STLC1: A COMPLETE SOLUTION FOR LED LAMP DRIVING IN MOTORCYCLE APPLICATIONS

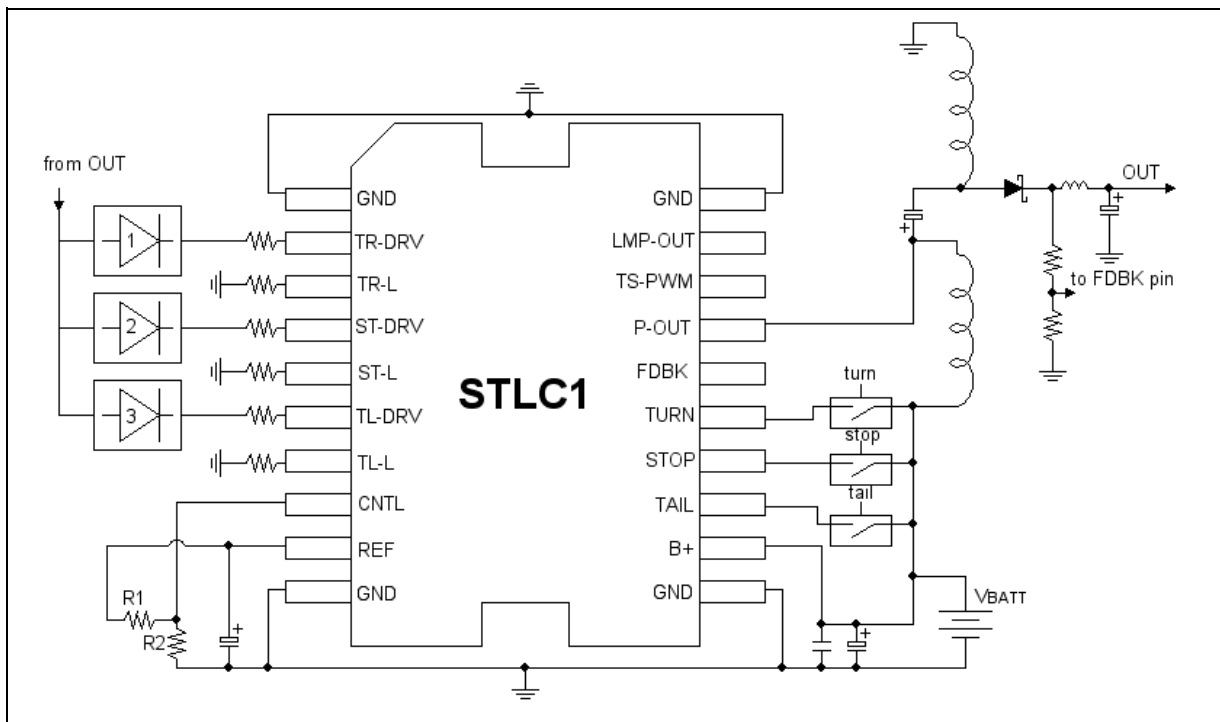**F. Macina (DSG VREGS Application Engineer)**

1. ABSTRACT

The use of high efficiency Light Emitting Diodes (LEDs) as the source of light for external lighting in cars is becoming more and more popular. Following this trend, motorcycle makers are also starting to replace the old incandescent bulbs, used for signal lighting, with LEDs.

In this paper the STLC1, primarily a LED driver for car rear lamps, is proposed as a driver for the whole signal light set present on a motorcycle which are tail, brake and both front and rear side markers, provided that only LEDs are used for such lights.

2. PROPOSED SOLUTION.

The STLC1 is basically an IC that integrates a high efficiency PWM DC-DC converter switching regulator, three smart Low Side Drivers (LSDs) and an internal logic capable both to detect LED fault condition and to control the LSDs driving.

Figure 1: STLC1 Simplified Typical Application Scheme

Figure 1 shows a simplified typical application scheme in which the STLC1 is used as a driver for three set of LED lamps. The DC-DC converter topology used is the so-called "SEPIC configuration" that is particularly suitable in battery powered systems, because it allows to regulate output voltages that are greater than or less than the DC input voltage applied to the power converter itself (like buck-boost converters); and last, but not least, the input ripple current is dramatically reduced and almost sinusoidal shaped. This greatly reduces the need for large bank capacitors for input filtering and lengthens the battery life (for more information, please refer to the AN1488).

It is necessary to control four sets of signal lights on a motorcycle, which are left turn (both front and rear), right turn (both front and rear), brake and tail.

These last two signals are generated using the same source of light by respectively increasing or decreasing the average current flowing into the filament bulb, which in turn means to increase or decrease the average electrical power transferred to the load.

Also, LEDs are current controlled devices, thus, by varying the flowing current into them it is also possible to set a desired output luminous intensity. For this reason both brake and tail signal lights could be generated using the same LED cluster by simply controlling the forward flowing current set according to the activated signal.

Thus, with a proper logic, it is possible to control all the signal lights present on motorcycles (left turn, right turn, brake / tail) using only three sets of LEDs.

The STLC1 is able to do this simply by slightly modifying the electrical scheme in figure 1 by adding some very low cost components.

The proposed electrical scheme solution is shown in figure 2. As it is possible to see, only two low power NPN transistors, one diode, and two resistors have been added to the typical application circuit.

Figure 2: Proposed Solution

3. CIRCUIT EXPLANATION.

The driving of both the right and left turn is self-explanatory: they are activated by switching respectively the STLC1 inputs named TURN (pin 15) and STOP (pin 14). The switching frequency is the frequency with which the right and left turn LED lights are activated. Notice that the TS-PWM input pin has been left intentionally floating because, according to the table 1, in this condition the STOP input pin directly controls the enabling of the corresponding low side driver in ON mode.

The tail and brake input signals are both connected to the TAIL (pin 13) input STLC1. They are directly connected to the tail command, while they are connected to the brake command by means of a diode.

When activated (brought high), the tail command enables the TAIL input pin, thus allowing the corresponding low side driver to conduct in PWM mode (see table 1). In this condition the average current flowing into the tail LED cluster is reduced (as well as the luminous intensity) by a factor corresponding to the duty cycle (δ) of the driving pulses, that is:

$$I_{TAIL} = I_{TAIL(DC)} \cdot \delta \tag{1}$$

The duty cycle is set according to the voltage present on the CNTL pin. The duty cycle law of variation with respect to the CNTL pin voltage, set with the R1,R2 resistor divider, is approximately as follows:

$$\delta = \begin{cases} 3.8\% \text{ if } \dfrac{R1}{R1+R2} \cdot 100 \le \dfrac{0.2}{V_{REF}} \\[3mm] \dfrac{R1}{R1+R2} \cdot 100 \text{ elsewhere} \end{cases} \tag{2}$$

where V_{REF} is the reference voltage generated by the STLC1 whose typical value is 3.8V.

In this condition the diode D1 is reverse biased, thus no current flows into the R4 resistor and consequently the T1 npn transistor is kept off while, thanks to the current that flows into the R3 resistor, the T2 npn transistor conducts. Of course the D1 minimum reverse blocking voltage must be greater than the maximum battery voltage, load dump included, otherwise a current could flow into R4 even if the brake signal is not activated. Moreover, a low forward voltage drop is useful in case of cold crank ignition, because this would limit the minimum battery voltage required to activate the brake LED constellation.

A 60V signal schottky diode 1N6263 is suggested.

In order to neglect the T2 collector to emitter voltage ($V_{CE(T2)}$) with respect to the V_{REF} voltage, the T2 transistor must be forced to work in the saturation region.

This is obtained by properly choosing the R1, R2 and R3 resistor values. If the sum of the resistors R1 and R2 is set to be 10kΩ, the T2 collector current is:

$$I_{C(T2)} = (V_{REF} - V_{CEsat(T2)})/(R1+R2) \cong V_{REF}/(R1+R2) = 380\mu A \tag{3}$$

Forcing a T2 base current equal to one-tenth of the collector current, assure us that the bipolar transistor is working in the saturation region. Assuming this condition and that the base to emitter saturation voltage is 0.8V, the R3 resistor is:

$$R3 = 10(V_{REF} - V_{BEsat(T2)})/I_{C(T2)} \cong 79k\Omega \tag{4}$$

The nearest R3 commercial resistor value is 82kΩ.

Activating the brake signal also activates the STLC1 TAIL input pin through the D1 schottky diode. A greater LED constellation luminous intensity is required in this condition when compared to the one that only activates the tail signal. This is obtained by changing the CNTL pin voltage of the STLC1. In fact the current flowing into R4 turns on the T1 npn transistor that consequently turns off the transistor T2. This means that no current flows through R1 and R2, thus the CNTL pin voltage is forced to be equal to the V_{REF} voltage, and according to formula (2) the duty cycle δ is equal to 100%.

The R4 resistor value is chosen in order to saturate the transistor T1.

Once again if a base current equal to one-tenth of the collector current and a minimum battery voltage of 6V are considered, the R4 resistor value is:

$$R4 = \frac{10(Vbatt - V_{BEsat(T1)})R3}{(V_{REF} - V_{CEsat(T1)})} \cong 1.1M\Omega \tag{5}$$

The nearest R4 commercial resistor value is 1MΩ. No particular tolerance is required on resistors R3 and R4.

T1 and T2 are low signal / low voltage transistors. A BC108 npn transistor could be used for both.

Table 1: TS-PWM Control Pin Truth Table

		DRIVE TYPE	
$V_{TS-PWM} < 0.1V_{REF}$	TAIL	PWM	PWM
	STOP	OFF	ON
	TAIL & STOP	PWM	ON
$V_{TS-PWM} = V_{REF/2}$ or floating	TAIL	PWM	OFF
	STOP	OFF	ON
	TAIL & STOP	PWM	ON
$V_{TS-PWM} > 0.98V_{REF}$	TAIL	PWM	PWM
	STOP	ON	ON
	TAIL & STOP	ON	ON

4. CONCLUSION.

A simple and low cost solution for the driving of the whole signal light set that is present on a motorcycle has been presented.

This solution is based on the STLC1, a smart LED driver module IC.

For further information please consult the Voltage Regulators web page at: http://www.st.com/vregs

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