LED DRIVER

Version : 1.1
Issue Date : 2001/05/30
File Name : LedDriver_app.doc
Total Pages : 12

Constant Current LED Drivers

Application Notes

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What is a Constant Current Driver?

SiTI's Constant Current driver is an integrated circuit device designed specifically for LED applications such as LED signs and LED displays. The employment of the constant current to control the LED brightness has several advantages over the administration by the constant voltage. One of the obvious advantages is the manageable control over the output.

Unlike the constant voltage driver whose output, the voltage, is subject to the variations in V_f (LED forward voltage) and shifts in power supply, the output current of the constant current driver is programmed and controlled only by the external resistor. Once the current level is selected, the driver will continuously monitor and dynamically adjust the current flow in the LED or in a string of LEDs.

How Does a Constant Current Driver Work?

The constant current LED driver functions as a sink drain in the LED circuit system. The programmed current, which is set by the external resistor, flows from V_{LED}, through one LED or a string of LEDs, hence lights up the LEDs. The current flow then continues the excursion passing the output pins to the ground. Please refer to the Figure 1 below for the LED circuit configuration.

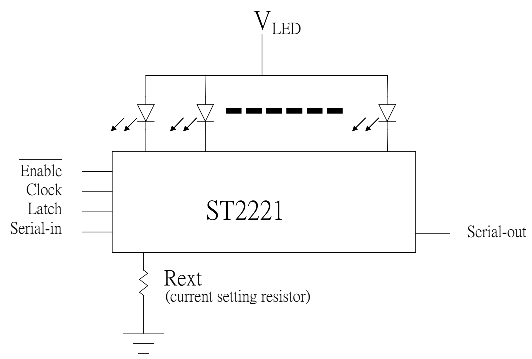

Fig.1 LED Circuit Diagram

How Does a Constant Current Driver Work?(Continued)

The lighting of one LED or the lighting of a string of LEDs is accomplished by a single external resistor. Figure 2 illustrates the configuration of monochromatic display module while Figure 3 the configuration of the full-color display module.

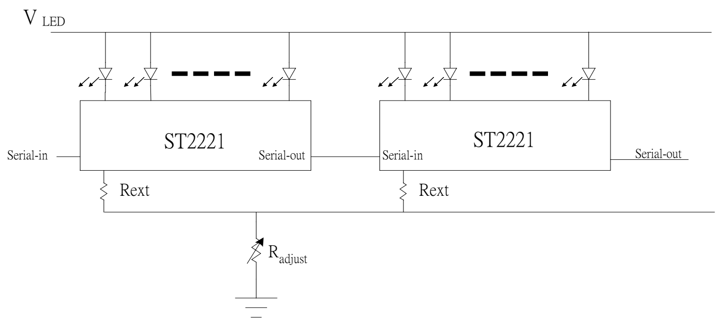

Fig.2 Monochromatic Display Module Adjustment Example

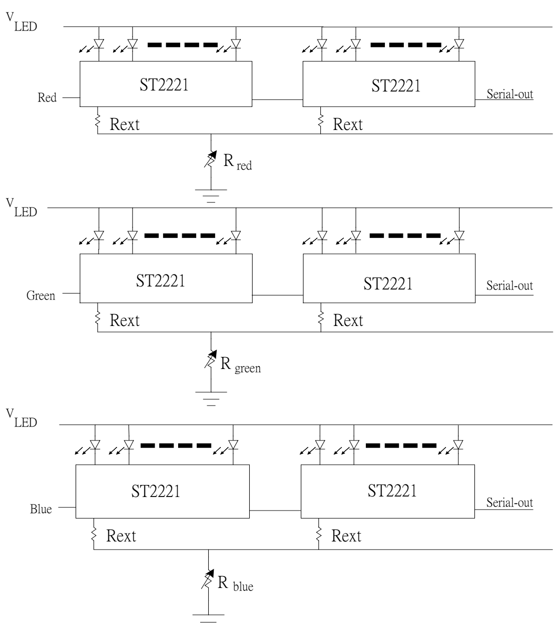

Fig.3 Full-Color Display Module Adjustment Example

How to Use the Constant Current Driver ?

As mentioned earlier, the external resistor (Rext) is a key component that determines the current flowing to each output. Different scales of resistor correspond to different scales of output current (Iout).

Experiment is conducted to depict the relationship between the scale of Rext and the scale of Iout. This relationship is explicated by the curve in the following Figure 4.

To select the value of Rext, the desired current value (Iout) shall be firstly be located on the vertical axis. And the intercept point on the curve is then mapped onto the value on the X-axis, which yields the desired current value.

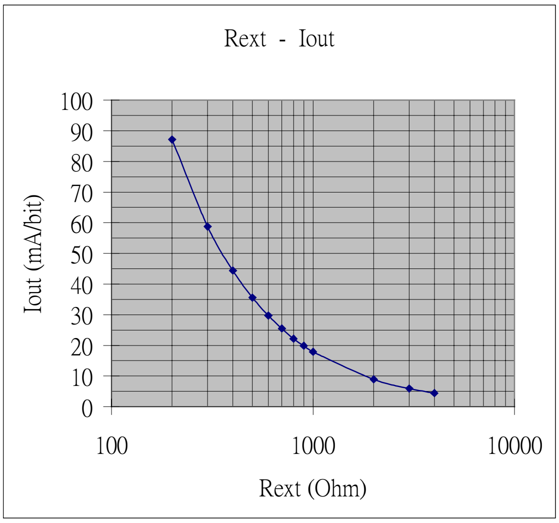

Fig. 4 Rext – Iout Relationship

How to Use the Constant Current Driver ?(Continued)

After the appropriate Iout value is selected, an adequate scale of Vout is then required to ensure the stable operation at saturation. In general, for programmed currents below 40mA, a minimum Vout of 0.4V is recommended for proper current regulation. For programmed currents of 40mA or above, a minimum Vout of 0.7V is instead suggested. Fig. 5 illustrates the relationship between Vout and Iout (programmed output current).

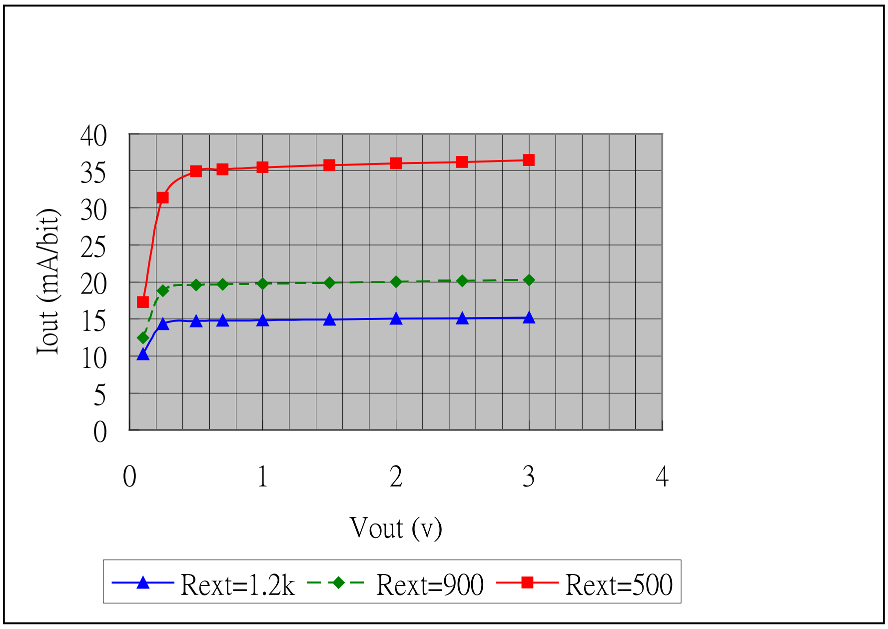

Fig. 5 Iout-Vout Relationship

How to Use the Constant Current Driver ?(Continued)

While choosing the output current (Iout), notice shall be placed on the heat dissipation. Given an operating condition, the output current shall beneath the calculated value in order to assure the driver's orderly operation in terms of heat dissipation. To calculate the maximum value of the output current, the maximum allowable power consumption (Pd (max)), that is related to the ambient temperature and the driver's package, should be recognized first. The maximum allowable power consumption (Pd (max)) of this driver is calculated as follows:

$$Pd(\max)(Watt) = \frac{\text{(Tj (junction temperature) (max) -Ta (ambient temperature))(°C)}}{Rth\,(°C\,/\,Watt)}$$

Whereas Rth (thermal resistance) varies from one package to another.

Based on the Pd (max), the maximum allowable current is then computed through the following calculation:

$$Iout = (Pd - VDD \cdot IDD) / (\#\ outputs \cdot Vo \cdot Duty)$$

Whereas V_{DD} and I_{DD} represent the supply voltage and supply current respectively. And driver output pin voltage is denoted as Vo.

Hence, the minimized LED power supply voltage, which could benefit the power dissipation, is then figured:

V_{LED} *(LED supply voltage)* = V_{CE} *(the saturation voltage of circuit multiplexing transistor)* + V_f *(LED forward voltage)* + V_O *(driver output pin voltage)*

How to Use the Constant Current Driver ?(Continued)

If V_{LED} forwards extra, unneeded voltage, lowering V_{LED} is firstly suggested. However, if this option is not workable, a zener diode is then proffered to reduce the voltage progressing to the LEDs and the consequent drivers as depicted in Figure 6.

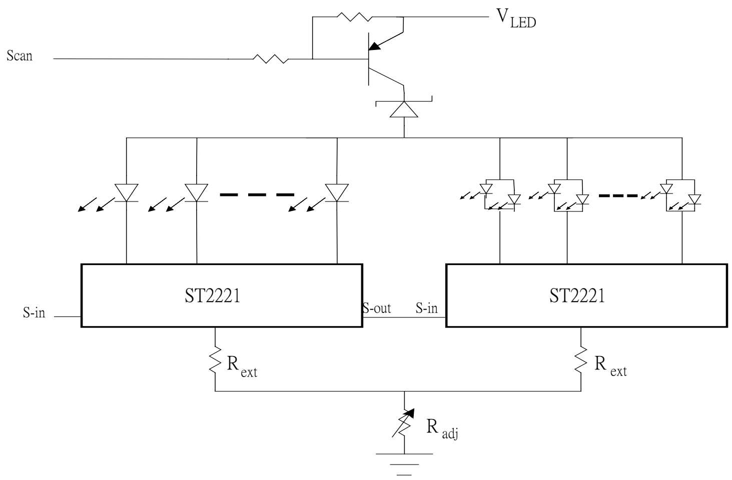

Fig. 6 Addition of Zener Diode

In addition, to prevent the overladen heat on ICs, the option of adding diode (Di) or resistor (Ri) is proposed as pictured in Figure 7. These devices will keep the extra heat from ICs and thus, release the heat on ICs.

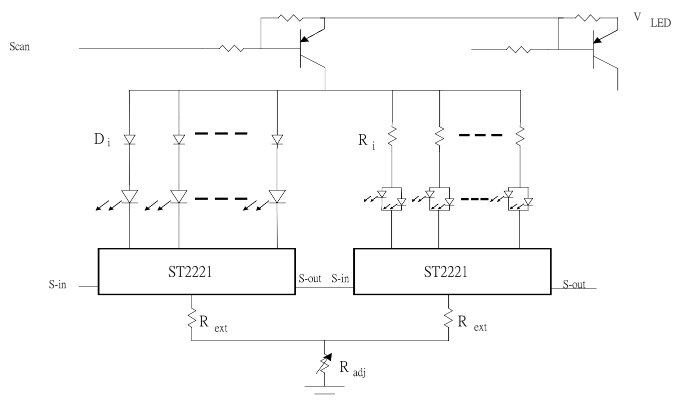

Fig. 7 Addition of Ri (or Di)

How to Use the Constant Current Driver ?(Continued)

With the use of PNP BJT or Power PMOS, the control center could operate the scanning function on different LED cells simultaneously. Please refer to Figure 8 for the explicit explanation.

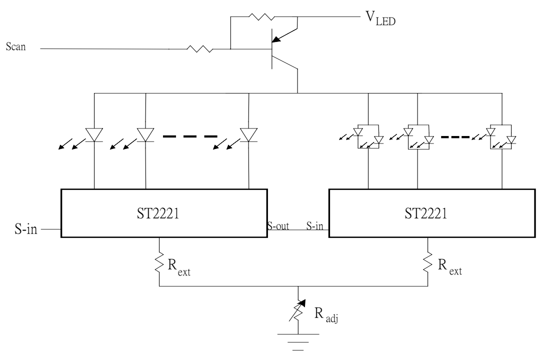

Fig. 8 Scan of Different LED Cells

Considerations on Printed Circuit Board Layout

In the LED circuit, electromagnetic effect result from the board layout, the current flow, the on-off switching characteristic and the power regulation may cause the driver malfunction. The driver outputs may be damaged by the over-voltage stress owing to the parasitic inductance in the output terminal, in the LEDs and in the power supply. The abnormal operation of the driver may also result from the large parasitic inductance and resistance of the ground line that induces the ground noise when the device is switching. Meanwhile, the unstable power supply voltage will also influence the quality of the image.

Therefore, the addition of a zener diode is strongly recommended to protect the driver outputs against the over-voltage effects. Notice that Vz (Zener diode voltage) could be selected as "V_{LED} + 1 Volt.". For the graphic simplification, please refer to Figure 9 and Figure 10 on the next page.

However, these application circuits are for the reference use only. The conformation to the configurations does not inherently ensure the successful operation in all conditions. The careful design on the power supply and ground lines on the pattern layout is called for to reduce the parasitic inductance and resistance.

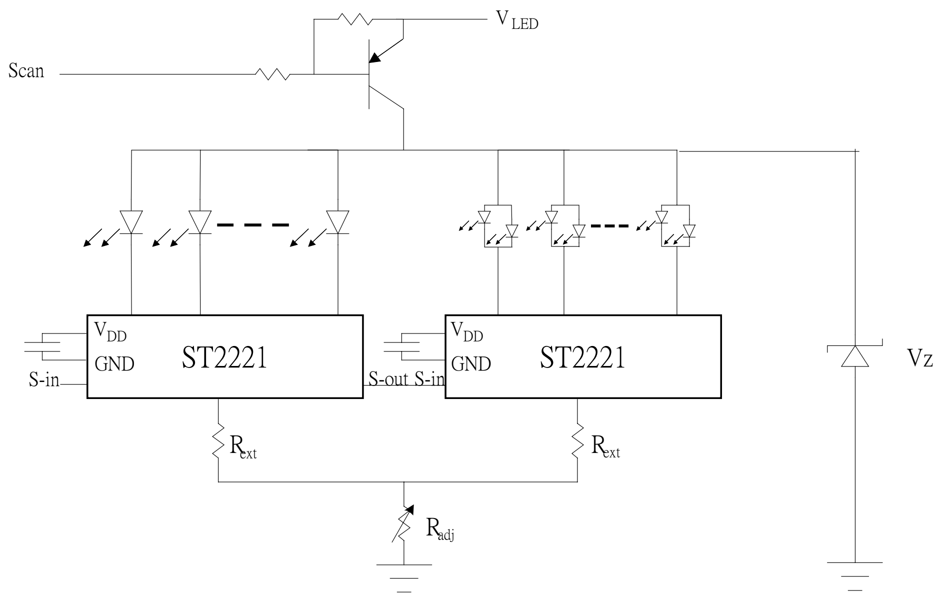

Fig. 9 Addition of Zener Diode

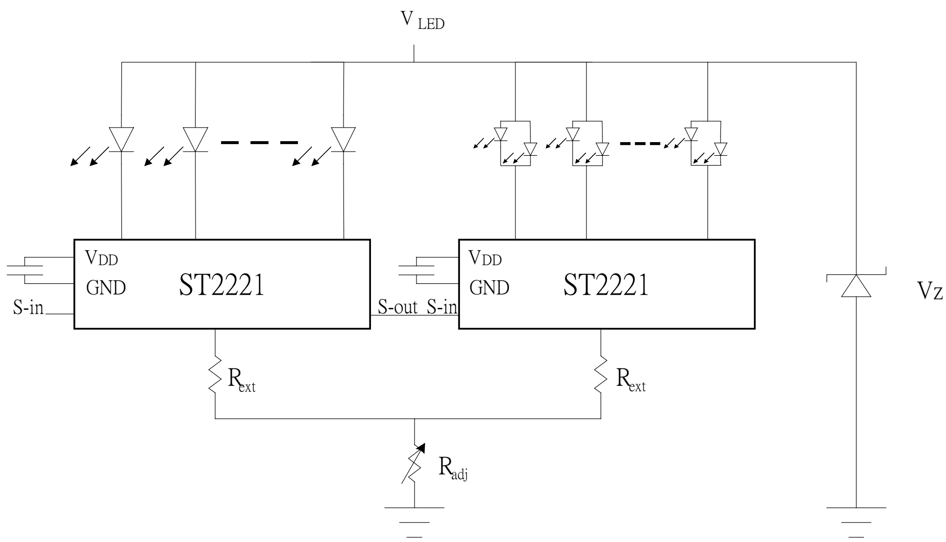

Fig. 10 Addition of Zener Diode