment, the Box pin would transition from Low to High in the exact same location in time to signal the beginning of a line of closed captioning text. However, due to the varying nature of the composite video signal, the Phase Lock Loop (PLL) may not be able accurately lock onto the same point in each frame of video. As a result, jitter can occur on the Box pin. Normally, this jitter is at a level that does not affect the on-screen display. However, in some cases where the incoming video signal is not at an optimum level, the amount of jitter on the Box pin becomes unacceptable, and can result in distortion of the closed captioning text on the screen or distortion of the box that contains the text.

There are two ways in which the Z86129/229 devices can derive horizontal synchronization (hsync). By default, hsync is acquired from the composite video signal. The other method is by supplying the Z86129/229 devices with a display synchronization signal through HIN (pin 5). In either case, the bandwidth of the

low pass portion of the PLL must be optimized to fit the incoming signal. When using composite video signal as a synchronization source, the loop filter is optimized to account for signal noise and overall input level. If the loop filters of the Z86129/229 devices are not optimized for the application, the closed captioning text is typically unstable or slightly distorted.

When HIN is used as a synchronization source, the loop filter must be optimized to exceed the bandwidth of the PLL (primary) that is supplying the synchronization signal. Any discrepancy between the primary PLL lock frequency and that of the PLL of the Z86129/229 devices will result in jitter. This jitter may manifest itself in the closed captioning box edges to become unstable, while the text remains solid.

With either option of hsync source, one must fine-tune the PLL by adjusting the bandwidth to accommodate the unique composite video signal. The criteria for optimizing the primary PLL is to provide a bandwidth to the Z86129/229 PLL that is wider than the bandwidth of the primary PLL. In some cases, it is prudent to design a primary PLL with a lower bandwidth to allow appropriate noise rejection for the Z86129/229 PLL. It is the purpose of this Application Note to describe the loop filter optimization process and provide an example of how to improve the inherent jitter problem associated with the Box pin.

Theory of Operation

There are many variables that can affect the quality of a video signal. In terms of quality, the aspect we are most interested in is the hsync frequency variance of the video signal. This variance will have the highest impact on jitter, because it affects the ability of the PLL to achieve an appropriate lock.

Generally speaking, the frequency of a composite video signal is 15.73kHz. Different sources of video, such as a DVD player, an RF Tuner, or a VCR can vary slightly in the frequency of their video signals. For example, all three of these sources produce, on average, a 15.73kHz signal. A DVD player can produce 15.73kHz ±3Hz, while an RF Tuner can produce 15.73kHz ±12Hz. Even the media playing in the DVD player can affect frequency variance, depending on how it was produced.

When using the composite video signal as the hsync frequency source, the bandwidth of the Low Pass Filter (LPF) portion of the PLL controls how well the lock on the frequency is maintained. The tighter the bandwidth on the LPF, the better the lock will be. Conversely, the wider the bandwidth on the LPF, the more likely it will deviate from the true frequency. Because each application exhibits unique composite video characteristics, the bandwidth must be tuned for that particular application.

When using the HIN (external synchronization mode) signal as the hsync source, the bandwidth of the Low Pass Filter (LPF) should be optimized. If the PLL that supplies the external synchronization (Primary PLL) has a low enough bandwidth,

the Z86129/229 (Secondary PLL) should not be troublesome at tracking the signal. However, if it is a high bandwidth PLL, tracking the signal through all levels of operation can be difficult. Adjustment of the bandwidth on the Secondary PLL to match that of the Primary is possible; however, this adjustment can introduce noise. Therefore, an optimal level that gets close enough to the Primary PLL but does not introduce too much noise into the system should be found.

Developing an Optimized Loop Filter

When using composite video as a hsync source, the Box pin (pin 17) is a very good indicator of the amount of jitter that is present, and it is easy to quantify. To perform good measurements on the Box pin, a digital oscilloscope is required. This digital oscilloscope should preferably be one that is capable of performing statistical analysis.

Measurement Techniques

After the application is set up to run with Closed Captioning enabled, connect one of the channels of the oscilloscope to pin 17 of either of the Z86129/229 Line 21 Decoders. Set the trigger for the rising edge and adjust the horizontal and vertical axes so that a series of pulses can be observed. Each pulse represents one line in the closed captioning box. The first pulse will not jitter, because it is the user that is triggering the pulse. Choose the seventh pulse and adjust the timing delay and the horizontal axis to *zoom in* on the rising edge of the pulse. The horizontal axis should read between 10ns and 50ns per division to achieve accurate results.

The illustrations in Figure 1 offer two examples of what the user can observe.

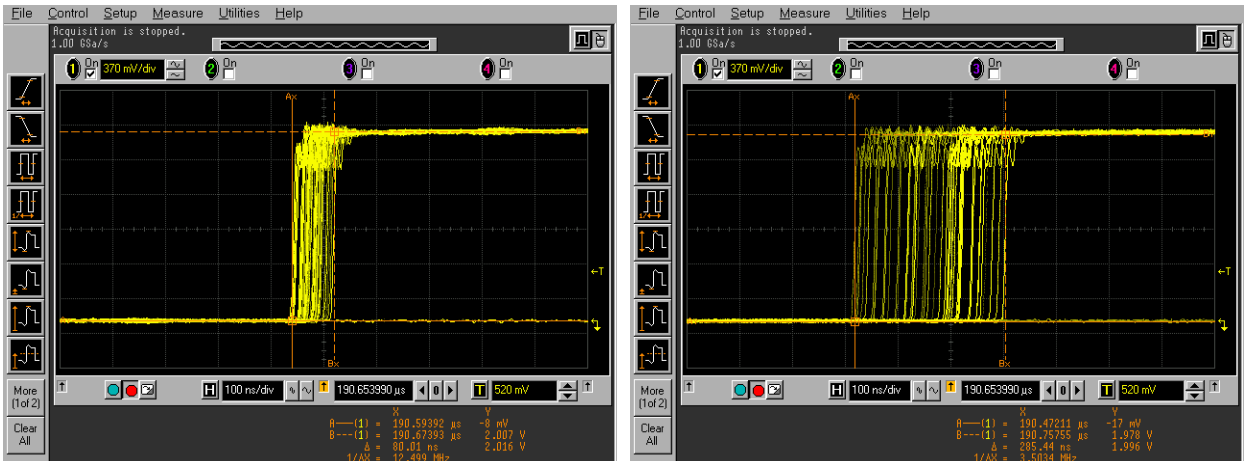

Figure 1. Example Observations of Jitter

The illustration on the left is representative of an acceptable amount of jitter, where the box pin still shows variation, but no distortion is visible on the television display. The illustration on the right, however, represents an unacceptable amount of jitter that is visible on the scope as well as on the display.

With the scope set in this manner, jitter can be quantified by either the range of when the transition occurs or by the standard deviation depending on what the scope is capable of providing.

When using an external synchronization source, there is no easy indicator of the amount of jitter. The judgment of what is acceptable as opposed to unacceptable is more subjective, and can only be observed on the screen of the application. In either case, adjustment of the bandwidth to either minimize the jitter measurements on the oscilloscope or minimize the amount observed on the screen is necessary.

Bandwidth Modifications

To adjust the bandwidth of the LPF, the capacitor values C2 and C3, noted in the schematic in Figure 2, can be modified to minimize the amount of jitter measured by the methods previously described.

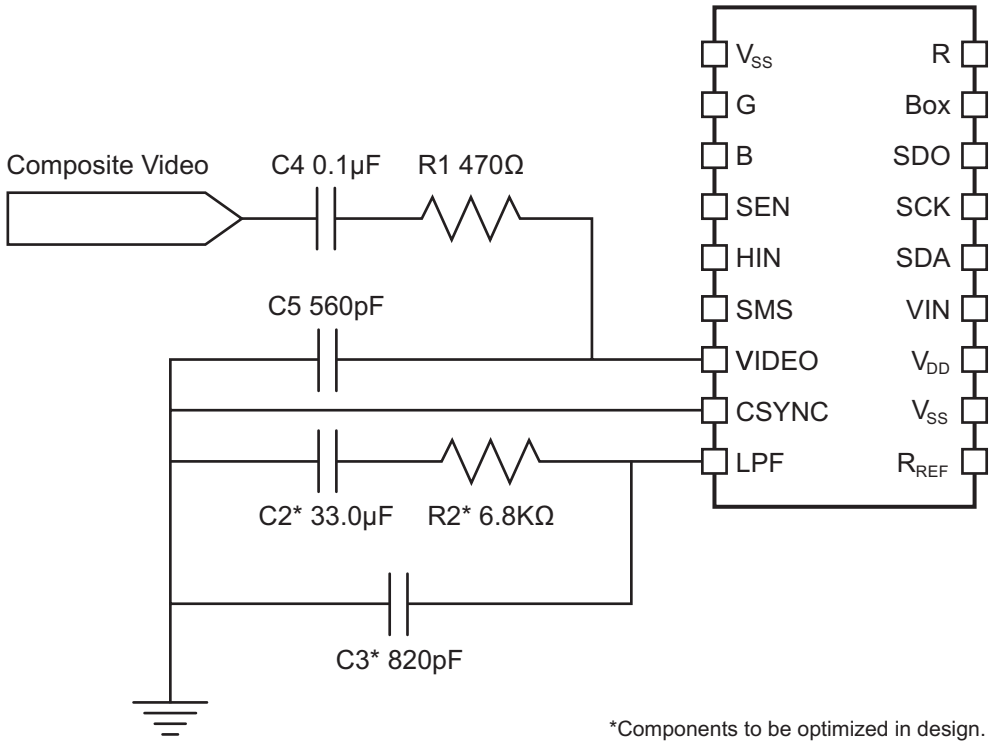

Figure 2. Recommended Loop Filter Configuration

Procedure

1. Adjust the oscilloscope to lower the value of C2 in set increments. The amount of jitter measured on the scope should also begin to decrease. When you observe that the jitter begins to increase, use the value prior to that observation.
2. Begin raising the value of C3 in set increments. The amount of jitter measured on the scope should also begin to decrease. When you observe that the jitter begins to increase, use the value prior to that observation.
3. These two capacitor values define an initial convergence point. To further fine-tune the amount of jitter, vary the value of C2 by two or three smaller increments in both directions, and observe the change in the amount of jitter.
4. Vary the value of C3 by two or three smaller increments in both directions and observe the change in the amount of jitter.
5. Increase the value of R2 up to 10KΩ and observe the results. Use the optimal value of R2 if it differs from that shown in Figure 2.

As indicated in Table 1, an initial point of convergence was found (blue) then later fine-tuned to achieve an optimal value (red) that generated the minimum amount of jitter. The new capacitor values were determined to effectively reduce the amount of jitter by 66%.

Table 1. Comparison of Loop Filter Values and Resulting Jitter

		C2					
STDev	**C3**	**1200 pF**	**1000 pF**	**820 pF**	**680 pF**	**560 pF**	**470 pF**
	4.7 µF	18.10	11.10	19.70	8.25	26.30	26.50
	6.8 µF	15.80	10.30	10.30	8.06	25.30	26.00
	10.0 µF	14.80	9.65	6.70	7.60	25.00	25.70
	15.0 µF	14.50	9.98	6.40	8.04	22.30	25.40
	22.0 µF	14.40	8.80	6.50	8.23	23.00	24.70
	33.0 µF	13.90	8.98	6.10	7.77	24.40	25.10
	47.0 µF	14.40	8.77	6.53	8.40	25.50	23.60
	68.0 µF	12.43	8.10	6.48	8.42	26.50	23.30

Other units were then placed in the same application and a comparison made between the amount of jitter using the original capacitor values, and the amount of jitter using the new capacitor values. These values are shown in Table 2.

Table 2. Before and After Comparison of Optimized Loop Filter Values Applied to a Sample of Units

	Original Jitter Amount		Optimized Jitter Amount	
Unit ID	**Stdev**	**Range**	**Stdev**	**Range**
A1	8.30	61.00	6.42	42.09
A2	8.10	66.20	7.87	52.33
A3	7.50	49.00	7.82	49.30
A4	9.20	70.50	5.53	41.00
B1	14.80	102.30	6.40	48.70
B2	8.70	78.70	5.91	45.00
B2	25.60	177.80	8.91	71.10
B4	11.00	103.20	7.74	53.30
Average	11.65	88.59	7.08	50.35
		Improvement	**39%**	**43%**

Conclusion

To optimize the functionality of ZiLOG's Z86129/229 devices, the bandwidth of the Low Pass Filter must be optimized for each application. This optimization is required due to the various methods of supplying a video signal and horizontal synchronization to either device.

Using the default mode, composite video, as a hsync source, a bandwidth that is too wide can result in the device not achieving an adequate rejection of noise in the PLL, thus producing jitter on the screen. Also, a bandwidth that is too narrow can result in the same jitter on the screen as well as jeopardize the part's ability to lock to the input signal and decode the data. The result can be complete nonfunctionality.

Using the external horizontal synchronization source mode, the bandwidth of the Z86129/229 devices must meet or exceed the bandwidth of the PLL of the device providing the hsync signal. If this requirement is not met, a discrepancy can occur between the horizontal sync frequencies, and cause jitter.

In either case, the bandwidth can be easily adjusted by altering two capacitors, external to the device, that connect to the Low Pass Filter circuit and then optimize serial resistor R2.

Appendix A—References

Further details about the Z86129 and Z86229 products can be found in the references listed in Table 3.

Table 3. List of References

Topic	Document Name
Video Measurement Techniques	Standard Handbook of Video and Television Engineering (Chapter 18); Jerry C. Whitaker and K. Blair Benson; McGraw-Hill, 2000.
Z86129, Z86229 Line 21 Decoders	Z86129/130/131 Product Specification (DS0072)
	Z86229 NTSC Line 21 CCD Decoder Product Specification (DS0051)
	Line 21 Decoder Demo Board Kit for Z86129/130/229/230 User Manual (UM0159)
	Using the eZSelect Line 21 Data Decoder Reference Design Application Note (AN0048)

Notes