Description

The AL5836Q is an automotive-complaint three-channel independent PWM controller offering excellent temperature stability and output ON/OFF control with current-sensing capability. It works with a wide-input voltage range from 3.5V to 50V. With an external LED driving power device or other application, the AL5836Q's internal power dissipation is minimized compared to traditional linear LED drivers. This makes it ideal for medium-to-high current automotive LED lighting applications.

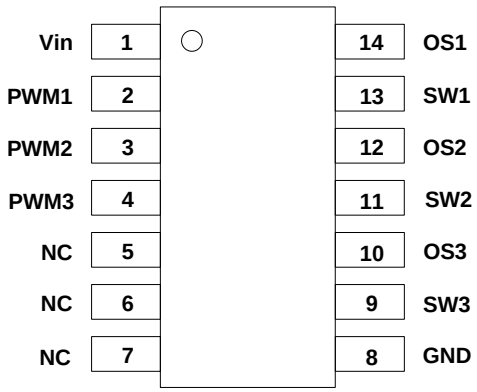
The AL5836Q has three independent drivers: PWM1, PWM2, and PWM3 control pins with individual PWM dimming and fault reporting capabilities. For improved system robustness, its PWM inputs withstand a -40 to 50V common-mode voltage range, which covers cold cranking and load dump conditions. The average current in each LED string can be regulated, with suitable options for duty cycle and battery voltage. Each individual channel has its own diagnostic to detect open load, and short circuit to ground or to battery.

For LED current-sensing applications, load currents can be easily programmed using an appropriate PWM duty-cycle control, as well as external resistors in series with the switching transistors. Multiple strings of LEDs can be operated with a single AL5836Q device.

The AL5836Q is available in the TSSOP-14 package and is automotive-compliant, qualified to AEC-Q100 Grade 1, and supports PPAP documentation.

Pin Assignments

(Top View – Not to Scale)



TSSOP-14

Features

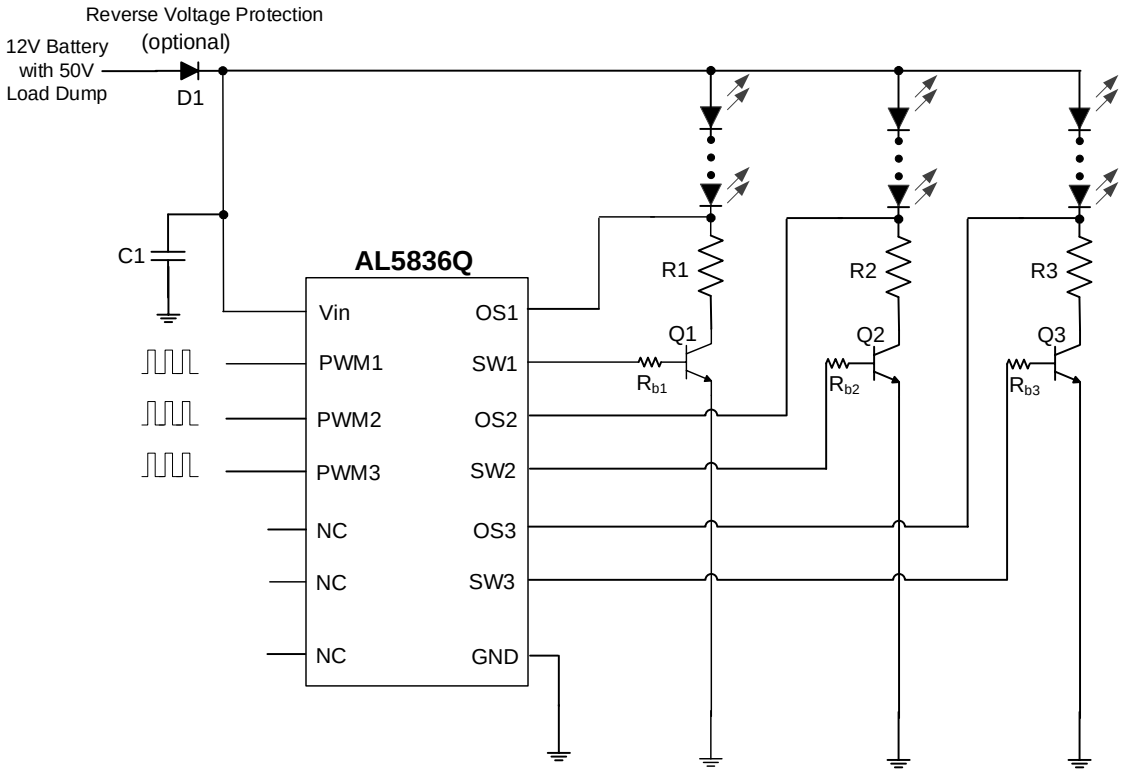
- Qualified to AEC-Q100 Grade 1
- Gate Drive Current 50mA per channel
- Three-Channel Pulse Width Modulation (PWM) Dimming
- Independent Diagnostic and Protection per Channel
- Drive External Power MOSFET or BJT
- External Resistors Define Peak Current
- Open/Short LED String Diagnostic and Protection
- Thermal Shutdown Protection
- Support Multiple Strings
- Undervoltage Lockout
- 6KV HBM ESD for Vin and PWM pins
- Good EMI Immunity
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The AL5836Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.**
  https://www.diodes.com/quality/product-definitions/

Applications

- Rear lamps
- Daytime running lights (DRLs)
- Fog lamps
- Center high-mounted stop lights (CHMSLs)
- Turn signals
- LED lighting modules

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Application Circuit



SW1, SW2, SW3 can drive either MOSFET or BJT

Figure 1. Application Diagram

Pin Descriptions

Pin Number	Pin Name	Function
1	Vin	Supply input
2	PWM1	I/O pin - PWM signal input 1 and diagnosis. SW1 on.
3	PWM2	I/O pin - PWM signal input 2 and diagnosis. SW2 on.
4	PWM3	I/O pin - PWM signal input 3 and diagnosis. SW3 on.
5	NC	No Connection
6	NC	No Connection
7	NC	No Connection
8	GND	Ground
9	SW3	Channel 3 gate drive output
10	OS3	Open/Short detection for channel 3
11	SW2	Channel 2 gate drive output
12	OS2	Open/Short detection for channel 2
13	SW1	Channel 1 gate drive output
14	OS1	Open/Short detection for channel 1

Functional Block Diagram

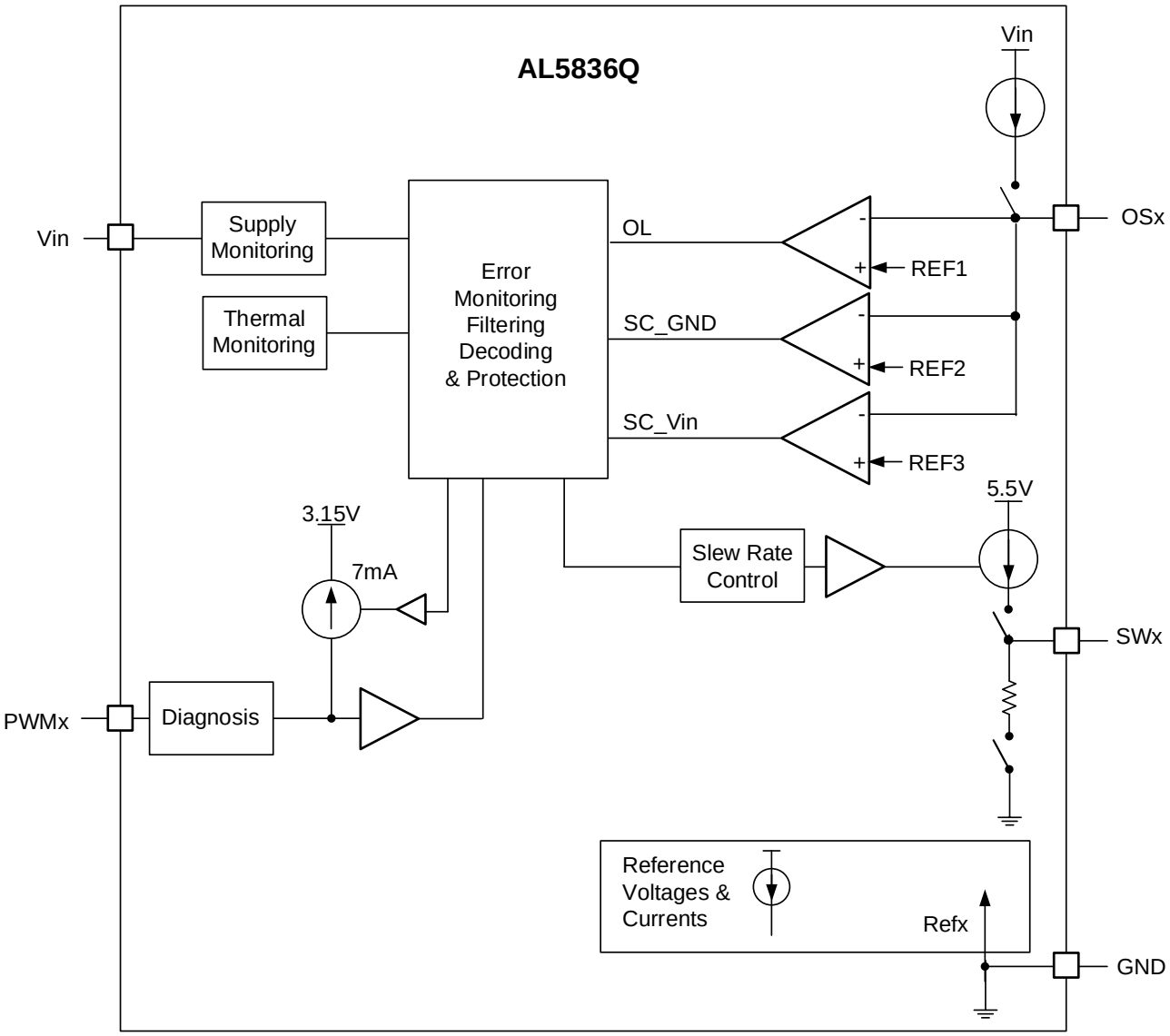


Figure 2. Block Diagram

Absolute Maximum Ratings (Note 4)

Symbol	Parameter	Rating	Unit
V_{Vin}	Supply Voltage Relative to GND	-0.3 to 55	V
V_{PWM1}, V_{PWM2}, V_{PWM3}	High Voltage Input-Output Pins (PWM1, PWM2, PWM3)	-40 to 55	V
V_{OS1}, V_{OS2}, V_{OS3}	High Voltage Input Pins (OS1, OS2, OS3)	-0.3 to 55	V
V_{SW1}, V_{SW2}, V_{SW3}	Low Voltage Pins (SW1, SW2, SW3)	-0.3 to 6.5	V
T_J	Operating Junction Temperature	-40 to +150	°C
T_{ST}	Storage Temperature	-55 to +150	°C

Note: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods may affect device reliability.
Voltage Rating in this table indicates Maximum Stress Voltages during latch-up immunity test

ESD Ratings

Symbol	Parameter		Rating	Unit
V_{ESD}	Human-Body Model (HBM), Per AEC Q100-002 (Note 5)	All PWMx versus GND and Vin versus GND	±6000	V
		All pin combinations	±2000	
	Charged-Device Model (CDM), per AEC Q100-011		±1000	

Note: 5. AEC-Q100-002 indicates that HBM stressing shall be accordance with the ANSI/ESDA/JEDEC JS-001 specification

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
T_A	Operating Ambient Temperature	-40	+125	°C

Package Thermal Data (Note 6)

Symbol	Thermal Resistance	TSSOP-14	Unit
$R_{\Theta JA}$	Junction-to-ambient thermal resistance	138.1	°C/W
$R_{\Theta JC(top)}$	Junction-to-case (top) thermal resistance	33.6	°C/W
$R_{\Theta JB}$	Junction-to-board thermal resistance	64.6	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	1.9	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	62.6	°C/W
$R_{\Theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	24.4	°C/W

Note: 6. Device mounted on FR-4 PCB (51mm × 51mm 2oz copper); minimum recommended pad layout on top layer and thermal vias to bottom layer ground plane. For better thermal performance, larger copper pad for heat-sink is required.

Electrical Characteristics (6.17V < V_{in} < 16V, Transistor NPN = BCP56TA or NMOS = DMG3402LQ, T_J = -40°C to +150°C)

Characteristic	Conditions		Min	Typ	Max	Unit
General Parameters						
Supply Current	Vin = 14 V, all PWMx > 2.2V, SWx current subtracted		2.2	5.2	10	mA
	Vin = 14 V, all PWMx = 0V		30	185	380	µA
Undervoltage Lockout	Vin rising		2.24	3.35	4.43	V
Undervoltage Lockout Hysteresis	-		-	1.6	-	V
Thermal Shutdown (TSD)	(Note 7)		155	170	190	°C
Thermal Hysteresis	(Note 7)		-	44	-	°C
Switch Driver						
Output Source Current	SWx = 0.7 V -40°C ≤ T_J ≤ +25°C		25	50	-	mA
Output Source Current	SWx = 0.7 V +25°C ≤ T_J ≤ +125°C		15	30	-	mA
Output Source Current	SWx = 0.7 V +125°C ≤ T_J ≤ +150°C		7.0	15	-	mA
SWx (PWMx = HIGH)	ISWx = -100 µA, 7 V < VIN < 19 V		4.5	5.5	6.5	V
	ISWx = -100 µA, 6.17 V < VIN < 16 V		4.5	-	-	V
VSWx_Dropout (VIN – VSWx)	5.5V > VIN > 3.5 V, PWMx = High	ISWx = -100µA	-	45	150	mV
		ISWx = -10µA	-	45	150	mV
		ISWx = 0µA	-	45	150	mV
Open Load						
Open Load Detection Threshold	PWMx High		0.7	0.85	1.0	V
Open Load Blanking Time	-		10	22	35	µs
Short Circuit to VIN						
Short Circuit Detection Threshold	PWMx High		VIN-1.0	VIN-1.2	VIN-1.4	V
Input pull-up current on OSx pins	Tested at V(OSx) = Vin - 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	PWMx Low		0.7	0.85	1.0	V
Short Circuit Blanking Time	Tested at 15V		10	22	35	µs
PWMx						
Input High Threshold	-		-	-	2.2	V
Input Low Threshold	-		1.1	-	-	V
Hysteresis	-		-	0.52	-	V
Input Pulldown Resistor	Tested at V(PWMx) = 15 V		75	150	300	kΩ
PWMx Clamp Voltage in error mode	PWMx > 5V, 2 mA < I(PWMx) < 9.5 mA		2.80	3.15	3.46	V
AC Characteristics						
Propagation Delay PWMx rising to $Iout_{BJT}$	50% criterion (Note 8)		-	5	15	µs
Propagation Delay PWMx falling to $Iout_{BJT}$	50% criterion (Note 8)		-	5	15	µs
Propagation Delay PWMx rising to $Vout_{NMOS}$	From PWMx input high threshold to 90% rising of SWx_ON Voltage, C_{load} = 470 pF		-	-	5	µs
Propagation Delay PWMx falling to $Vout_{NMOS}$	From PWMx input low threshold to 10% falling of SWx_ON Voltage, C_{load} = 470 pF		-	-	5	µs

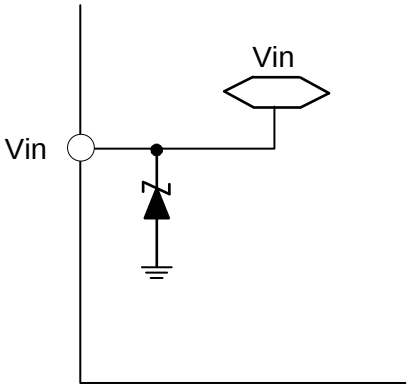
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

Notes: 7. Guaranteed by design.
8. Evaluated at Vin = 14V.

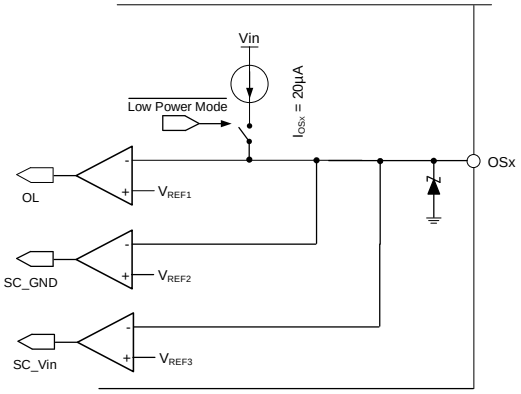
Typical Performance Characteristics

Equivalent schematics

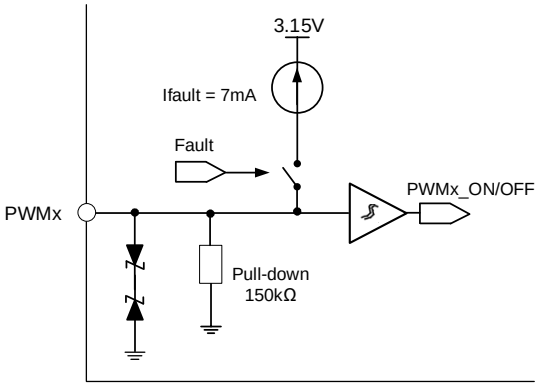
The following figure gives the equivalent schematics of the user relevant inputs and outputs. The diagrams are simplified representations of the circuits used.



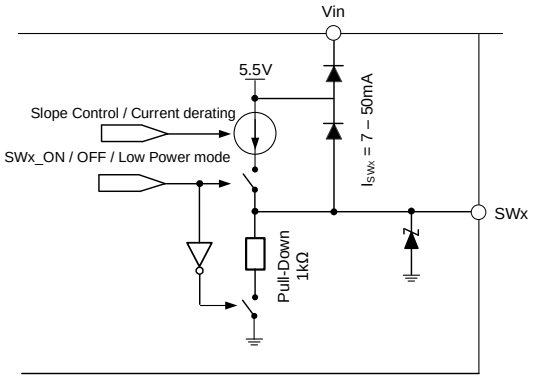
Type 1: Vin supply pin



Type 2: OSx input pins



Type 3: PWMx output pins



Type 4: SWx output pins

Figure 3. Input and Output Equivalent Diagrams

Application Information

Detailed Operating Description

The AL5836Q 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 VCE or the VDS of the transistor, is supposed to be above 1V in normal operation. Dimming is performed using the dedicated PWM at the IC's PWMx pins.

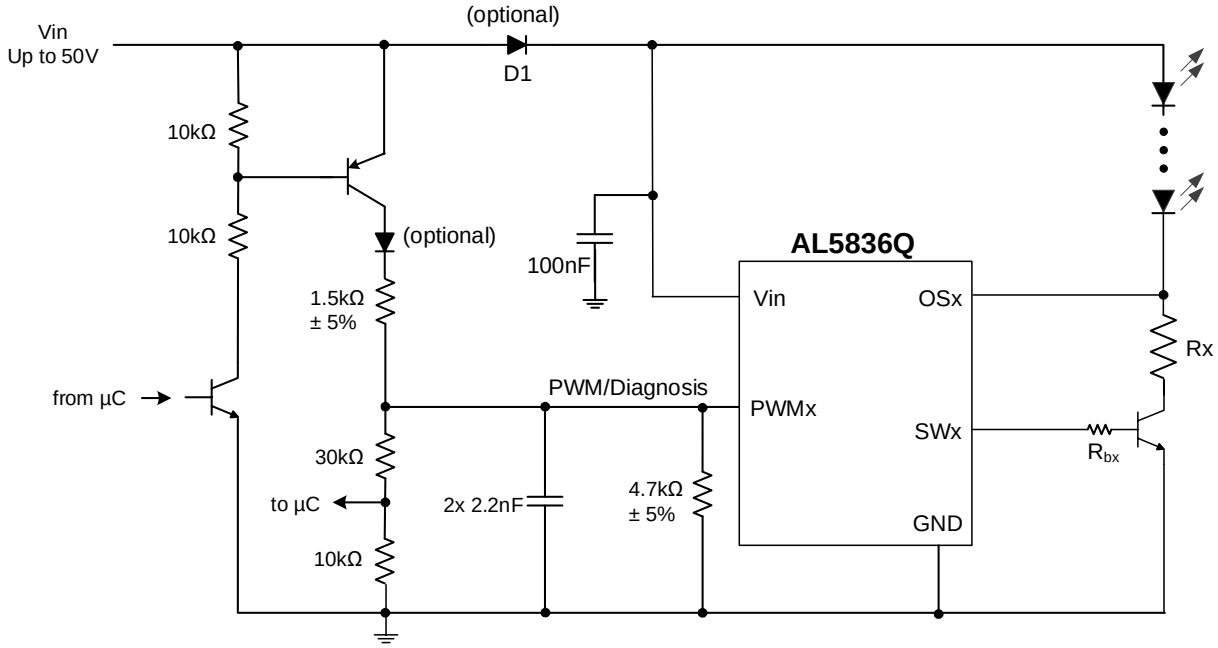
Output Drive

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

$$I_{LED} = \frac{Vin - VF - VDROP}{R} \times PWMDC$$

Where;

Vin is the Automotive Battery input voltage,
VF is the sum of the forward voltage of the LEDs,
VDROP is either VCEsat (saturation voltage of the chosen BJT) or VDS (in case NMOSFET is chosen),
PWMDC is the Duty Cycle present at the input of the PWMx pins and
R the series resistance with the LEDs (typical value range is in between 50 and 100 Ω).



PWMx = PWM1, 2, 3, OSx = OS1, 2, 3 and SWx = SW1, 2, 3

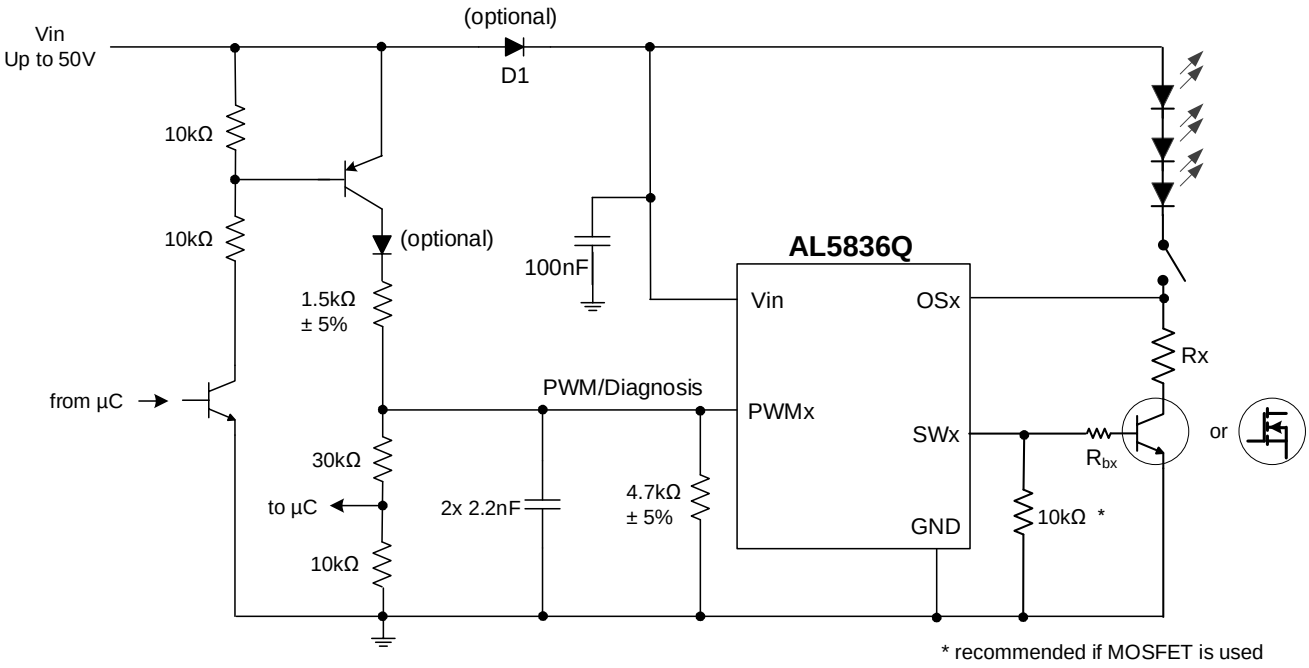
Figure 4. Output Drive Configuration

Application Information (continued)

Open Load Detection

Faulted output strings due to open load conditions sometimes require detection in an automotive rear lighting system.

When LED driver is ON (PWM is active high) and the voltage on the OSx pin is detected below 0.85V for more than 22µs typical, an open load error is activated. The PWMx pin is pulled down to 3.15V typical, allowing the microcontroller 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 will work properly and the diagnostic flag disappears.



OSx = OS1, 2, 3 and SWx = SW1, 2, 3

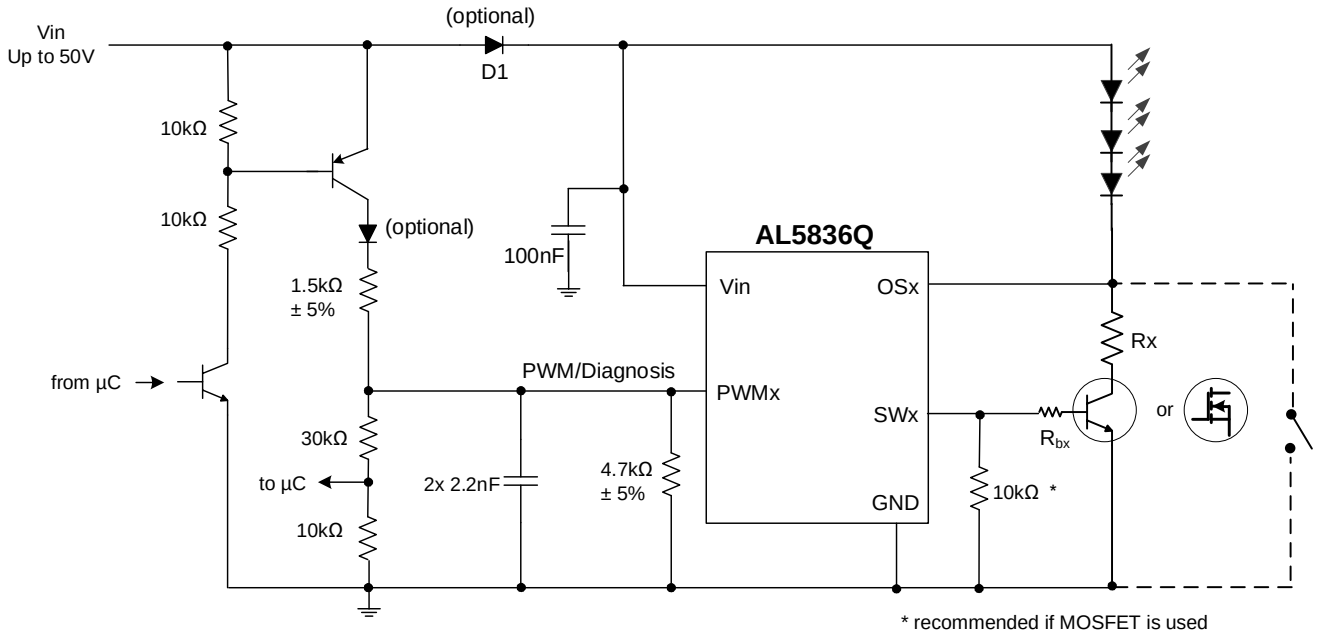
Figure 5. Open Load Detection

Application Information (continued)

Short Circuit to Ground Detection

The OSx 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 the LED driver is OFF (PWM is low) and the voltage on the OSx pin is detected below 0.85V for more than 22µs typical, then a short to Ground is latched. The PWMx pin is then pulled down to 3.15V typical, allowing the microcontroller to detect the error when the PWM input signal is activated High. During short to Ground condition, the driver stays active. If the short circuit disappears, the device works properly on the next falling edge of the PWM input pin.

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



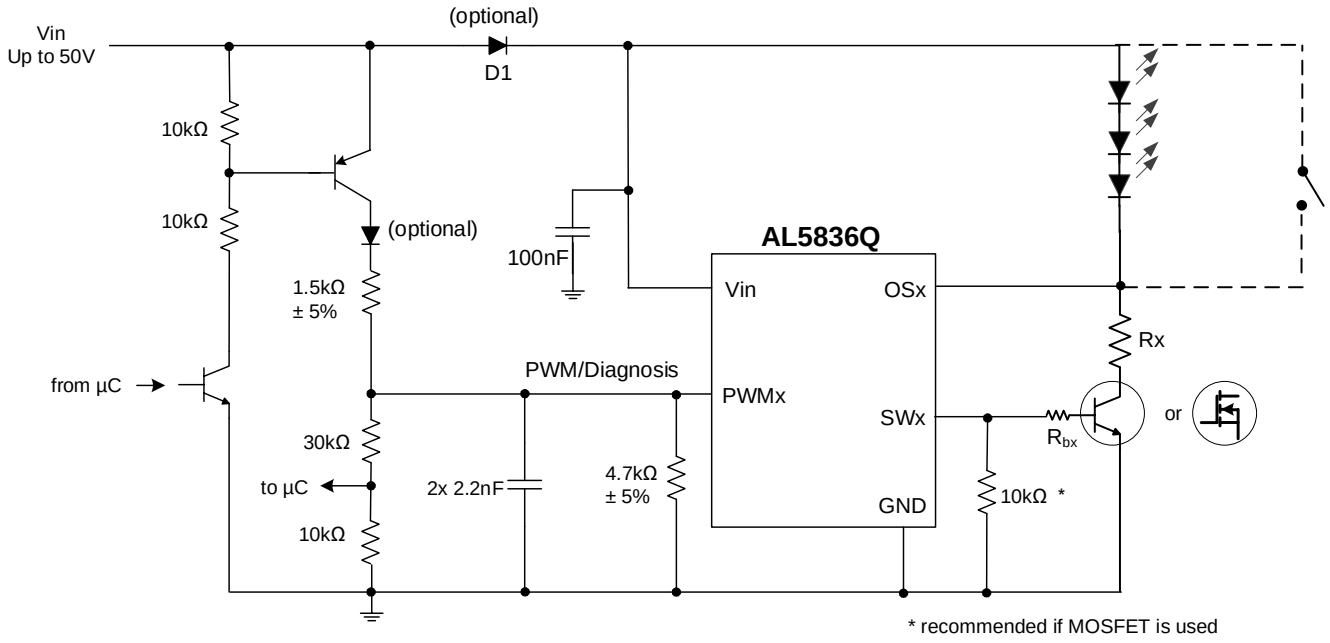
PWMx = PWM1, 2, 3, OSx = OS1, 2, 3 and SWx = SW1, 2, 3

Figure 6. Short Circuit to Ground Detection

Application Information (continued)

Short Circuit to Vin Detection

The OSx 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 as 1.2V typical down from the VIN pin. If a voltage is less than 1.2V between VIN and OSx for more than 10µs, this channel's short to Vin fault is detected. The PWMx pin is then pulled down to 3.15V typical, allowing the microcontroller to detect the error when the PWM input signal is activated High. Because of the potentially large power dissipation during this error, the driver is switched OFF. If the short disappears, the device will resume normal working conditions. In case multiple strings are connected to the same driver (see Figure 9), this error is only detected at the condition that each string is shorted to VIN (a single string detection is not detected because of the blocking diodes).



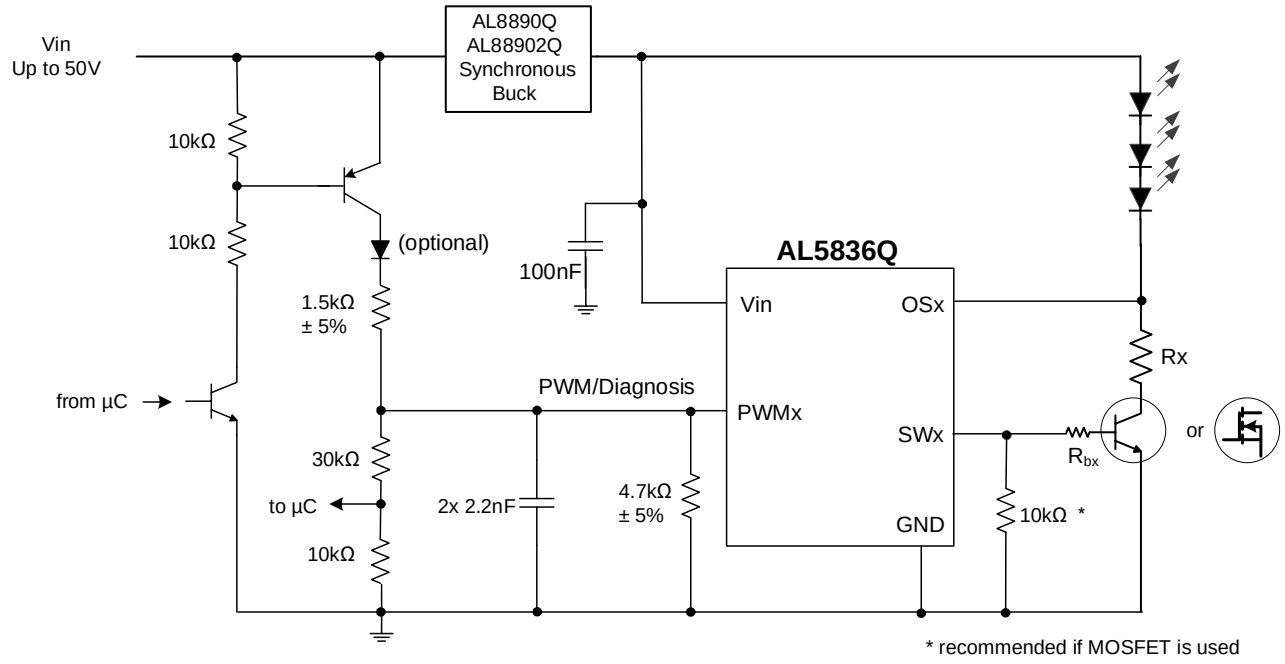
PWMx = PWM1, 2, 3, OSx = OS1, 2, 3 and SWx = SW1, 2, 3

Figure 7. Short Circuit to Vin Detection

Thermal Shutdown

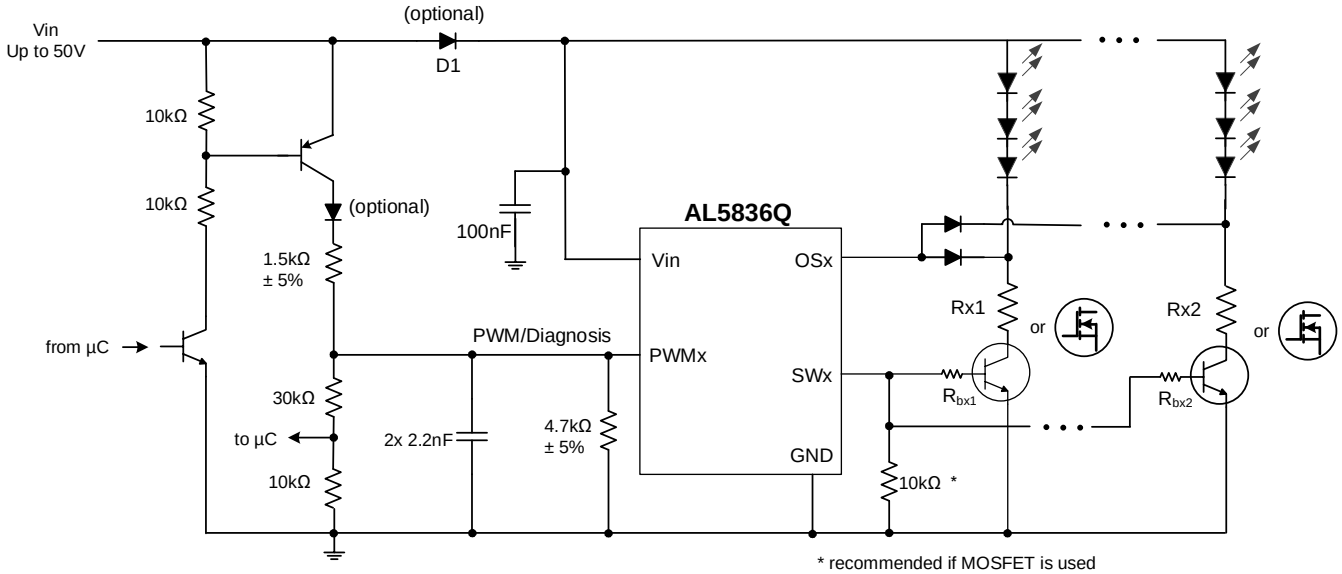
The thermal shut down circuit checks the internal junction temperature of the device. When the internal temperature rises above the Thermal Shutdown Threshold all the output SWx channels are switched off. A filter is implemented to avoid parasitic thermal shutdown. A thermal shutdown causes a fault detection and pulls the PWMx pins down to 3.15V typical. When the temperature drops below the thermal shutdown threshold, plus the hysteresis, the fault condition is cleared and normal operation is restored.

Application Information (continued)



OSx = OS1, 2, 3 and SWx = SW1, 2, 3

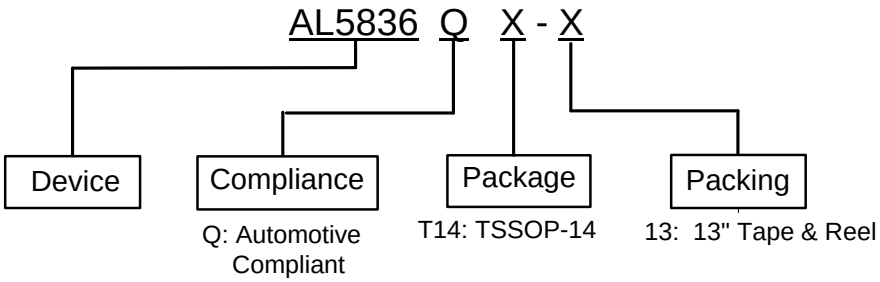
Figure 8. Application diagram with a DC-DC



OSx = OS1, 2, 3 and SWx = SW1, 2, 3

Figure 9. Application diagram for multiple strings

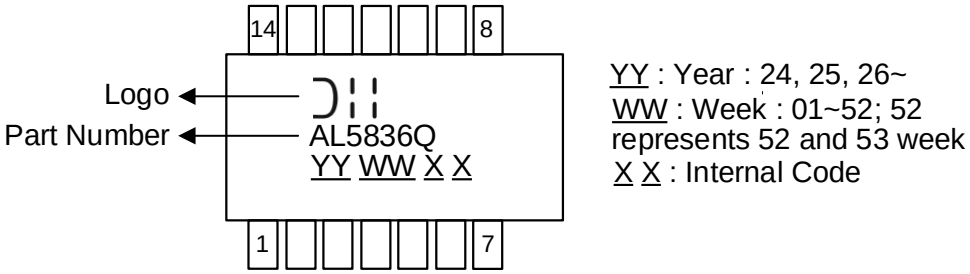
Ordering Information



Orderable Part Number	Package Code	Package	Packing		
			Quantity	Carrier	Part Number Suffix
AL5836QT14-13	T14	TSSOP-14	2500	13” Tape and Reel	-13

Marking Information

(Top View)

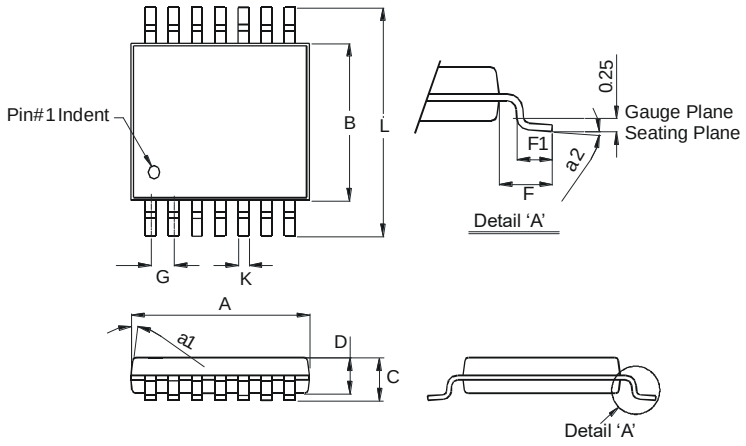


Orderable Part Number	Package
AL5836QT14-13	TSSOP-14

Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

TSSOP-14

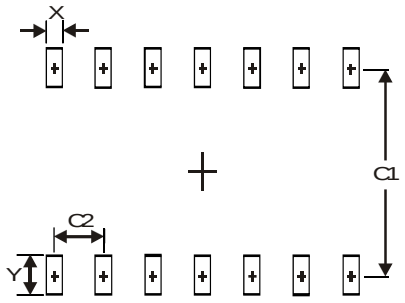


TSSOP-14		
Dim	**Min**	**Max**
a1	7° (4X)	
a2	0°	8°
A	4.9	5.10
B	4.30	4.50
C	-	1.2
D	0.8	1.05
F	1.00 Typ	
F1	0.45	0.75
G	0.65 Typ	
K	0.19	0.30
L	6.40 Typ	
All Dimensions in mm		

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

TSSOP-14



Dimensions	Value (in mm)
X	0.45
Y	1.45
C1	5.9
C2	0.65

Tape and Reel Information

Please see https://www.diodes.com/assets/Packaging-Support-Docs/AP02007.pdf for tape and reel details.

Mechanical Data

- Moisture Sensitivity: MSL Level 1 per J-STD-020
- Terminals: Finish - Matte Tin Plated Leads, Solderable per JESD22-B102 (e3)
- Weight: 0.052 grams (Approximate)

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