Driving Avago AvaLux High Power LED
ADJD-MJ00, -MJ10, -MJ50 & -MJ60

Preliminary Application Note AN-xxxx

1. INTRODUCTION

Avago AvaLux RGB LED light source consist of four LED strings. Each LED string consists of ten LEDs connected in series, except for red which consist of 10 pairs of parallel connected LEDs. Each pair of parallel connected LEDs can be considered equivalent to a single large LED. I.e. for RED color, between R+ and R- terminal, there is an equivalent of ten series connected red LEDs.

The LED strings are:

Red color. Connect with R+ and R- terminals.

Green color. Connect with G1+ and G1- terminals

Green color. Connect with G2+ and G2- terminals

Blue color. Connect with B+ and B- terminals.

The circuit is shown in figure 1. The three colors in the LED light source will mix to form a resultant color. Depending on the mix ratio, any color within the color gamut of the LED can be obtained. The color gamut of the LED light source is the triangle formed by the three colors points on the CIE chromaticity chart. The three color points are from RED, Green and Blue LED color.

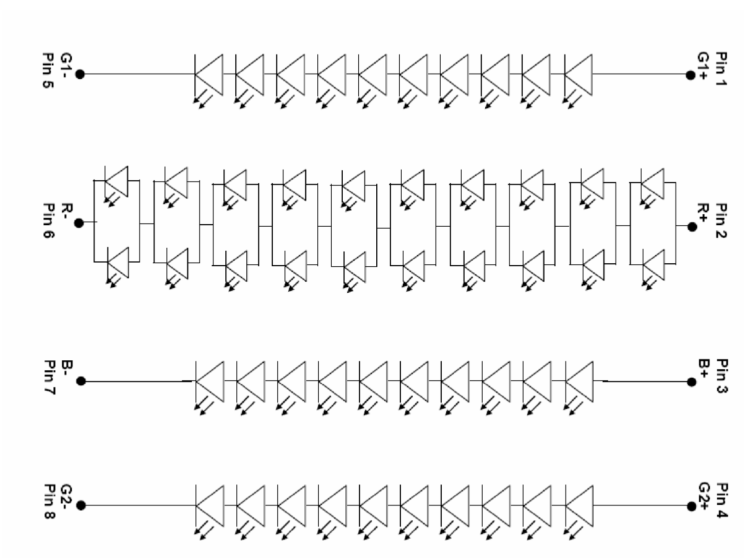

Figure 1. ADJD-MJ00 / ADJD-MJ10 circuit diagram.

Each of the LED string can be driven independently.

2. RESISTIVE CURRENT LIMITING

A fixed voltage is applied to the positive terminal of each LED string through a resistor. The negative terminal is connected to GND. The value of the resistor is determined by the current needed and the input voltage, according to the equation

$$R = \frac{V_{IN} - V_F}{I_F}$$

The current required for red, green and blue color LEDs are determined from the required luminous intensity needed to obtain the color. The forward voltage drop, V_F of the LED strings is determined from the I_F/V_F graphs in the datasheet. The resistor required can thus, be calculated from the equation above. Figure 2 shows the circuit of the simple resistive current driver.

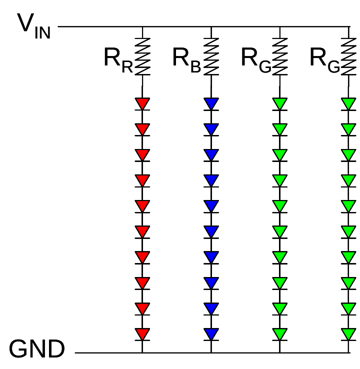

Figure 2. Resistive current limiting driver.

This simple circuit works but the color and brightness will shift if the VF drifts. If the color or brightness is to be changed, the resistor has to be changed and replaced. A potentiometer can be added to the fixed resistor. The fixed resistor is set to the maximum operating current for each LED color string. The potentiometer adjusts the maximum allowable current to a lower desired current level to flow through. This is shown in Figure 3.

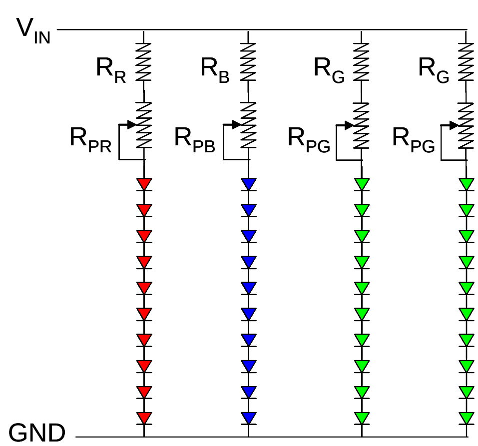

Figure 3. Modified for manual color adjustment.

Resistor R_R, R_B, R_G is determined by the maximum allowable LED current.

This method is simple but suffers from lower efficiency due to the higher power dissipation. It is also sensitive to input voltage variation and V_F drift, causing color and brightness shift.

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3. PWM DIMMING

Figure 2 can be modified to allow PWM dimming instead of using a potentiometer.

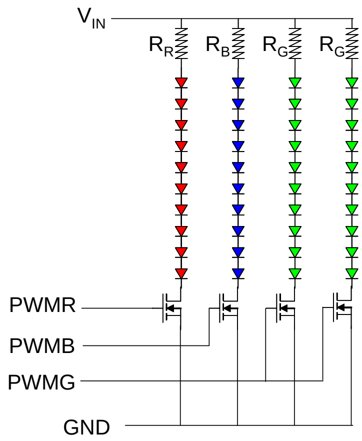

Figure 4. Simple resistive driver with FETs for pulse width dimming.

PWMR, PWMB and PWMG signals provide the pulse width modulation to dim the LED strings. Resistor R_R, R_B, R_G is to limit the maximum current in each LED string. The voltage sustained by the FET for each LED string is $V_{IN} - V_F - (I_F * R)$, where

$R = R_R$ for red LED string or R_B for blue LED string or R_G for green LED string.

I_F is the forward LED current flowing in the LED string.

V_F is the forward voltage drop in the LED string and

V_{IN} is the input voltage supply.

It is important to choose the FET transistor with the lowest possible ON resistance and with a suitable voltage and current rating.

This circuit is simple but also suffers from current variation, causing brightness shifts and color change. The circuit is not recommended for use in Avago's color controller products, HDJD-J822 and ADJD-J823.

4. CONSTANT CURRENT METHODS

The constant current methods as the name implies mean that the LED current through the red, green and blue LED strings are constant. The constant current method is best in providing a constant light intensity and therefore a consistent mix ratio to produce a resultant color. There are two constant current methods:

a) linear current driver

b) switch mode current driver.

Linear IC constant current LED driver

Example of such ICs is the Maxim 16800 and Austriamicrosystems AS3691 and the AS3692 LED driver.

For details, refer to the manufacturers' web site, http://www.maxim-ic.com or http://www.austriamicrosystems.com

Linear integrated IC LED driver typically used a single resistor to set the LED current.

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AS3691/AS3692.

The AS3691 maximum LED current is 400mA, while the AS3692 is 200mA. However, the AS3692 has a higher voltage rating at 50V versus AS3691 of 15V. Two AS3692 CURRx[1] channels can be combined to provide 300mA current required for red color. Figure 5 shows the circuit using the AS3691 or AS3692

Note 1: x, a number from 1 to 4.

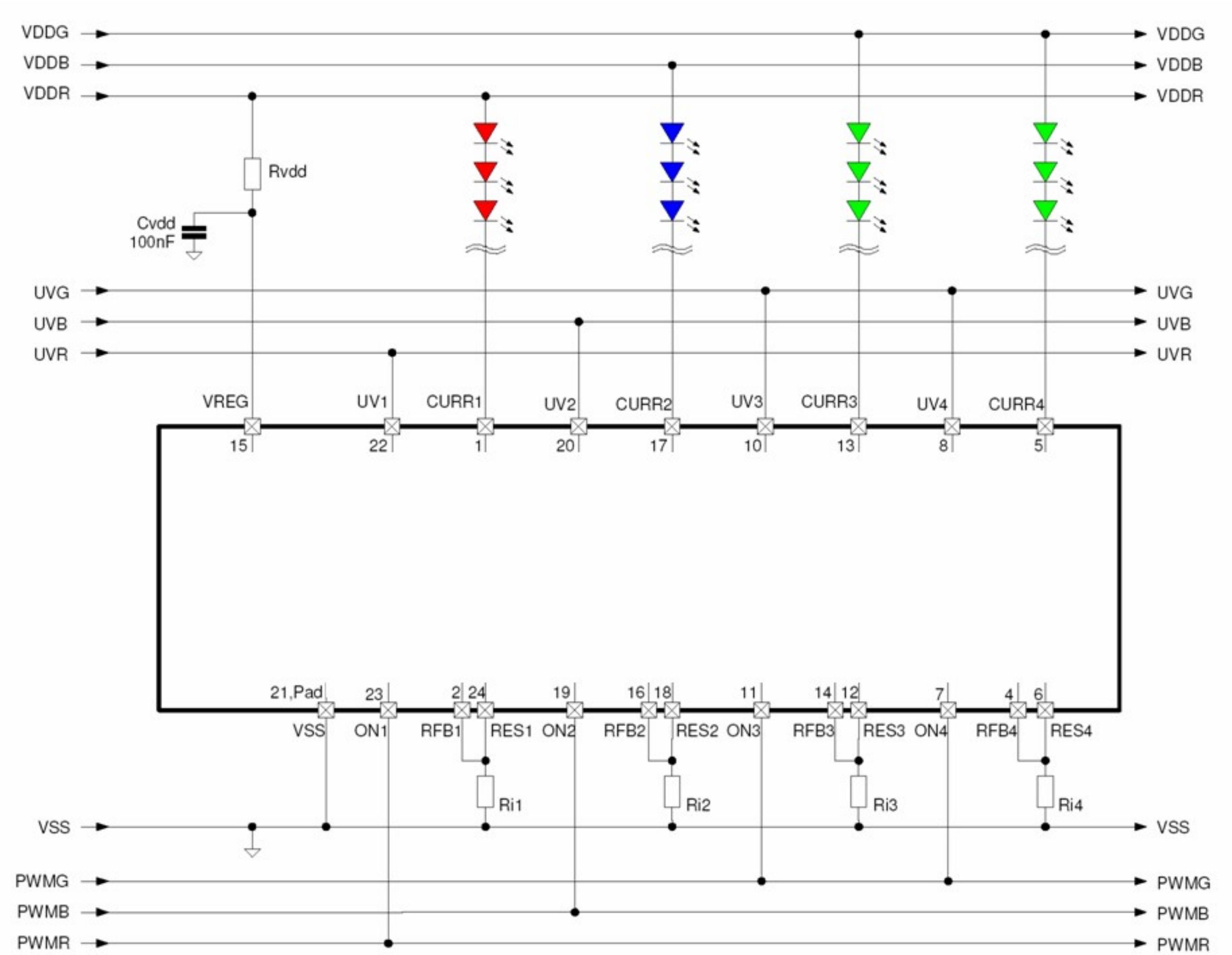

Figure 5. Typical circuit with AS3691 or AS3692.

The current is selected by selecting suitable Ri1 to Ri4 resistor using the equation below.

$$Ri_{1-4} = \frac{250mV}{ICURR_{1-4}}$$

The UVR, UVG and UVB are voltage feedback lines to the DC to DC converter so that the optimum VDDR, VDDG, and VDDB are obtained respectively to reduce power dissipation. The PWMR, PWMG and PWMB can be connected to the PWM outputs of the Avago's color controller ADJD-J823 and HDJD-J822 for LED color management application.

MAX16800

For each LED string, one MAX16800 will be used. A minimum of four MAX16800 is required to drive one unit of ADJD-MJ00 and ADJD-MJ10

The V_{OUT} pin is connected to the anode of the LED string. The cathode of the LED string is connected to the CS+ pin.

The input voltage supply must be higher than V_{OUT} to provide the voltage V_Q. I.e. $V_{IN} = V_F + V_Q$, where

V_F = total VF of the LED string

V_Q = Incremental LED driver voltage = 1.2V for $V_{IN} > 12V$.

As the maximum operating V_{IN} is 40V, the LED driver can only be used if the V_F is less than 38.8V. This is usually the case for typical V_F of the green or blue LED strings. However, the driver will not be suitable if the green or blue LED string V_F are more than 38.8V or is at the maximum V_F specification.

The value of R_S is calculated from the equation,

$R_S = \frac{V_{sense}}{I_{LED}}$, where

V_{sense} is the voltage across CS+ and CS- pin. Typical value is 0.204V

I_{LED} = 300mA for red LED string, 150mA for green or blue LED string.

The EN input can be tied to V_{IN} if the LED current must be always on.   Alternatively, the pulse width modulation high voltage supply can be connected to both EN and V_{IN} inputs to provide PWM dimming.

For LED color management application with the ADJD-J823 and the HDJD-J822, the PWM output of each channel is not sufficient to drive both the EN input and V_{IN} input together. Instead, the PWM output from the ADJD-J823/HDJD-J822 is connected to the EN input of the MAX16800. A constant voltage supply is connected to V_{IN}. Figure 6 illustrates the simplified circuit for the red pulse width modulation (PWMR) to drive red LED string.

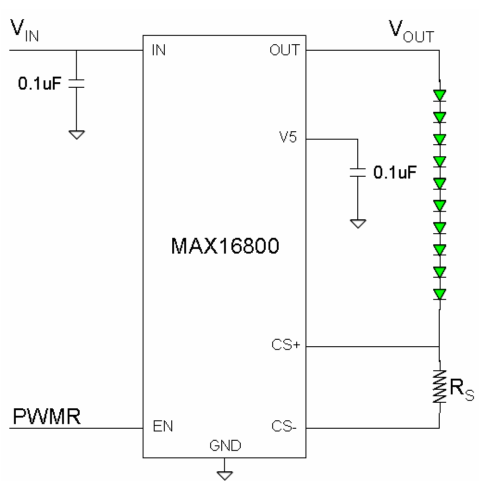

Figure 6. Simplified LED driver circuit with PWMR dimming control.

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5. SWITCH MODE LED DRIVER

The switch mode regulator can be used for step up (boost) or step down (buck) or step up / step down (buck – boost), depending on circuit and the input voltage supply. The voltage at the output is controlled by pulse width modulation at a switching frequency of a few kHz to a few hundred kHz. The chief advantage is that its efficiency is generally higher than linear mode. On the other hand, the main disadvantage is the complexities in design. Most IC switching regulator can be designed in any of these configurations. Designers should obtain information on the IC datasheets and application notes from the manufacturer.

Example of switch mode LED driver is the Supertex HV9911. This Supertex HV9911 switch mode LED driver provides control input for dimming.

a) Dimming by linear voltage input which modifies the LED current level. This is done by designing the proper combination of voltage at I_{REF} pin and the current sense resistor at FDBK pin.

b) Dimming by pulse width modulation input. This is done through the PWMD pin.

The typical circuit is shown in figure 7 for continuous conduction mode boost LED driver. The actual component calculation spreadsheet can be obtained from the manufacturer.

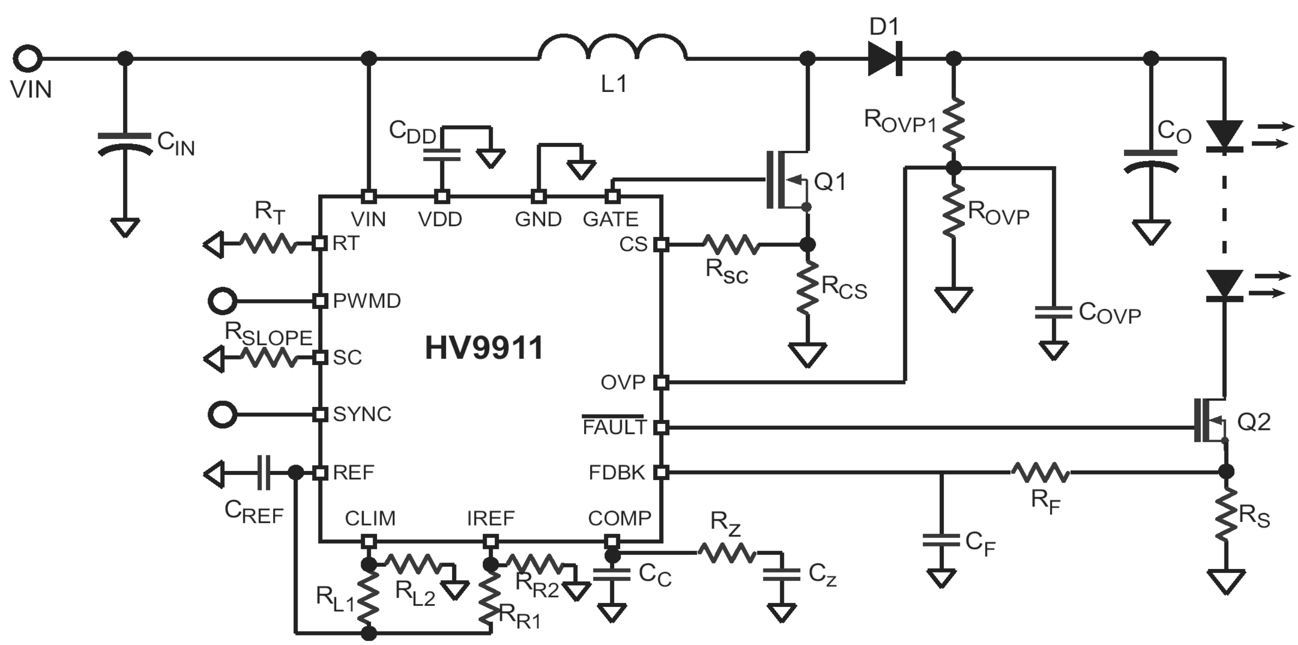

Figure 7. Typical HV9911 circuit.

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APPENDIX 1. LED DRIVER MANUFACTURER WEB SITES

The list is not an endorsement from Avago Technologies.

It main purpose is to help engineers who are choosing appropriate LED driver for Avago Technologies LED products.

Advanced Analogic Technologies Inc.	www.analogictech.com
Allegro Microsystems Inc.	www.allegromicro.com
Austriamicrosystem	www.austriamicrosystems.com
Intersil Corporation	www.intersil.com
Fairchild Semiconductor Corporation	www.fairchildsemi.com
Infineon Technologies AG	www.infineon.com
IXYS Corporation	www.ixys.com
LEDdynamics	www.leddynamics.com
Linear Technology Corporation	www.linear.com
Lumidrives Ltd.	www.lumidrives.com
Maxim Integrated Products	www.maxim-ic.com
Melexis Microelectronic Systems	www.melexis.com
Microsemi Corporation	www.microsemi.com
National Semiconductor Corporation	www.national.com
On Semiconductor	www.onsemi.com
Power Integrations Incorporated	www.powerint.com
ST Microelectronics	www.st.com
Supertex Incorporated	www.supertex.com
Sipex Corporation	www.sipex.com
Texas Instruments Incorporated	www.ti.com
Toko Incorporated	www.toko.com
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For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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