AL1794EV1 User Guide
Quad-Channel Current-Ratio-Optimized LED Driver with Analog and PWM Dimming

General Description

These four key elements, AC-to-DC Power Stage, LED Driver, LED Emitter Module and Wireless Connectivity block (enabled by embedded MCU and RF), form a typical system configuration for Smart Connected Lighting (SCL) bulbs. AL1794, a four-channel Constant Current Regulator (CCR) LED driver with analog and PWM dimming control, is targeted for Tunable White/Color SCL applications. Powered by Constant Voltage (CV) power source(s) provided by an AC-DC Power Conversion Block, AL1794 generates Constant Currents (CC) driving attached LED emitter strings. The channel currents are further modulated by analog or digital PWM signals generated by the associated external MCU.

Key Merits

- Cost-Effectiveness
- Dimming Performance
- Ease of System Implementation

Key Features

- Input voltage range: 6.5V_{DC} to 30V_{DC}
- 4-Channel LED drivers: Independent Analog or PWM dimming control for each channel
- Reference Current: Adjustable R_{SET}
- Low Standby Power with Enable pin
- E-flicker free High PWM Frequency dimming: 0.1%@1KHz, 0.4%@4KHz, 1.0%@10KHz
- UVLO, OTP, Open, and Short protection
- Operating Temperature Range: -40°C to +125°C
- Low system BOM cost
- U-DFN4030-14 “Green” Moulding Compound package

Applications

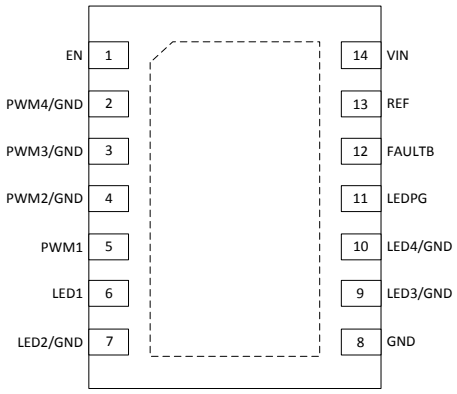
- 1-Channel Dimmable SCL Bulbs
- 2-Channel Tunable White SCL Bulbs
- 3-Channel Tunable White SCL Bulbs
- 4-Channel Tunable White+Color SCL Bulbs
- Smart Connected LED Tubes, Panel Lights, Troffers, and Ceiling Lights

AL1794 EV1 Specifications

Parameter	Value
VLED1 Input Voltage	6.5VDC to 24VDC (Note 1), connect to Anode of LEDs strings
VLED2 Input Voltage	Connect to Anode of LEDs strings if a separate voltage for LEDs stings is required
Input Voltages for LED1, 2, 3, and 4	0.25V (Minimum)
3.3V LDO	150mA (Maximum)
LED_Bar Connectors (Top, Male)	6pins, Power and LED Inputs
MCU1 Connectors (Bottom, Male)	10pins, PWM Signals Input
IC Pin Test points	16 test points (J3 and J4)
XYZ Dimension	1.9 ” x 2.0” x 0.6”

Note 1: Vin(max) for AL1794 is capable of up to 30V, but Vin(max) for AP2204K (3.3V @ 150mA for MCU Power) limits the Vin(max) of AL1794EV1 Board to 24V only. If higher than 24V is required for testing, users can drive Vin up to 30V as long as 3.3V power output from the AP2204K is NOT used.

AL1794 IC Pin Assignment



Pin Name	Part Number U-DFN4030-14	Descriptions
EN	1	Active-high to Enable, Internally Pulled Down
PWM4/GND	2	PWM Signal Input for channel 4, Internally Pulled Down for AL1794. GND for AL1791, AL1792, and AL1793.
PWM3/GND	3	PWM Signal Input for channel 3, Internally Pulled Down for AL1793 and AL1794. GND for AL1791 and AL1792.
PWM2/GND	4	PWM Signal Input for channel 2, Internally Pulled Down for AL1792, AL1793, and AL1794. GND for AL1791.
PWM1	5	PWM Signal Input for channel 1, Internally Pulled Down (Tied to GND when this channel is NOT used).
LED1	6	Channel 1 LED Cathode
LED2/GND	7	Channel 2 LED Cathode for AL1792, AL1793, and AL1794. GND for AL1791.
GND	8	Ground
LED3/GND	9	Channel 3 LED Cathode for AL1793 and AL1794. GND for AL1791 and AL1792.
LED4/GND	10	Channel 4 LED Cathode for AL1794. GND for AL1791, AL1792, and AL1793.
LEDPG	11	LED Power Good Indication. Asserted Low to report insufficient headroom. Needs an external pull-up resistor.
FAULTB	12	Fault Report. Asserted Low to report faulty conditions. Needs an external pull-up resistor.
REF	13	Reference Current Setting through External Resistor (R_{SET})
VIN	14	Voltage Input
Exposed PAD	Exposed PAD	Exposed pad. Internally connected to GND. It should be externally connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical conduction path.

Evaluation Board

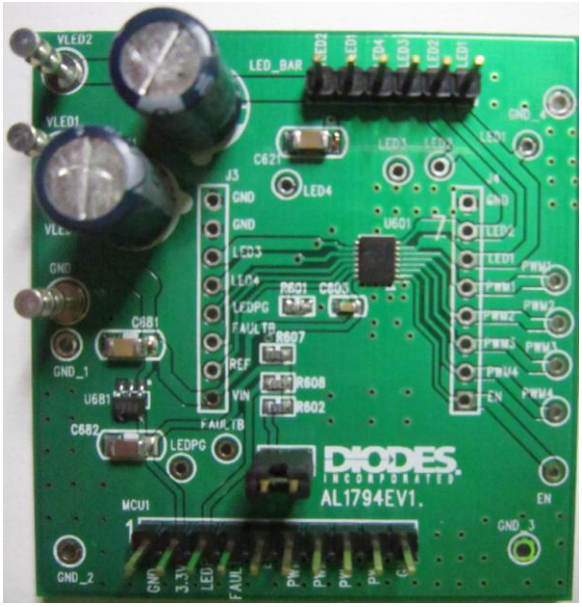


Figure 1: Top View

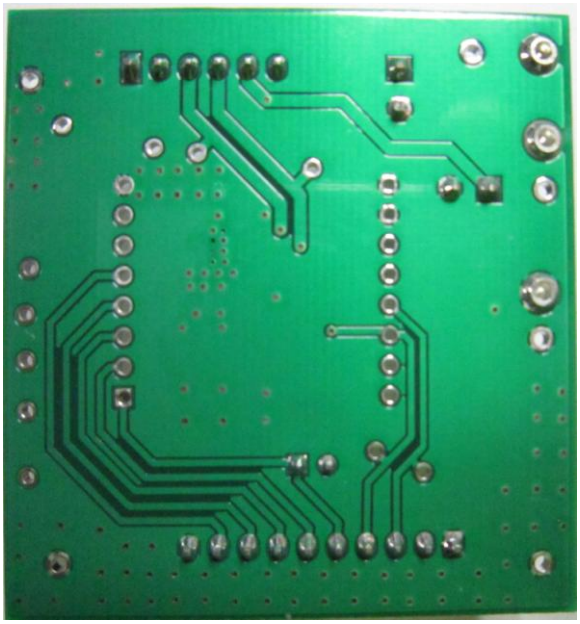


Figure 2: Bottom View

Connector Pin Definition:

1. **Power and Ground Terminals (3 pins)**
   1) **VLED1** - AL1794 VIN, 3.3V LDO Input, and Emitter String Power Input to Anode of Emitter Strings. – Upper left corner (Top View)
   2) **VLED2** - Emitter String Power Input to Anode of Emitter Strings.
   3) **GND** - Ground

2. **LED_BAR Connectors (6 pins) - (Left to Right Pin Sequence)**
   1) **LED1** (IN) - Connected to Cathode of Emitter String #1 - Right most pin (Top View)
   2) **LED2** (IN) - Connected to Cathode of Emitter String #2
   3) **LED3** (IN) - Connected to Cathode of Emitter String #3
   4) **LED4** (IN) - Connected to Cathode of Emitter String #4
   5) **VLED1** (OUT) - Emitter String Power Input to Anode of Emitter Strings.
   6) **VLED2** (OUT) - Emitter String Power Input to Anode of Emitter Strings.

3. **MCU1 Connectors (10 pins) - (Left to Right Pin Sequence)**
   1) **GND** - Ground - Leftmost pin (Top View)
   2) **3.3V** (OUT) - 3.3V (output for MCU Power); Generated by AP2204K-3.3 (**WIDE INPUT VOLTAGE RANGE, 150mA ULDO REGULATOR,** *http://diodes.com/datasheets/AP2204.pdf*) with Vin(max) at 24V.
   3) **LEDPG** (OUT) - LED Power Good signal
   4) **FAULTB** (OUT) - FaultB, active low, indication of fault occurrence
   5) **EN** (IN) - Enable AL1794 to turn ON
   6) **PWM4** (IN) - PWM signal for Channel #4
   7) **PWM3** (IN) - PWM signal for Channel #3
   8) **PWM2** (IN) - PWM signal for Channel #2
   9) **PWM1** (IN) - PWM signal for Channel #1
   10) **GND**

4. **Test Points**
   1) **VLED1** Connected to VLED1
   2) **VLED2** Connected to VLED2
   3) **GND_1, GND_2, GND_3, GND_4** Connected to GND
   4) **EN** Connected to AL179x Pin#1
   5) **PWM4** Connected to AL179x Pin#2
   6) **PWM3** Connected to AL179x Pin#3
   7) **PWM2** Connected to AL179x Pin#4
   8) **PWM1** Connected to AL179x Pin#5
   9) **LED1** Connected to AL179x Pin#6
   10) **LED2** Connected to AL179x Pin#7
   11) **LED3** Connected to AL179x Pin#9
   12) **LED4** Connected to AL179x Pin#10
   13) **LEDPG** Connected to AL179x Pin#11
   14) **FAULTB** Connected to AL179x Pin#12

Board Setup Procedure

The channel current ratio for Channel 1, 2, 3 and 4 are fixed at 1:1:0.75:0.25. The default Channel Current of LED1, LED2, LED3 and LED4, are preset at 250mA, 250mA, 187.5mA and 62.5mA, respectively with Rset (R601) of 12KΩ. Users can change the current setting by replacing Rset to obtain desired current value as follows:

$$ILED1 = 2000 * \frac{VREF}{RSET}$$

$$ILED2 = 2000 * \frac{VREF}{RSET}$$

$$ILED3 = 1500 * \frac{VREF}{RSET}$$

$$ILED4 = 500 * \frac{VREF}{RSET}$$

$$where\ VREF = 1.5V\ nominally\ for\ all\ devices$$

1. Ensure that the DC source is switched OFF or disconnected.
2. Connect the DC line wires of power supply to VIN and GND terminals on the board.
3. Connect the anode wire of external LED string to VLED1 of the board.
4. Connect the cathode wire of the external LED emitter strings to relevant LED channels inputs (LED1, LED2, LED3, LED4) of the board.
5. Make sure the length of both anode/cathode wires connected between AL1794EV1 and LEDs strings is minimized (less than 1 inch) to reduce wire inductance and improve ringing performance.
6. Ensure that the area around the board is clear and safe, and preferably that the board and LEDs are enclosed in a transparent safety cover.
7. Turn on the main DC Power switch.
8. Send proper PWM Signal pattern and then turn ON the EN pin (High) to enable the AL1794 IC.
9. LED strings should light up according to the Dimming pattern driven by PWM signals.

CAUTION:

1. Make sure the maximum DC input voltage is not higher than $30V_{DC}$ (if 3.3V Power Output is NOT used), or $24V_{DC}$ (if 3.3V Power Output is used).

2. If different current is required, please modify the Rset (R601) to proper value before start the Turn-On procedure.
3. The maximum recommended channel current is at 500mA (for channel 1 and 2) with Rset (R601) at 6KΩ.
4. Channel PWM Dimming patterns are recommended to be spread out to avoid sharp turn-on and turn-off rush currents.
5. Though there are various protection mechanism built in AL1794, it is good practice to check maximum dimming pattern to avoid Thermal Shutdown (when Case Ambient Temperature exceeds 160ºC). Thermal resistivity θja (Junction-to-Ambient) of AL1794 is 55 ºC/Watt. AL1794 will have to absorb any additional voltage headroom provided by the VLED power input to the Anodes of Emitter Strings. Therefore, thermal management of AL1794 must follow the following guidelines:

   - PDmax (Maximum Power Dissipation) = (160ºC Junction Shutdown Temperature - Ambient Temperature, e.g. 85ºC) / 55ºC/W = 1.364Watts
   - PAmax (Power to be Absorbed by AL179x) = Σ(VLEDx * Current through the emitter string * Associated PWM Dimming Duty Cycle)
   - Thermal Management Guideline PAmax < PDmax

PWM Dimming Linearity Tests

Using PWM Dimming signals to create desired dimming effects had the advantages of reducing current to desired ratio without changing either CCT (Correlated Color Temperate) of White emitters or causing Color shifts of Color emitters. To avoid **eFlicker** ("Dark Stripes on Images" when taking photos or videos with Smartphones under PWM dimmed Lighting situation), users can use **higher PWM frequency** (e.g. **4KHz and above**). The dimming linearity performance at **Deep Dimming (less than 1% light output)** is very important as human eyes are very sensitive to low light situations.

For example,

- **10% of measured light is 30% of perceived light**
- **5% of measured light is 22% of perceived light**
- **1% of measured light is 10% of perceived light**
- **0.1% of measured light is 3% of perceived light**

Source: IESNA Lighting Handbook, 9th Edition, (New York; IESNA, 2000), 27-4.

Dimming Performances: (PWM Frequency 4KHz, 1KHz, and 10KHz)

1. **4KHz PWM Dimming Current Linearity Test for Channel 1, 2, 3 and 4 (250mA:250mA:187.5mA:62.5mA)**

   Full-Range (0 - 100%) 4KHz PWM Dimming Performance

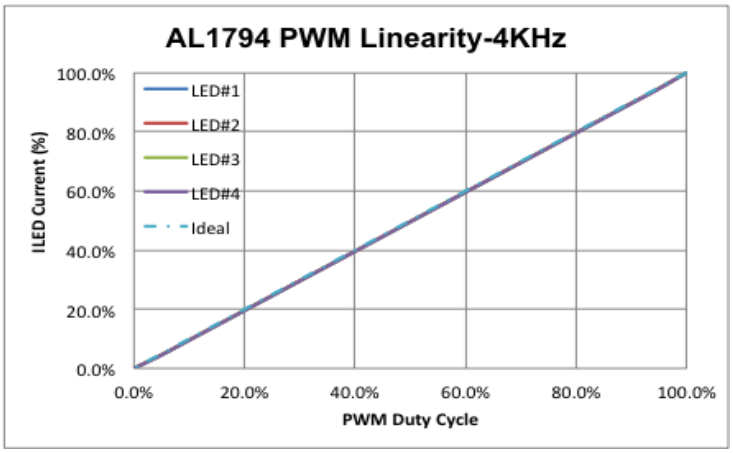


Figure 3: 4KHz PWM Dimming Performance

Deep Dimming (0 - 10%) 4KHz PWM Dimming Performance

Deep dimming performance of PWM signals are critical performance factor as human eyes are more sensitive to brightness change at low light level

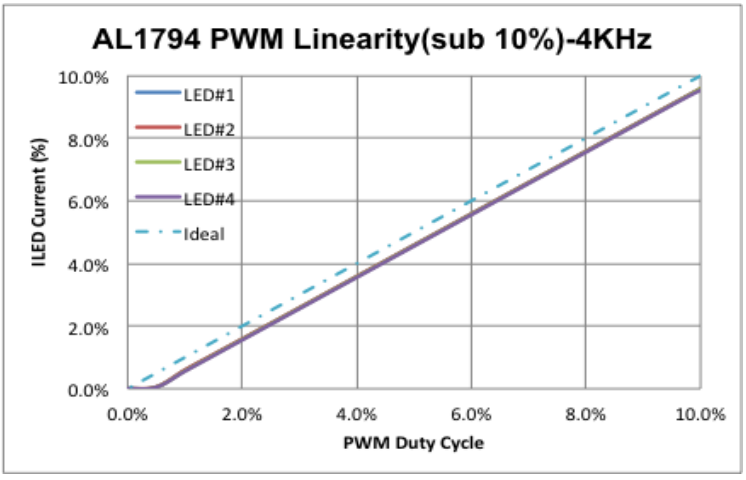


Figure 4: 4KHz PWM Dimming Performance below 10% Dimming

2. **1KHz PWM Dimming Current Linearity Test for Channel 1, 2, 3 and 4 (250mA:250mA:187.5mA:62.5mA)**

Full-Range (0 - 100%) 10KHz PWM Dimming Performance

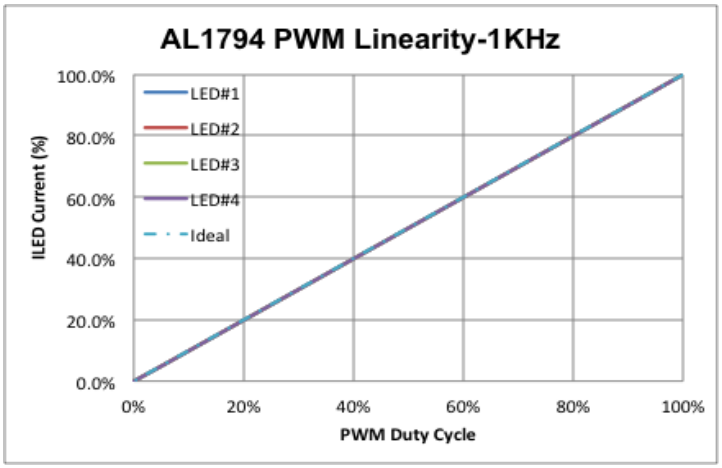


Figure 5: 1KHz PWM Dimming Performance

Deep Dimming (0 - 10%) 1KHz PWM Dimming Performance

Using 1KHz PWM signal (vs. 4KHz) will further improve Deep Dimming Linearity performance.

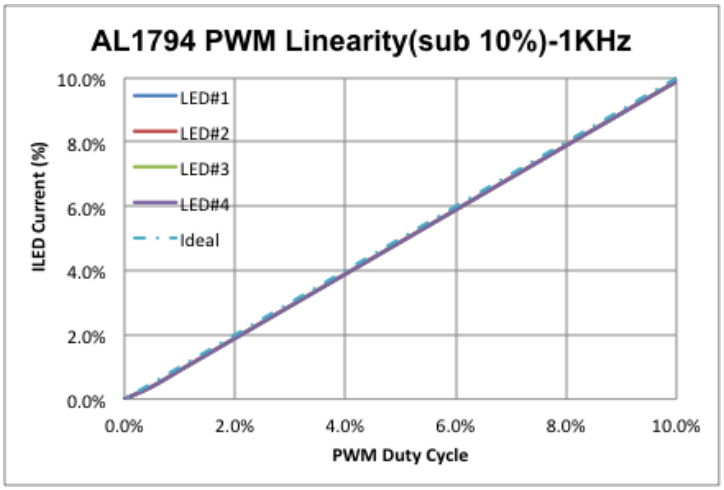


Figure 6: 1KHz PWM Dimming Performance below 10% Dimming

3. **10KHz PWM Dimming Current Linearity Test for Channel 2**

Full-Range (0 - 100%) Dimming Performance

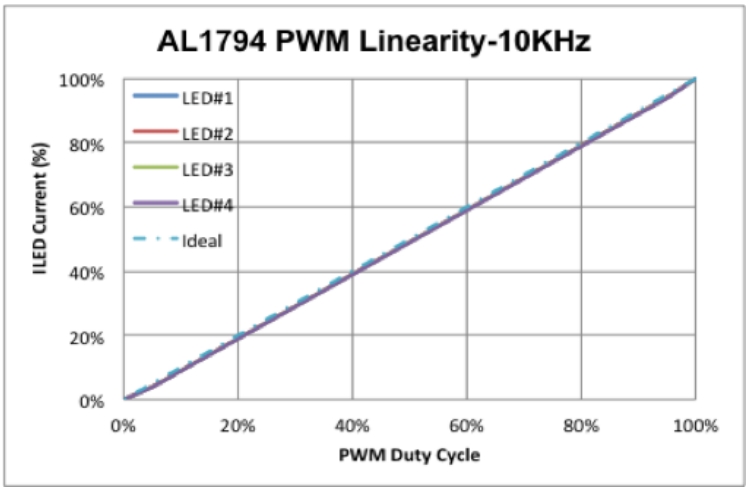


Figure 7: 10KHz PWM Dimming Performance

Deep Dimming (0 - 10%) 10KHz PWM Dimming Performance

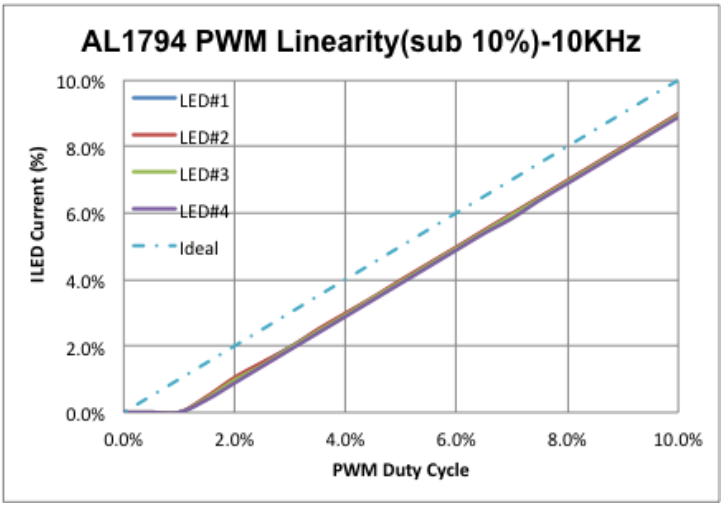


Figure 8: 10KHz PWM Dimming Performance 0%-10% Dimming

Evaluation Board Schematic

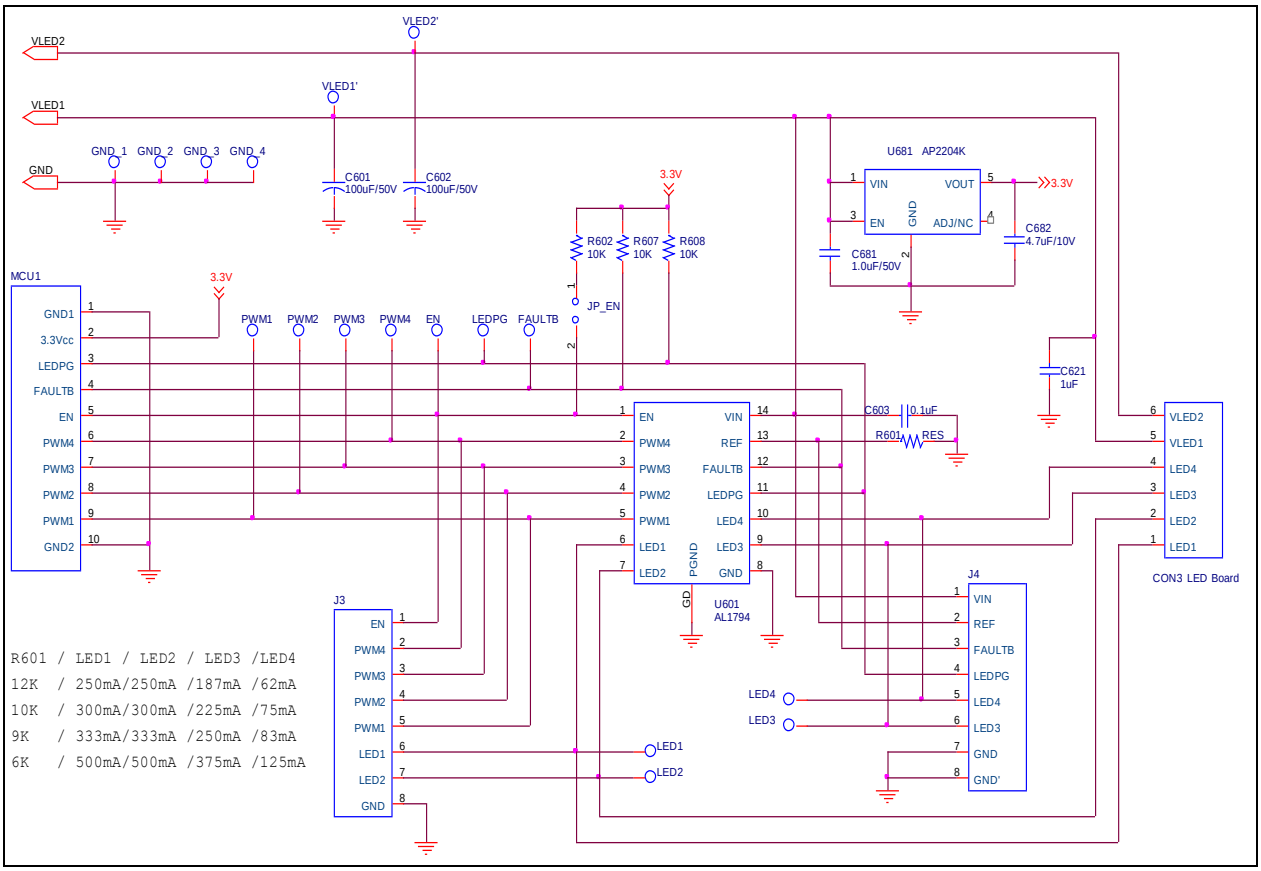


Figure 9: Evaluation Board Schematic

单击下面可查看定价，库存，交付和生命周期等信息

>>Diodes Incorporated(达迩科技（美台）)