

NCV7691

Current Controller for Automotive LED Lamp

The NCV7691 is a device which uses an external NPN bipolar device combined with feedback resistor(s) to regulate a current for use in driving LEDs. The target application for this device is automotive rear combination lamps. A single driver gives the user flexibility to add single channels to multichannel systems. A dedicated dimming feature is included via the PWM input pin. The individual driver is turned off when an open load or short circuit is detected.

LED brightness levels are easily programmed using an external resistor in series with the bipolar transistor. The use of the resistor gives the user the flexibility to use the device over a wide range of currents.

Multiple strings of LEDs can be operated with a single NCV7691 device.

Set back power limit reduces the drive current during overvoltage conditions.

The device is available in a SOIC8 package.

Features

- Constant Current Output for LED String Drive
- External Bipolar Device for Wide Current Range Flexibility

- AEC-Q100 Qualified and PPAP Capable
- These are Pb-Free Devices

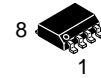
Applications

- Rear Combination Lamps (RCL)
- Daytime Running Lights (DRL)
- Fog Lights
- Center High Mounted Stop Lamps (CHMSL) Arrays
- Turn Signal and Other Externally Modulated Applications
- General Automotive Linear Current LED Driver



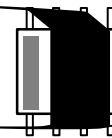
ON Semiconductor

www.onsemi.com



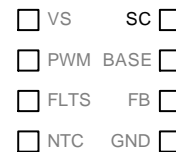
SOIC 8
CASE 751AZ

MARKING DIAGRAM



IC (Pb-Free)

PINOUT DIAGRAM



ORDERING INFORMATION

Device	Package	Shipping†
NCV7691D10R2G	SOIC8 (Pb-Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



Figure 1. Application Diagram

NCV7691

MAXIMUM RATINGS

(Voltages are with respect to GND, unless otherwise specified)

Rating	Value	Unit
Supply Voltage (VS) DC Peak Transient	-0.3 to 50 50	V
High Voltage Pins (PWM, SC)	-0.3 to (VS + 0.3)	V
Low Voltage Pins (FB, NTC)	-0.3 to 3.6	V
Low Voltage Pin (BASE)	-0.3 to 3.6 or VS + 0.6 whichever is lower	V
Fault Input / Output (FLTS)	-0.3 to (VS + 0.3) *Internally limited charge voltage	V
Junction Temperature, T _J	-40 to 150	°C
Peak Reflow Soldering Temperature: Pb-Free, 60 to 150 seconds at 217°C (Note 1)	260 peak	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- For additional information, please see or download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D and Application Note AND8003/D.

ATTRIBUTES

Characteristic	Value
ESD Capability Human Body Model Machine Model Charge Device Model	±4.0 kV ≥ ±200 V ≥ ±1 kV
Moisture Sensitivity	MSL2
Storage Temperature	-55 to 150°C
Package Thermal Resistance SOIC-8 Junction-to-Board, R _{JB} (Note 2) Junction-to-Ambient, R _{JA} Junction-to-Lead, R _{JL}	129°C/W 179°C/W 100°C/W

- Values represent typical still air steady-state thermal performance on 1 oz. copper FR4 PCB with 650 mm² copper area.

NCV7691

ELECTRICAL CHARACTERISTICS

(4.5 V < VS < 18 V, C_{FLTS} = 0.1 μF, R1 = 1 kΩ, Transistor NPN = BCP56, -40°C ≤ T_J ≤ 150°C, unless otherwise specified) (Note 3)

Characteristic	Conditions	Min	Typ	Max	Unit
----------------	------------	-----	-----	-----	------

Short Circuit

Short Circuit Detection Threshold		VS - 1.7	VS - 2	VS - 2.3	V
Short Circuit Output Current	Current out of the SC pin	-	8	16	mA

PWM

Input High Threshold		-	-	2.2	V
Input Low Threshold		0.7	-	-	V
Hysteresis		-	0.35	-	V
Input Pull-down Resistor		30	120	190	kΩ

Temperature Compensation

NTC Attenuation	0.4 V < NTC < 2.1 V	-	1/10	-	
Regulation Offset (referenced to FB)	0.4 V < NTC < 2.1 V, VS = 14 V	-2 -7	- -	+2 +7	% mV
NTC Input Pull-down Resistor	NTC = 150 mV (low impedance) NTC = 400 mV (high impedance) (Note 5)	15	22 1	31	kΩ MΩ
NTC Detection Level		170	220	300	mV

AC Characteristics

LED Current rise time	10% / 90% criterion, PWM rising (Note 6)	1	2.5	7.5	μs
LED Current fall time	90% / 10% criterion, PWM falling (Note 6)	1	2.5	7.5	μs
Propagation Delay PWM rising to I _{outB/T}	50% criterion (Note 6)	-	5	15	μs
Propagation Delay PWM falling to I _{outB/T}	50% criterion (Note 6)	-	5	15	μs
PWM Propagation Delay Delta	(Falling time) - (Rising time)	-		4	μs
Delay Time VS to BASE	VS rising through UVLO to BASE going high through 0.5 V C _{BASE} = 50 pF, R _{BASE} = 680 Ω PWM = VS, SC = floating, FB = GND, NTC = GND	-	4	9	μs
Open Load Blanking Delay	FLTS capacitor charge time not included	25	42	70	μs
Short Circuit Blanking Time		10	23	36	μs
Power-Up Blanking Time		10	23	36	μs

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

3. Designed to meet these characteristics over the stated voltage and temperature recommended operating ranges, though may not be 100% parametrically tested in production.
4. Guaranteed by design.
5. NTC = 400 mV is > NTC detection level and is a higher impedance than when operating within the detection level.
6. Evaluated at VS = 14V, (LED string current)_{max} = 15 mA to 37 mA.
7. Device tested at 18 V. Upper limit of 6 V applies across the VS input supply range, but the maximum rating for FLTS (-0.3V to VS to -0.3V) must be considered for all system designs especially at the minimum extreme of VS = 4.5 V.

TYPICAL PERFORMANCE CHARACTERISTICS

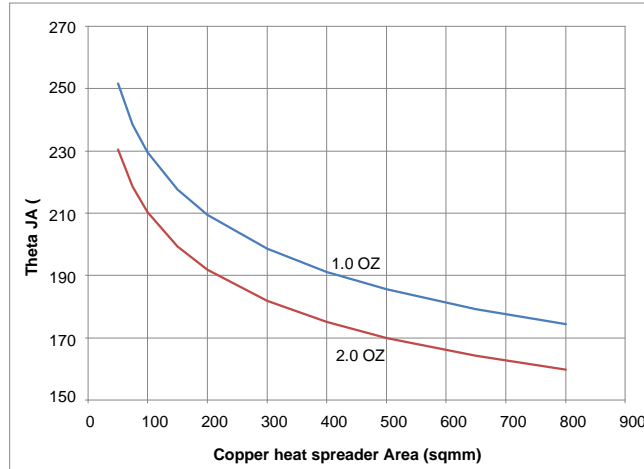


Figure 4. θ_{JA} vs. Copper Spreader Area

NCV7691

Detailed Operating Description

The NCV7691 device provides low-side current drive via an external bipolar transistor. The low voltage (152 mV) current sense threshold allows for maximum dropout voltage in the system. Dimming is performed using the dedicated PWM pin on the IC. Average output current is directly related to the intensity of the LED (or LED string).

Output Drive

Figure 7 shows the typical output drive configuration. A feedback loop regulates the current through the external LED. U1 monitors the voltage across the external sense resistor (R1). When the voltage exceeds the 152 mV reference, the output of U1 goes from high to low sending

a signal the buffer (U2) decreasing the base drive to the external transistor (BCP56). For loads above 150 mA, a PZT651 device (replacing the BCP56) is recommended for stable operation.

Normal operation includes a substantial voltage drop across the three LEDs limiting the power dissipation across

Open Load Detection

Faulted output strings due to open load conditions sometimes require the complete shutdown of illumination within an automotive rear lighting system. The NCV7691 provides that feature option.

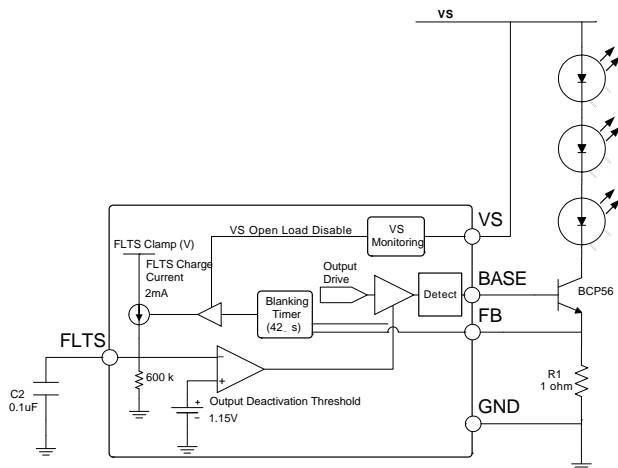
There are two open load detections schemes in the NCV7691. These are OR'd conditions.

1. In normal regulation, the IC monitors the FB voltage (typ 152 mV). When this voltage falls by 50% (to typ 76 mV), an open circuit is detected and a current starts to charge FLTS to flag open load, once FLTS voltage crosses the output deactivation threshold the driver is switched off resulting in a latched off-state. When regulating via the NTC pin, the open load detection threshold is $V(NTC)/20$.
2. During open load, the base current increases to try and satisfy the regulation loop. Internal circuitry monitors the base current. When the Base Current Drive reaches the Output Source Current (typ 25 mA) threshold, an open circuit is flagged and the driver is latched off.

Two schemes are used should the rise in base current create a regulated voltage on the feedback pin (FB). If this occurs scheme #1 would not detect the open load.

When an open load is detected, the output turns off, and can be turned back on again by a toggle of the PWM pin or a power down of the supply (VS).

If the open load feature is not used, FLTS should be tied to GND. Grounding FLTS disables open load detection. Short circuit detection and thermal shutdown functions remain active but are not reported externally. The BASE pin is actively held low in this case.



Open load can be disabled by connecting FLTS to GND.

Figure 8. Open Load Detection Circuitry

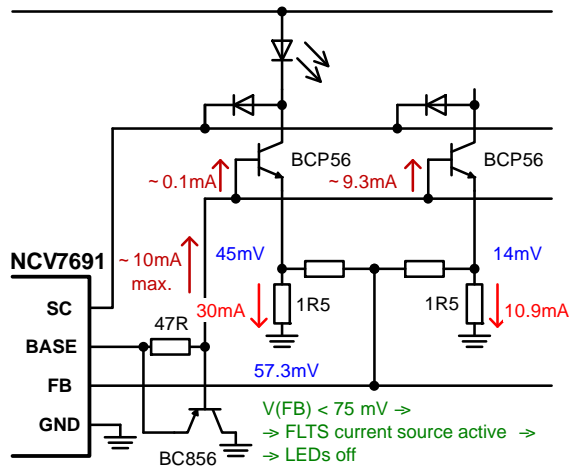


Figure 9. Improved Open Load Detection for Multiple Strings

System Voltage and Overvoltage Fold-back

Low voltage system operation is typically limited by head room in the LED string. Because of this limitation, detection of open loads is inactive below $V_S = \text{typ } 8.5 \text{ V}$ (Open Load Disable voltage). There is also an upper limitation. The current roll off feature of the part resets the loop at a lower reference voltage and consequential lower current for V_S above the Overvoltage Fold-back threshold on V_S , (typ 19.5 V). The open load Detection circuitry is inactive for V_S above this Overvoltage Fold-back threshold voltage.

Open Load Timing

The timing for open load detection is programmed using the FLTS pin. The NCV7691 device regulates a 152 mV reference point (Figure 8 on the feedback pin (FB)). When the voltage decreases (half of the FB Regulation Voltage) or the base current reaches the internal 25 mA (typ) limit for 42 s the timer associated with the FLTS pin starts by charging the capacitor with a 2 mA current source. When the voltage on FLTS exceeds the output Deactivation Threshold (1.15 V (typ)), the BASE pin is pulled low and is held low by an internal pulldown resistor.

A 42 s blanking time during power up ensures there is enough time for power-up to eliminate false open-load detections. The slow FLTS discharge (600 k [typ]) load (and resultant long time to restart LED drive) eliminates flickering effects.

FLTS Interface

Figure 10 shows an open-drain logic level FET serving as a buffer to the microprocessor.

Figure 11 shows the proper wired “OR” connection for applications which require all channels to latch-off with an open load condition. An open load condition will be reported back to the microprocessor regardless of which channel it occurs on. Note the NCV7691 device uses a feature which allows any channel to charge the FLTS capacitor due to its definition at a charge current value much higher than the discharge value (2 mA versus 600 k [typ]). Additional NCV7691 Single Current Controller devices may share the same common FLTS capacitors in systems requiring multiple ICs.

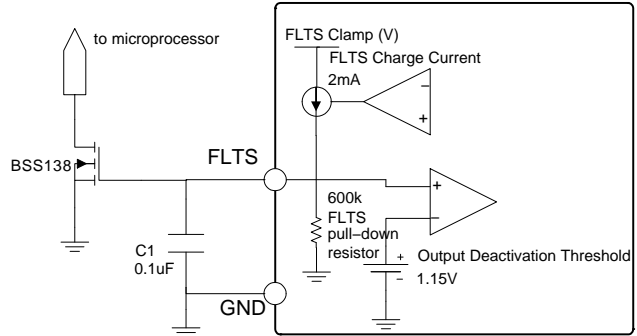
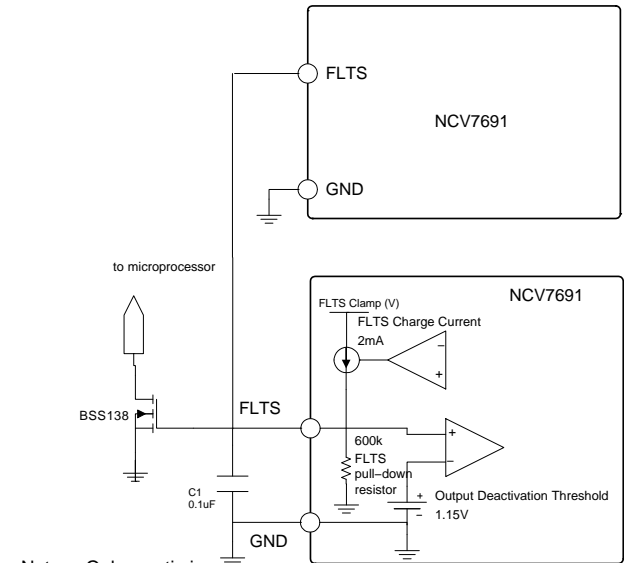


Figure 10. Open Drain Output Interface to Microprocessor



Note – Only one timing capacitor and interface transistor are required for system operation.

Figure 11. FLTS Wired OR to Microprocessor

Temperature Compensation

The NCV7691 device typically operates with a zero TC output current source. The NTC (Negative Temperature Coefficient) pin provides an alternative for an output current which degrades with temperature as defined by the designer's external components.

Zero TC operation is provided when the NTC pin is connected to GND. When a negative temperature coefficient output current is desired to compensate for effects of external LED illumination, the setup shown in Figure 12 will provide the function. On the NTC pin, a comparator detects when the voltage is higher than typ 220 mV, and this voltage is used to provide the feedback reference voltage for the current feedback regulation loop.

The zener provides a reference voltage for the negative temperature coefficient NTC device through an external divider. Be careful of your choice of the zener diode as the temperature coefficients of the devices have a wide variation with the low voltage zeners having a high negative temperature coefficient and the high voltage zeners having

a positive temperature coefficient. The regulation loop voltage on NTC should be sufficiently higher than the 220 mV reference voltage to avoid interactions. A typical regulation voltage of 1.6 V is suggested.

The overall tolerance specification for the NTC functionalit7-0 Tw[ts.

Short Circuit Detection

NCV7691

Short Circuit Detection with 4 or more Channels

Interfacing the short circuit detection for multiple channels with one NCV7691 driver system is done easily using diodes or a diode resistor combination depending on your system requirements.

Figure 14 shows the implementation using 4 individual diodes which will work for all applications.

Figure 15 shows an implementation which will work provided the drop across the loads is < 3.4 V. This limitation is due to the SC minimum specification of $V_S - 1.7$ V. This setup saves the user 2 diodes.

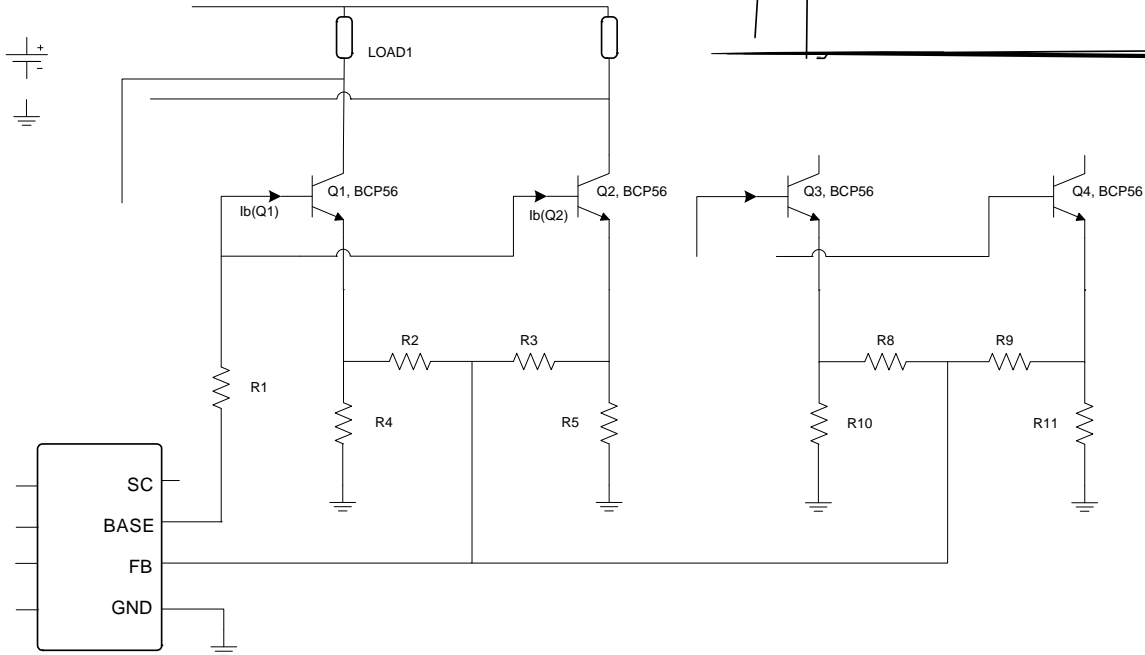


Figure 14. Short Circuit Detection with 4 or more Channels

Thermal ShutDown

NCV7691

Figure 19: Application Diagram with no microprocessor.

A resistor pull-up from PWM to VS illustrates how the device can be used as a standalone LED driver without using a microprocessor to drive the PWM input.

Figure 20 along with Figure 21 and Figure 22 highlight the use of the NCV7691 device with multiple strings connected to a common drive BASE pin and using external resistors to tie additional strings to a common feedback point (FB). The FB pin will maintain regulation with the FB pin at 152 mV.

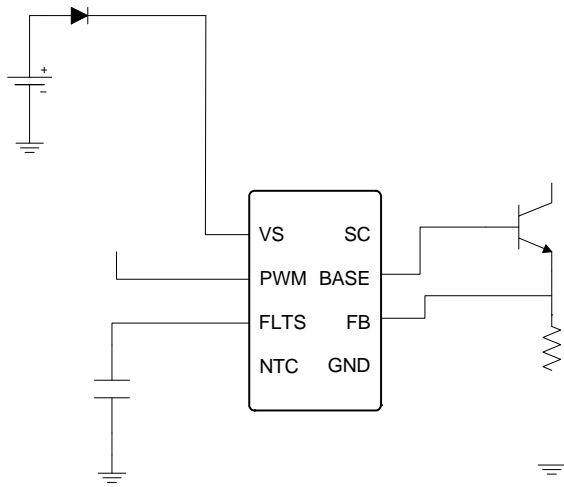


Figure 19. Application Diagram with No Microprocessor

R1 is used to limit current in the event of an open circuit on one of the strings.

Figure 21: Open Circuit.

It shows the change in BASE drive which occurs with an open circuit in one of the strings. The drive current out of BASE changes from $(I_b(Q1) + I_b(Q2))$ to $(I_b(Q1) + I_c(Q2))$ as regulation will try to maintain in the loop to get 152 mV on FB. Figure 22 shows the equivalent circuit when an open load occurs.

Table 2. FAULT HANDLING TABLE

Fault	Fault Memory	Sense Condition	Driver Condition During Fault	Driver Condition after Parameters Within Specified Limits	Output Fault Clear or Operation Restitution Requirement	Fault Reporting
Open Load (FLTS active)	Latched off.	42. s w / FB < Vref/2 76 mV or I _{base} > 25 mA 8.5 V < VS < 19.5 V	Driver is latched Off.	Driver is latched Off.	Toggle PWM pin. VS power down below UVLO.	FLTS low to high
Open Load (FLTS = GND)	No effect.	n/a	No effect.	No effect.	n/a	n/a
Short Circuit to Vbat (FLTS active)	Latched off.	23. s SC < VS – 2 V VS > 8.5 V	Driver is latched Off.	Driver is latched Off.	Toggle PWM pin. VS power down below UVLO.	FLTS low to high
Short Circuit to Vbat (FLTS = GND)	Latched off.	23. s SC < VS – 2 V VS > 8.5 V	Driver is latched Off.	Driver is latched Off.	Toggle PWM pin. VS power down below UVLO.	FLTS low to high
Under Voltage Lockout	Driver Off	VS < 4 V	Driver Off	Driver back on.	VS > 4 V minus 200mV hysteresis.	n/a
Over Voltage	Output Current Reduced	Threshold 1 VS > 19.5 V Threshold 2 VS > 31 V	Reduced output current (FB Regulation Voltage)	Driver back to normal operation.	VS < threshold minus 700 mV hysteresis.	n/a
Thermal Shutdown (FLTS active)	Driver Off	23. s T _J > 170°C	Driver Off	Driver back on.	Die temperature below shutdown hysteresis	FLTS low to high

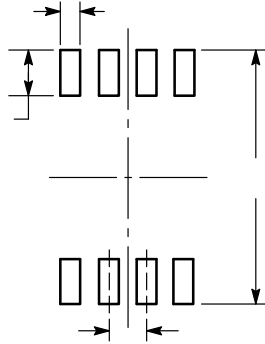
Thermal Shutdown (FLTS =h =h =h



SCALE 1:1

SOIC 8

**RECOMMENDED
SOLDERING FOOTPRINT***



onsemi

onsemi, **onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi**
