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Controller for Automotive LED Lamps

NCV7693

The NCV7693 is a device which drives multiple external switching components for 3 independent functions. The average current in each LED string can be regulated with a proper choice of duty-cycle and battery voltage. The target application for this device is automotive rear combination lamps. Each individual driver has its own diagnostic to detect open load, short circuit to ground or to battery.

LED average brightness levels are easily programmed using appropriate duty cycle control and external resistors in series with the switching transistors.

Multiple strings of LEDs can be operated with a single NCV7693 device. The device is available in a TSSOP-14 package.

Features

- 3x Pulse Width Modulation (PWM) Control
- Independent Diagnostic Feedback per Function
- External Switching Device for Wide Current Range Flexibility
- External Resistors Define Maximum Current
- Open LED String Diagnostic
- Short-Circuit LED String Diagnostic
- Thermal Shut-down Diagnostic and Protection
- Protection against Short-Circuit on the PWM Input Pins
- Multiple LED String Control
- TSSOP-14 Package
- AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

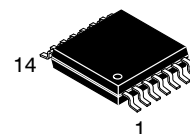
Applications

- 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 LED Driver



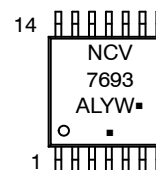
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TSSOP-14 WB
CASE 948G

MARKING DIAGRAM



- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

Device	Package	Shipping†
NCV7693DB0R2G	TSSOP-14 (Pb-Free)	2500 / 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.

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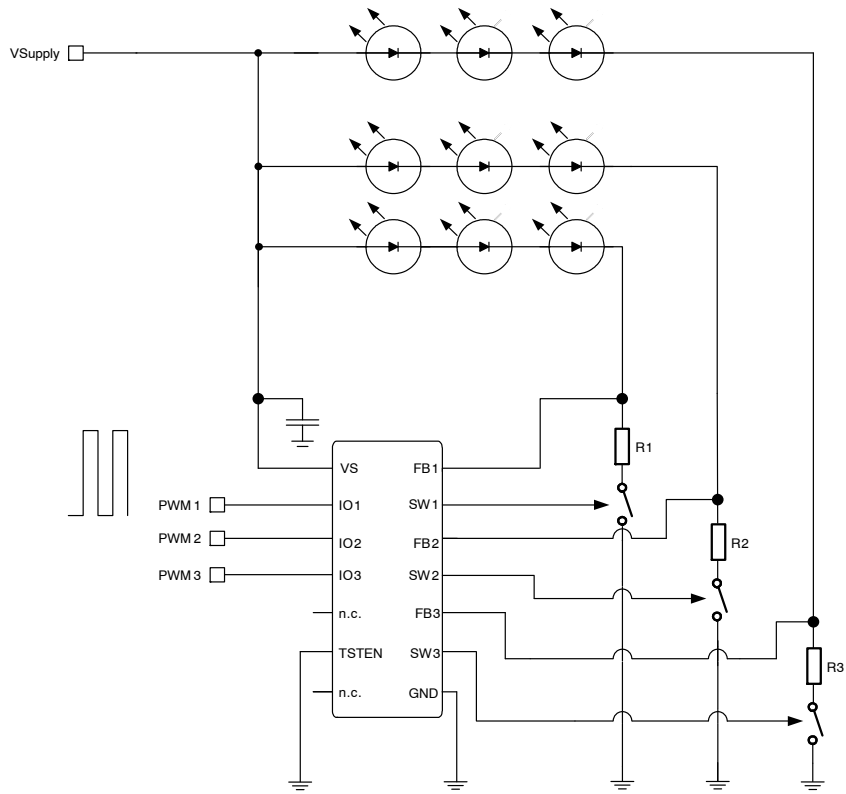


Figure 1. Application Diagram

NCV7693

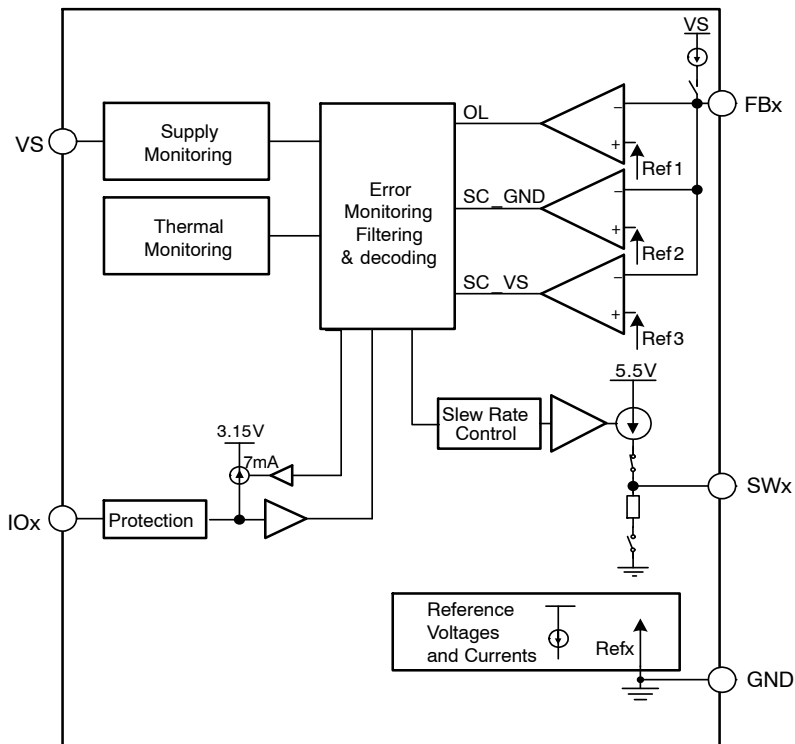


Figure 2. Block Diagram

PIN FUNCTION DESCRIPTION

TSSOP-14 Package		
Pin #	Label	Description
1	VS	Automotive Battery input voltage
2	IO1	Logic input1 for output SW1 on / off control and diagnostic feedback. Pull high for output on.
3	IO2	Logic input2 for output SW2 on / off control and diagnostic feedback. Pull high for output on.
4	IO3	Logic input3 for output SW3 on / off control and diagnostic feedback. Pull high for output on.
5	NC	Not connected
6	TSTEN	Pin used for test purpose only, has to be connected to GND pin during the normal operation.
7	NC	Not connected
8	GND	Ground
9	SW3	Switch Driver 3 for external transistor
10	FB3	Feedback pin for error detection on SW3
11	SW2	Switch Driver 2 for external transistor
12	FB2	Feedback pin for error detection on SW2
13	SW1	Switch Driver 1 for external transistor
14	FB1	Feedback pin for error detection on SW1

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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 V
High Voltage Input-Output Pins (IO1, IO2, IO3)	-40 to 50	V
High Voltage Input Pins (FB1, FB2, FB3)	-0.3 to 50	V
Low Voltage Pins (SW1, SW2, SW3)	-0.3 to 6.5	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 without any filter all I _{ox} versus GND and VS versus GND Charge Device Model	±6.0 kV (Note 2) ≥ ±750 V
Moisture Sensitivity	MSL2
Storage Temperature Range	-55 to 150°C
Package Thermal Resistance - TSSOP-14 (Note 3) Junction-to-Ambient, R _{θJA} Junction-to-Case, R _{ψJC}	135°C/W 45°C/W

- Minimum ±2 kV HBM for all pin combinations.
- Values represent typical still air steady-state thermal performance on 1 oz. copper FR4 PCB with 650 mm² copper area.

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ELECTRICAL CHARACTERISTICS

(6.17 V < VS < 16 V, Transistor NPN = BCP56 or NMOS = NVR5198, -40°C ≤ TJ ≤ 150°C, unless otherwise specified) (Note 4)

Characteristic	Conditions	Min	Typ	Max	Unit
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General Parameters

Supply Current	VS = 14 V, all IOx > 2.2 V, SWx current subtracted VS = 14 V, all IOx = 0 V	2.2 30	5.2 185	10 380	mA μA
Under Voltage Lockout	VS rising (Note 5)	2.24	3.35	4.43	V
Under Voltage Lockout Hysteresis	(Note 5)	-	500	-	mV
Thermal Shutdown (TSD)	(Note 5)	155	170	190	°C
Thermal Hysteresis	(Note 5)	-	15	-	°C

Switch Driver

Output Source Current	SWx = 0.7 V (Note 6), -40°C ≤ TJ ≤ +25°C	25	50	-	mA
Output Source Current	SWx = 0.7 V (Note 6), +25°C ≤ TJ ≤ +125°C	15	30	-	mA
Output Source Current	SWx = 0.7 V (Note 6), +125°C ≤ TJ ≤ +150°C	7.0	15	-	mA
Swx ON Voltage	ISWx = -100 μA, 7 V < VS < 19 V ISWx = -100 μA	4.5 4.5	5.5 -	6.5 -	V V

Open Load Timing

Open Load Detection Threshold	IOx High	0.7	0.85	1.0	V
Open Load Blanking Time		10	22	35	μs

Short Circuit to VS

Short Circuit Detection Threshold	IOx High	VS-1.0	VS-1.2	VS-1.4	V
Input pull-up current on FBx pins	Tested at V(FBx) = VS - 1.0 V	-35	-20	-2.0	μA
Short Circuit Blanking Time	Tested at 15 V	5.0	10	15	μs

Short Circuit to Ground

Short Circuit Detection Threshold	IOx Low	0.7	0.85	1.0	V
Short Circuit Blanking Time	Tested at 15 V	10	22	35	μs

IOx

Input High Threshold		-	-	2.2	V
Input Low Threshold		1.1	-	-	V
Hysteresis		-	0.52	-	V
Input Pull-down Resistor	Tested at V(IOx) = 15 V	75	150	300	kΩ
IOx Clamp Voltage in error mode	PWMx > 5 V, 2 mA < I(IOx) < 9.5 mA	2.80	3.15	3.46	V

AC Characteristics

Propagation Delay IOx rising to IoutBJT	50% criterion (Note 7)	-	5	15	μs
Propagation Delay IOx falling to IoutBJT	50% criterion (Note 7)	-	5	15	μs
Propagation Delay IOx rising to VoutNMOS	From IOx input high threshold to 90% rising of SWx_ON Voltage, Cload = 470 pF	-	-	5	μs
Propagation Delay IOx falling to VoutNMOS	From IOx input low threshold to 10% falling of SWx_ON Voltage, Cload = 470 pF	-	-	5	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.

- Designed to meet these characteristics over the stated voltage and temperature recommended operating ranges, though may not be 100% parametrically tested in production.
- Guaranteed by design.
- This current is designed to decrease over temperature in case the switching element is an external bipolar to compensate internal heating and Beta.
- Evaluated at VS = 14V.

TYPICAL PERFORMANCE CHARACTERISTICS

Equivalent schematics

The following figure gives the equivalent schematics of the user relevant inputs and outputs. The diagrams are simplified representations of the circuits used.

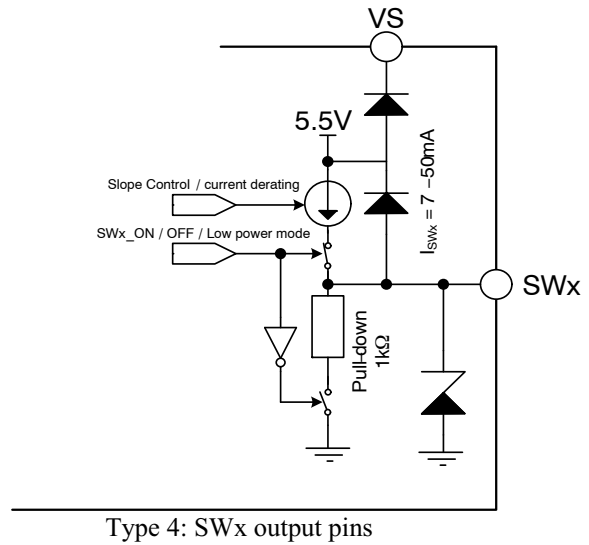
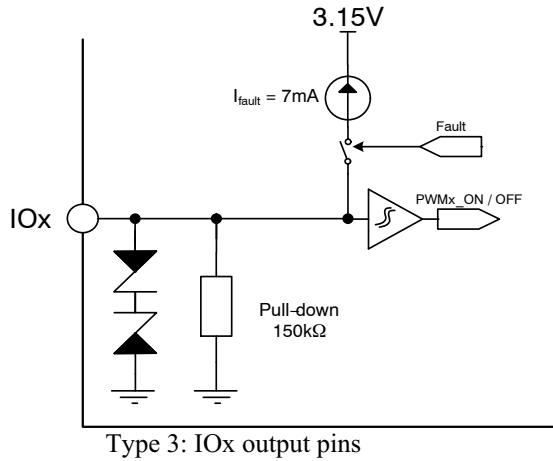
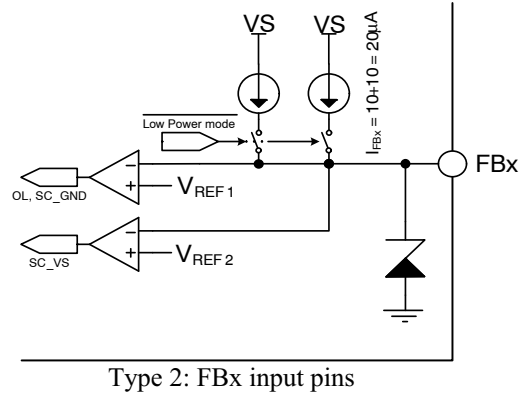
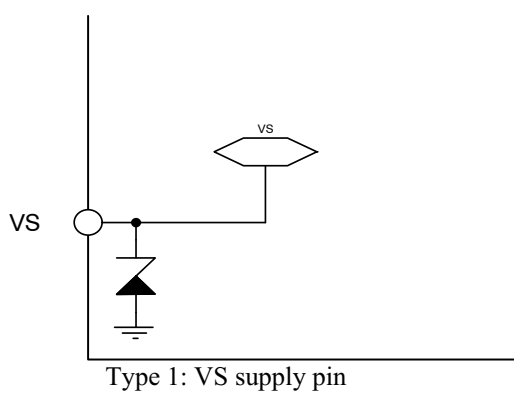


Figure 3. Input and Output Equivalent Diagrams

Detailed Operating Description

The NCV7693 device provides low-side current drive via an external switching transistor in series with the LEDs and a resistor. The drop across the resistor plus either the V_{CE} or the V_{DS} of the transistor is supposed to be above 1V in normal operation. Dimming is performed using the dedicated PWM at the IOx pins of the IC.

Output Drive

Figure 4 shows an example of the typical output drive configuration. The average current through the external LED is equal to:

$$I_{LED} = \frac{(V_S - V_F - V_{DROP})}{R} \times DC$$

Where;

V_S is the Automotive Battery input voltage,

V_F is the sum of the forward voltage of the LEDs,

V_{DROP} is either V_{CEsat} (saturation voltage of the chosen BJT) or V_{DS} (in case NMOSFET is chosen),

DC is the Duty Cycle present at the input of the IOx pins and

R the series resistance with the LEDs (typical value range is in between 50 and 100 Ω).

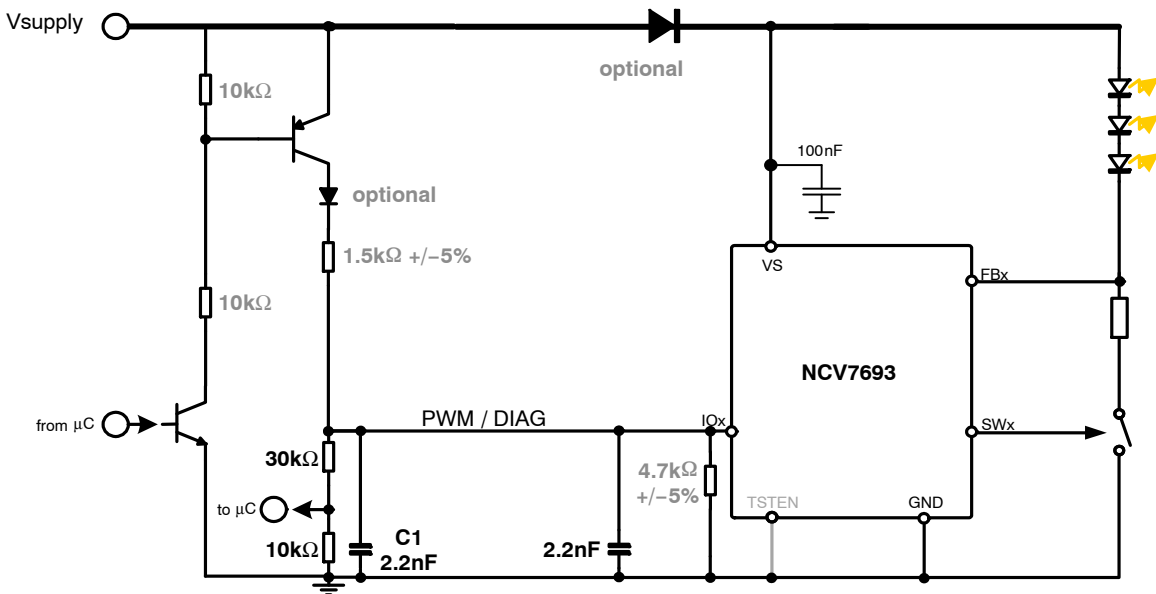


Figure 4. Output Drive configuration

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Open Load Detection

Faulted output strings due to open load conditions sometimes require detection in an automotive rear lighting system. The NCV7693 provides that feature.

When LED driver is ON (PWM is active high) and when the voltage on the FBx pin is detected below 0.85 V for more

than 22 μ s typical then an open load error is activated. The IOx pin is pulled down to 3.15 V typical allowing the μ controller to detect the error when the PWM input signal is activated High. During open load condition the driver stays active. If the open load disappears the device is working properly again and the diagnostic flag disappears.

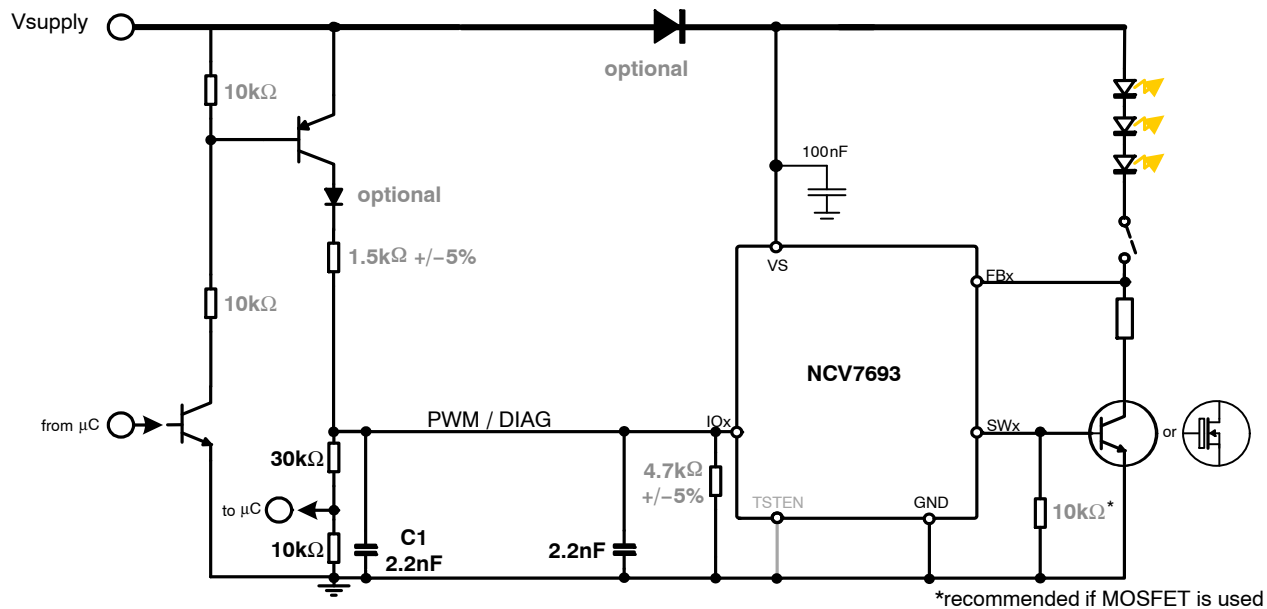


Figure 5. Open Load Detection

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Short Circuit to Ground Detection

The FeedBack (FBx) pins of the device are used as inputs to detect a fault when the resistor on top of either the collector or the drain of the external transistor is shorted to Ground. When LED driver is OFF (PWM is low) and when the voltage on the FBx pin is detected below 0.85 V for more than 22 μ s typical then a SC to Ground is latched. The IOx pin is then pulled down to 3.15 V typical allowing the

μ controller to detect the error when the PWM input signal is activated High. During SC to Ground condition the driver stays active. If the short circuit disappears the device is working properly on next falling edge of the PWM input pin.

If at least one IOx pin remains High, then short to Ground detection is guaranteed. Note that in case all IOx pins are Low, the device is in low power mode and a short to Ground cannot be detected.

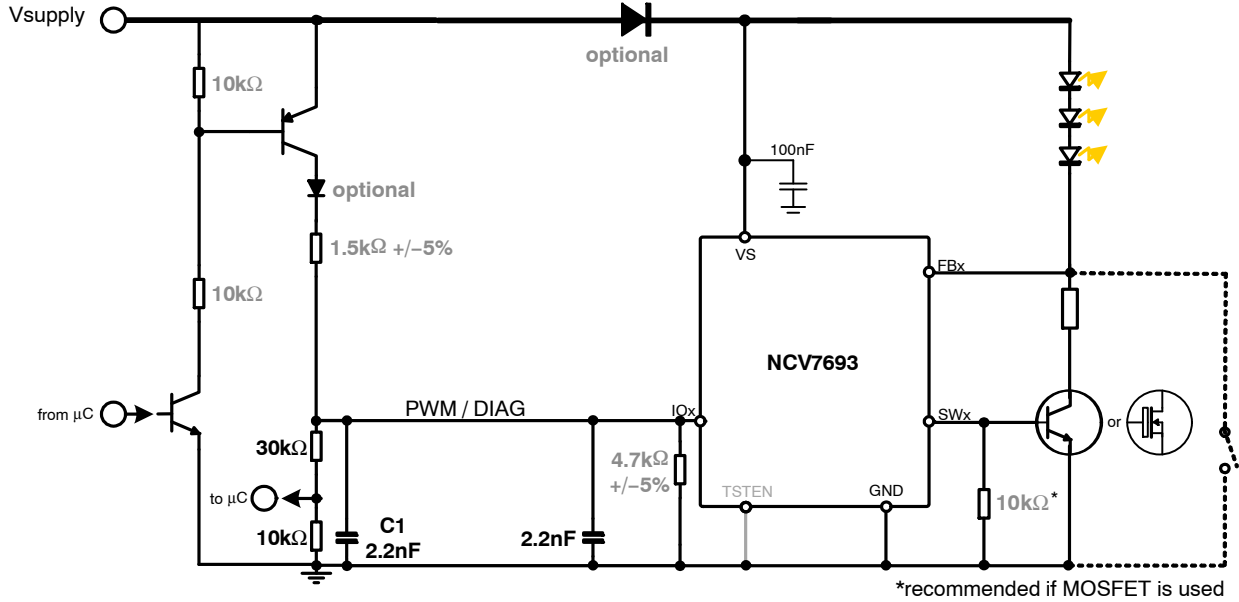


Figure 6. Short Circuit to Ground Detection

Short Circuit to VS Detection

The FeedBack (FBx) pins of the device are used as inputs to detect a fault when the resistor on top of either the collector or the drain of the external transistor is shorted to the battery voltage. This error is detected when the driver is ON (PWM active High). The threshold voltage detection is referenced 1.2 V typical down from the VS pin. A voltage of less than 1.2 V between VS and FBx for more than 10 μ s then a SC to VS is detected. The IOx pin is then pulled down

to 3.15 V typical allowing the μ controller to detect the error when the PWM input signal is activated High. Because of the large power dissipation possible during this error, the driver is switched OFF. If the SC disappears the device is working properly on next rising edge of the PWM input pin. In case multiple strings are connected to the same driver (see Figure 9), this error is only detected at the condition each string is shorted to VS (a single string detection is not detected because of the blocking diodes).

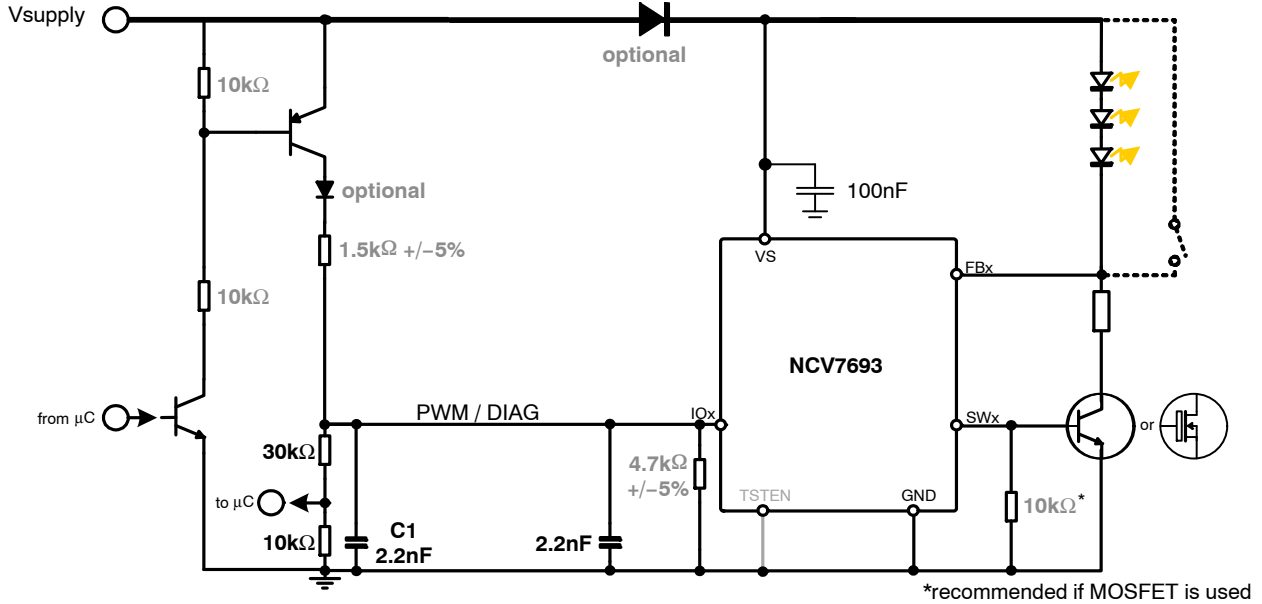


Figure 7. Short Circuit to VS Detection

Thermal shut down

The thermal shut down circuit checks the internal junction temperature of the device. When the internal temperature rises above the Thermal shutdown threshold, then after a short filter time the output channels are switched off. The filter is implemented to avoid parasitic TSD, switching off the driver in case of TSD, will also make the IOx pin is then

pulled down to 3.15 V typical allowing the μ controller to detect the error when the PWM input signal is activated High. It is the responsibility of the μ controller to switch-OFF all IOx when the error is detected to avoid large power dissipation in the device due to the large current flowing in the IOx pins.

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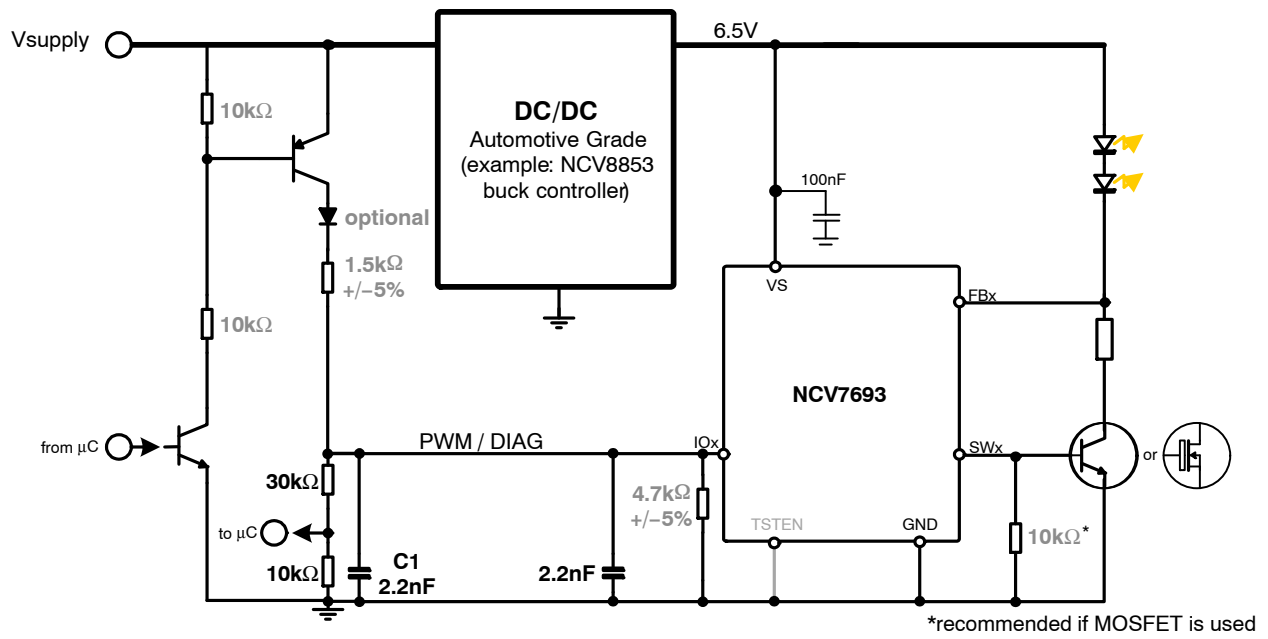


Figure 8. Application diagram with a DC/DC

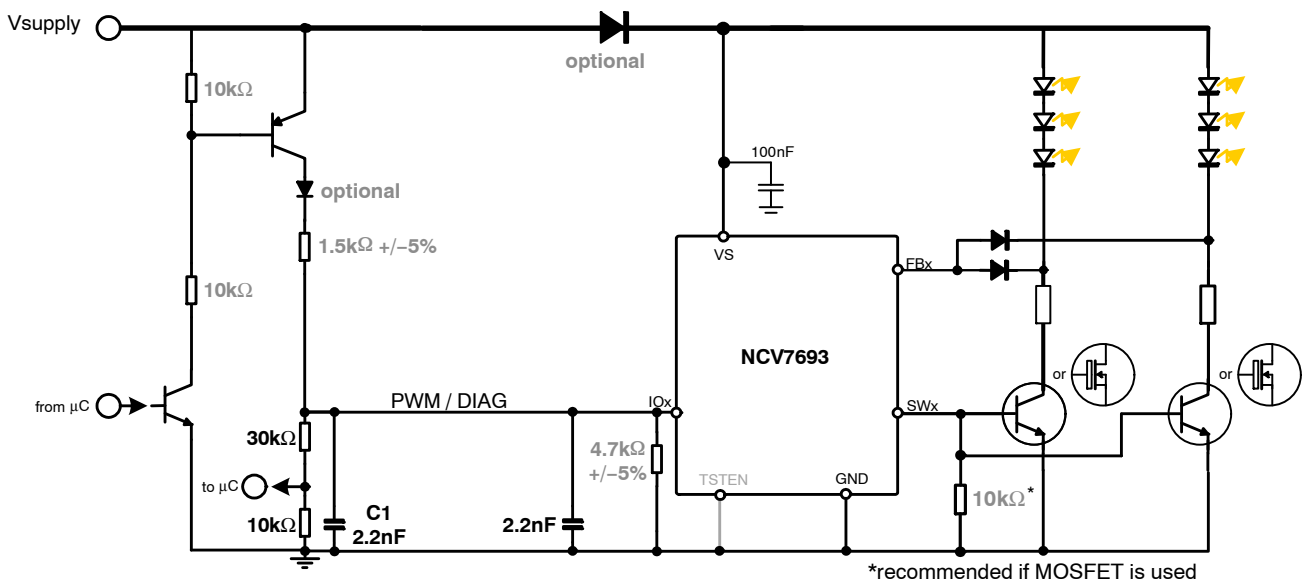
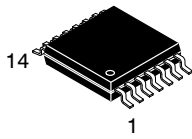


Figure 9. Application diagram with multiple strings

MECHANICAL CASE OUTLINE

PACKAGE DIMENSIONS

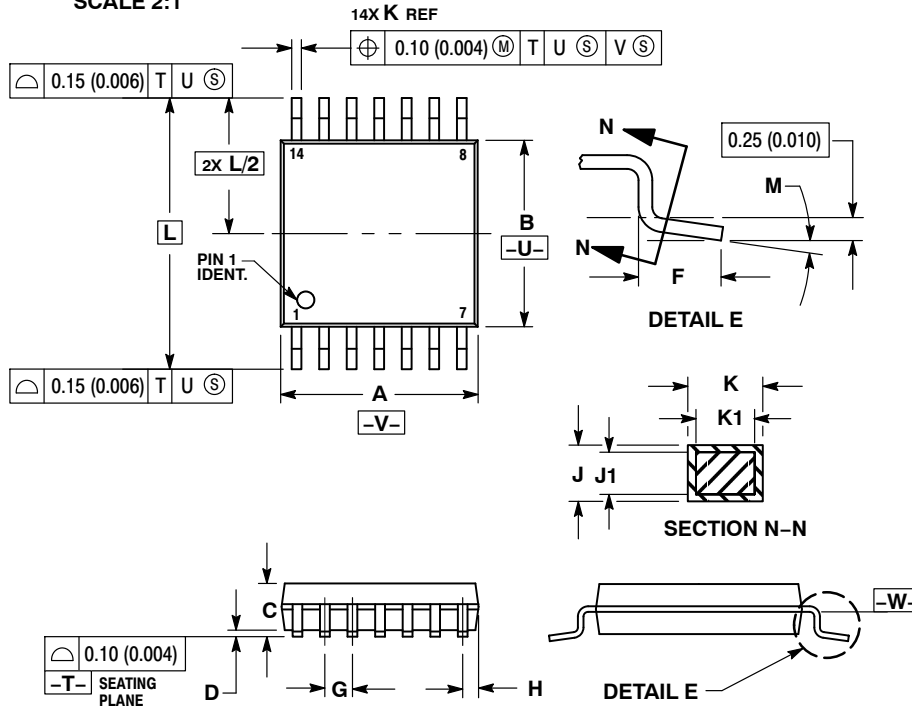
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CASE 948G
ISSUE C

DATE 17 FEB 2016

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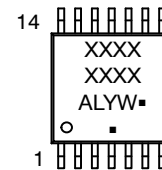


NOTES:

- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
- CONTROLLING DIMENSION: MILLIMETER.
- DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
- DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
- DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
- TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
- DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	---	1.20	---	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.50	0.60	0.020	0.024
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0°	8°	0°	8°

GENERIC MARKING DIAGRAM*

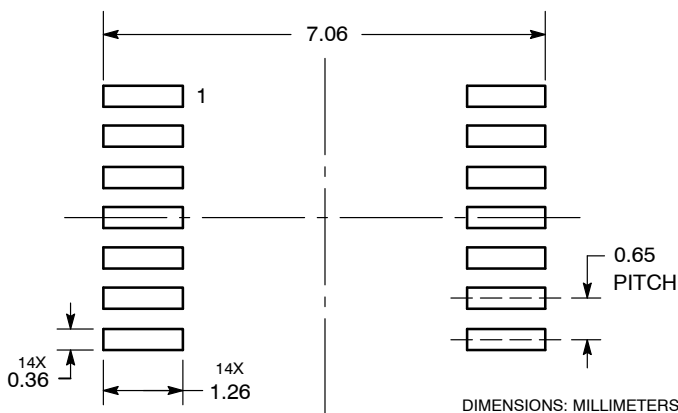


- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)


*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

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