A CCR is a nearly ideal current source providing constant current regardless of applied voltage above its operating minimum. In simple terms, a CCR can be considered a nonlinear voltage controlled resistor.

The Power Dissipation (P_d) in an LED is P_d = I V. Since the CCR acts as a voltage controlled resistor while the resistor biasing fixes the resistor value, the LED Power dissipation is shown to be nearly constant over a variable battery range. (Figure 3)

For automotive CHMSLs, a constant current source for LEDs reduces stress conditions caused by overdriving with current as compared to resistor biasing. A Reverse protection diode (MBRS140T3 in Figure 4) prevents a reverse voltage condition which can permanently damage an LED and protects the CCR from conducting in the reverse bias mode (Figure 1).

A basic CHMSL configuration with 3 Red LEDs in series is shown in Figure 4. A CCR provides a uniform intensity over full line voltage swings and greatly reduces LED power dissipation as compared to common resistor biasing. At 9 V battery input, a CCR provides a higher current than a typical biasing resistor value would provide (Figure 3). At 16 V a stable, constant current is supplied by the CCR.

Figure 2 shows a comparison of CCR vs. Resistor Bias current over battery voltage variation from 9 V to 16 V. The LED current, and therefore intensity, is constant with the CCR device compared to the resistor bias.

V_{in}vid]e

the CCR acts as a voltage contr 2889925.rent i6 386.4189 T436 T8tvid]e

Figure 2. Series Circuit Current

Figure 3. LED Power

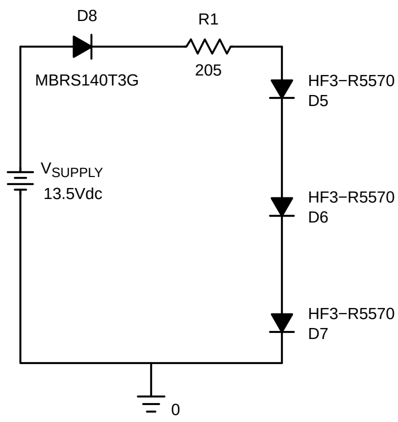

Figure 5.

Figure 5 shows a typical resistive bias for a single CHMSL LED string. The resistor value is calculated to take into account the V_{fwd} across the series connected LED string. If a specific supply voltage, such as 13.5 V, is used, a specific resistor can be chosen to supply a 30 mA drive current.

Example for a 3 Red LED String:

$V_{supply} - V_{sw\_bat} - V_{rpd} - (I_{\_led} \times R_1) - (3 \times V_{fwd}) = 0\ V$

$V_{sw\_bat} = 0\ V$

$V_{supply} = 13.5\ V$ Typical

$V_{rpd} = 0.8\ V$

$V_{fwd} = 2.20\ V$

$I_{\_led} = 30\ mA$

$$R_1 = \frac{13.5\ V - 0.8\ V - 3(2.20\ V)}{30\ mA} \quad \text{(eq. 1)}$$

$$= 203\ \Omega \text{ or } 205\ \Omega \text{ (Standard 1\% Value).}$$

This method for setting the current with a specific resistor is well known. By knowing the LEDs worst case V_{fwd}, and the light intensity required, a specific range of resistor values can be chosen. However, as the supply voltage varies from

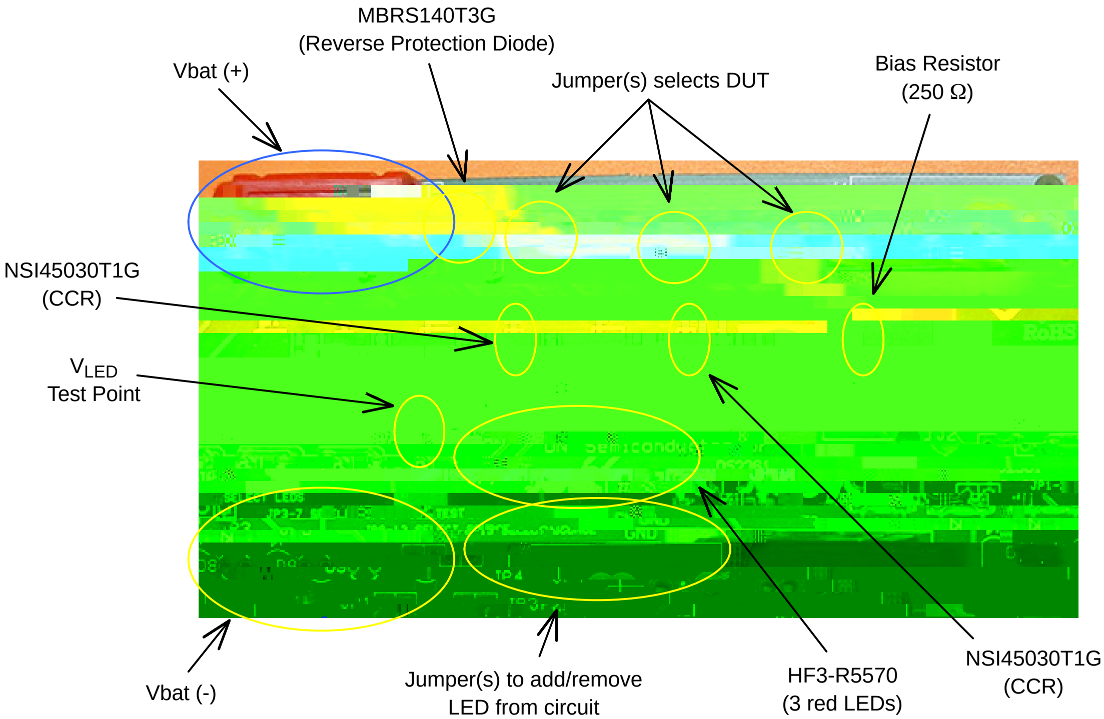

Figure 8.

CCR Demo Board

This demo board (Figure 8) is the circuit shown in Figure 6. It is used to generate several curves and can be used to validate the CCR operation.

Figure 9 shows a comparison of power dissipation in a CCR vs. Power dissipation in a Bias Resistor over battery voltage variation from 9 V to 16 V. The CCR Power is less than a Bias Resistor at higher operating voltages. At higher Battery voltage, a higher wattage Power resistor would be required increasing the circuit cost.

Figure 10 shows a typical Current/Voltage curve for a CCR device. ON Semiconductor's CCR is designed to have a slight negative trend as the power dissipation increases. This negative trend reduces the power dissipation in the CCR compared to the increasing power dissipation for a bias resistor (Figure 9) and helps to prevent thermal runaway. Since reduction in current is small, the change in LED intensity is minimal.

Figure 11 shows thermal estimates for the NSI45030T1G device with various heatsink footprints. If the heatsink area is increased, the ambient operating temperature may be increased. It is up to the circuit designer to understand the thermal environment of the application and allow for device thermals as specified in the device data sheet.

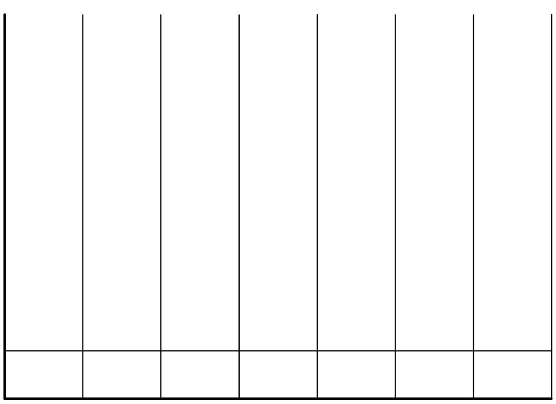

Figure 9. CCR P_d vs. Resistor Pd

THERMAL ESTIMATES FOR THE SOD-123 CCR DEVICE

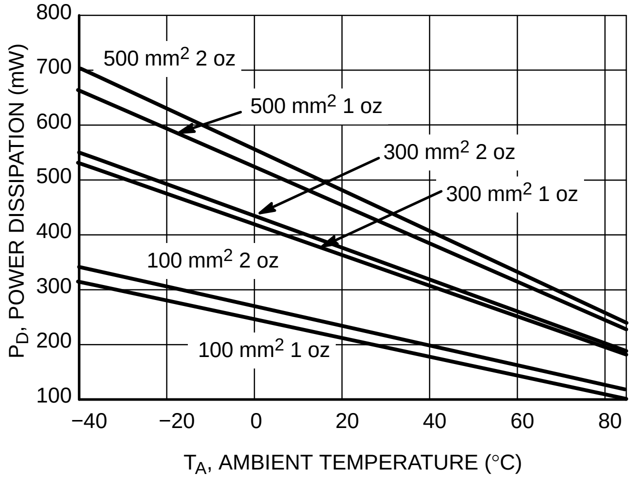

Figure 11. Power Dissipation vs. Ambient Temperature @ T_J = 150°C for Variable Copper Heat Spreader

P_D max @ 85°C

500 mm^2 2 oz Cu	241 mW
500 mm^2 1 oz Cu	228 mW
300 mm^2 2 oz Cu	189 mW
300 mm^2 1 oz Cu	182 mW
100 mm^2 2 oz Cu	117 mW
100 mm^2 1 oz Cu	108 mW

Summary:

Simple, Economical and Robust (SER), the solid state CCR will allow the user to achieve the expected long life of their LED array.

CCRs will improve the efficiency and extend the life of CHMSL LEDs. They will minimize design time and speed

APPENDIX A

SOD−123 Devices are:

NSI45020T1G, Steady State $I_{reg(SS)}$ = 20 mA