Keywords: CCFL, DC inverter, DS3984, DS3988, Cold Cathode Fluorescent Lamps, burst dimming, backlight, multiple lamps

Sep 23, 2005

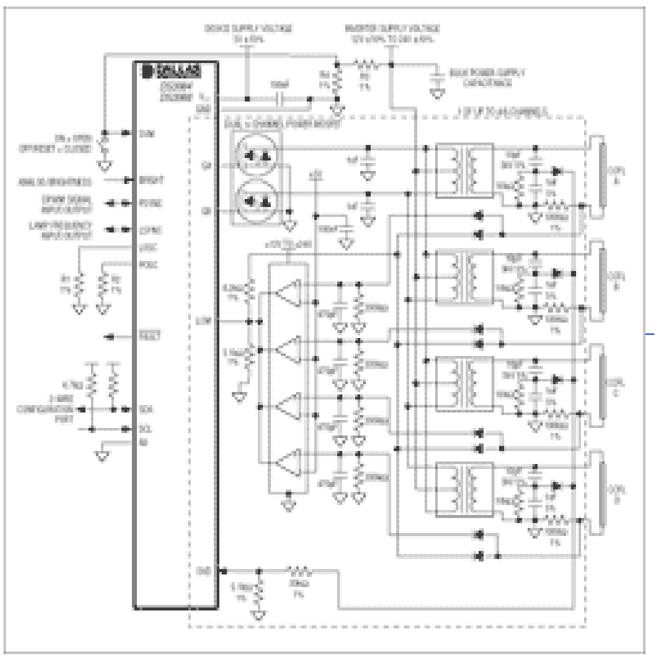
APPLICATION NOTE 3615

DS3984/DS3988 Multiple Lamp Drive Scheme

Abstract: The DS3984 and DS3988 are multi-channel Cold-Cathode Fluorescent Lamp (CCFL) controllers. The DS3984 supports up to four channels and the DS3988 supports up to eight channels. These controllers use a push-pull drive architecture to convert a DC supply voltage to the high voltage AC waveform that is required to power the CCFL lamps. This application note describes how to drive more than one CCFL lamp per channel.

Multiple Lamp Drive Scheme

With some additional support circuitry, each channel on the DS3984 and DS3988 can drive more than one CCFL. **Figure 1** details a four-lamp-per-channel drive arrangement. Such an arrangement can be modified to support two, three, four, or more lamps per channel as needed.



For Larger Image

Figure 1. Four lamps per channel example application.

Lamp Current Monitor

The DS3984/DS3988 CCFL controllers have a single lamp-current monitor (LCM) input per channel. To drive multiple lamps, the lamp currents must be wire OR'ed and fed to the LCM input on the controllers. To eliminate some of the effect that the series small signal diodes may have on the accuracy of the reported lamp current, the lamp current feedback resistor (set to 1000Ω in Figure 1) is set larger than it would be in the single-lamp-per-channel application. In the Figure 1 application , the lamp current feedback resistor was chosen to create a $5.0V_{RMS}$ ($7.07V_{PEAK}$) level at the nominal lamp current of $5.0mA_{RMS}$. The voltage waveforms across the 1000Ω feedback resistors for lamps A and B are shown in **Figure 2**.

The Figure 2 example also demonstrates one of the compromises made by driving multiple lamps with a single channel. Because the lamp B feedback resistor is at a higher voltage than the other feedback resistors and it controls the duty cycle of the power MOSFET that the multiple lamps share, lamp B controls the amount of power delivered to the other lamps. As shown in Figure 2, this results in other lamps receiving less than their target of $5mA_{RMS}$.

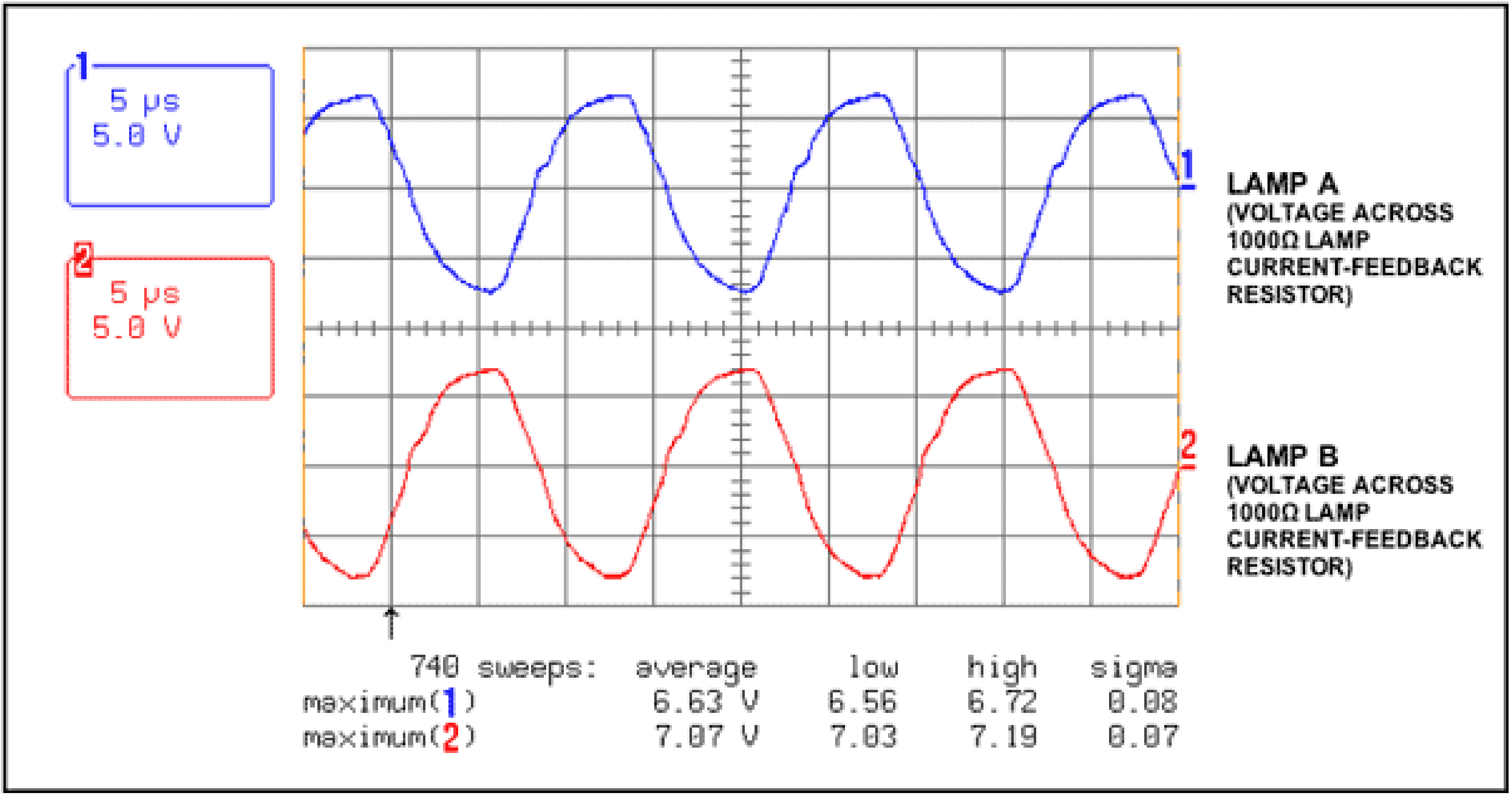


Figure 2. Voltage across lamp feedback resistor (only two lamps shown).

Figure 3 shows the lamp current feedback signal as it transitions to the LCM input on the DS3984 or DS3988. Unlike the single-lamp-per-channel application, the multiple-lamps-per-channel application does not use an AC-coupling capacitor at the LCM input. The DS3984/DS3988 controllers control the lamp current based on the peak signal measured at the LCM input. With no AC-coupling capacitor, the peak control level is the DC common voltage (1.35V) plus the lamp regulation threshold (1.0V) or 2.35V (nom). Hence the peak voltage level created by the lamp current feedback resistor must be attenuated to a target value of $2.35V_{PEAK}$ at the LCM input for the device to control the lamp current to the proper level. As an example, in Figure 1, the 1000Ω lamp current feedback resistor creates a $7.07V_{PEAK}$ signal, and it must be attenuated down to $2.35V_{PEAK}$ before reaching the LCM input.

As the signal passes through the small signal diodes, it loses about 500mV of amplitude. The remainder of the attenuation is accomplished with a resistive divider. In the Figure 1 example, a resistive divider is formed by 8.2kΩ and 5.1kΩ resistors. The internal 50kΩ input impedance on the LCM pin causes slight attenuation. The internal 50kΩ impedance drops the effective shunt resistance from 5.1kΩ to 4630Ω; this increases the attenuation.

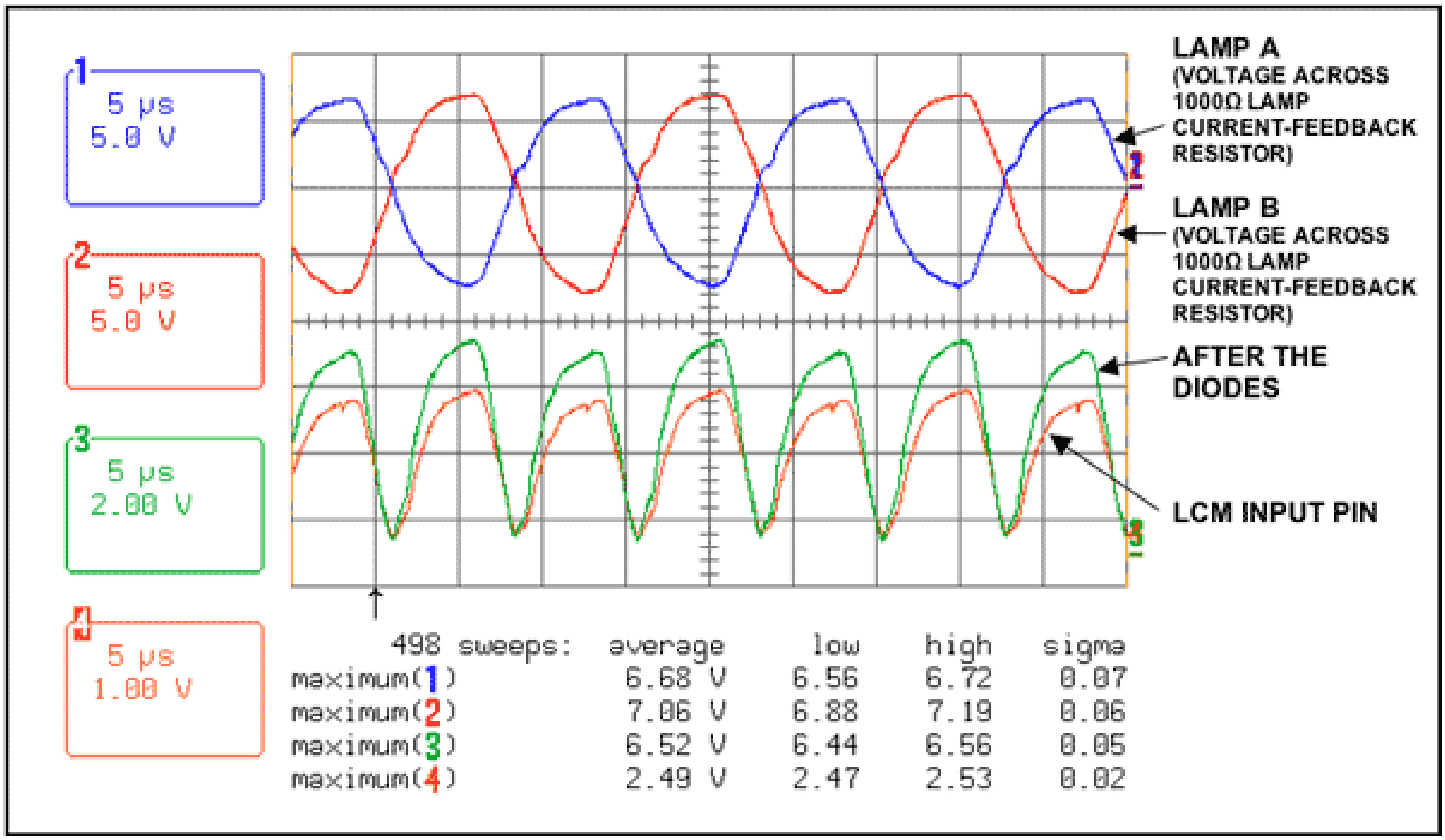


Figure 3. Lamp current feedback signal path.

Overvoltage Detection

As in the single-lamp-per-channel application, the high voltage created by each transformer is detected through a capacitor divider. In the Figure 1 application, this divider is formed by the 10pF (3kV) and 1nF series pair at the high-voltage side of the transformer secondary. In the multiple lamp application, the capacitor dividers are wire OR'ed and then routed to the OVD input. The capacitor divider is set lower than in the single-lamp-per-channel application to help eliminate some of the affect that the small signal diodes series may have on the accuracy of the reported lamp voltage. In the Figure 1 example, the capacitor divider is set to 1:101 (10pF/1010pF). As there is no DC reference in the capacitor divider, a resistor (10kΩ in Figure 1) is added across the low-side capacitor to provide a DC reference level. Depending on the relative size of this resistor vs. the impedance of the low-side capacitor at the lamp frequency, this may change the effective divider ratio. In Figure 1, the application is set to operate at a lamp frequency of 68kHz, meaning the 1nF capacitor has an impedance of about 2.3kΩ. Adding the 10kΩ resistor in parallel drops the impedance to 1896Ω, which changes the effective divider from 1:101 to 1:124. As shown in **Figure 4**, the capacitor divider voltage is about $7.2V_{RMS}$, implying a lamp operating voltage of about $893V_{RMS}$. Note the small amount of negative DC offset on the waveforms in Figure 4. Changing the value of the 10kΩ shunt resistor changes the amount of this DC offset. A larger shunt resistor causes a larger DC offset, and a smaller value decreases the offset. Of course, changing the shunt resistor value also affects the divider ratio.

Figure 4 shows the overvoltage feedback signal as it transitions to the OVD input on the DS3984 or DS3988. As the signal passes through the small signal diodes, it loses about 500mV of amplitude. The remainder of the attenuation is accomplished with a resistive divider. In the Figure 1 example, a resistor divider is formed by 33kΩ and 5.1kΩ resistors. The internal 50kΩ input impedance on the OVD pin causes slight attenuation. The internal 50kΩ impedance drops the effective shunt resistance from 5.1kΩ to 4630Ω, which increases the attenuation.

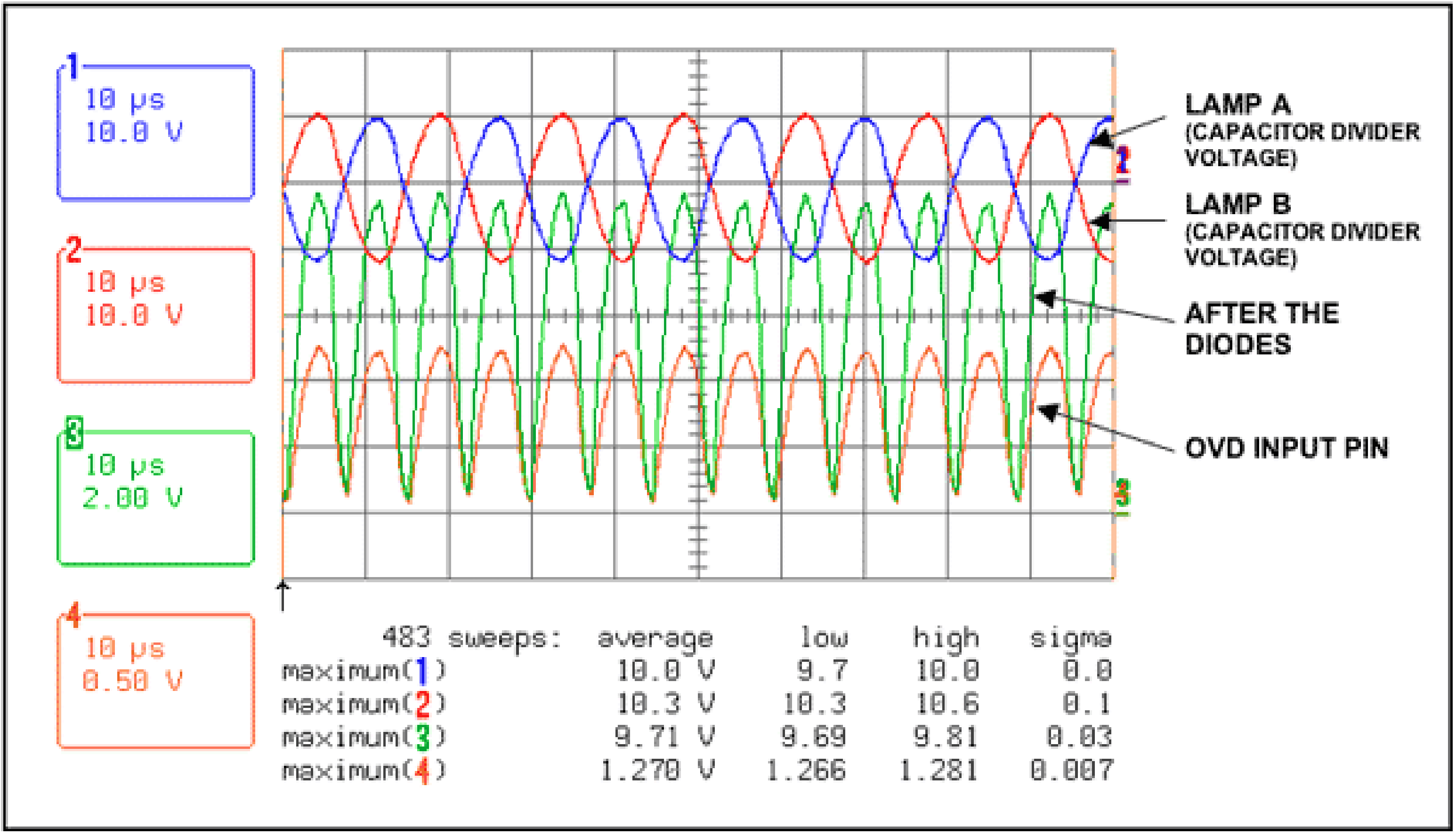


Figure 4. Capacitor divider voltage and OVD signal path.

Failure to Strike and Open Lamp Detection

Wire OR'ing the lamp currents allows the controller to regulate the lamp current through the lamp with the highest current at any particular operating point. This type of operation insures maximum lamp brightness and maximum lamp lifetime, as none of the lamps will be driven to a current higher than their rated value.

To make sure that all of the lamps strike, and also to detect if any of the lamps go out during normal operation, some extra circuitry is needed to pull down the LCM input if any of the lamps are not lit. The LM339 quad comparator is used for this purpose. Each comparator is assigned to one lamp. If all four lamps are lit, the positive voltage swing on the lamp current feedback resistor charges up the peak detector (formed by a diode, 470pF capacitor, and 330kΩ resistor) to above the 5V reference. Also, the open-collector outputs of all four comparators (which are wire OR'ed) turn off, allowing the lamp current signal to enter the LCM pin. If one or more of the lamps are not lit, then the comparator assigned to that lamp pulls the LCM pin low, alerting the DS3984/DS3988 that a lamp is not lit.

Figure 5 shows the peak detect signal as it appears at the input to the comparators. **Figures 6, 7,** and **8** display a normal and abnormal strike event, as well as what occurs when a lamp goes open circuit.

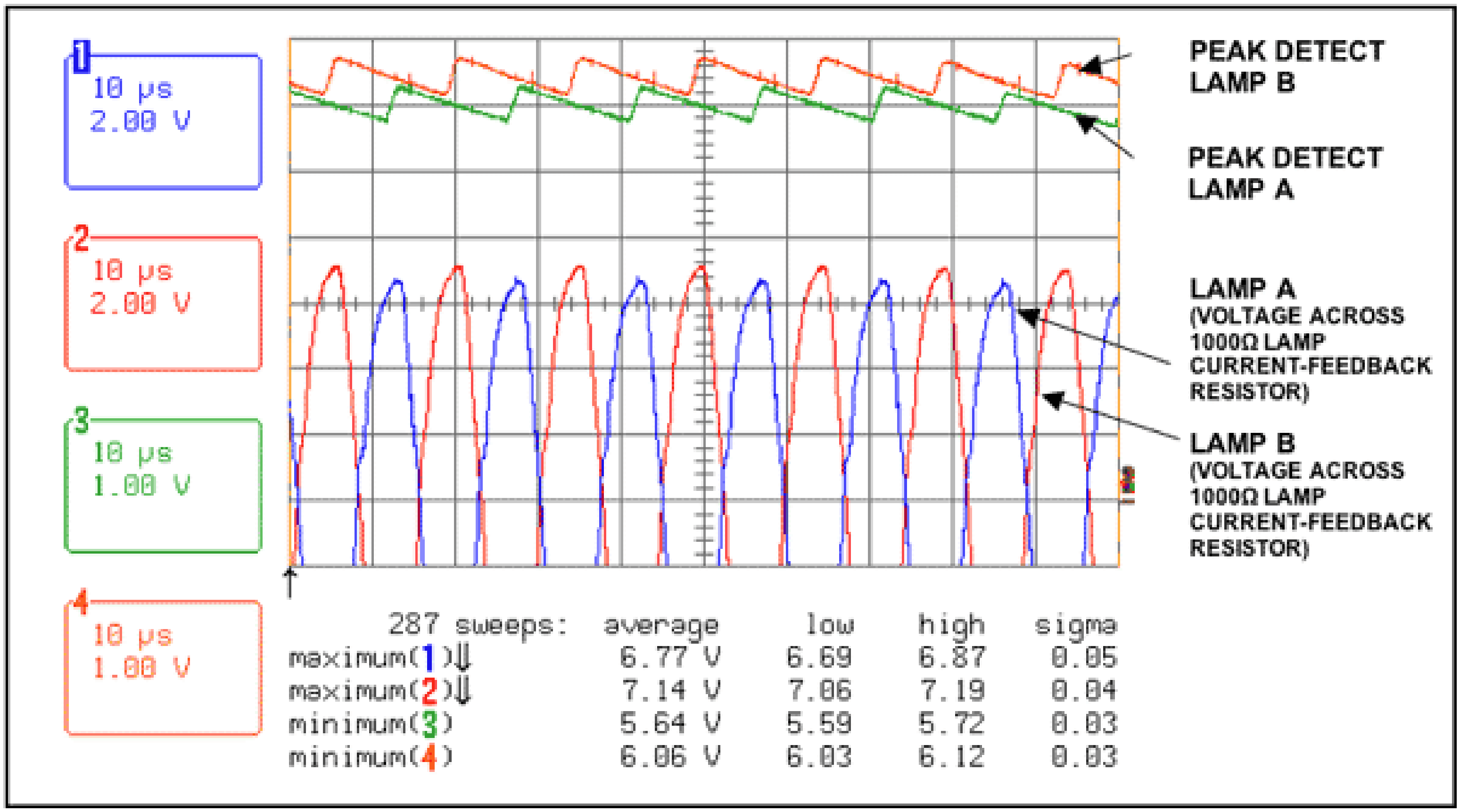


Figure 5. Peak detect signals.

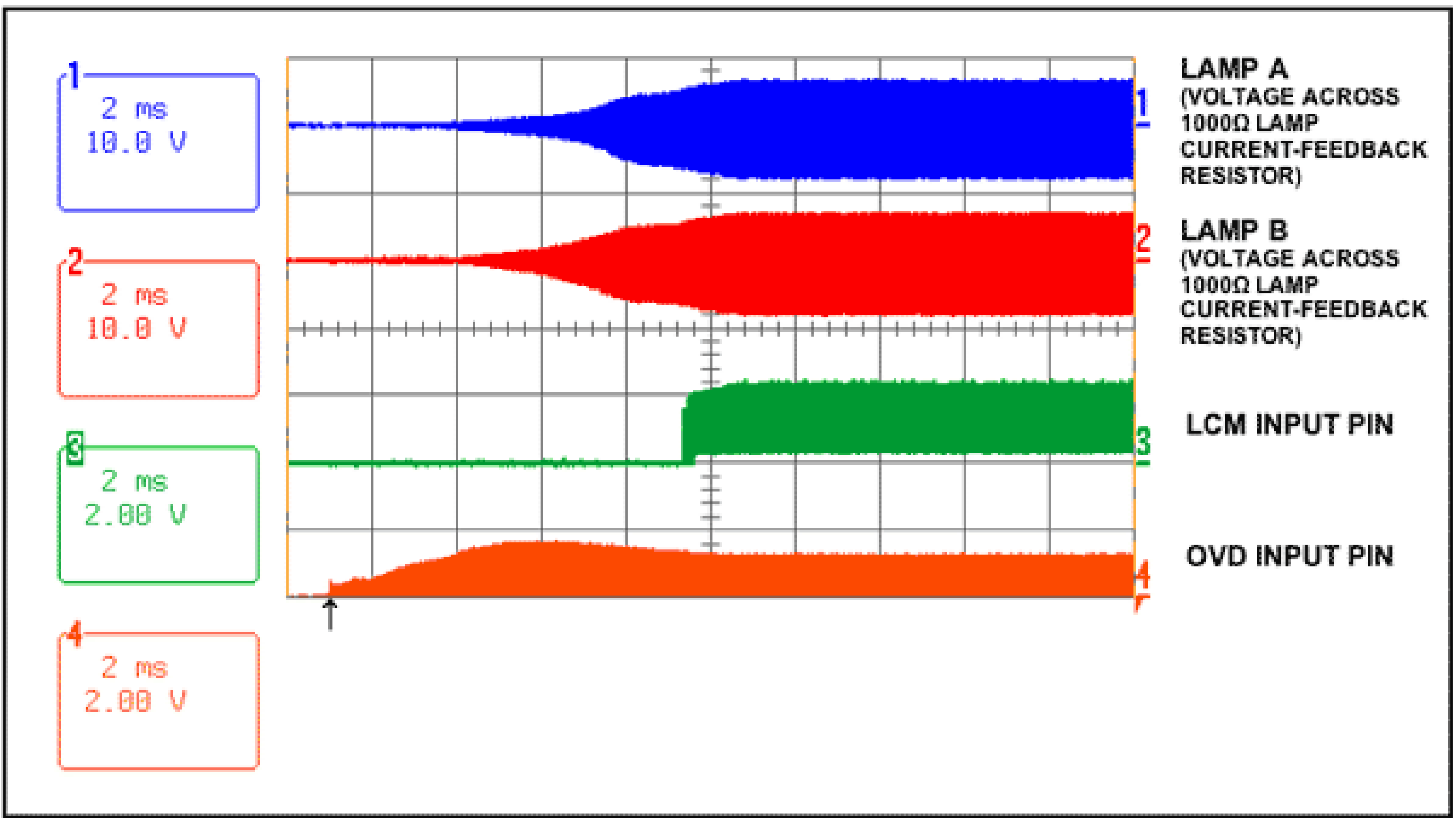


Figure 6. Normal lamp strike.

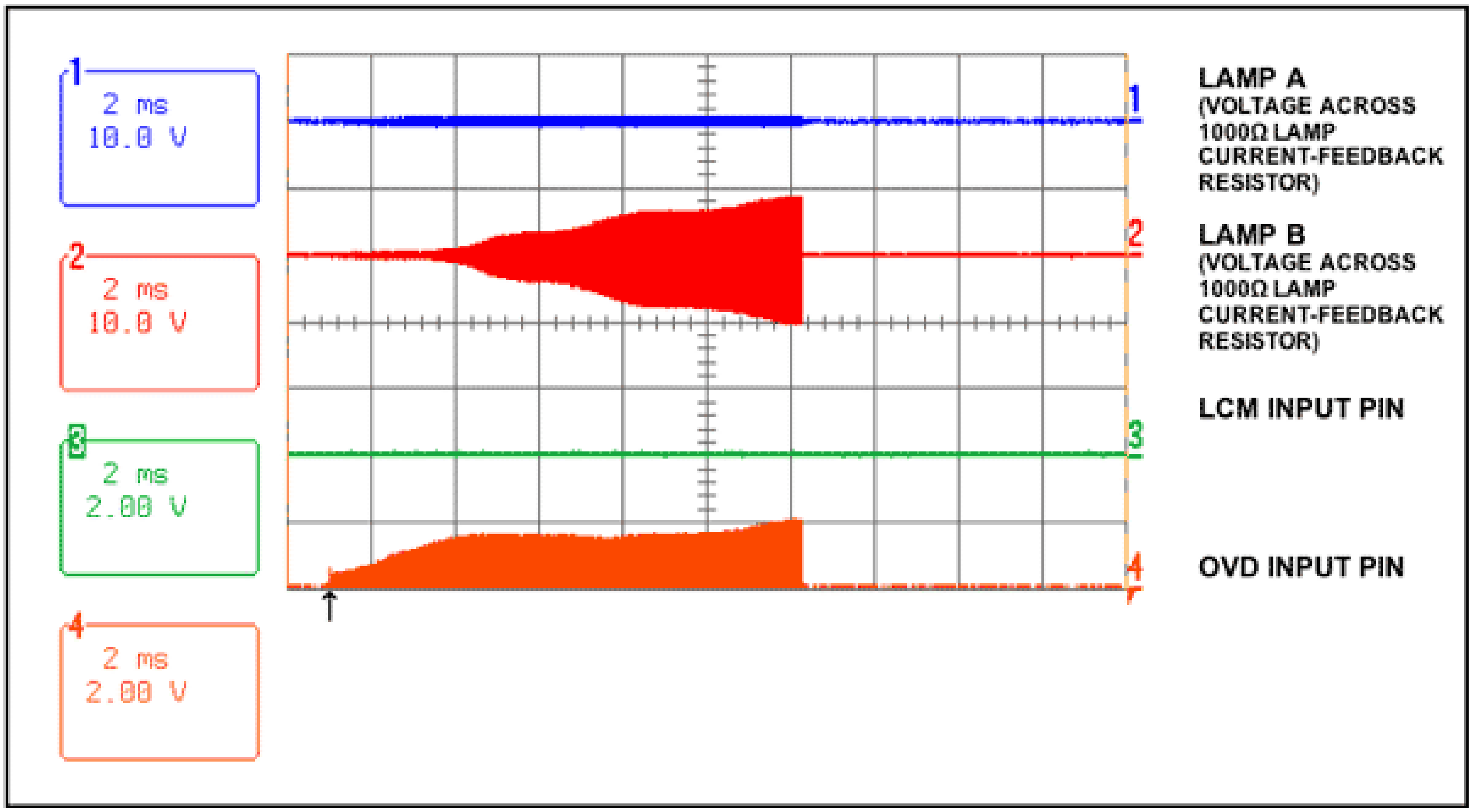


Figure 7. Attempted lamp strike with lamp a disconnected.

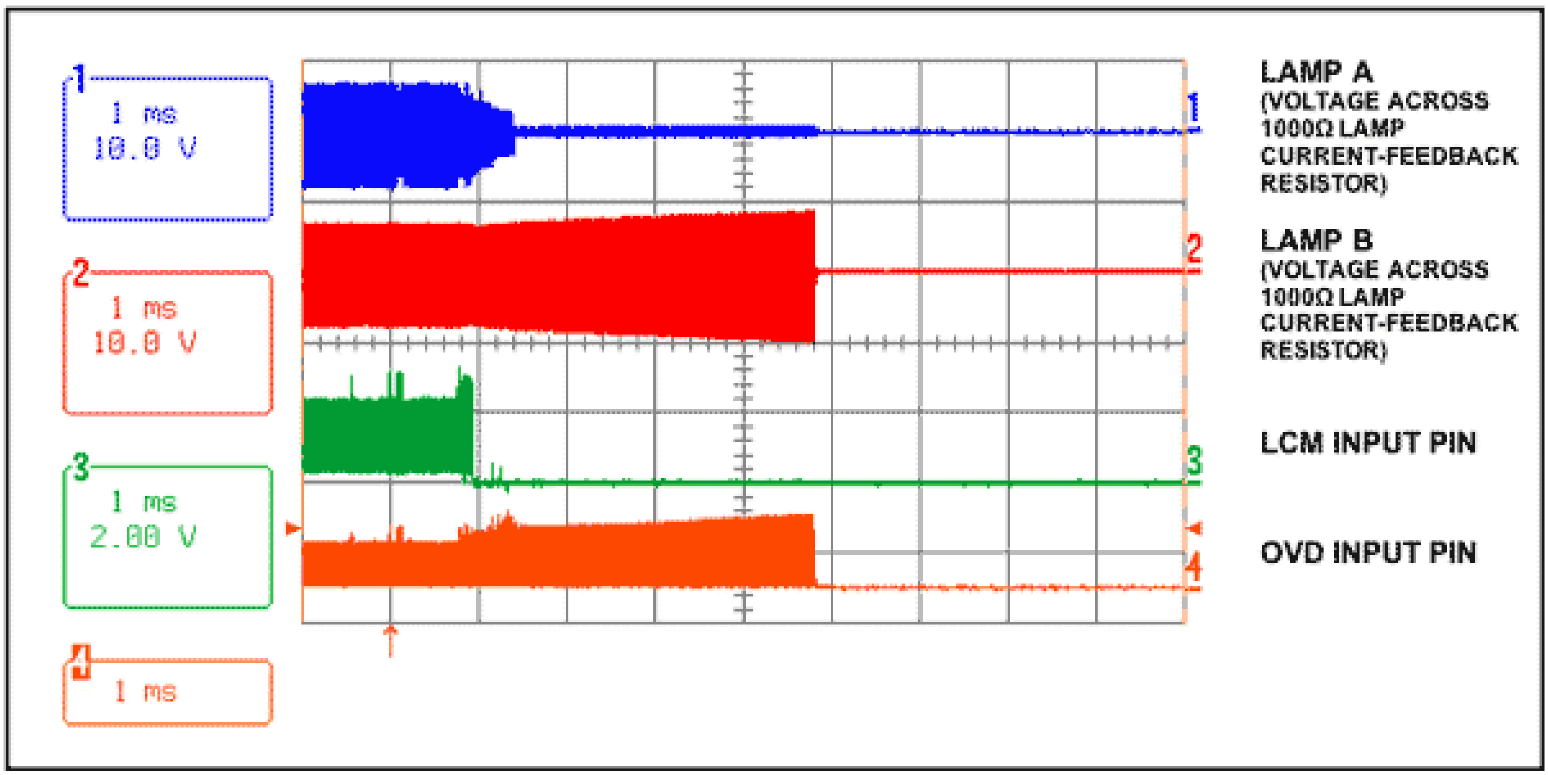


Figure 8. Lamp a is disconnected during normal operation.

Application Note 3615: www.maxim-ic.com/an3615

More Information
For technical support: www.maxim-ic.com/support

For samples: www.maxim-ic.com/samples
Other questions and comments: www.maxim-ic.com/contact

Automatic Updates
Would you like to be automatically notified when new application notes are published in your areas of interest? Sign up for EE-Mail™.

Related Parts

DS3984: QuickView -- Full (PDF) Data Sheet -- Free Samples

DS3988: QuickView -- Full (PDF) Data Sheet -- Free Samples

AN3615, AN 3615, APP3615, Appnote3615, Appnote 3615