EFFICIENT DESIGN OF LED BASED REAR BRAKE LIGHT WITH BSC71K818A

INTRODUCTION

Rear Brake Lights are one of the most common OEM and Aftermarket products for the Automotive Market. They are mandated by most countries Departments of Transportation as a critical safety requirement. Not only are the Rear Brake Lights used in common passenger and cargo vehicles, they are also used in motorcycles, bicycles, scooters, hoverboards, trailers, etc.

Historically, automotive lights were manufactured using Halogen lamps, nowadays, however, almost all of Rear Brake Lights are manufactured using high brightness LED lights. LED lights are powered by a DC current fed off an automotive battery.

TECHNICAL CONSIDERATIONS OF DESIGNING AN LED-based REAR BRAKE LIGHT

Rear Brake Lights must have two distinct brightness conditions; high brightness for the Braking Indication and low brightness for the Night Driving indication. These two brightness conditions are achieved by sinking or sourcing different current levels across the LEDs.

The simplest and straight forward solution would be to use discrete components such as transistors and resistors to setup the required currents for proper LED intensity. However, the discrete component based solution is prohibitive as all the LEDs should be lit up equally bright, but with the parameter variations between the discrete components, the current levels, and therefore, the brightness levels between LED in the same Brake Light could vary by upto 30% making the Brake Light shine inconsistently.

Due to the abovementioned component variation, the use of discrete devices in Brake Light design is almost nonexistent. Instead, majority of Brake Light designs utilize a Constant Current Regulator (CCR) integrated circuit to achieve predictable and consistent current level for LED illumination. A CCR can be set by an external resistor for one specific level of current. For a second current level, for a different brightness level, either another CCR is used or a design circuit is utilized to vary the value of setup resistor to change the CCR current level.

BRAVE Semiconductor has introduced an innovative Constant Current Regulator – BSC71K818A to reduce the complexity of Brake Light circuit design and integrate majority of external components into a single Integrated Circuit solution.

ECONOMICS OF MANUFACTURING A REAR BRAKE LIGHT

Given the very high volume of Rear Brake Lights manufactured for the end market needs, it is imperative to utilize the most economical technical solution for Brake Light design. The use of multiple CCRs or discrete components directly impacts the cost of the Brake Light. Additionally, the indirect cost of procuring, storing and keeping track of multiple inventory components adds to the production costs of the Brake Light.

The high level of functional integration of the BSC71K818A device not only reduces the critical external component count, but also allows for a single layer PCB routing for the complete LED Rear Brake Light solution.

BENFITS OF BRAVE Semiconductor - BSC71K818A

The BSC71K818A is a low cost two-channel linear Constant Current Regulator (CCR) specifically designed for automotive Rear Tail Light application. The LED sink current can be preset at the end customer desired current level for most optimal and reliable operation. The device offers a resistor selectable LED brightness intensity levels “Stop” bright (DC mode) and “Tail” dim (PWM mode). The dimming condition is achieved by using Pulse Width Modulation (PWM) engine which makes the LED brightness appear dimmer by changing the Duty Cycle of the current operation.

The “Stop” condition bypasses the PWM engine for the brightest LED intensity, while the “Tail” condition reduces the LED brightness by setting the duty cycle of the internally generated PWM signal. The LED sink current level can be selected upto 150mA per Output Channel by a single resistor value at the R_{EXT} pin.

Resistor R_{DC} at the BRIGHT/STOP pin sets the duty cycle of the internal PWM oscillator for reducing the LED brightness intensity when operating in the “Tail” condition.

TYPICAL APPLICATION CIRCUIT

A typical reference circuit utilizing BSC71K818A consist of 2 strings of LEDs connected to Out1 and Out2 pins of the CCR. The High Brightness Current Level is setup by the Rext resistor and the Low Brightness Current Level is setup by the Rdc resistor. Additional passive components could be used to provide wider operating range or more stable circuit operation.

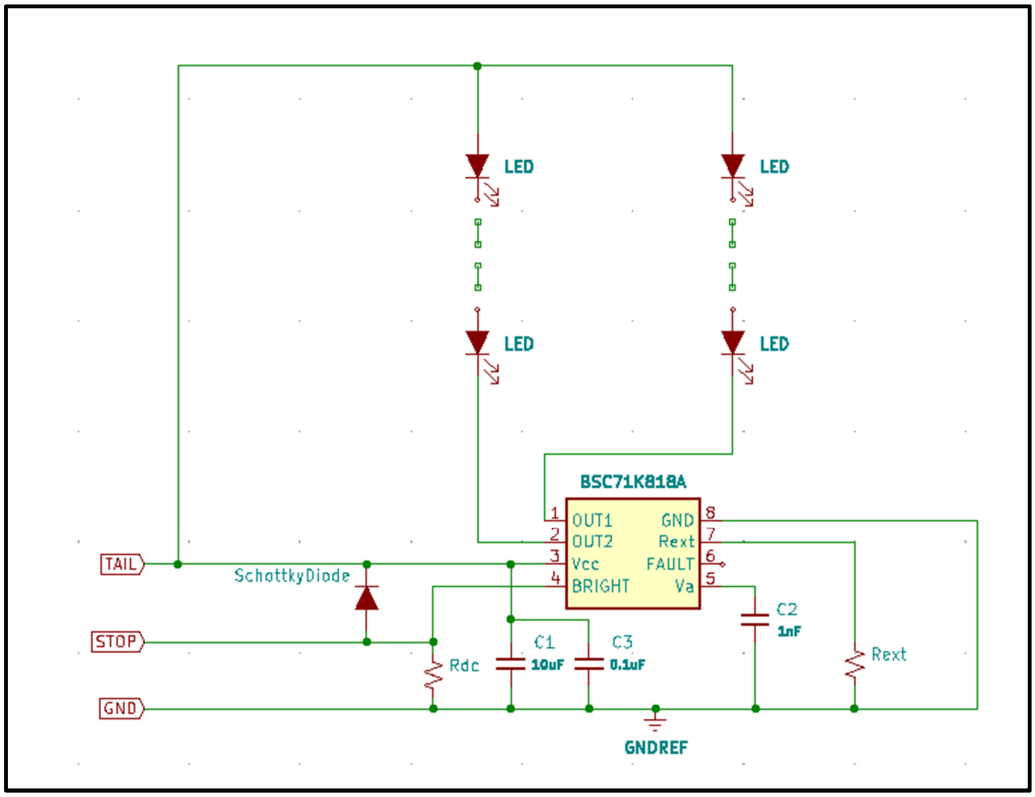

Figure 1 Typical Application Circuit (Single Device LED Brake Light Operation)

REAL LIVE ILLUSTRATION OF 15-LED BRAKE LIGHT DESIGN FOR CUSTOMER A

To illustrate the economic benefits and design simplicity of using BSC71K818A device in a Brake Light application we want to present a real example of Brake Light design at Customer A.

Customer A manufactures 3.5" 15-LED Round Real Brake Light. See the photograph below of the original 15-LED Brake Light circuit board.

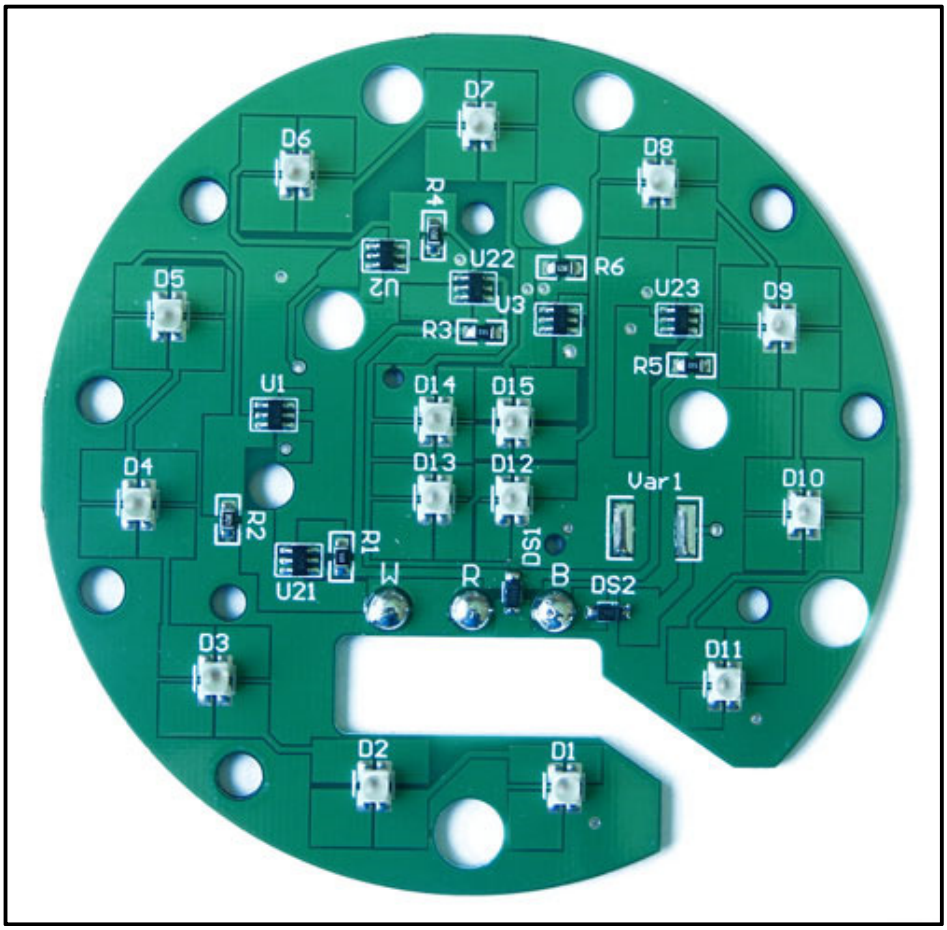

Figure 2 Customer A Existing Design with 6 of Infineon CCRs used

The existing design architecture is using 3 LED strings in series of 5 LEDs each. The design uses 6 of Infineon CCRs – 3 of BCR405U for High Intensity Brightness (60mA) and 3 of BCR401R for Low Intensity Brightness (10mA). See the schematic below of the existing Customer A design.

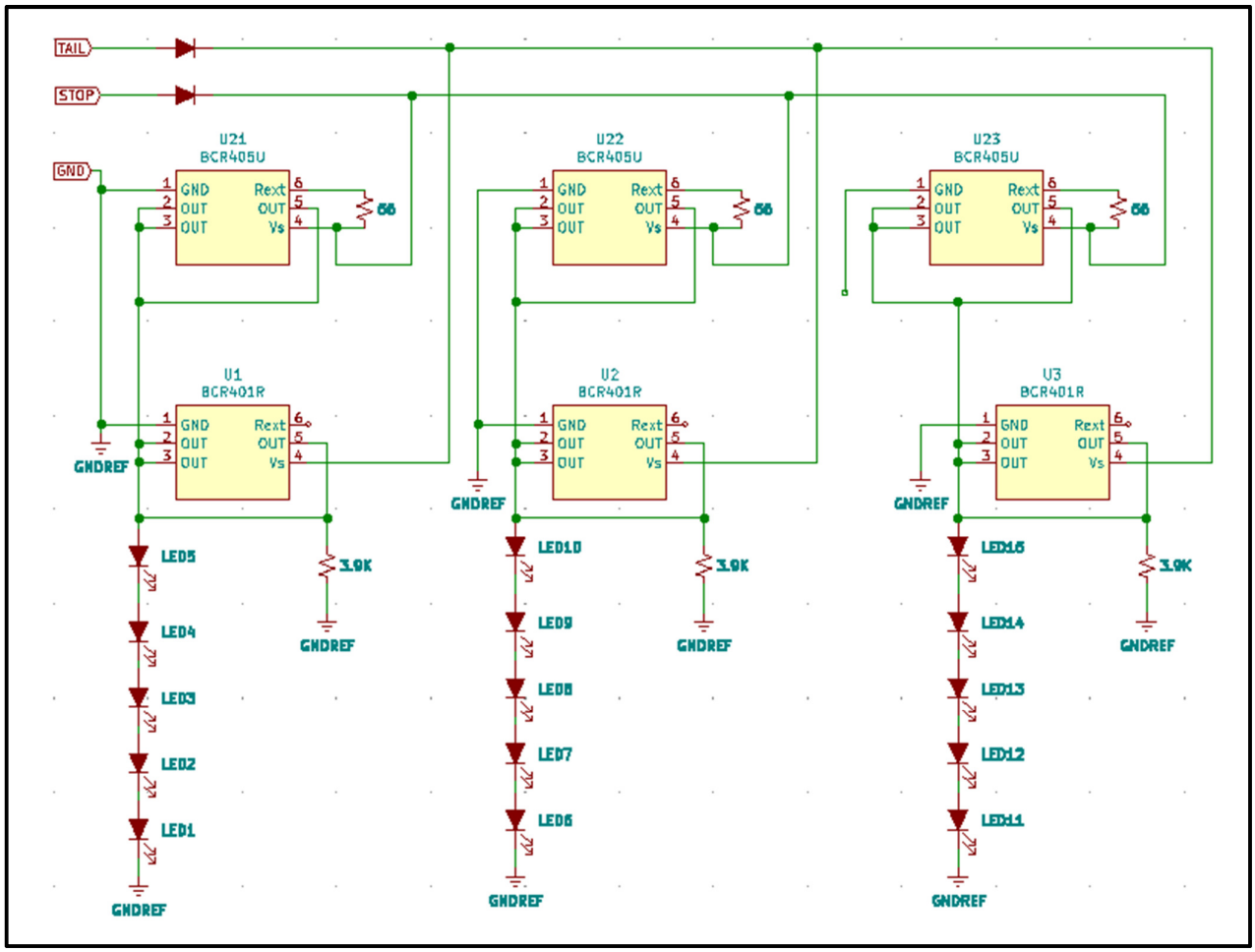

Figure 2 Customer A Existing Design with Infineon CCRs

With the BRAVE Semiconductor fully integrated BSC71K818A device customer's Brake Light design can be implemented using only one active component.

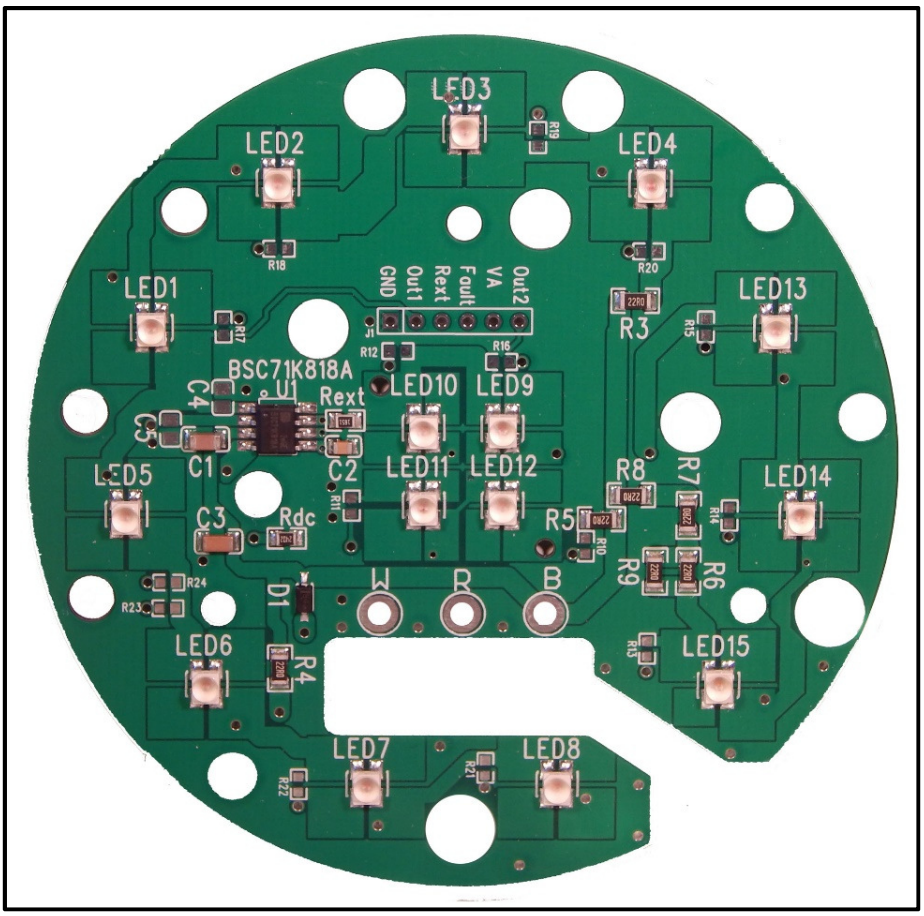

Figure 3 Customer A modified design based on one BSC71K818A CCR

The device schematic below shows the simplicity of BSC71K818A based design.

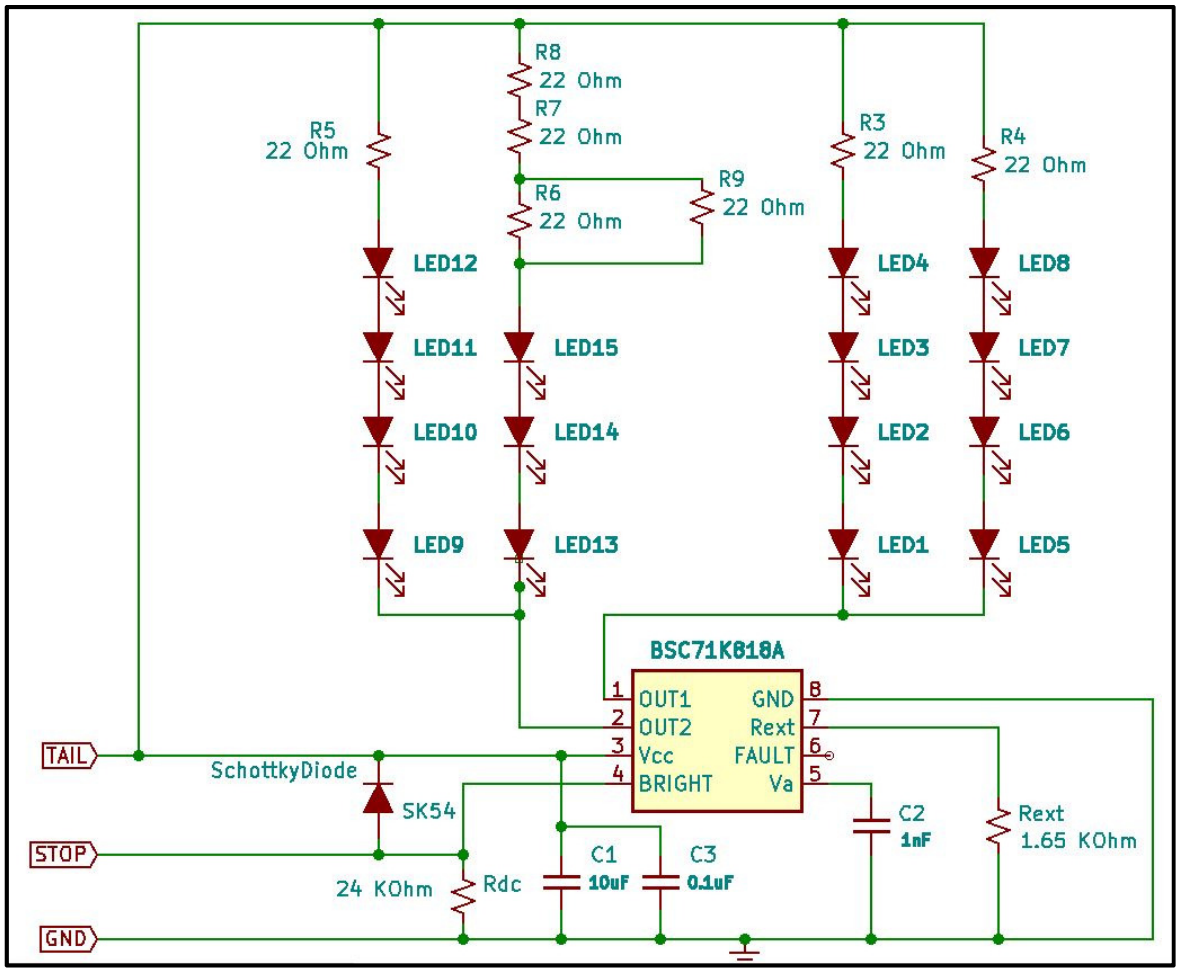

Figure 4 Customer A Equivalent Brake Light Design with BSC871K818A

The circuit above follows the Reference Design shown in Figure 1. Instead of 3 LED chains of 5 LEDs each, the equivalent circuit has 4 LED chains of 4 LEDs each. However, one of the LEDs has been replaced by a resistor equivalent (Two 22Ohm resistors R6 and R9 in parallel) to make a 15-LED Brake Light. Each LED chain has to sink 60mA of current for high intensity operation, Therefore the Iout1 and Iout2 current has to be set to 120mA each for the 60mA current to flow through each LED string. Equivalently, the Iout1 and Iout2 low brightness current needs to be set at 20mA each to have 10mA current from though each LED string.

Based on the above-mentioned design requirements, the value of Rext was selected to 1.65KOhm to set the LED high brightness sink current to 120mA for each output pin. The value of Rdc was respectively selected to 24KOhm for the PWM engine to produce and equivalent 20mA low intensity current for each output pin. The circuit balancing resistors R5, R8, R3 and R4 were chosen at 22 Ohms to improve the current balancing between the LED strings.

PERFORMANCE RESULTS

Table below shows the test results for High Brightness operation. The Yellow Highlighted values are the measured results in the original design. The Blue Italicized values are the measured results in the BSC71K818A based design. These results also show that not only does the BSC71K818A based design perform equivalently to the original design, but also offers a wider operating voltage range. At 10V battery voltage, the current through the LEDs is twice as much in the BSC71K818A than in the original design. Therefore, at 10V battery operation the High Brightness and Low Brightness luminosity would be indistinguishable in the original design, while in a BSC71K818A the High Brightness luminosity would be dimmer than the targeted 60mA operation but would still be almost twice as bright than the Low Brightness luminosity.

				BSC71K818A current level						Original Design Current Level	
				string1	string2	string3	string4	total	unit	String 1/2/3	unit
Vstop=	15	V		*0.0616*	*0.0614*	*0.0614*	*0.0612*	*0.2456*	A	0.062	A
	14.5	V		*0.0615*	*0.0613*	*0.0613*	*0.0611*	*0.2452*	A	0.062	A
	14	V		*0.0614*	*0.0611*	*0.0611*	*0.0610*	*0.2446*	A	0.062	A
	13.5	V		*0.0612*	*0.0608*	*0.0610*	*0.0609*	*0.2439*	A	0.062	A
	13	V		*0.0609*	*0.0603*	*0.0609*	*0.0607*	*0.2428*	A	0.062	A
	12.5	V		*0.0608*	*0.0600*	*0.0606*	*0.0604*	*0.2418*	A	0.058	A
	12	V		*0.0604*	*0.0595*	*0.0599*	*0.0595*	*0.2393*	A	0.055	A
	11.5	V		*0.0557*	*0.0561*	*0.0560*	*0.0557*	*0.2235*	A	0.050	A
	11	V		*0.0505*	*0.0507*	*0.0506*	*0.0505*	*0.2023*	A	0.037	A
	10.5	V		*0.0450*	*0.0454*	*0.0454*	*0.0451*	*0.1809*	A	0.022	A
	10	V		*0.0399*	*0.0404*	*0.0391*	*0.0392*	*0.1586*	A	0.015	A

ECONOMIC BENEFIT OF USING BSC71K818A CONSTANT CURRENT REGULATOR

It is easy to visualize the economic benefit of using the highly integrated BSC71K818A over the other CCR solutions in Brake Light application. In the above-mentioned 15-LED Brake Light, the BSC71K818A replaced 6 of discrete CCRs. By converting to a BSC71K818A customer was able to save over 30% of active component Bill of Material.

The cost saving become even more profound when a larger number of LEDs is used in the end product. Considering that the BSC71K818A can drive upto 150mA per Output (upto 300mA total) the number of LEDs that could be powered in parallel could be easily increased.

REVISION HISTORY

Revision	Detail Information	Date
A	Initial release	2023.01.16

ADDITIONAL REFERENCES AND DOCUMENTS

DOCUMENT NAME	Description
BSC71K8181/A	DATA SHEET FOR BSC71K8181/A 150mA, DUAL CHANNEL LED DRIVER WITH INTEGRATED PWM AND FAULT DETECTION FOR AUTOMOTIVE REAR TAIL LIGHT
BSC71K8181_EB Rev B Final	EVALUATON BOARD FOR BSC71K8181 150mA, DUAL CHANNEL LED DRIVER WITH INTEGRATED PWM AND FAULT DETECTION FOR AUTOMOTIVE REAR TAIL LIGHT