

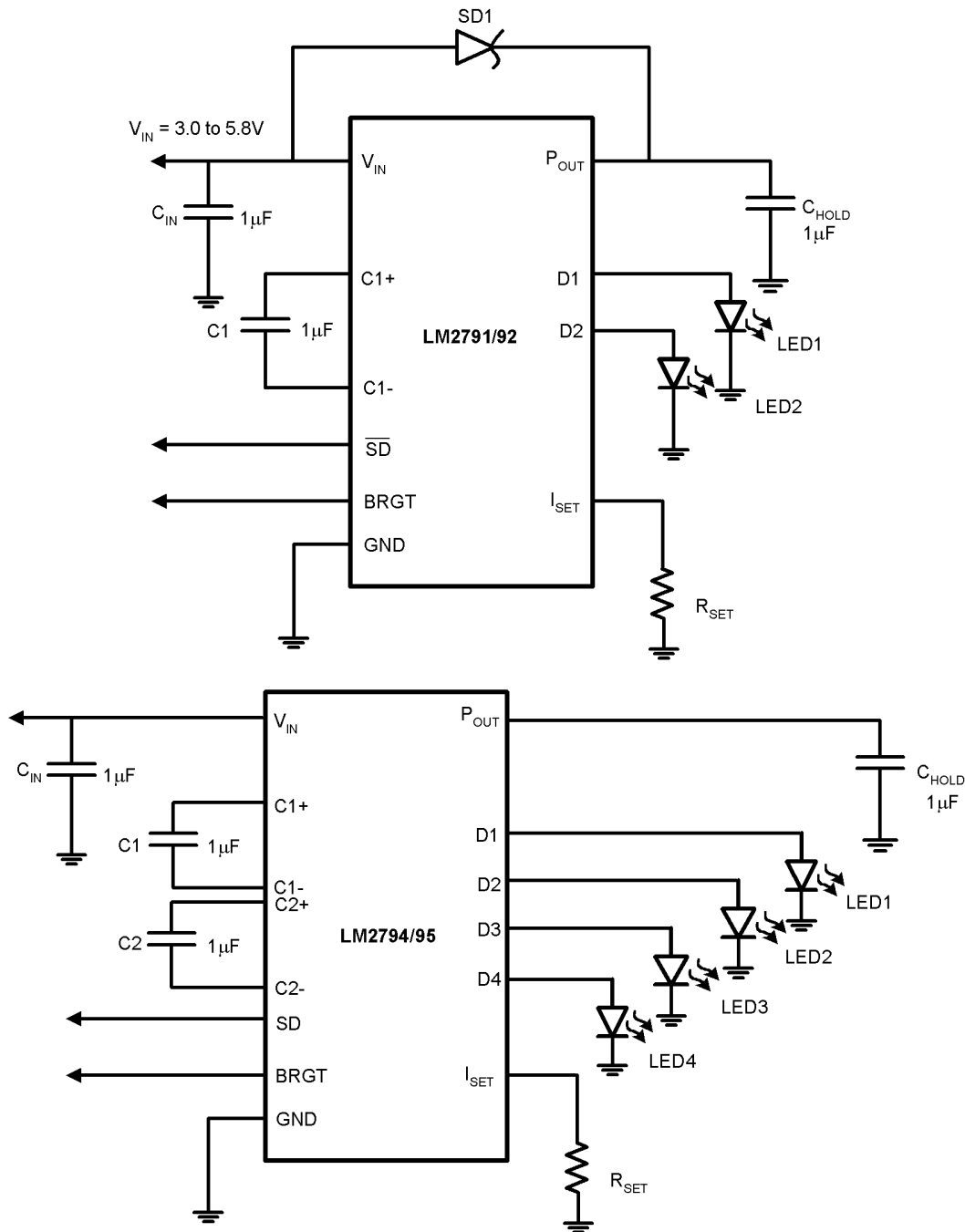
AN-1218 LM2791/2/4/5 Evaluation Board

1 Introduction

The LM2791, LM2792, LM2794 and LM2795 are a family of CMOS Current Regulated Switched Capacitor. They are designed to drive white (or blue) LEDs with matched currents to produce balanced light sources for display backlights. The LM2791/2 is offered in a 10 pin (QFN) package. The LM2791/2 is a charge-pump voltage doubler that provides two regulated current sources. The LM2791 delivers up to a total of 36mA through the LEDs with an offset voltage of 200mV at the Iset pin. The LM2792 delivers up to 34mA with zero offset at the Iset to provide fully off to maximum current control. The switching frequency is between 450KHz to 850KHz for the LM2791 and 900KHz to 1800KHz for LM2792. Both devices accept an input voltage range of 3V to 5.8V. The LM2791 and the LM2792 are also available in active high and low shutdown versions.

The LM2794/5 is offered in a 14 bump DSGBA package. LM2794/5 is a fractional charge pump that provides four regulated current sources. The devices deliver up to 80mA with an offset voltage of 188mV at the Iset pin. The switching frequency for both device are 325kHz to 675kHz and the input voltage range is 2.7V to 5.5V. Note that if V_{IN} is greater than 4.5V, the device will switch from charge pump mode to pass mode. During pass mode, the device output (P_{OUT}) will follow V_{IN} . This is done to prevent P_{OUT} from exceeding the package voltage rating if V_{IN} is greater than 4.5V. The LM2794 option offers active low for shutdown while the LM2795 offers active high for shutdown.

2 Typical Application Circuit



3 R_{SET} Selection (LM2791/2)

R_{SET} is the resistor that sets the current through both LEDs. It is left intentionally for the end users to set the desired current range. Equations below are used for determining R_{SET} value:

$$\text{Eq. 1 for LM2792: } R_{\text{SET}} = ((0.42 \cdot \text{BRGT}) / \text{ILED}) \cdot 25 \quad (1)$$

$$\text{Eq. 2 for LM2791: } R_{\text{SET}} = (((0.42 \cdot \text{BRGT}) + 0.200) / \text{ILED}) \cdot 25 \quad (2)$$

For example, if 15mA is the desired current per LED and BRGT = 3V, using the above equation 1 yields R_{SET} = 2.1K ohms. [Table 1](#) below shows a typical LED current when BRGT is at 3V(LM2792) maximum and [Table 2](#) shows a typical LED current when BRGT is at 0V(LM2791). If BRGT voltage is other than 3V, [Table 5](#) shows R_{SET} and BRGT combination per LED current.

**Table 1. R_{SET} when BRGT = 3V
(example given for LM2792)**

I _{LED}	R _{SET} ⁽¹⁾
15mA	2.1kΩ
10mA	3.15kΩ
5mA	6.3kΩ

⁽¹⁾ Use 1% resistor for Rset

**Table 2. R_{SET} when BRGT = 0V
(example given for LM2791)**

I _{LED}	R _{SET} ⁽¹⁾
15mA	330Ω
10mA	500Ω
5mA	1KΩ

⁽¹⁾ Use 1% resistor for Rset

4 R_{SET} Selection (LM2794/5)

Similar to the LM2791/2, R_{SET} is left intentionally for the end users to set the desired current range. Below is the equation for determining R_{SET} value:

$$\text{Eq. 3 for LM2794/5: } R_{\text{SET}} = ((0.188 + (0.385 \cdot \text{BRGT})) / I_{\text{LED}}) \cdot 10 \quad (3)$$

For example, if 15mA is the desired current per LED and BRGT = 0V (or ground), using the above equation 3 yields R_{SET} = 124 ohms. [Table 3](#) below shows typical LED current when BRGT is tied to ground and [Table 4](#) shows typical LED current when BRGT is at 3V maximum. If BRGT is used in the application, [Table 5](#) shows R_{SET} and BRGT combination per LED current.

Table 3. R_{SET} when BRGT = 0V

I _{LED}	R _{SET} ⁽¹⁾
15mA	124Ω
10mA	196Ω
5mA	383Ω

⁽¹⁾ Rset value is rounded off to the nearest 1% value

Table 4. R_{SET} when BRGT = 3V

I _{LED}	R _{SET} ⁽¹⁾
15mA	909Ω
10mA	1.4KΩ
5mA	2.67Ω

⁽¹⁾ Rset value is rounded off to the nearest 1% value

5 BRGT (LM2791/2)

A voltage from 0 to 3V may be applied to the BRGT pin to control the brightness of the LEDs by varying the current through the LEDs. Note that some voltage must be provided at BRGT pin or no current will flow through the LEDs for the LM2792. BRGT pin is connected to an internal resistor divider that gives a factor of 0.42 (LM2792). The product of this factor and the voltage at BRGT is fed to the input of an internal amplifier that sets the current mirror resistor R_{SET}. [Table 5](#) shows the relationship between LED current with various R_{SET} and BRGT values. Care must be taken to ensure that the voltage at BRGT does not cause LEDs current to exceed a total of 34mA (LM2792). Note that calculations are based on when both D1 and D2 are in use.

**Table 5. LED Current When Using BRGT Input
(Example for LM2792 & both D1 & D2 are in use)**

Voltage on BRGT (V)	R _{SET}			
	1000Ω	1500Ω	2000Ω	2500Ω
	Current through LED (mA)			
0	0	0	0	0
0.5	5.25	3.5	2.6	2.1
1.0	10.05	7	5.25	4.2
1.5	15.75	10.5	7.88	6.3
2.0	21	14	10.5	8.4
2.5	26.25	17.5	13.1	10.5
3.0	31.5	21	15.75	12.6

(Values Highlighted in **Boldface** exceed maximum current range of the device if both D1 & D2 are in use)

By rearranging equation 1, the following equation can be used to determine ILED:

$$\text{Eq. 4 for LM2792: ILED} = ((0.42 \cdot \text{BRGT}) / R_{\text{SET}}) \cdot 25 \quad (4)$$

$$\text{Eq. 5 for LM2791: ILED} = (((0.42) + 0.200) \cdot \text{BRGT}) / R_{\text{SET}} \cdot 25 \quad (5)$$

6 BRGT (LM2794/5)

A voltage from 0 to 3V may be applied to the BRGT pin to control the brightness of the LEDs by varying the current through the LEDs. BRGT pin is connected to an internal resistor divider and summed with an offset voltage from the internal bandgap (188mV). This voltage is fed to the input of an internal amplifier that sets the current mirror resistor R_{SET}. Table 6 below shows the relationship between LED current with various R_{SET} and BRGT values. Care must be taken to ensure that the voltage at BRGT does not cause LEDs current to exceed total of 80mA. By rearranging equation 3, the following equation can be used to determine the ILED:

$$\text{Eq. 6: ILED} = ((0.188 + (0.385 \cdot \text{BRGT})) / R_{\text{SET}}) \cdot 10 \quad (6)$$

**Table 6. LED Current When Using BRGT Input
(D1-D4 are active)**

Voltage on BRGT (V)	R _{SET}			
	124Ω	500Ω	900Ω	1750Ω
	Current through LED (mA)			
0	15.16	3.76	2.09	1.07
0.5	30.69	7.61	4.23	2.17
1.0	46.21	11.46	6.37	3.27
1.5	61.73	15.31	8.51	4.37
2.0	77.26	19.16	10.64	5.47
2.5	92.78	23.01	12.78	6.57
3.0	101.88	26.86	14.92	7.67

NOTE: Values Highlighted in **Boldface** exceed Maximum current range of the device if all D1-D4 are in use.

Besides adjusting the BRGT pin to control the brightness of the LEDs, SD pin can also be used to control the brightness by applying a PWM signal at the SD pin and varying the duty cycle. A duty cycle of zero will turn off the device and a 50% duty cycle waveform will produce an average current of 7.5mA if the intended LED(s) current is 15mA.

7 Shutdown (LM2791/2)

During normal operation, SD pin is connected to V_{IN} (for LM2792LD-H) or connected to ground (for LM2792LD-L). If SD pin is used to control the brightness instead of the BRGT pin, applying a pulse width modulation (PWM) signal in the range of 100Hz to 1KHz is recommended for best result. In the case of the LM2792, connect BRGT to 3V before applying a PWM signal at SD or connect BRGT pin to GND if LM2791 is used),

8 Shutdown (LM2794/5)

During normal operation, SD pin is connected to V_{IN} (for LM2794) or connected to ground (for LM2795). If SD pin is used to control the brightness instead of the BRGT pin, a PWM signal in the range of 100Hz to 1KHz is recommended.

Table 7. Components List for LM2791/2

Component Name	Type	Value	Size	Manufacturer
U1	LM2791/2	LM2791/2	WSO-10	Texas Instruments
C_{IN}	X7R	C2012X7R1C105K, 16V uF	0805	TDK
C1	X7R	C2012X7R1C105K, 16V uF	0805	TDK
C_{HOLD}	X7R	C2012X7R1C105K, 16V uF	0805	TDK
R_{SET}	Through hold	Value to be determined by the end users, +/-1%		
White LEDs	Surface Mount Device, White LEDs (TOPLED)	LWT67C/LWT673		Osram
Schottky Diode	Surface Mount Device	BAT-54 =4P	SOT23-3	Fairchild

9 LM2791/2 Evaluation Board

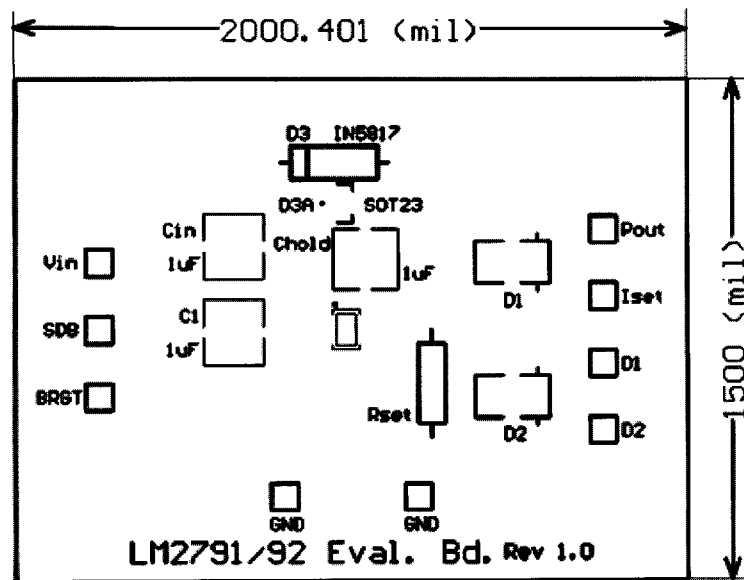


Figure 1. Silkscreen

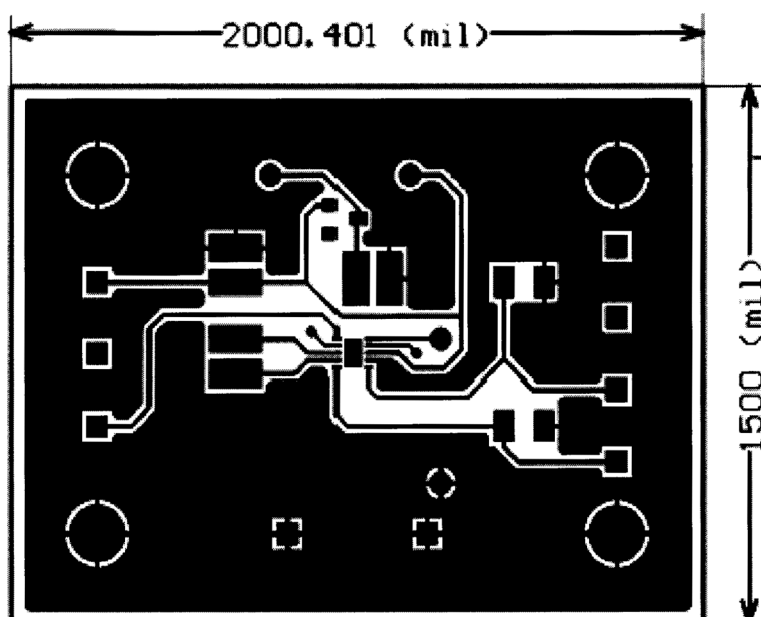


Figure 2. PCB Layout

Table 8. Component List for LM2794/5

Component Name	Type	Value	Size	Manufacturer
U1	LM2794/5	LM2794 --- Active Low Shutdown LM2795 --- Active High Shutdown	14 Bump DSBGA	
C _{IN}	X7R	C2012X7R1C105K, 16V uF	0805	TDK
C1	X7R	C2012X7R1C105K, 16V uF	0805	TDK
C _{HOLD}	X7R	C2012X7R1C105K, 16V uF	0805	TDK
R _{SET}	Through hold	Value to be determined by the end users, +/-1%		
Diode1 - 4	Surface Mount Device, White LEDs (TOPLED)	LWT67C/LWT673	SOT23-3	Osram

10 LM2794/5 Evaluation Board

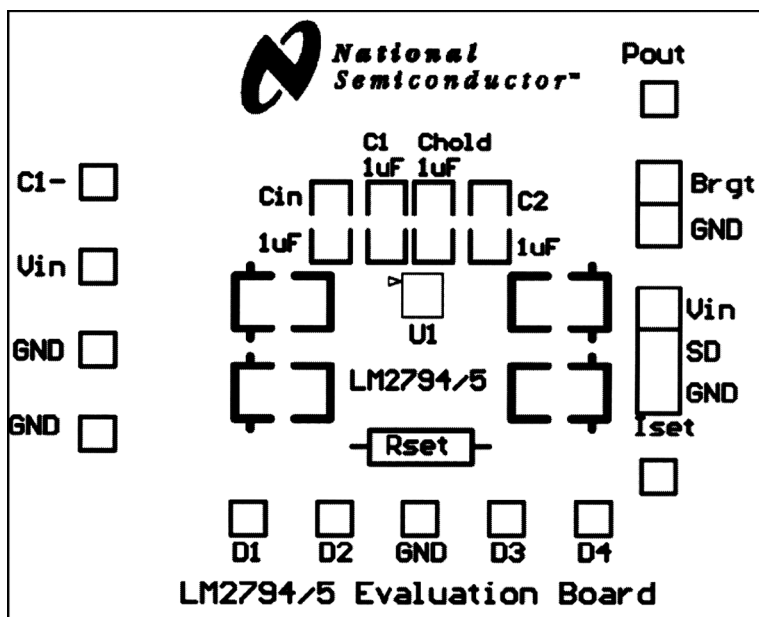


Figure 3. Silkscreen

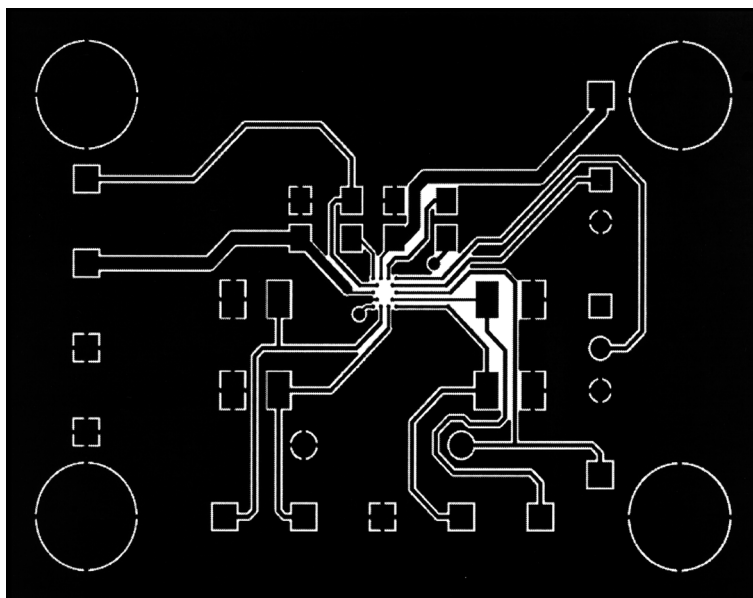


Figure 4. PCB Layout

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com