

# Flexible Active Shutter Control Interface using the MC1323x

by: **Dennis Lui**  
**Freescale Hong Kong**

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## 1 Introduction

This application note describes how to use the MC1323x to implement various active shutter glass control interfaces in 3D-glasses applications. 3D-glasses are one of the key components used in a 3D-TV system and allows the user to have a 3D-visual effect when watching a 3D-movie, 3D-photo, or playing a 3D-game. The shutter controller must be able to switch the on and off state of left and right lenses in an alternating sequence, so the display of the left-eye image is not seen by the right and vice versa. The reference timing is based on a standard sync signal called VESA sync received from the 3D-TV through a wireless transmission. However, there is no standard format on shutter control interface; therefore the controller device must be designed with flexibility to support various formats.

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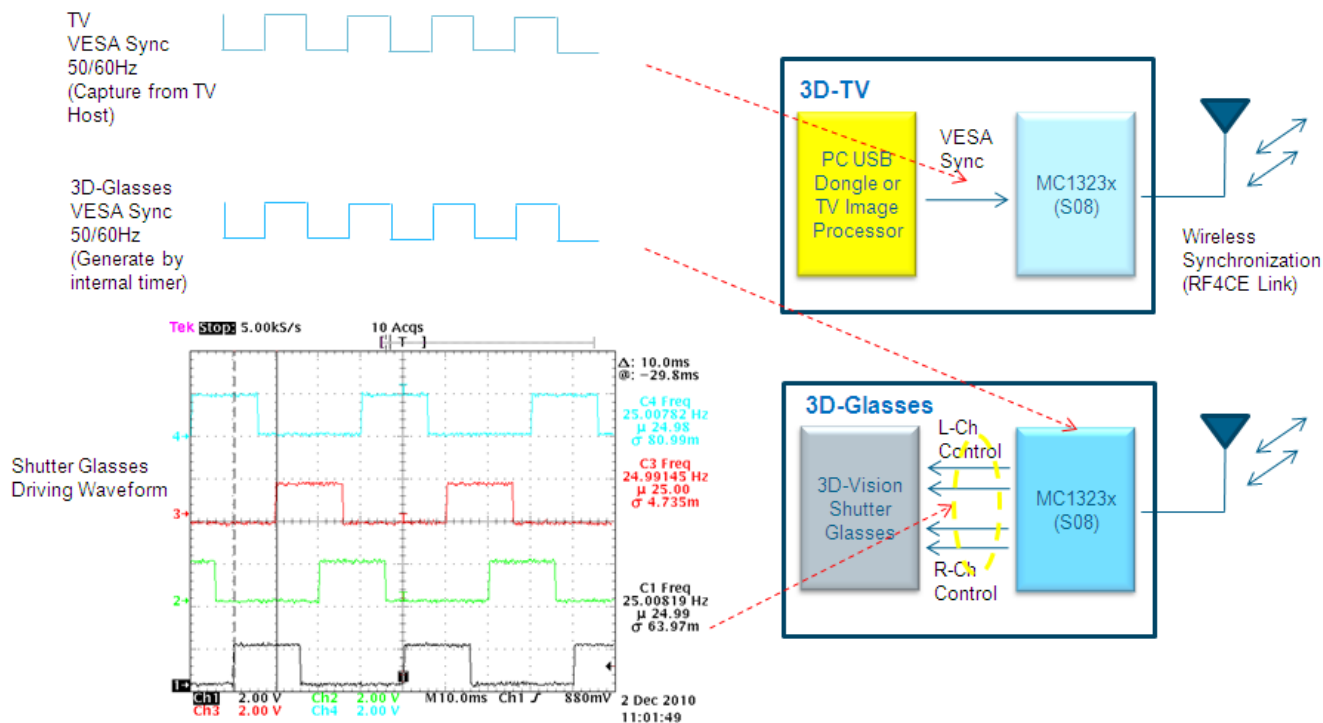
## 2 System Overview

On the side of the 3D-TV, the VESA sync signal is captured from the host processor and converted into a sync message sent to the 3D-glasses using the RF4CE transmission. The received sync message in 3D-glasses is decoded and VESA sync is generated as a timing reference for the whole system, which is shutter control, power saving, user interface and so on. Freescale documents called, *BeeStack Consumer Application User's Guide* (document number BSCONAUG)

## Shutter Control Interface

and *Zigbee Remote Control (ZRC) Application Profile User's Guide* (document number ZRCAPUG) provide detail descriptions of the RF4CE application. This application note focuses on implementation of a flexible shutter control interface for various shutter control interfaces.

In typical applications, the VESA sync signal is a nominal 50 % duty cycle square wave at one-half the vertical sync rate currently in use, for example VESA sync frequency is equal to 50 Hz when vertical sync is 100 Hz. The display of left or right field is determined by the polarity of VESA sync, the high state corresponds to the display of the left-eye image, and the low state corresponds to the display of the right-eye image. The falling edge of VESA sync is used as a trigger point for all alternating events.



**Figure 1. System block diagram**

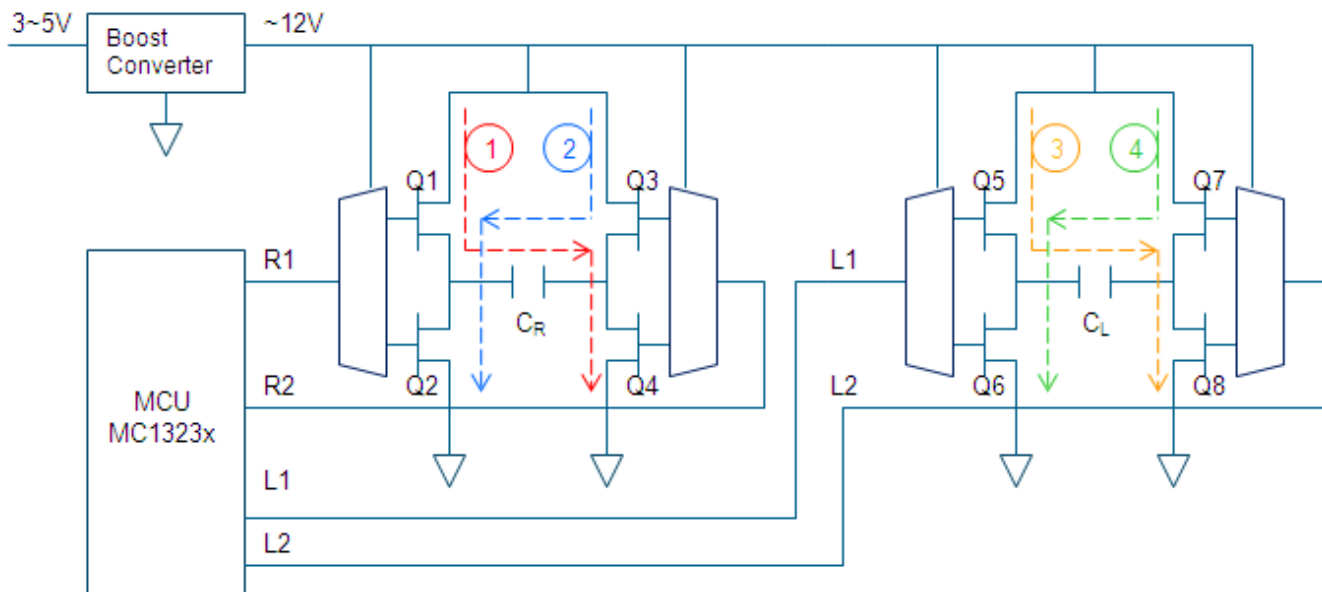
## 3 Shutter Control Interface

There are many shutter control interfaces used in 3D-glass applications. This selection criteria is based on system cost, complexity, and compatibility to the legacy platform.

- The controller sends only synchronization commands periodically to a dedicated lens switching ASIC device through a serial bus interface or parallel I/O port. The ASIC device handles all driving signals for lens switching.
- The controller makes use of the downward sampling technique to convert the VESA sync into a lower frequency sync pulse for backward compatibility on some legacy systems not using VESA sync as a timing reference.
- The controller generates all timing information from the VESA sync signal for lens switching and is able to drive the lens module directly with discrete H-Bridge analog switches. The switching function is integrated into the controller to reduce cost, improve system design flexibility on most of timing control signals, for example the pulse width setting for switching signals and time delay adjustment between switching signals and VESA sync. The application note focuses on this kind of direct driving scheme.

## 4 Hardware Implementation

The hardware components for lens switching include the DC-DC boost converter, H-bridge analog switches, and the MCU internal Timer/Pulse-Width Modulation (TPM) module. Figure 2 shows the full H-Bridge control diagram.



**Figure 2. H-bridge analog switch for lens switching**

- The DC-DC boost converter is used to boost the system voltage from 3 V or 5 V to around 12 V, such that the driving voltage level is capable to toggle the on / off states of the lenses quickly. The transient time for charge and discharge of the lens polarity must be fast enough to eliminate any overlapping on display of the left and right-eye images.
- The two full H-bridge analog switches are used for left and right lens switching. The following descriptions for right channel operation are also applied to left channel.
  - When both R1 and R2 are low, all Q1, Q2, Q3, and Q4 will be off. There is no charging state across the lens and in normal state allows the user to see the image.
  - When R1 is low and R2 is high, Q1 and Q4 will be on and Q2 and Q3 will be off. The current flow is indicated by the dotted line 1 (red). The state of the lens CR is off. (Blank the image)
  - When R1 is high and R2 is low, Q1 and Q4 will be off and Q2 and Q3 will be on. The current flow is indicated by the dotted line 2 (blue). The state of the lens CR is also off. (Blank the image)

The lens state for case 2 and 3 are the same but the current direction across the lens is reversed such that the overall DC current flowing through the lens is equal to zero. This is one of driving requirements for most of the shutter lenses. Please refer to the manufacturer's datasheet for details.

- The MC1323x has four independent timer/PWM modules, each with one channel. Each TPM module is based on a 16-bit counter and provides input capture, output compare, and pulse width modulation. Each TPM module has one associated I/O pin for input capture or counter/PWM output. The requirements on the MCU resource are:
  - One hardware timer input pin for VESA sync input capture.
  - Two timer modules for timing event control.
  - Any four general purpose I/Os for H-bridge switch control.

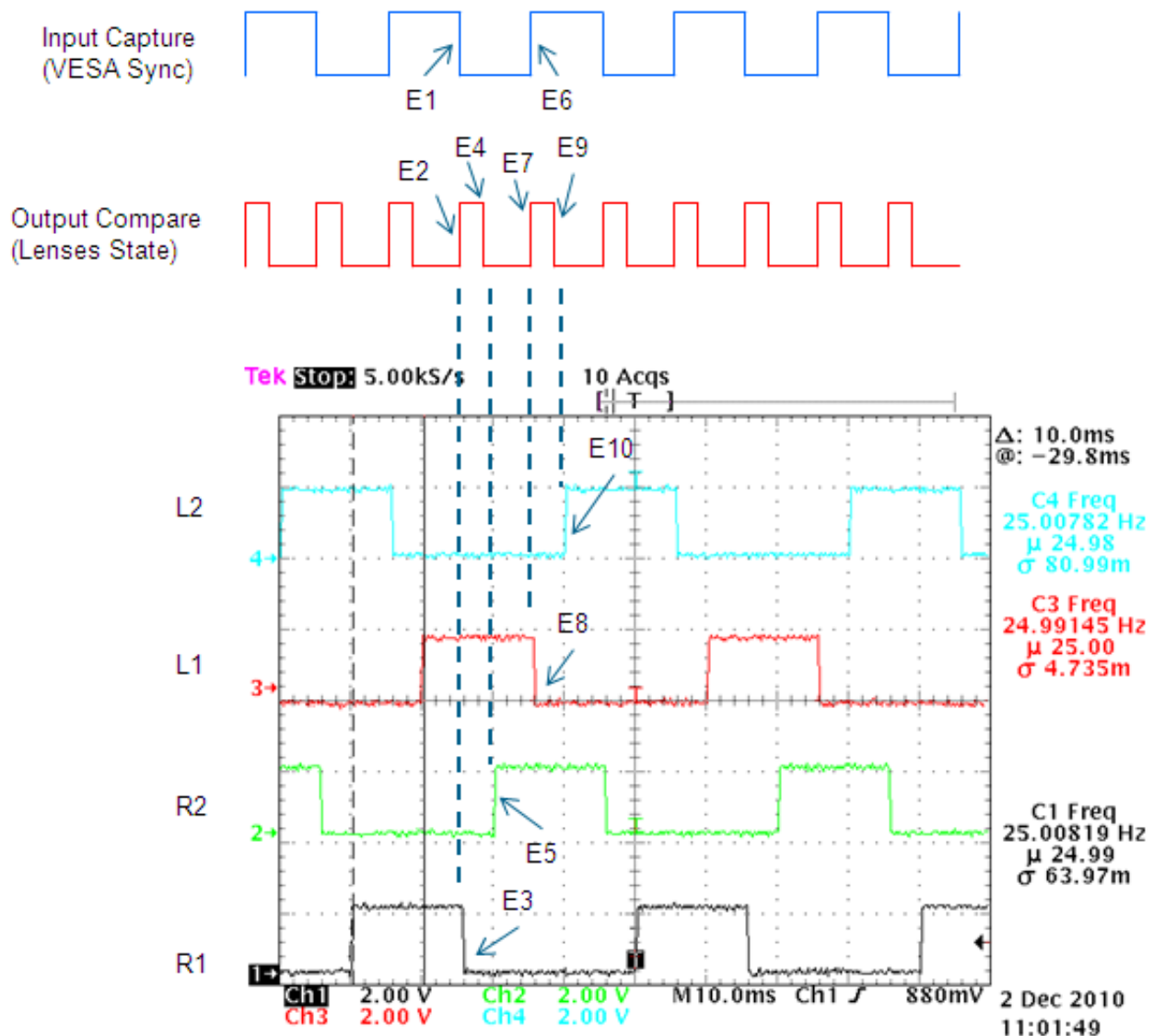
## 5 Software Implementation

Two TPM modules are used to generate all timing waveforms for left and right channel H-bridge analog switch controls. One TPM module is configured with the input capture function to capture the time where an external event occurs. The timing parameters of input VESA sync, for example, the frequency, duty cycle, rising edge, and falling edge can easily be calculated based on the timer counter values triggered by the active edges. Another TPM module is operated in output compare mode and can generate timed pulses with programmable position, polarity, duration, and frequency. The pulse width is used as a parameter to control the duration of the lens state in normal mode (allow to see the image through the lenses).

The settings for two TPM modules:

- Select bus clock (16 MHz) as the TPM counter clock source.
- Set TPM clock pre-scale divider to 64, so TPM clock frequency is equal to 250 kHz (16 MHz / 64).
- Configure one TPM in Input Capture and another in Output Compare mode.
- Enable channel interrupt function for both TPM modules (overflow interrupt function is optional).
- Start the hardware counter in free-running condition.
- Handle all timing critical events in corresponding interrupt service routines and other event driven tasks in the main loop.

Figure 3 shows the timing diagram on how to generate four H-bridge control signals using two TPM modules.



**Figure 3. Timing diagram**

Steps to generate four H-bridge control signals using two TPM modules.

1. The falling edge (E1) of the VESA Sync input capture is used as a timing reference to trigger the output compare event (E2) for phase synchronization and then sets the H-bridge control signal R1 from high to low (E3).
2. The next output compare event (E4) is triggered with a timer counter value equal to the required duration of the lens state in normal mode and then sets R2 from low to high (E5)
3. A Similar mechanism is applied to the rising edge of the VESA sync input capture, E6 triggers E7 and then sets L1 from high to low, configure the next output compare event to E9 and then set L2 from low to high (E10).
4. Repeat steps 1 to 3 for next the VESA sync falling edge cycle. The toggle sequence for R1 and R2 or L1 and L2 is exchanged, for example toggle R2 instead of R1 at the next VESA Sync falling edge.

## 6 Conclusion

This application note provides guidelines on the active shutter design for 3D-glasses applications. The method of lens switching with the H-bridge switch circuit and timing control using the MC1323x is designed as a typical example to help customers to adapt to Freescale solutions in their products more effectively.

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Japan  
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[support.japan@freescale.com](mailto:support.japan@freescale.com)

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Freescale Semiconductor China Ltd.  
Exchange Building 23F  
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