TLC5940 One-Wire Control – Eliminating Microprocessor Control for Integrated LED Driver

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ABSTRACT

LED drivers such as the TLC5940 provide many integrated features that require a microprocessor interface to use. When these features are not needed, the TLC5940 can be configured with a single-wire interface for simple on/off control. This provides a low-cost solution to drive multiple LEDs with tight current matching while still allowing for PWM dimming in applications such as backlighting or general illumination.

The Texas Instruments TLC5940 LED driver provides up to 120 mA of constant-current sink for driving multiple LEDs. This LED driver includes features such as 16 individually controlled outputs, 1% current matching, 6-bit dot correction, 12-bit PWM dimming, controlled inrush current, error detection, and a 30-MHz data bus. It is ideal for applications such as large screen LED displays, LED signboards, and LED backlighting. In high-end applications such as large screen LED displays and LED signboards, a microprocessor programs the IC to independently control the brightness of each LED with dot correction and/or PWM dimming (also referred to as grayscale dimming). See TI Literature numbers SLYT225 and SLYT238 for more information on dot correction and PWM dimming. Lower end lighting applications require a constant-current source to drive LEDs but do not require the sophisticated control available in these devices. This application report shows how to use a Texas Instruments TLC5940 constant-current LED driver without microprocessor control.

Figure 1 shows the TLC5940 16-channel LED driver in a typical configuration driving 16 individual LEDs. Each LED's cathode is connected to the constant-current sinks OUT0 to OUT15, which provides exceptional LED brightness control. In this configuration, a microprocessor interfaces to the seven control signals to individually control each LED's brightness. The maximum LED current is set at the IC level with the Iset resistor, R1. This current is calculated with

$$I_{MAX} = \frac{1.24V}{R_1} \times 31.5 \qquad (1)$$

where I_{max} is the maximum programmed LED current, R_1 is the resistor connected between Iref and ground, 1.24V is the internal reference voltage of the TLC5940, and 31.5 is a constant-current gain parameter internal to the IC. The microprocessor then programs the TLC5940 with dot correction and PWM dimming information to adjust each LED's brightness.

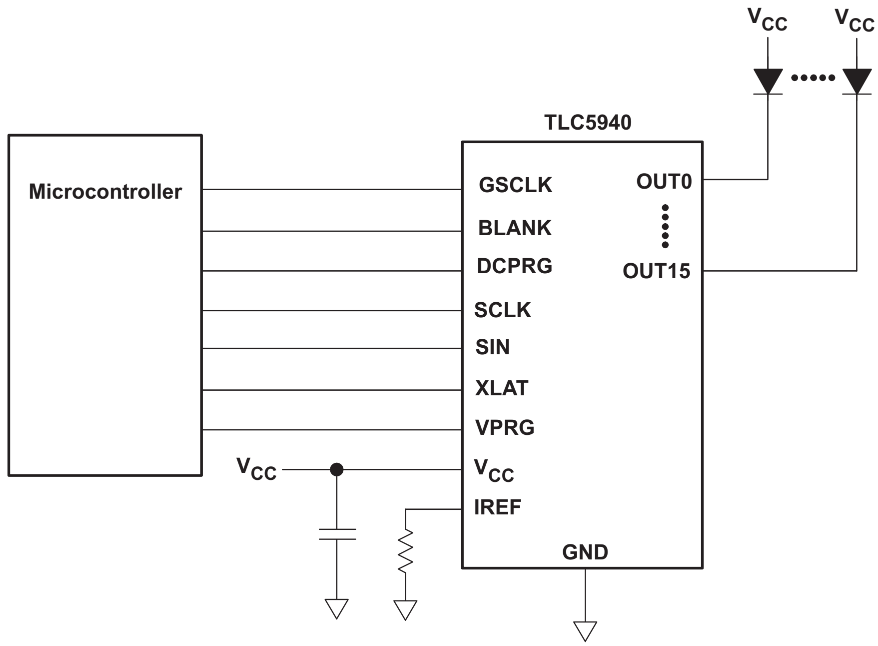

Figure 1. TLC5940 Controlled by MCU

Careful examination of the control signals and timing diagrams shows that the IC can be configured with a single-wire interface to provide a simple enable function. In this configuration, the IC turns all LEDs on and off at the same time. When on, each LED's current is set by the resistor connected to Iref. The single-wire interface is achieved by replacing the microprocessor with a SN74LVC1G04 logic inverter and using a single control signal for on/off control.

Figure 2 shows the TLC5940 single-wire on/off control implementation. The inputs to the IC are connected as follows:

- DCPRG = GND. Sets the TLC5940 to use its internal EEPROM for dot correction.
- VPRG = VCC. Sets the TLC5940 to dot correction.
- SCLK = GND. Disables the input
- SIN = GND. Disables the input
- XLAT = GND. Disables the input
- BLANK = $\overline{\text{ENABLE}}$. Pulling $\overline{\text{ENABLE}}$ low enables the IC. Pulling $\overline{\text{ENABLE}}$ high disables the IC.
- GSCLK = inverted and delayed BLANK signal.

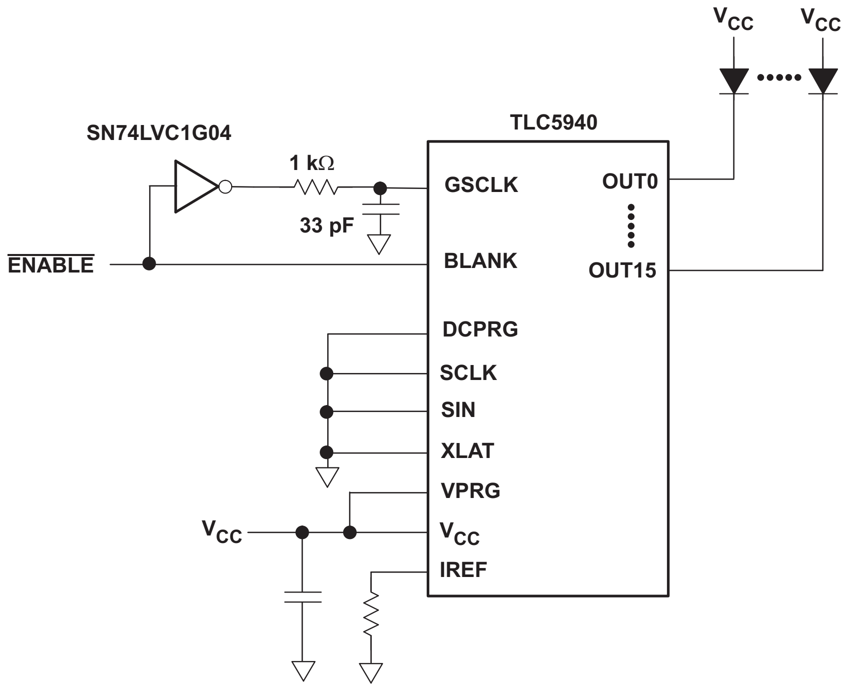

Figure 2. TLC5940 Controlled With One PWM/ENABLE Signal

Connecting DCPRG to ground configures the IC to use its internal EEPROM, which eliminates the need to externally program each individual output's dot correction value. This EEPROM can be programmed by the customer at final assembly or left at the default setting. If not programmed by the customer, the EEPROM's default setting is 111111 binary, or 3Fh, which provides 100% dot correction (full current brightness) to all LEDs. VPRG is connected to VCC to set the IC to dot correction mode, which is required to use the internal EEPROM. A single, external ENABLE signal drives both the BLANK and GSCLK pins. The GSCLK signal must be inverted and delayed by at least 10 nS to meet the IC's timing requirements, which are shown in Figure 3. The SN74LVC1G04 provides the inversion while the RC filter provides the delay. Pulling BLANK low, waiting longer than 10 nS, then pulling GSCLK high turns on all outputs, OUT0-OUT15. All outputs turn off with the falling edge of the BLANK signal. If ENABLE is pulled low and held low, the LEDs stay on indefinitely because the TLC5940's internal grayscale counter stays at a count of 1. The next rising edge of ENABLE turns off all outputs and resets the grayscale counter. All other inputs to the IC are disabled by pulling them to ground.

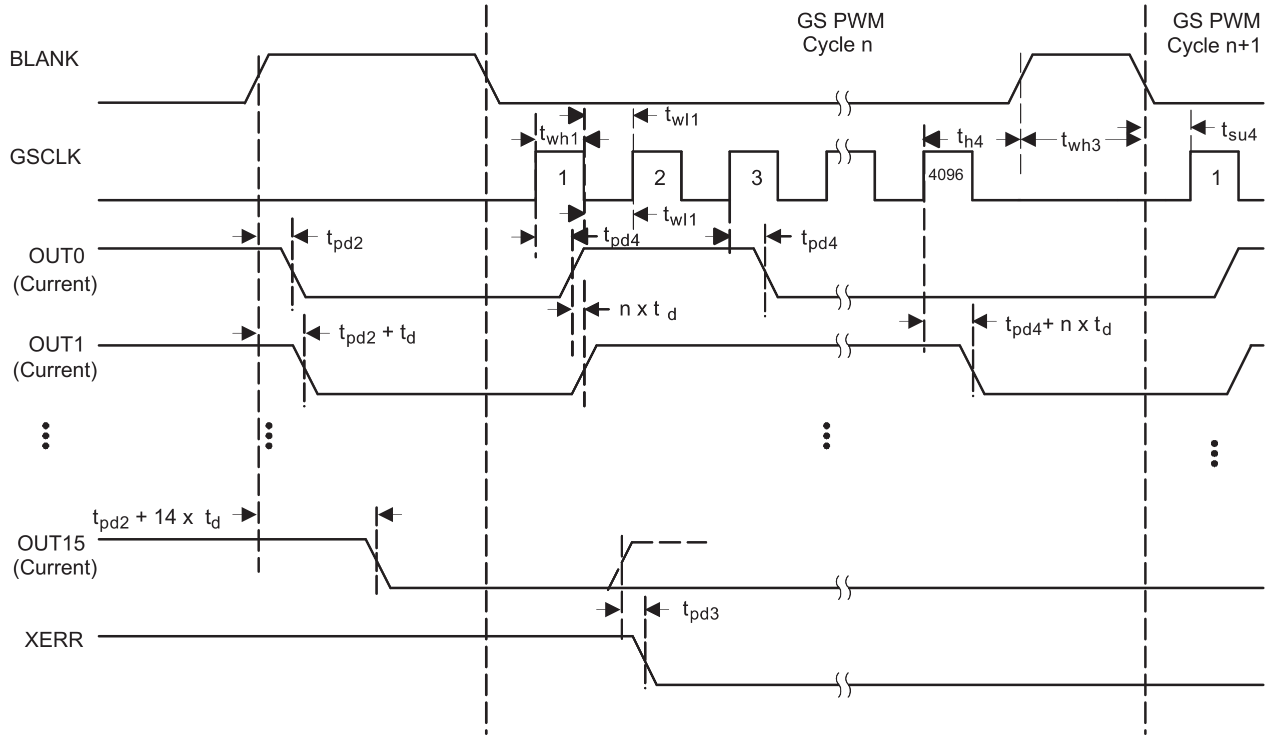

Figure 3. TLC5940 Grayscale PWM Cycle Timing Chart

Figure 4 shows the BLANK and GSCLK signals at turnon. When BLANK goes low, the SN74LVC1G04 inverts the signal. The RC filter delays the rising edge of the GSCLK signal to meet the required setup time of 10 nS. This setup time is represented by t_{su4} in the TLC5940 data sheet. Although the schematic in Figure 2 shows a 33-nS time constant, the actual time constant is higher due to board capacitance and the input capacitance of the IC. The waveform in Figure 4 shows that the actual rise time of the GSCLK signal is longer than the required 10 nS. Pulling $\overline{\text{ENABLE}}$ low turns the current on. Pulling $\overline{\text{ENABLE}}$ high turns the current off. Figure 5 shows the IC operating with PWM dimming to provide 30% dimming.

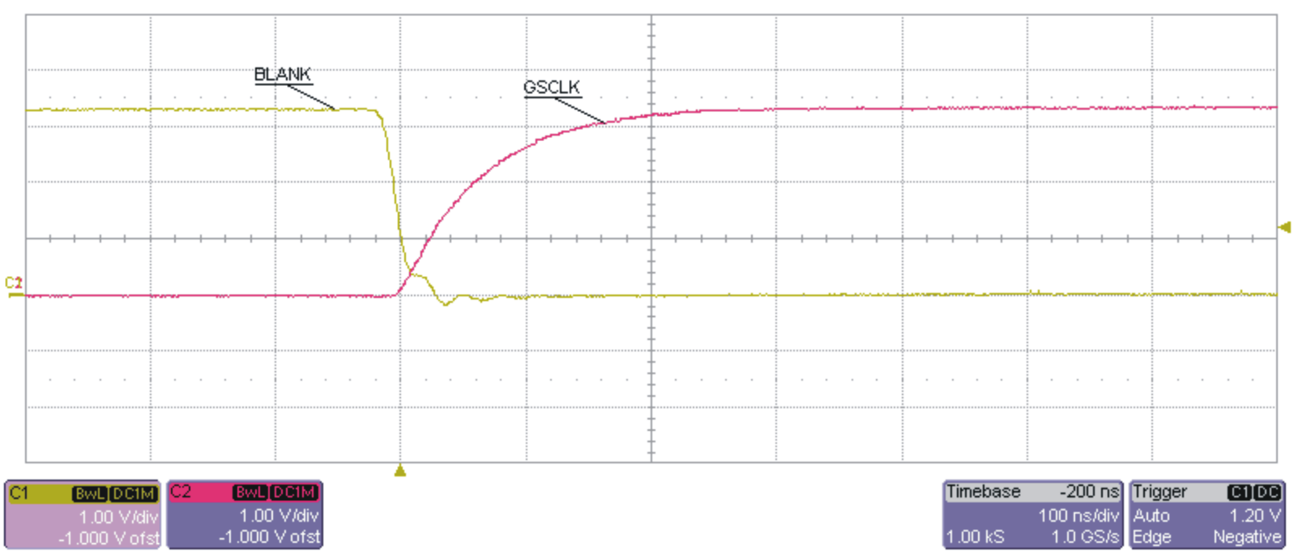

Figure 4. TLC5940 Control Signal Waveforms at Turnon

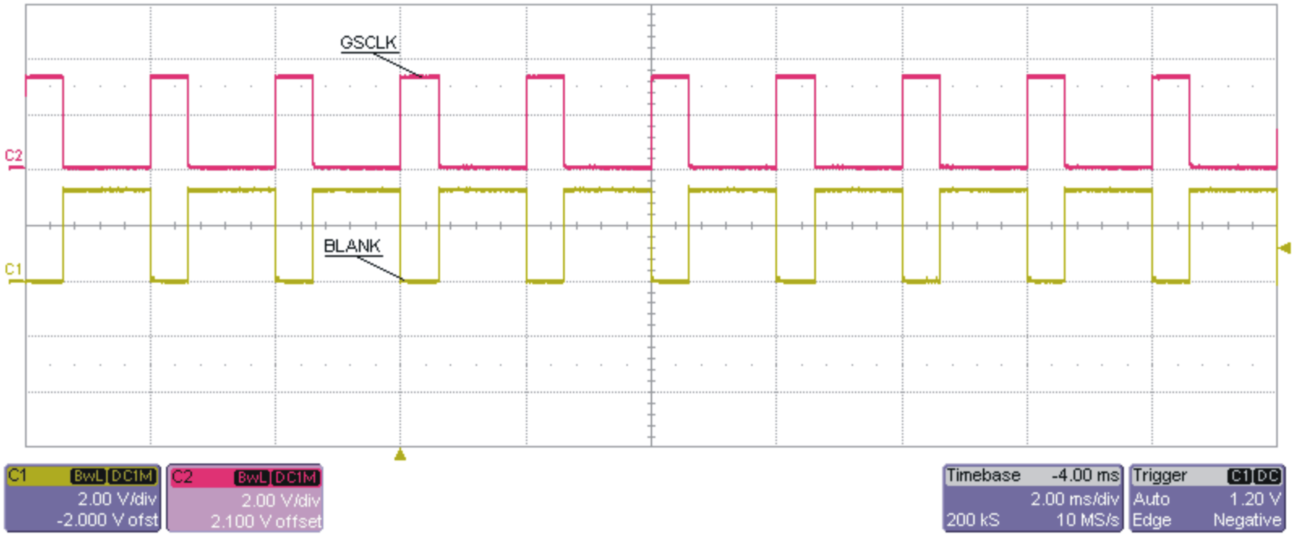

Figure 5. TLC5940 PWM Dimming

Some applications require more than 16 LEDs. This circuit can easily be expanded with additional LED drivers. Only one logic inverter and RC filter are needed to generate the delayed GSCLK signal for all LED drivers used.

Other applications may require a higher current drive than 120 mA per LED. In these applications, OUT0 to OUT15 can be connected in parallel to increase the drive current. With all outputs connected in parallel, the TLC5940 can drive a single LED with 1.92 A. See TI application report (SLVA253) for more information on paralleling outputs.

For more advanced applications, the internal EEPROM can be programmed at assembly to provide a different current for each constant-current sink OUT0 to OUT15. An example of this application would be to connect a red, a green, and a blue LED to different outputs. The EEPROM can be factory-programmed to drive the three LEDs to the appropriate current levels to generate any desired color.

References

1. *TLC5940, 16 Channel LED Driver With Dot Correction and Grayscale PWM Control* data sheet (SLVS515)
2. *TLC5940 EVM User's Guide* (SLVU139)
3. *TLC5940 dot correction compensates for variations in LED brightness* application report (SLYT225)
4. *TLC5940 PWM dimming provides superior color quality in LED video displays* application report (SLYT238)
5. *LED Driver–Paralleled Outputs Provide High-Current Outputs* application report (SLVA253)
6. *SN74LVC1G04, Single Inverter Gate* data sheet (SCES214)

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