4-CH 150mA Constant Current LED Driver

General Description

The RT8300 is a 4-CH 150mA constant current sink LED driver capable of driving four channel constant currents with good matching ability and wide range V_F variations.

The RT8300 provides four channel constant currents with less than 3% differences in output current value among the 4-CH and ICs respectively. The constant current output is adjustable from 5mA to 150mA via an external resistor (R_{ISET}). The LED brightness can also be adjusted via the PWMI pin with pulse width modulation from 0% to 100%. Thus allowing for wide V_F variation. Moreover, the RT8300 provides Dynamic Headroom Control (DHC) function which can generate feedback signal to DC/DC control loop and regulate the output voltage of the RT8300.

The RT8300 features LED open/short protection. If any channel has open or short condition, that particular output channel will be turned off and the FAULT pin will pull low. The RT8300 also supports Over Temperature Protection (OTP). When OTP is triggered, all output channels will be turned off and the FAULT pin will pull low.

The RT8300 is available in DIP-16 (BW) and SOP-16 packages to achieve optimized solution for PCB space.

Ordering Information

RT8300□□

- Package Type
  - N : DIP-16 (BW)
  - S : SOP-16
- Lead Plating System
  - G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

Features

- **4 Constant Current Output Channels**
- **Wide Power Supply Voltage Range : 5V to 24V**
- **Maximum Constant Current Output Voltage : 60V**
- **Low Dropout Voltage : 600mV at 120mA Output Current**
- **Constant Output Current Accuracy Between Channels : <±3%**
- **Dynamic Headroom Control (DHC) Function**
- **Constant Output Current Range : 5mA to 150mA**
- **Support 400ns Narrow PWM Pulse**
- **Fault Detection for OTP, LED Open/Short**
- **RoHS Compliant and Halogen Free**

Applications

- LED Backlight

Marking Information

RT8300GN

RichTek RT8300 GNYMDNN

RT8300GN : Product Number

YMDNN : Date Code

RT8300GS

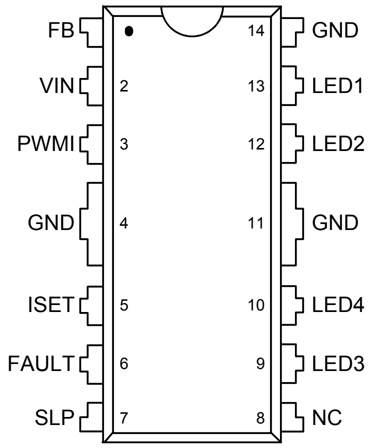
RT8300 GSYMDNN

RT8300GS : Product Number

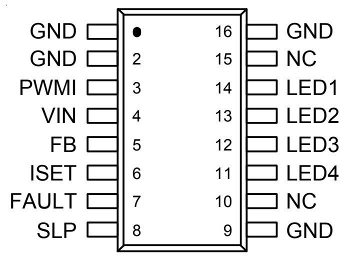
YMDNN : Date Code

Pin Configurations

(TOP VIEW)

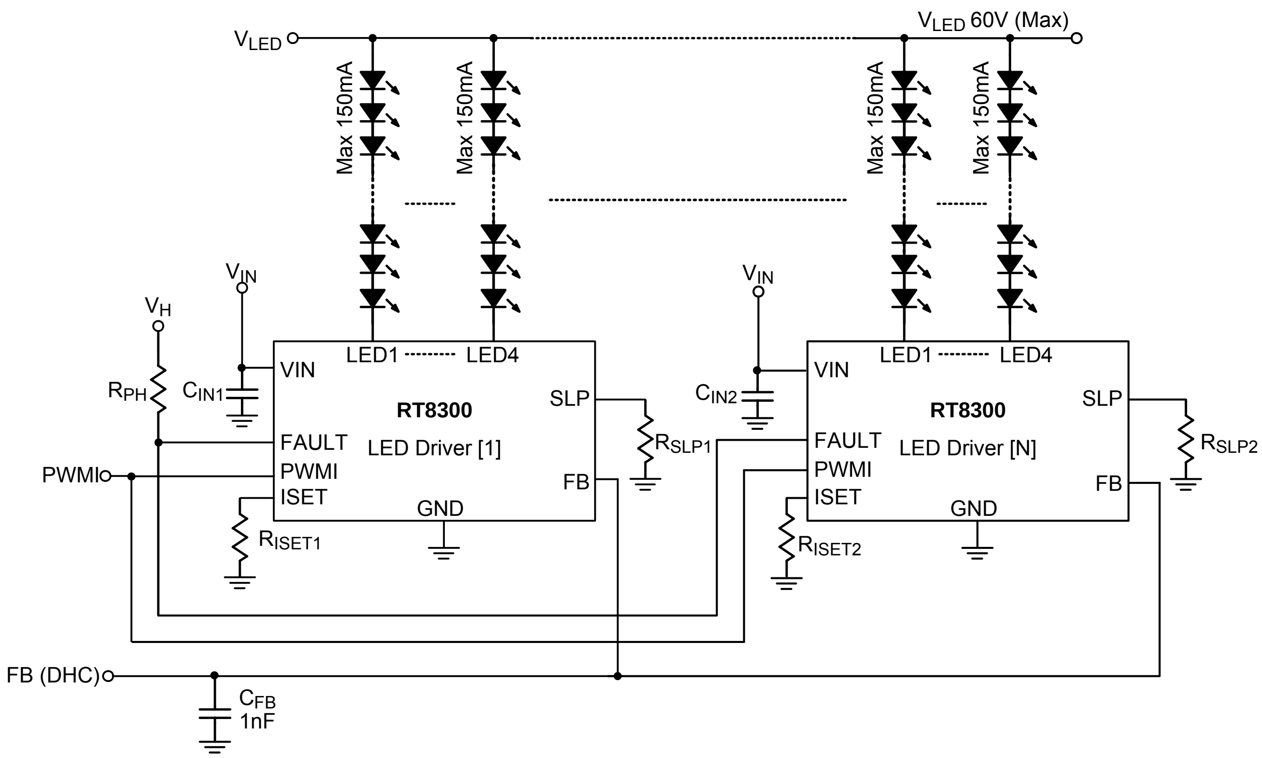


DIP-16 (BW)



SOP-16

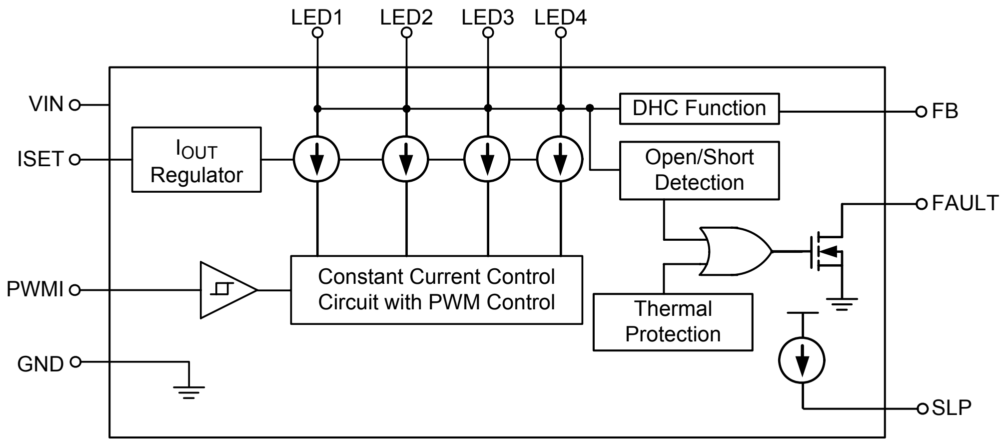
Typical Application Circuit



Functional Pin Description

Pin No.		Pin Name	Pin Function
DIP-16 (BW)	SOP-16		
3	3	PWMI	Constant Current Output Channel Enable/Disable Input. High : Enable, Low : Disable
2	4	VIN	Power Supply Input.
1	5	FB	Feedback Control Voltage Output.
5	6	ISET	Constant Current Set Pin. Connect to an external resistor to adjust constant current output.
6	7	FAULT	Open Drain Output for Fault Detection.
7	8	SLP	LED Short Protection Voltage Set Pin.
4, 11, 14	1, 2, 9, 16	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
10, 9, 12, 13	11 to 14	LED4 to LED1	Constant Current Sink Output.
8	10, 15	NC	No Internal Connection.

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, V_{IN} ---------- –0.3V to 32V
- Output Voltage LED1 to LED4 ---------- –0.3V to 70V
- FB, PWMI, FAULT, ISET to GND ---------- –0.3V to 28V
- Power Dissipation, P_D @ T_A = 25°C
  DIP-16 (BW) ---------- 2.5W
  SOP-16 ---------- 1.176W
- Package Thermal Resistance (Note 2)
  DIP-16 (BW), θ_{JA} ---------- 40°C/W
  SOP-16, θ_{JA} ---------- 85°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C

Recommended Operating Conditions (Note 3)

- Supply Input Voltage, V_{IN} ---------- 5V to 24V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 24V, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Under Voltage Lockout Threshold		V_{UVLO}	VIN Rising	--	3.6	--	V
			VIN Falling	--	3.1	--	
Output Voltage		V_{LEDx}	LED1 to LED4, all CHs off	--	--	60	V
LED Current Accuracy		I_{LEDX2}	V_{LEDX} = 0.6V, R_{ISET} = 900Ω	116.4	120	123.6	mA
LED Current Matching		dI_{LEDX2}	I_{LEDX} = 120mA, V_{LEDX} = 0.6V, R_{ISET} = 900Ω	--	±0.5	±3	%
Output Current vs. Output Voltage Regulation		$\%/dV_{LEDX}$	V_{LEDX} within 0.5V and 3V, R_{ISET} = 900Ω	--	±0.1	±0.5	%/V
Output Current of SLP		I_{SLP}	V_{SLP} = 0.43V to 2V	--	16	--	μA
SLP Pin Voltage		V_{SLPH}	V_{LEDX} = 14V	--	2	--	V
		V_{SLPL}	V_{LEDX} = 3.03V	--	0.43	--	
Open LED Protection (OLP) Voltage		V_{OLP}	V_{LEDx}	--	50	--	mV
PWMI Input Voltage	Logic-High	V_{PWMIH}	T_A = –40°C to 85°C	2	--	--	
	Logic-Low	V_{PWMIL}	T_A = –40°C to 85°C	--	--	0.8	
Feedback Voltage		V_{FBH}	I_{FBH} = 50μA	--	3.3	--	V
		V_{FBL}	I_{FBL} = 1mA	--	0.2	--	

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
FB Pin Output Current	I_{FBH}	V_{FB} = 3.3V	--	50	--	μA
	I_{FBL}	V_{FB} = 0.2V	--	1	--	mA
Output Leakage Current	I_{OH}	V_{LEDx} = 50V, all CHs off, PWMI = Low	--	---	0.5	μA
Thermal Protection Temperature	T_{OTP}	Junction Temperature	--	140	--	°C
Thermal Protection Temperature Hysteresis	ΔT_{OTP}	Junction Temperature	--	50	--	°C
Supply Current	$I_{DD(ON)}$	R_{ISET} = 3.6kΩ, PWMI = High	--	3	5	mA
Shutdown Current	I_{SHDN}	Shutdown	--	6	20	μA
PWMI to LEDx Propagation Delay Time — Low to High Transition	t_{PLH}		0.1	0.3	0.6	μs
PWMI to LEDx Propagation Delay Time — High to Low Transition	t_{PHL}		0.05	0.1	0.4	μs
Shutdown Delay Time	t_{SHDN}		--	32	--	ms
Power On Reset Time	t_{RESET}		--	256	--	μs
Soft-Start Time	t_{SS}		--	128	--	ms
Fault Blanking Time	t_{FB}	PWM = 100%	--	32	--	ms
PWMI High Blanking Time	t_{RB}		--	4	--	μs
Fault Detection Time	t_F		--	2	--	μs

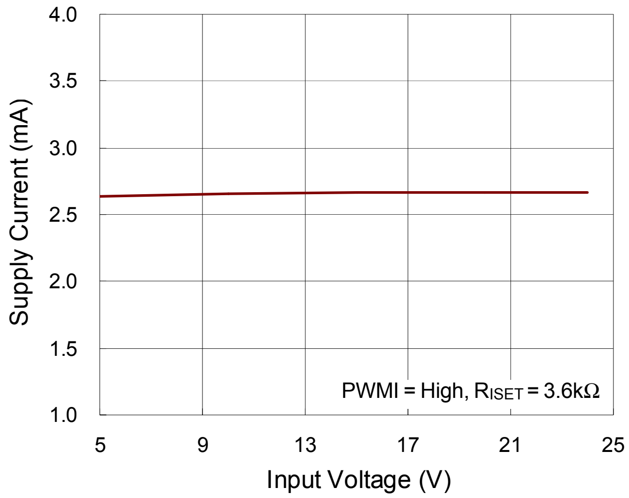
Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ_{JC} is measured at the exposed pad of the package.

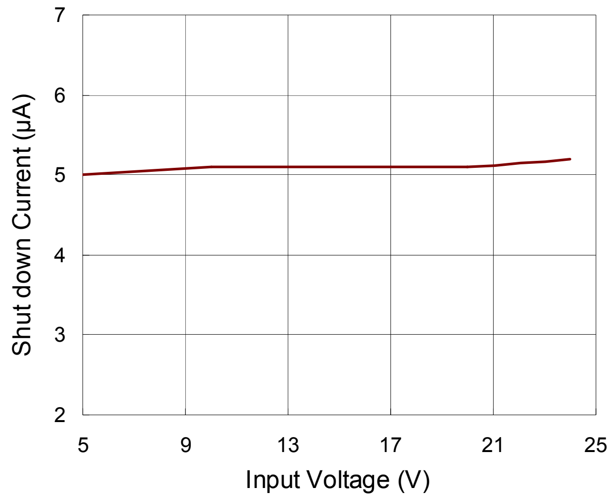
Note 3. The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics

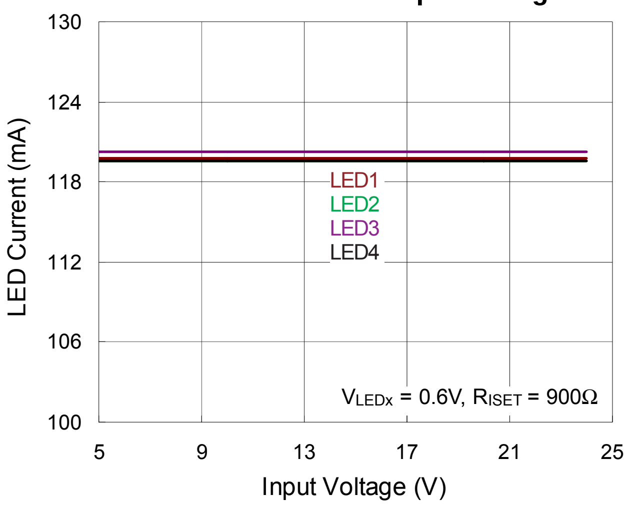
Supply Current vs. Input Voltage



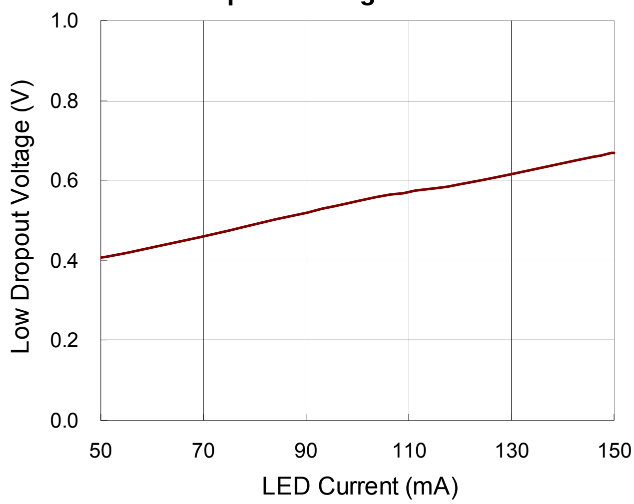
Shutdown Current vs. Input Voltage



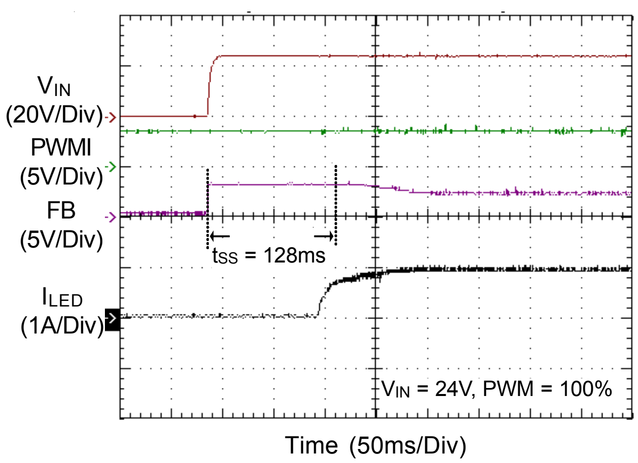
LED Current vs. Input Voltage



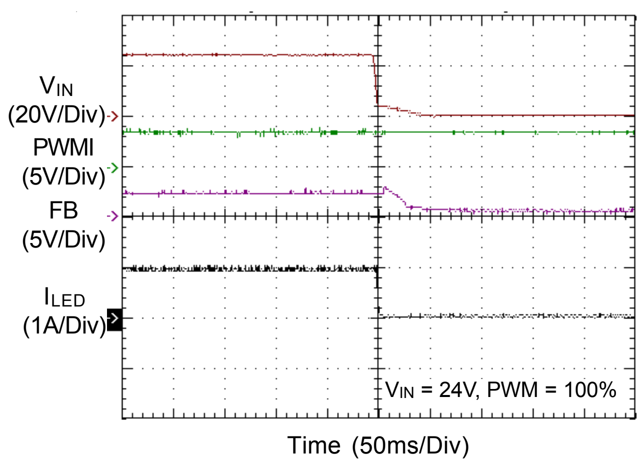
Low Dropout Voltage vs. LED Current



Power On Sequence



Power Off Sequence



Application Information

The RT8300 is a 4-CH LED current source controller with an internal N-MOSFET driver. The RT8300 regulates the lowest voltage of the LED strings and generates a feedback control signal to a primary controller to regulate the LED current. Each LED channel current is accurately matched and controlled by sensing an internal resistor in series with the MOSFET. All channels' LED brightness can be precisely controlled by applying a PWM signal to the PWMI pin. The RT8300 also features several protections including Short LED Protection (SLP), Open LED Protection (OLP), and Over Temperature Protection (OTP).

LED Current Setting

Each channel's LED current can be calculated by following equation :

$$I_{LED} \cong \frac{108}{R_{ISET}}$$

Where R_{ISET} is the resistor between the ISET pin and GND. This setting is the reference for the LED current at the LED pin and represents the sensed LED current for each string.

Brightness Control

The RT8300 brightness dimming control is decided by the signal on the PWMI pin. Refer to the following figure. The minimum dimming duty can be as low as 1% for the 200Hz frequency.

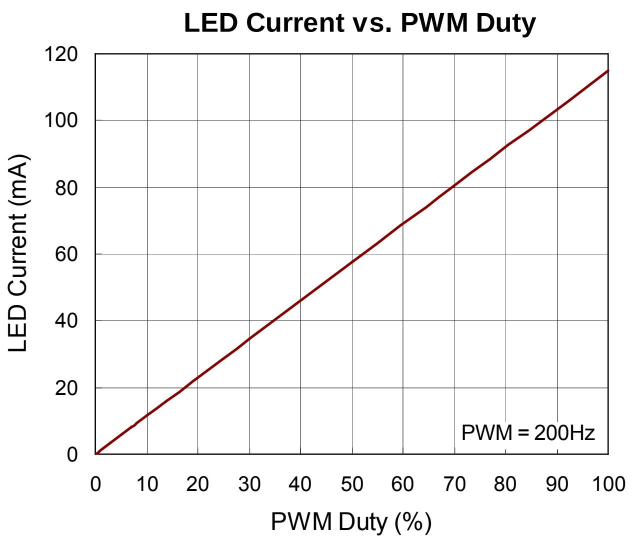


Figure 1

Dynamic Headroom Control Function

The Dynamic Headroom Control (DHC) function is used to generate feedback signal to primary DC/DC control loop and regulate the LED current of the RT8300. This function can improve IC's thermal performance and efficiency. The R1, R2 and R3 selection is shown in below equation :

$$V_{OUT\ (Default)} = V_{REF}\left(1+\frac{R1}{R2}\right)$$

$$V_{OUT\ (MAX)} = V_{OUT\ (Default)} + R_1\left(\frac{V_{REF} - 0.2}{R3}\right)$$

$$V_{OUT\ (MIN)} = V_{OUT\ (Default)} + R_1\left(\frac{V_{REF} - 3.3}{R3}\right)$$

$$R3_{\ (MIN)} = \left|\frac{V_{FB} - V_{REF}}{I_{FB(typ.)}}\right|$$

Where V_{OUT} is converter output voltage, V_{REF} is converter reference voltage and typical I_{FB} is 50μA. The connection is shown as the following figure.

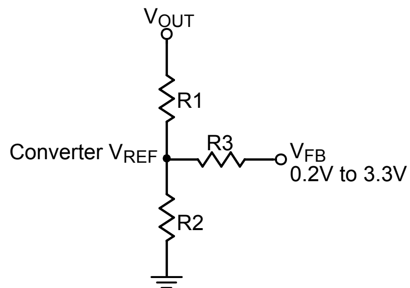


Figure 2

Power On and Power Off Sequence

When power converter output voltage and V_{IN} are both ready. PWMI pulled high will enable the RT8300, and IC will check channel unused or not in first period (256μs).The unused channel is needed to short to GND or FAULT will be turned on. The second period is 128ms soft start time, the RT8300 feedback voltage is 3.3V in this period. Then, IC gets into the fault blanking time (32ms) when PWM duty is 100% since fault blanking counter depends on the PWM on period. After the third period, fault function will turn on. About power off sequence, IC will shut down after 32ms when PWMI pin is pulled low. The power on and power off sequence are shown as the following figure.

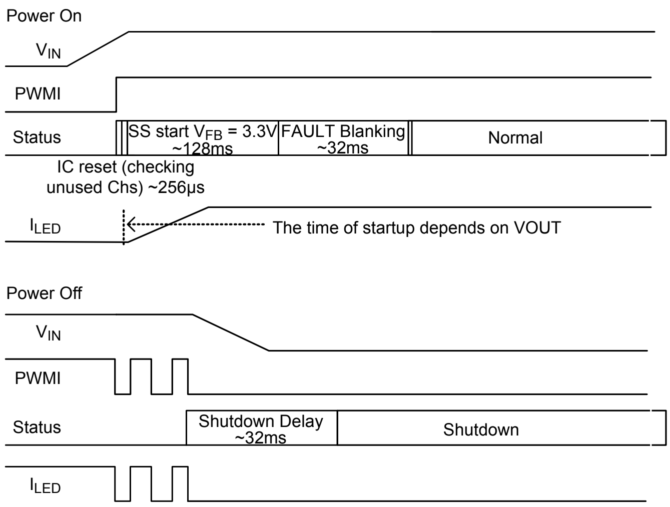


Figure 3

Over Temperature

The RT8300 has an Over Temperature Protection function to prevent excessive power dissipation from overheating the device. The OTP will disable all channels if the junction temperature exceeds 140°C and sends a fault signal. The channels are re-enabled when the junction temperature cools down by approximately 50°C.

Open LED Protection

If the V_{LEDx} is < 50mV after a fault blanking period, the counter will be triggered when PWM is high. Moreover, there is a 4μs blanking time on every rising part of PWM. When the counter accumulates to 2μs, only this open channel will be off but not latched. The FAULT will be turned on and pulled low.

Short LED Protection

If the voltage of V_{LEDx} is >112 x 10^{-6} x R_{SLP} (7 x V_{SLP}) after fault blanking period, the counter will be triggered when PWM is high. Moreover, there is a 4μs blanking time on every rising part of PWM. When the counter accumulates to 2μs, this short channel will be off and latched. The FAULT pin will be pulled low. The fault state can only be released by PWM off after 32ms. The operation and protection flow is shown as the following figure.

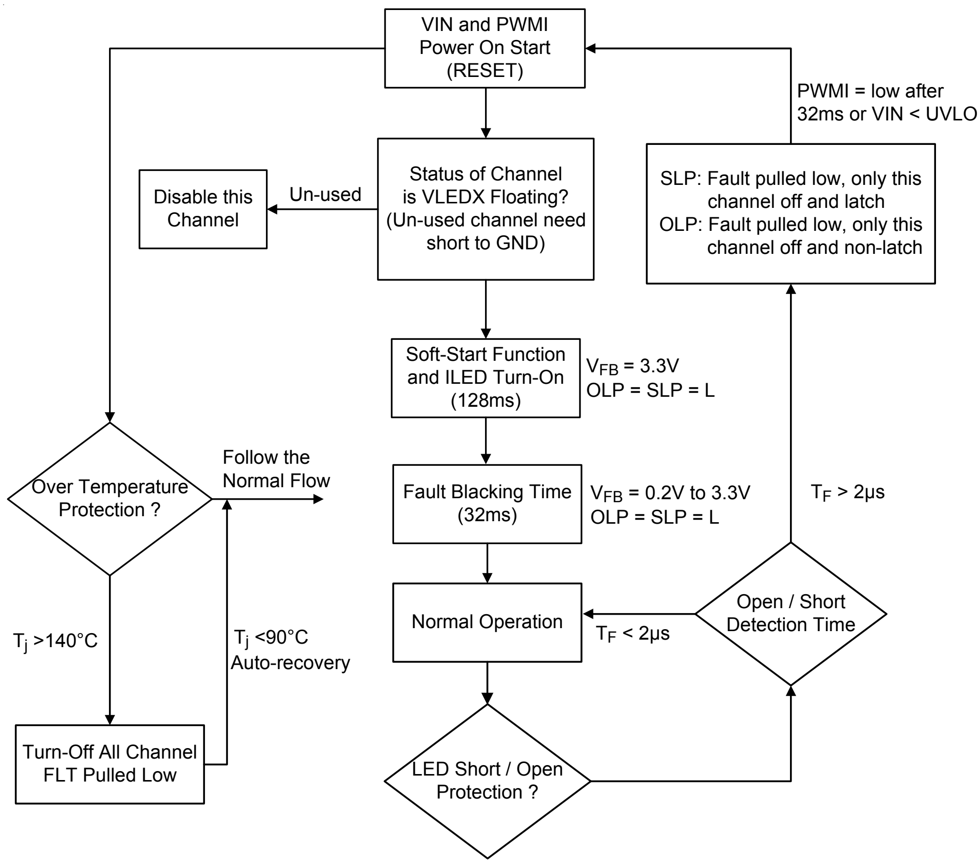


Figure 4

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications of the RT8300, the maximum junction temperature is 125°C and T_A is the ambient temperature. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For DIP-16 (BW) package, the thermal resistance, θ_{JA}, is 40°C/W on a standard JEDEC 51-7 four-layer thermal test board. For SOP-16 packages, the thermal resistance, θ_{JA}, is 85°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

$P_{D(MAX)}$ = (125°C − 25°C) / (40°C/W) = 2.5W for DIP-16 (BW) package

$P_{D(MAX)}$ = (125°C − 25°C) / (85°C/W) = 1.176W for

SOP-16 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. For the RT8300 packages, the derating curves in Figure 5 allow the designer to see the effect of rising ambient temperature on the maximum power dissipation.

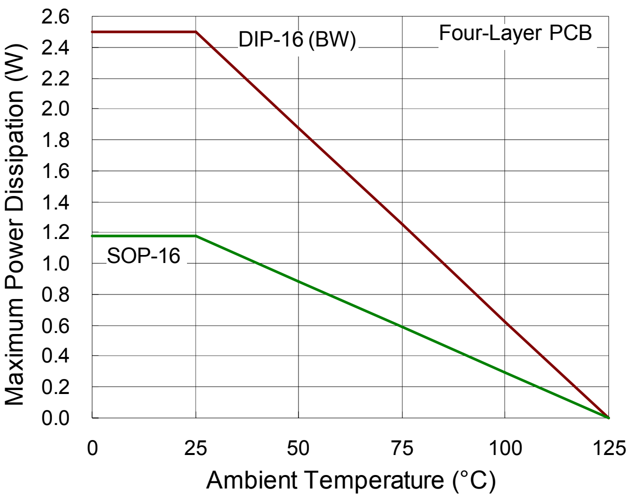
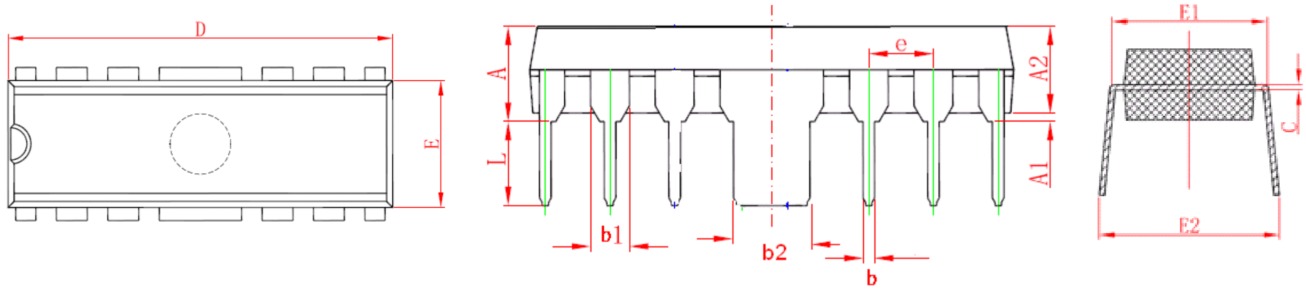


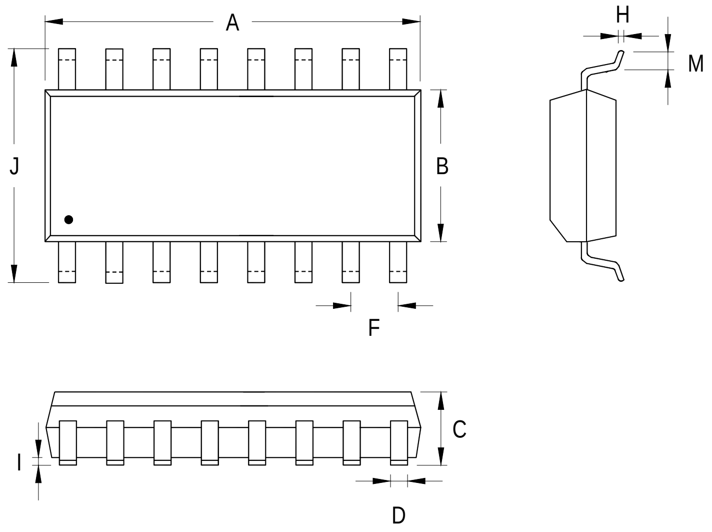
Figure 5. Derating Curves for the RT8300 Packages

Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.700	4.320	0.146	0.170
A1	0.381	0.710	0.015	0.028
A2	3.200	3.600	0.126	0.142
b	0.360	0.560	0.014	0.022
b1	1.143	1.778	0.045	0.070
b2	2.920	3.100	0.115	0.122
c	0.204	0.360	0.008	0.014
D	18.80	19.30	0.740	0.760
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
E2	8.350	9.250	0.329	0.364
e	2.540		0.100	
L	3.000	3.600	0.118	0.142

16-Lead DIP (BW) Plastic Package



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	9.804	10.008	0.386	0.394
B	3.810	3.988	0.150	0.157
C	1.346	1.753	0.053	0.069
D	0.330	0.508	0.013	0.020
F	1.194	1.346	0.047	0.053
H	0.178	0.254	0.007	0.010
I	0.102	0.254	0.004	0.010
J	5.791	6.198	0.228	0.244
M	0.406	1.270	0.016	0.050

16–Lead SOP Plastic Package

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