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APPLICATION NOTE 4147

How to Modify the Soft-Start Profile of the DS3994

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Abstract: This application note describes the Soft-Start Profile (SSP) used on the DS3994, a 4-channel cold-cathode fluorescent lamp (CCFL) controller, to gradually ramp up the MOSFET duty cycles at the beginning of each lamp burst. The article explains how to customize the device's default SSP values to accommodate the ramping time required in an application.

Introduction

The DS3994 is a 4-channel controller for cold-cathode fluorescent lamps (CCFLs) that backlight liquid crystal displays (LCDs). When burst dimming is used to dim the lamps, the DS3994 uses a soft-start at the beginning of each lamp burst to minimize the audible transformer noise. The soft-start profile (SSP) of the DS3994 is controlled by four Soft-Start Profile registers (SSP1/2/3/4). The SSP registers are factory-programmed and the default values suit most applications. Users can, however, modify the values of the SSP registers with the I²C interface to obtain customized SSPs. This application note describes how to do that modification.

DPWM Soft-Start

The DS3994 uses a digital pulse-width-modulated (DPWM) signal (22.5Hz to 440Hz) to provide efficient and precise lamp dimming. During the high period of the PWM cycle, the CCFLs are turned on and work at the lamp frequency. This part of the cycle is called the "burst" period. During the low period of the PWM cycle, the CCFLs are turned off and no current flows through them. By adjusting the duty cycle of the PWM pulses, one can increase or decrease CCFL brightness.

At the beginning of each lamp burst, the DS3994 provides a soft-start that slowly increases (i.e., "ramps up") the MOSFET gate-driver duty cycle. This ramping minimizes the possibility of audible transformer noise that could result from current surges in the transformer primary. The soft-start ramp profile is controlled by four SSP registers (SSP1/2/3/4). The SSP registers allow eight different MOSFET gate-duty cycles to be programmed; each programmed cycle repeats twice to total 16 lamp cycles. Although the soft-start length is fixed at 16 lamp cycles, the soft-start ramp profile is programmable and can be modified for an application.

Default Values of the SSP registers

There are eight driver duty cycles to select among when customizing the DS3994's soft-start ramp profile. Each of the four SSP registers (SSP1/2/3/4) contains two 4-bit codes that determine the MOSFET's duty cycle (MDC) for two lamp cycles at the beginning of each DPWM burst. **Table 1** shows the duty cycles

that correspond to each code. The soft-start gate cycles are based on a percentage of the most recent lamp duty cycle.

Table 1. Available MOSFET Duty-Cycle (MDC) Profiles

MDC Code	MOSFET Duty Cycle—Percentage of the Most Recent Control Value (%)
0h	0
1h	25
2h	37.5
3h	50
4h	62.5
5h	75
6h	87.5
7h	100
8h-Fh	Reserved

Table 2 shows the addresses and default values of the SSP registers.

Table 2. SSP Register Addresses and Default Values

SSP#	Address	Default	MSB						LSB
			7	6	5	4	3	2	1	0
SSP1	F0h	21h	Lamp Cycles 3 and 4				Lamp Cycles 1 and 2			
SSP2	F1h	43h	Lamp Cycles 7 and 8				Lamp Cycles 5 and 6			
SSP3	F2h	65h	Lamp Cycles 11 and 12				Lamp Cycles 9 and 10			
SSP4	F3h	77h	Lamp Cycles 15 and 16				Lamp Cycles 13 and 14			

Modifying the Soft-Start Profile

The SSP registers determine the 16 MOSFET duty cycles (MDCs) during the soft-start period to ensure that those MDCs ramp up gradually from 0 to its most recent value (or the nominal value). The time for the MDC to complete this ramp up is called the ramping time. The ramping time can be set from 0 to 16 lamp cycles in increments of two lamp cycles. The shorter the ramping time, the steeper the slope of the current envelope.

Table 3 gives the suggested values of the SSP registers for various ramping times. Users can select the appropriate SSP register values to achieve a desired ramping time. The default SSP of the DS3994 has 12 ramping cycles.

Table 3. Suggested SSP Register Values for Various Ramping Times

Number of Ramping Cycles	SSP Register Values			
	SSP1 (F0h)	SSP2 (F1h)	SSP3 (F2h)	SSP4 (F3h)
0	77h	77h	77h	77h
2	73h	77h	77h	77h
4	42h	77h	77h	77h
6	31h	75h	77h	77h
8	21h	54h	77h	77h

10	21h	43h	76h	77h
12	21h	43h	65h	77h
14	11h	32h	54h	76h
16	11h	32h	43h	65h

The DS3994's software can be used to program the SSP registers. The software is available for download. The software interface is shown in **Figure 1**. Users can use the Byte Read/Write section to adjust the SSP register values.

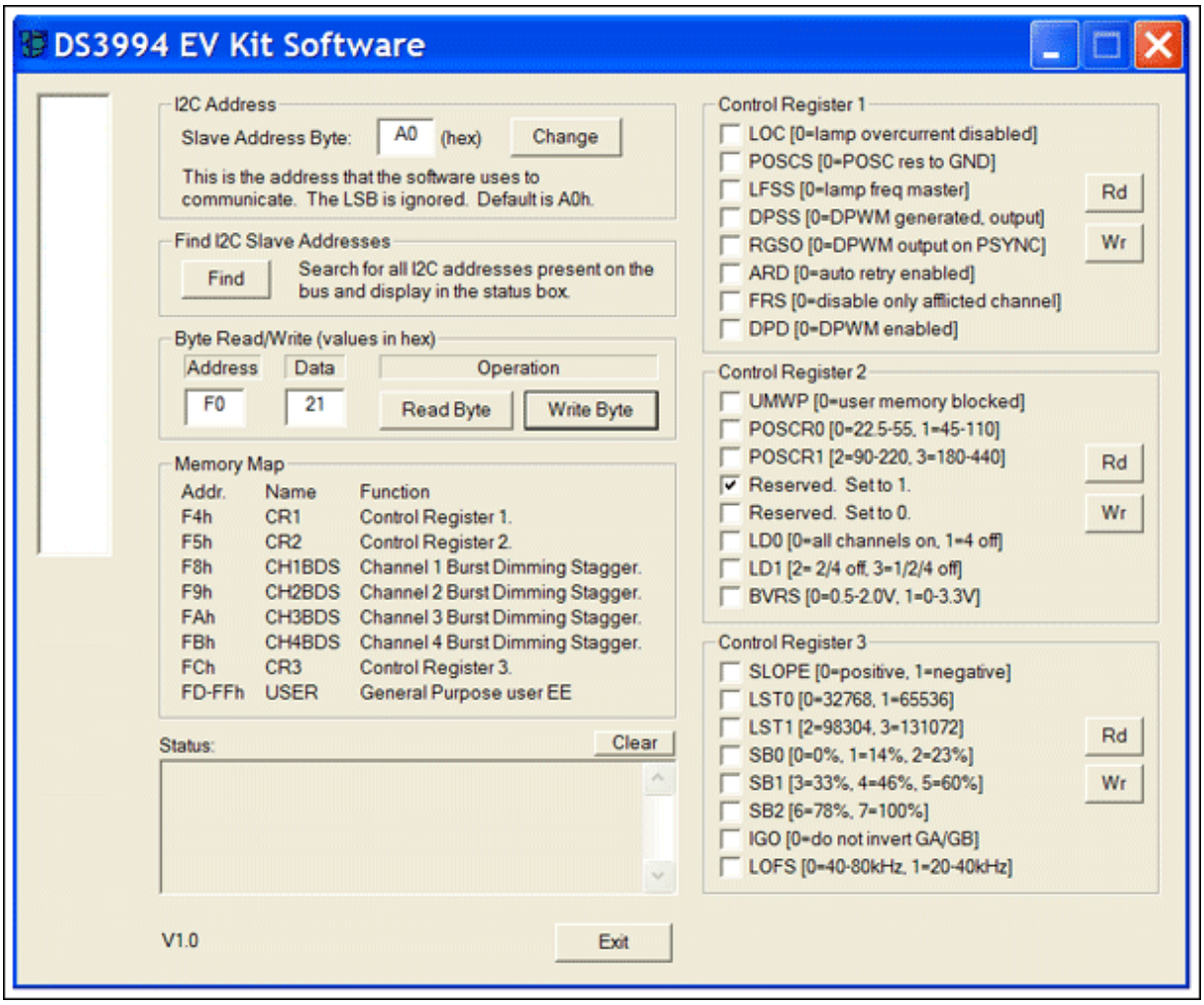

Figure 1. DS3994 software interface where users can program the SSP registers.

Figures 2, **3** and **4** show the measured CCFL current waveforms during soft-start periods with different numbers of ramping cycles and using the suggested register values in Table 3. Figure 3 illustrates the SSP with 12 ramping cycles, the default setting of the DS3994. Figures 2 and 4 correspond to SSPs with eight and 16 ramping cycles, respectively.

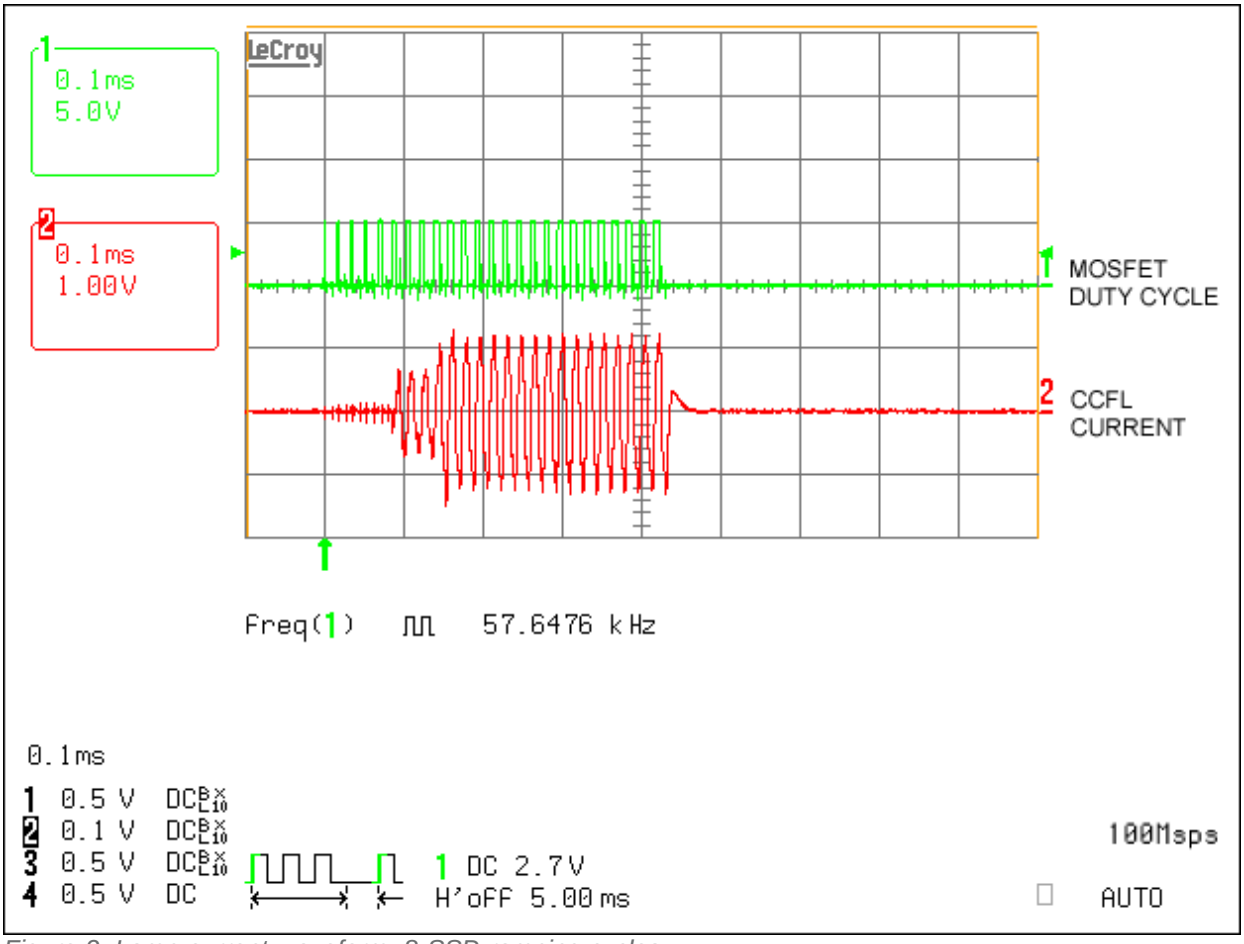

Figure 2. Lamp current waveform, 8 SSP ramping cycles.

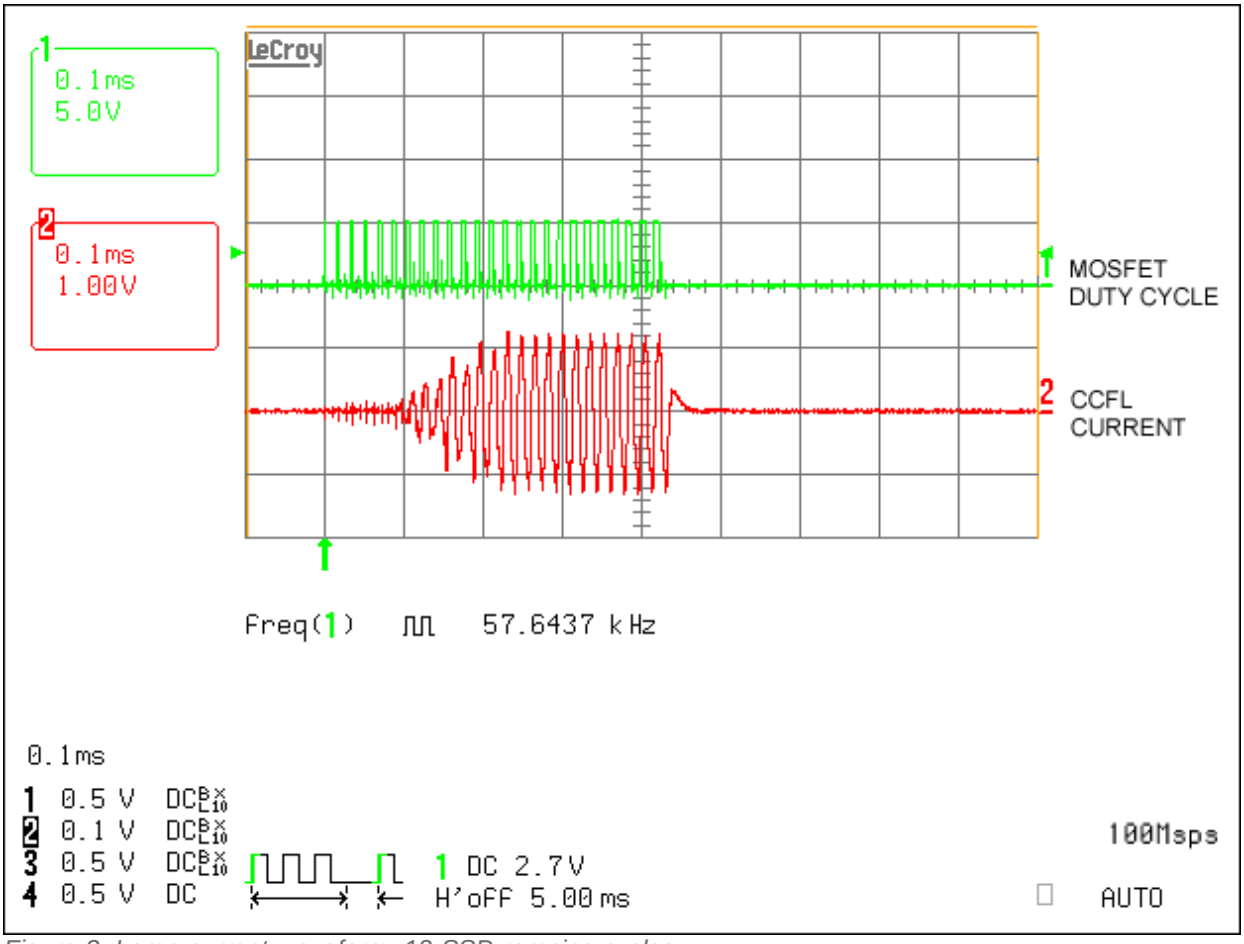

Figure 3. Lamp current waveform, 12 SSP ramping cycles.

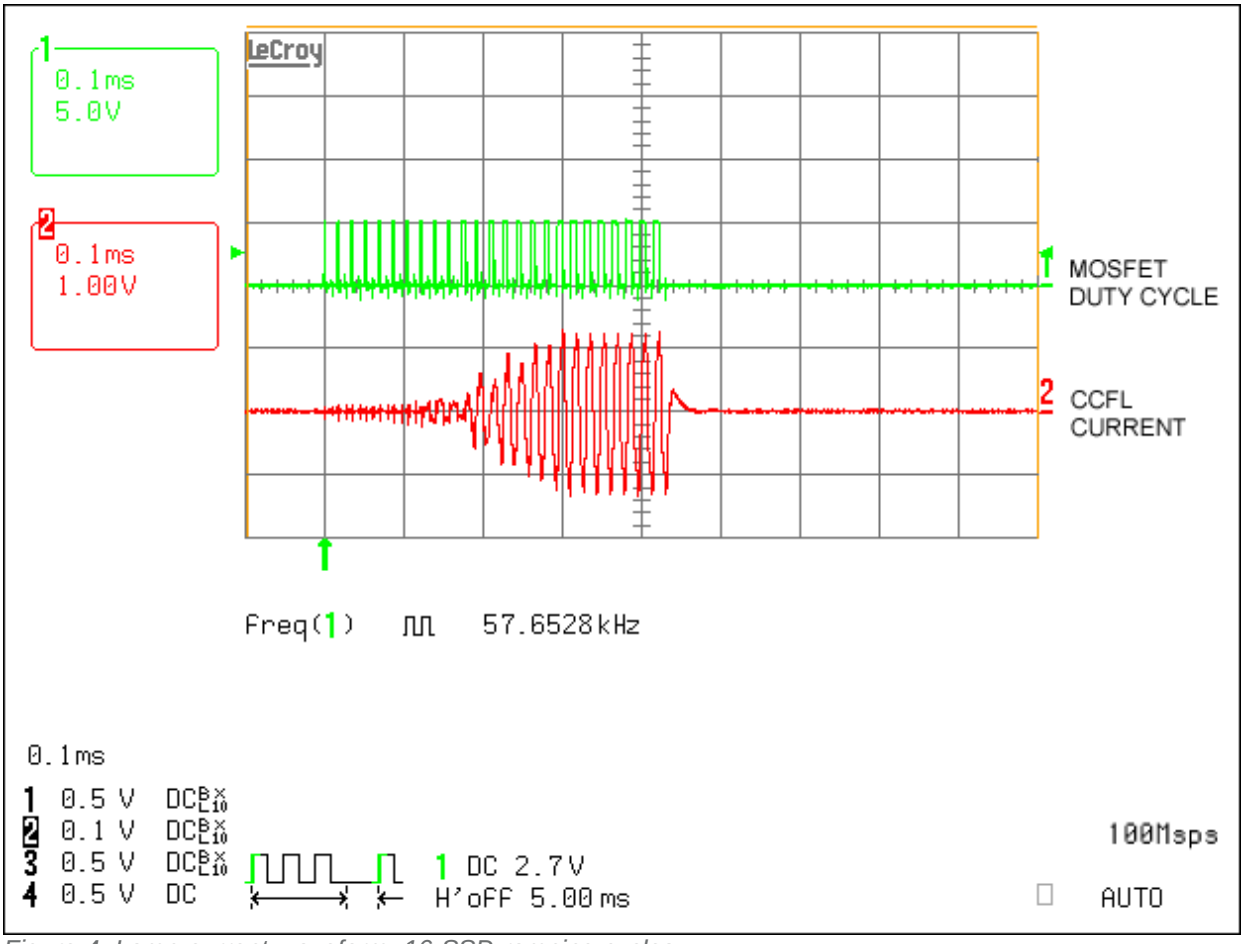

Figure 4. Lamp current waveform, 16 SSP ramping cycles.

Related Parts		
DS3994	4-Channel Cold-Cathode Fluorescent Lamp Controller	Free Samples

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