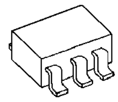
Constant Current LED Driver with PWM Dimming Control

■ GENERAL DESCRIPTION

The NJW4615A is a constant current LED driver with PWM dimming control. The output current can be set by external sensing resister, and the NJW4615A can set up to 100mA.
Because the withstand voltage of the output (LED) pin is 35V, it can series-connect the LED depending on forward voltage of the LED.
The LED dimming control can be regulated via PWM duty cycle.
It is suitable for back light, light source and so on.

■ PACKAGE OUTLINE

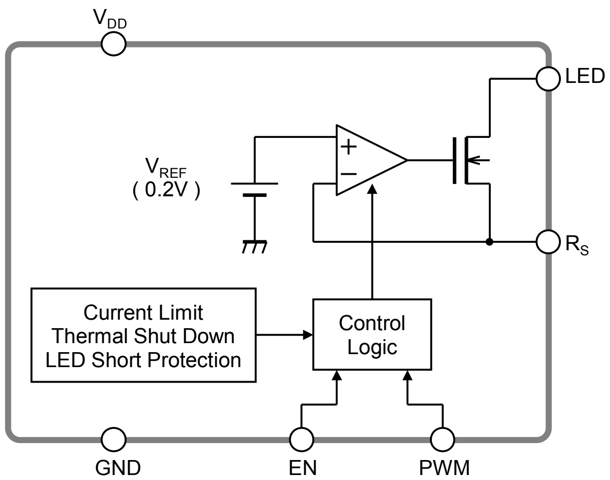


NJW4615AF1
(SOT-23-6-1)

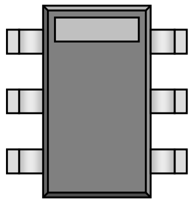
■ FEATURES

- Supply Voltage Range 2.5V to 35V
- Output Voltage V_{LED} = 35V max.
- Output Current I_{LED} = 5mA to 100mA
- Output Current Accuracy ± 1.2%
- To 10 of White LED can be operated. (at LED Vf=3.2V)
- Quiescent Current 370µA max.
- PWM Dimming Control
- Enable Function
- Over Current Protection (with Hysteresis)
- Thermal Shutdown Protection
- LED Short Protection
- Package SOT-23-6-1

■ BLOCK DIAGRAM



■ PIN CONFIGURATION



■ PIN DESCRIPTIONS

Pin No.	Pin Name	I/O	Function
1	PWM	I	PWM signal input pin for dimming control. The LED dimming control can be regulated by PWM duty cycle. When this pin is open or input High level, I_{LED} becomes set current by an external resistor (R_S).
2	GND	-	Ground pin
3	R_S	O	Resistor connect pin of I_{LED} setting. The LED current can be set with connected resistor (R_S) between R_S pin and GND pin. R_S [Ω] = 0.2 [V] / I_{LED} [A]
4	LED	O	Constant current circuit output pin Connect cathode pin of LED.
5	EN	I	Standby control pin Normal operation: High Level. Standby mode: Low Level.
6	V_{DD}	-	Power supply pin

■ ABSOLUTE MAXIMUM RATINGS

(Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{DD}	-0.3 to +40	V
Output Voltage	V_{LED}	-0.3 to +40	V
EN Pin Voltage	V_{EN}	-0.3 to +40	V
PWM Pin Voltage	V_{PWM}	-0.3 to +6	V
Power Dissipation	P_D	510 (*1) 710 (*2)	mW
Junction Temperature Range	T_j	-40 to +150	°C
Operating Temperature Range	T_{opr}	-40 to +125	°C
Storage Temperature Range	T_{stg}	-50 to +150	°C

(*1) Mounted on glass epoxy board based on EIA/JEDEC. (76.2 × 114.3 × 1.6mm: 2Layers FR-4)

(*2) Mounted on glass epoxy board based on EIA/JEDEC. (76.2 × 114.3 × 1.6mm: 4Layers FR-4), Internal Cu area: 74.2 × 74.2mm

■ RECOMMENDED OPERATING CONDITIONS

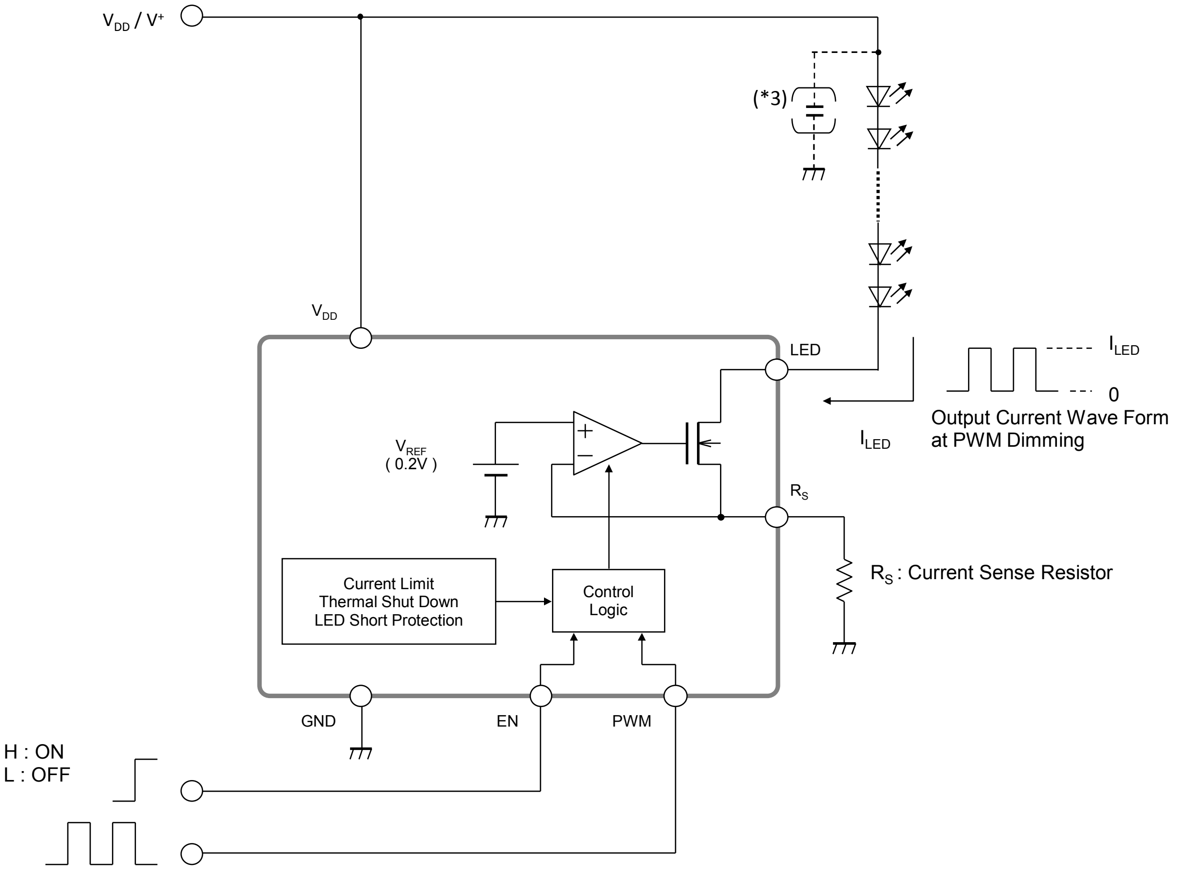
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply Voltage	V_{DD}		2.5	-	35	V
Output Current	I_{LED}		5	-	100	mA
Output Voltage	V_{LED}		-	-	35	V

■ ELECTRICAL CHARACTERISTICS

(Unless otherwise noted, V_{DD}= V_{EN}=12V, V_{LED}=1V, R_S=10Ω, V_{PWM}=OPEN, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Quiescent Current	I_{DD}		-	260	370	µA
Quiescent Current at OFF State	I_{DD_OFF}	V_{EN} = GND	-	-	0.1	µA
Output Current Accuracy	ΔI_{LED}		-1.2	-	+1.2	%
Output (LED) Pin Leak Current 1	$I_{LEAK}1$	V_{EN} = GND, V_{DD} = 35V, V_{LED} = 35V	-	-	0.1	µA
Output (LED) Pin Leak Current 2	$I_{LEAK}2$	V_{PWM} = GND V_{DD} = 35V, V_{LED} = 35V	-	-	0.1	µA
EN Pin ON Voltage	V_{EN_ON}	I_{LED} = OFF→ON	1.6	-	V_{DD}	V
EN Pin OFF Voltage	V_{EN_OFF}	I_{LED} = ON→OFF	0	-	0.3	V
PWM Pin ON Voltage 1	$V_{PWM\_ON}1$	V_{DD} < 5V, I_{LED} = OFF → ON	$0.7V_{DD}$	-	V_{DD}	V
PWM Pin OFF Voltage 1	$V_{PWM\_OFF}1$	V_{DD} < 5V, I_{LED} = ON → OFF	0	-	$0.3V_{DD}$	V
PWM Pin ON Voltage 2	$V_{PWM\_ON}2$	$V_{DD} \geq$ 5V, I_{LED} = OFF → ON	3.5	-	5.5	V
PWM Pin OFF Voltage 2	$V_{PWM\_OFF}2$	$V_{DD} \geq$ 5V, I_{LED} = ON → OFF	0	-	1.5	V
EN Pin Input Current	I_{EN}	V_{EN} = 12V	-	7	-	µA
PWM Pin Pull Up Resistance	R_{PWM}		-	1	-	MΩ
R_S Pin Output Current	I_{OUT_RS}	LED = OPEN	-	2.3	-	µA
PWM Pin ON Delay Time	t_{PWM_ON}	V_{PWM} = L → H, I_{LED} = OFF → ON	-	3	-	µs
PWM Pin OFF Delay Time	t_{PWM_OFF}	V_{PWM} = H → L, I_{LED} = ON → OFF	-	1	-	µs
LED Short Protection Detect Voltage	V_{LED_SHORT}		17	20	23	V
Maximum Output Current	I_{LED_MAX}	R_S = 0 Ω	100	170	-	mA

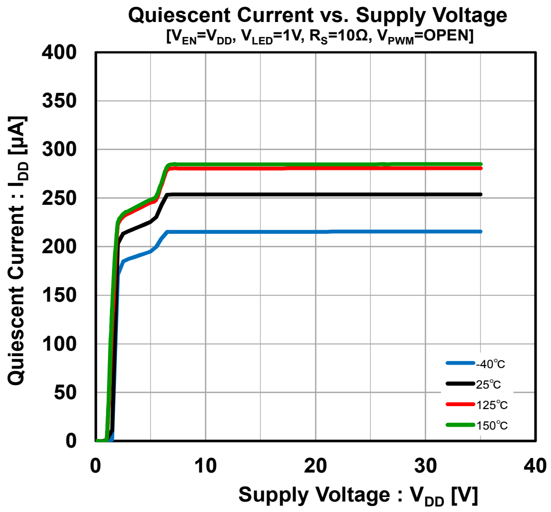
■ TYPICAL APPLICATIONS

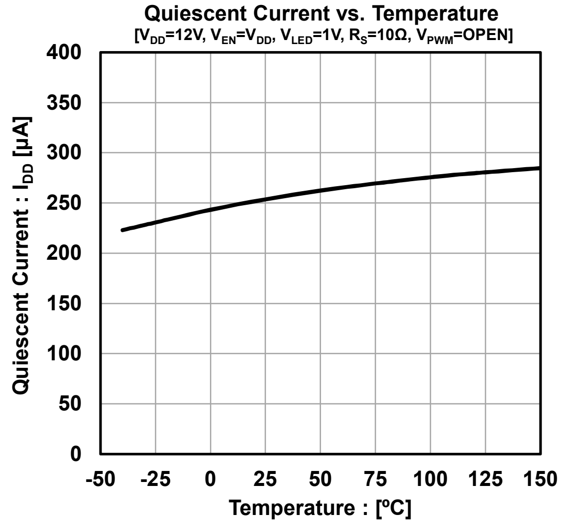


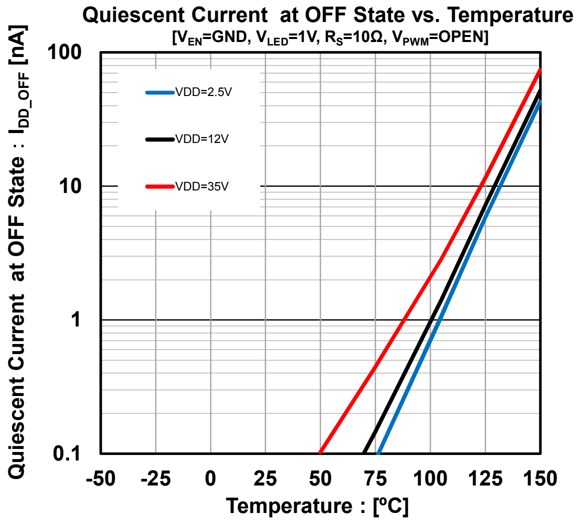
The R_s Resistance Setting formula: $R_S(\Omega) = \frac{0.2(V)}{I_{LED}(A)}$

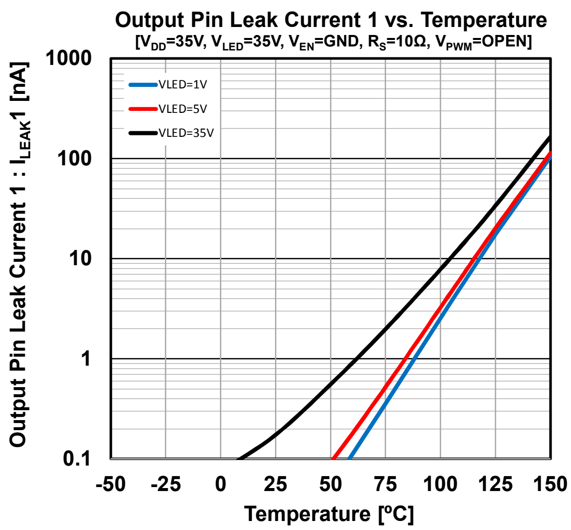
(*3) If the wiring from the power supply to the LED anode pin is long, the voltage may change due to the influence of the parasitic elements.
As the countermeasure, it should connect a decoupling capacitor as close to the LED as possible.

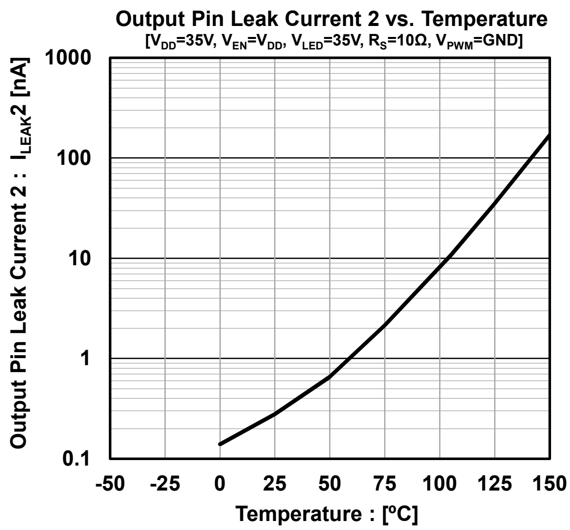
■ TYPICAL CHARACTERISTICS





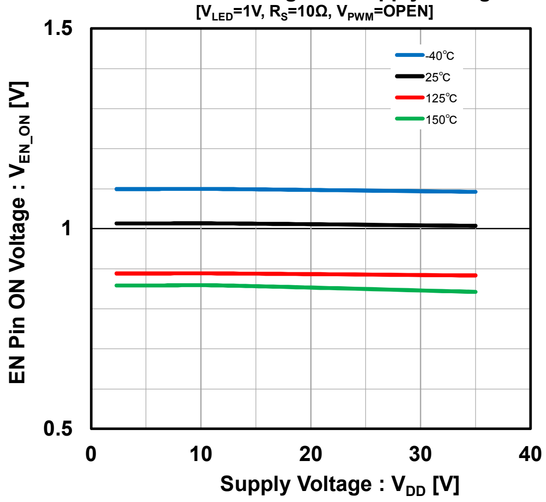




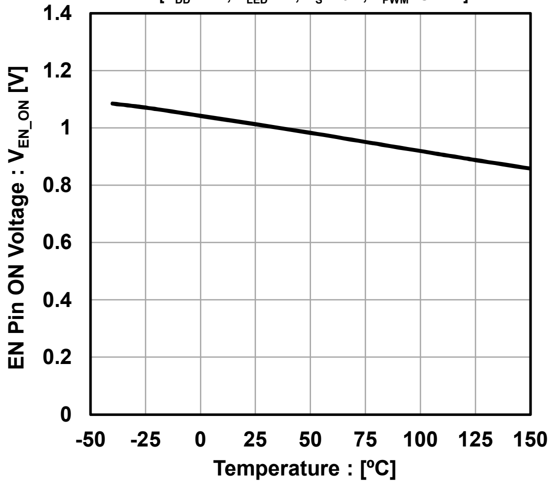


■ TYPICAL CHARACTERISTICS

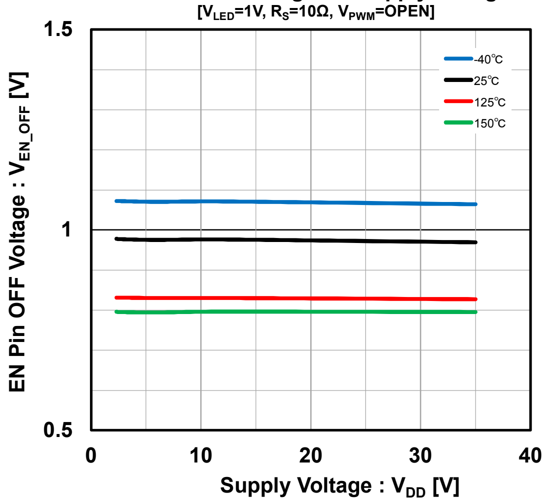
EN Pin ON Voltage vs. Supply Voltage
[V_{LED}=1V, R_S=10Ω, V_{PWM}=OPEN]



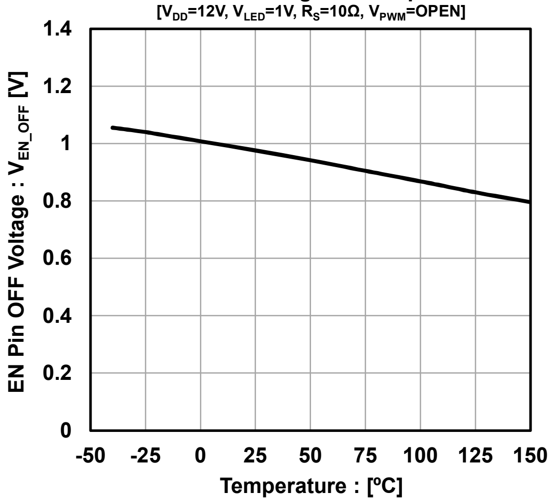
EN Pin ON Voltage vs. Temperature
[V_{DD}=12V, V_{LED}=1V, R_S=10Ω, V_{PWM}=OPEN]



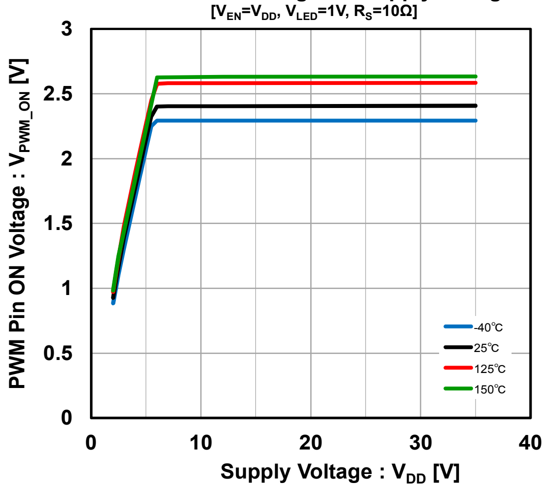
EN Pin OFF Voltage vs. Supply Voltage
[V_{LED}=1V, R_S=10Ω, V_{PWM}=OPEN]



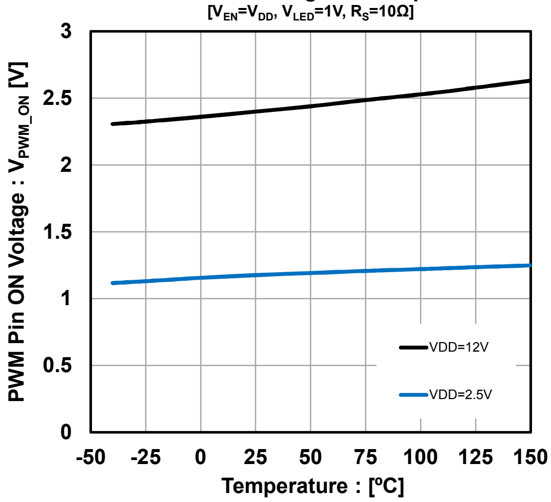
EN Pin OFF Voltage vs. Temperature
[V_{DD}=12V, V_{LED}=1V, R_S=10Ω, V_{PWM}=OPEN]



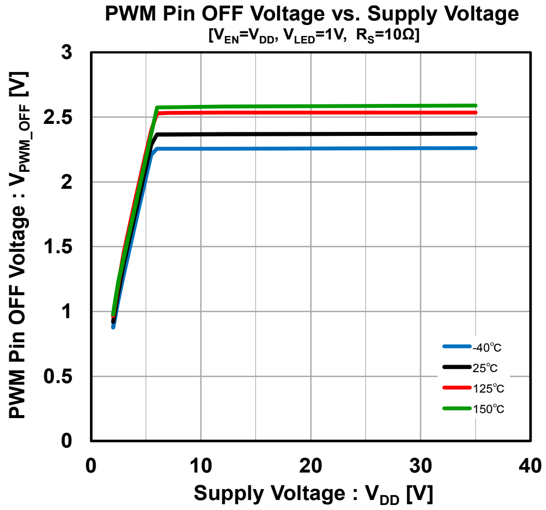
PWM Pin ON Voltage vs. Supply Voltage
[V_{EN}=V_{DD}, V_{LED}=1V, R_S=10Ω]

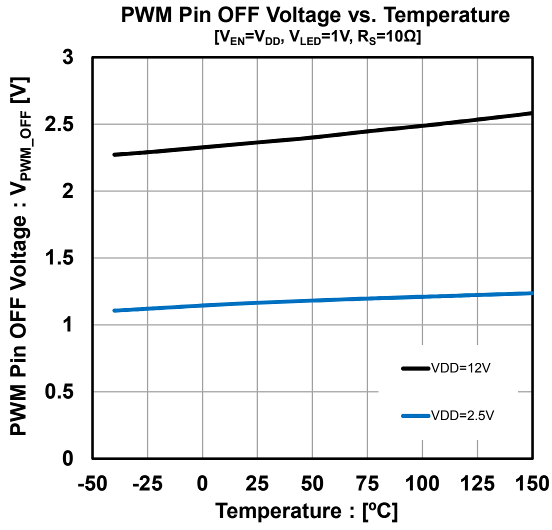


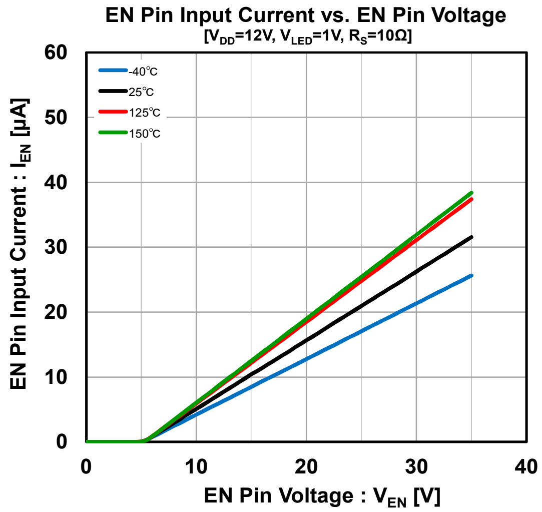
PWM Pin ON Voltage vs. Temperature
[V_{EN}=V_{DD}, V_{LED}=1V, R_S=10Ω]

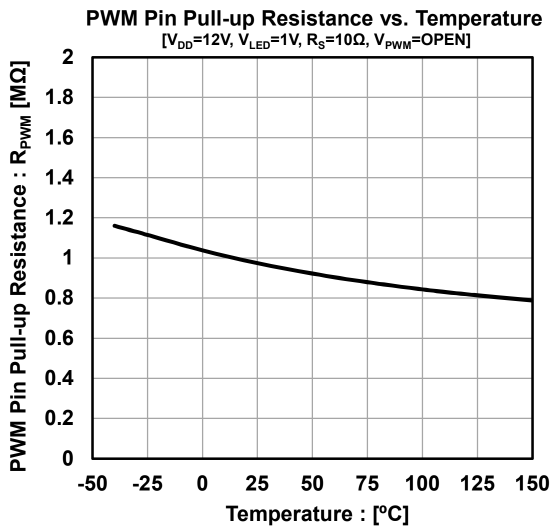


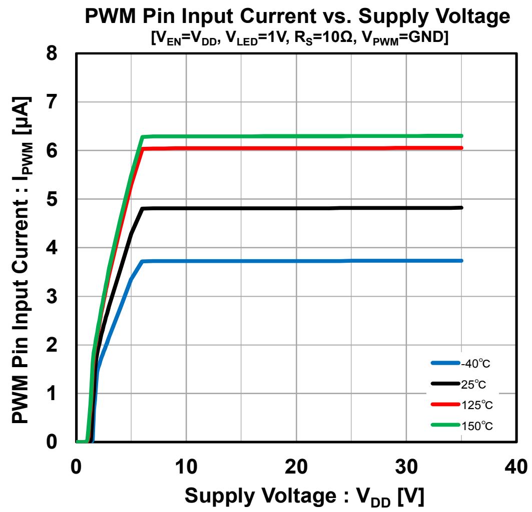
■ TYPICAL CHARACTERISTICS











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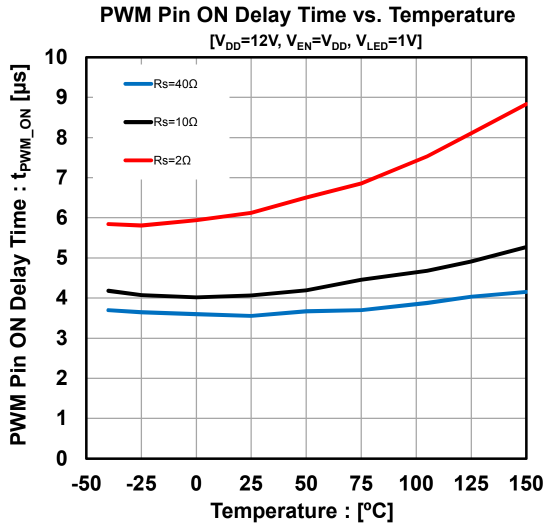

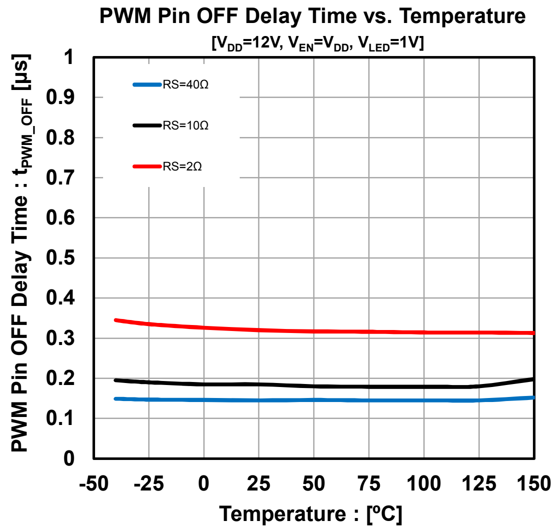

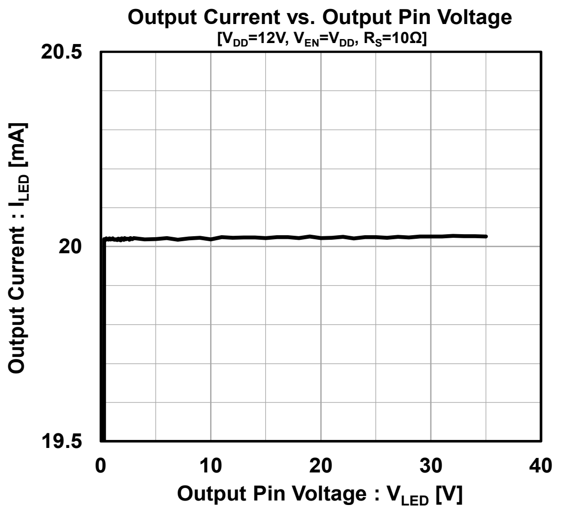

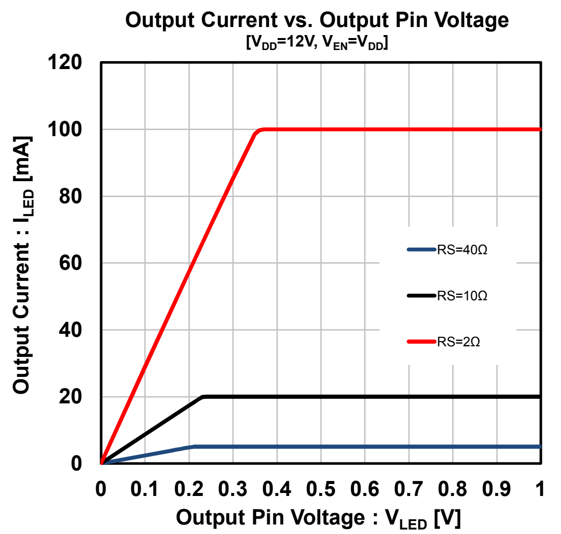

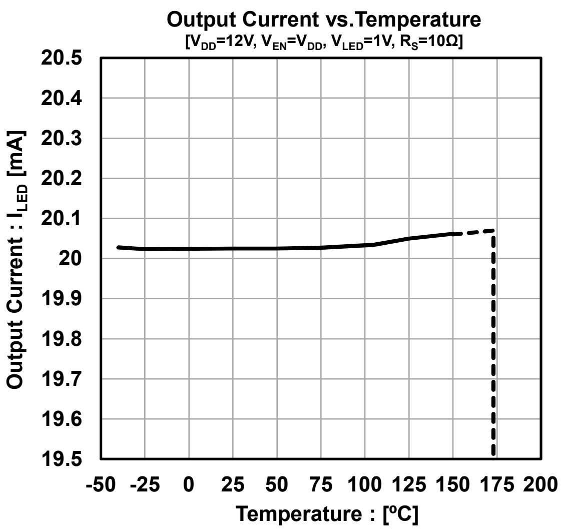

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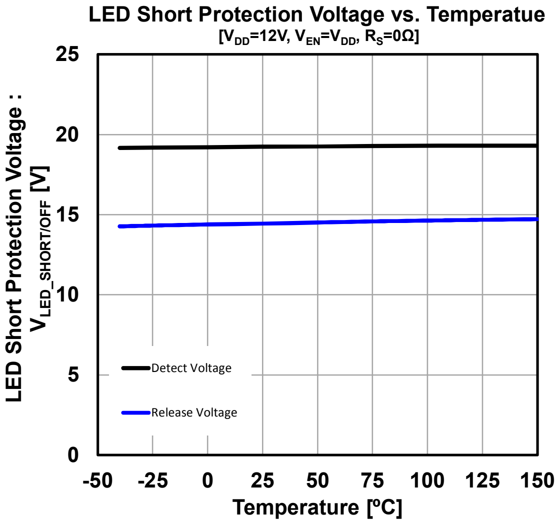
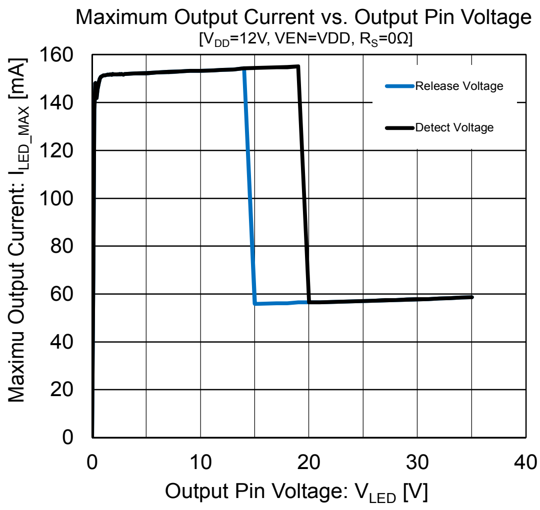
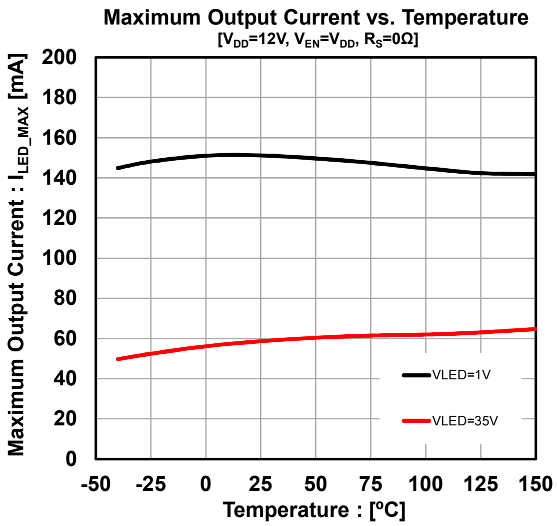
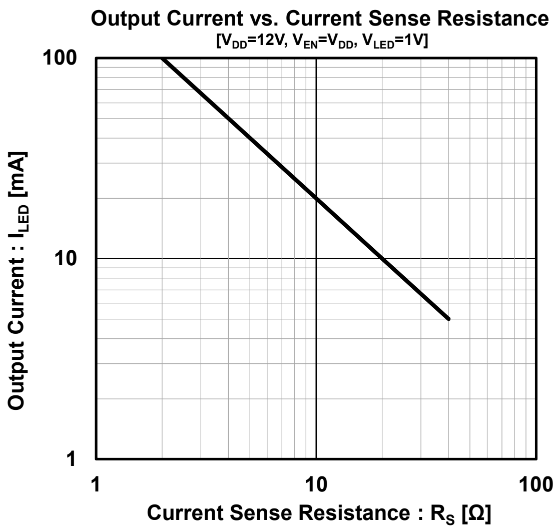








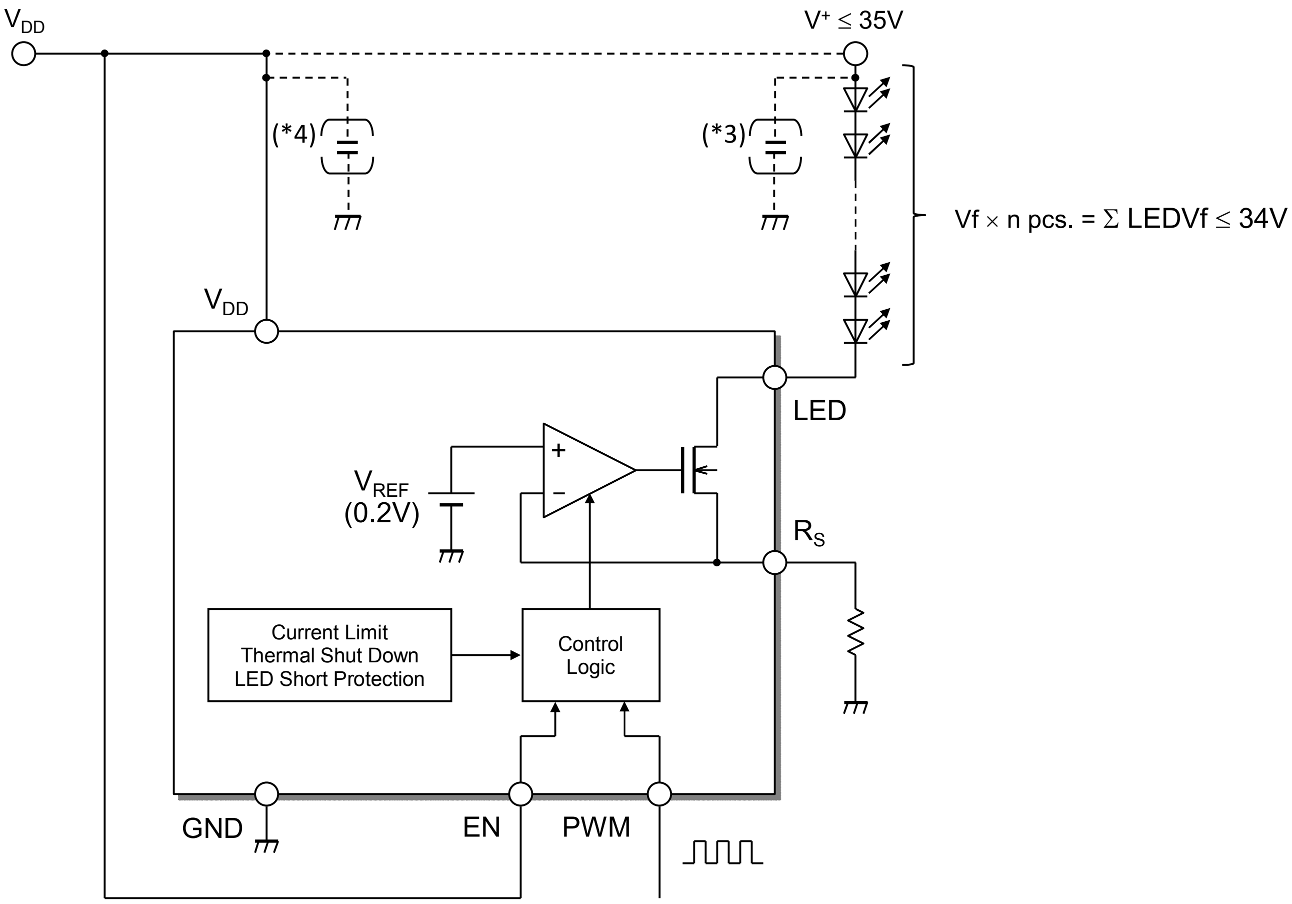
Application Manual

■ The number of LED series connection

It is necessary to drive LED that is the LED forward voltage (Vf) or more.
When the LED was series connected, the supply voltage should be input sum of LED Vf (ΣLED Vf) the series connected or more. In NJW4615A, it is necessary as minimum V^+ that is ΣLED Vf + NJW4615A output voltage (V_{LED} = 1V). The maximum LED connected number that NJW4615A can drive is limited by the recommended output voltage maximum value (35V). Moreover, it should be used with ΣLED Vf within 34V that is subtracted the V_{LED} = 1V.

The table below shows maximum LED number at each Vf. (All LED Vf assumes ideally same)

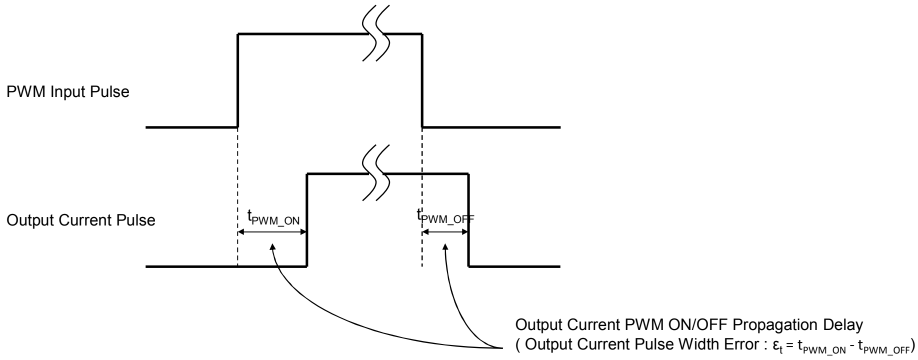
LED Vf is up to 3.0V	▪▪▪	up to 11 lights
LED Vf is up to 3.2V	▪▪▪	up to 10 lights
LED Vf is up to 3.7V	▪▪▪	up to 9 lights
LED Vf is up to 4.2V	▪▪▪	up to 8 lights



(*4) If the wiring from the power supply to the V_{DD} pin is long, the voltage may change due to the influence of the parasitic elements.
As the countermeasure, it should connect a decoupling capacitor as close to the V_{DD} pin as possible.

■ PWM input pulse and PWM dimming accuracy

The I_{LED} transient behavior corresponding to PWM input pulse has some delay at rise/fall time.



If enter a PWM signal with short pulse width, for the output current pulse width error becomes larger against the PWM input pulse width, it is incapable of accurate PWM dimming. The Output current pulse width error rate (ε_t) becomes the following value. ($\varepsilon_t = t_{PWM\_ON} - t_{PWM\_OFF}$)

ε_t = approx. 2µs (Output Current: I_{LED}=20mA,Ta=25°C typ. <Reference Value>)

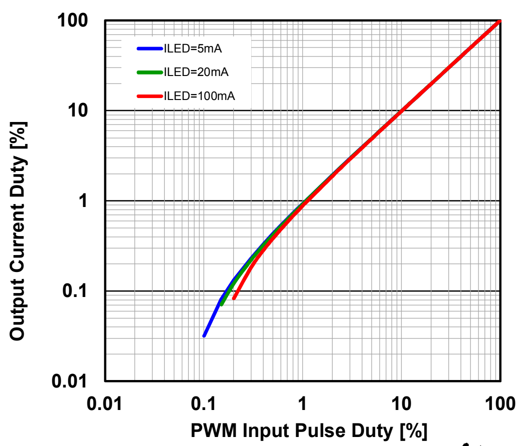
The actual value of the output current pulse width error rate can calculate by above error rate (ε_t) and the frequency and Duty of the PWM input pulse. (f_{PWM}: PWM input pulse frequency, D: PWM input pulse Duty)
Based on the allowable value of the output current pulse width error rate, you should determine the frequency and Duty of the PWM input pulse.

PWM Input pulse width = D / 100 × (1 / f_{PWM})
Output Current pulse width = PWM Input pulse width - ε_t
Output Current pulse width error rate
= (Output Current pulse width - PWM Input pulse width) / PWM Input pulse width × 100
= -ε_t / PWM Input pulse width × 100 [%]

【 Output current pulse width error rate calculation example:
operation with PWM input pulse frequency 200Hz and Duty1% 】

PWM Input pulse width = 1 [%] / 100 × (1 / 200[Hz]) = 50 [µs]
Output Current pulse width error rate = -2 [µs] / 50 [µs] × 100
= -4 [%]

Output Current Duty vs. PWM Input Pulse Duty



【 Measurement Conditions 】

Output Current (I_{LED})	5mA	(R_S = 40Ω)
	20mA	(R_S = 10Ω)
	100mA	(R_S = 2Ω)
Supply Voltage	12V	
Output (LED) pin	Input Voltage at 1V	
PWM Input Pulse	200Hz, 0 to 5V	
Output Current I_{LED} Pulse Width	The time is more than 90% of set current.	
Ambient Temperature	Ta=25°C	

■ Protection Circuit

▪ Over Current Protection (Refer to Maximum Output Current vs. Output Pin Voltage)

This protection function limits the output current, when the RS pin and GND pin was shorted. The limited current is dependence on output (LED) pin voltage.
When the output (LED) pin voltage is less than "LED Short Protection Detect Voltage", maximum output current is limited to approx. 170mA (output (LED) pin voltage=1V, Ta=25°C).
The output current returns to set current, when the short status is release.

▪ LED Short Protection (Refer to Maximum Output Current vs. Output Pin Voltage)

This protection function limits the output current, when the output (LED) pin rises as in LED shorten at output FET ON.
The output current is limited to approx. 60mA when the output (LED) pin voltage rose to approx. 20V.

▪ Thermal Shutdown Function (Refer to Output Current vs. Temperature)

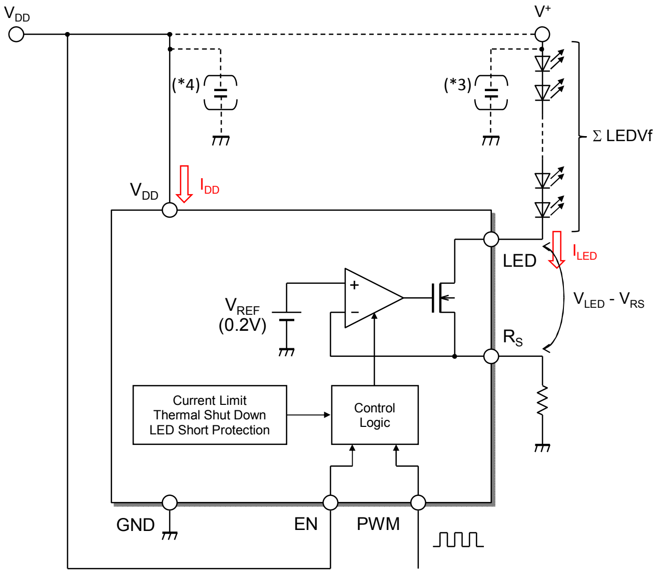
When junction temperature of the NJW4615A exceeds the 170°C*, internal thermal shutdown circuit function stops the device function. When junction temperature decreases to 150°C* or less, the device operation returns to normal operation.
The purpose of this function is to prevent malfunctioning of IC at the high junction temperature. Therefore it is not something that urges positive use. It should make sure to operate within the junction temperature range rated (≤+150°C).

*) Design value

Application Manual

■ The Loss of Constant Current Driver

The power consumption of the LED lighting circuit is classified as "the power consumption of the constant current driver" "the power consumption of the LED" and "the power consumption of the current sense resistor (R_S)".
The loss of constant current driver is caused mainly by quiescent current (I_{DD}) and output current (I_{LED}).
The power dissipation of the device can calculate by follow equation.



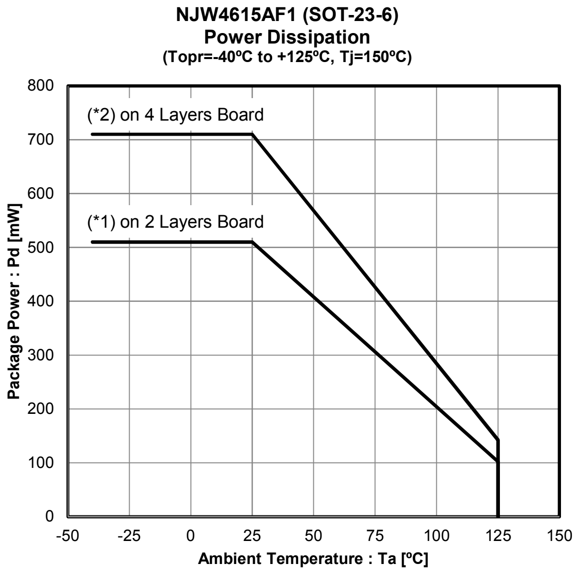
$$P_D \approx V_{DD} \times I_{DD} + (V_{LED} - V_{RS}) \times I_{LED}$$
$$= V_{DD} \times I_{DD} + (V^+ - \Sigma LED\ Vf - 0.2) \times I_{LED}\ [W]$$

Rs pin voltage (V_{RS}): 0.2V
Σ LED Vf represents the sum of the LED Vf of use.

e.g.)
$V_{DD} = V^+ = 12[V]$, I_{DD}=260[μA], ΣLED Vf = 9[V],
I_{LED} = 100[mA]

$$P_D \approx 12[V] \times 260[\mu A] + (12[V] - 9[V] - 0.2[V]) \times 100[mA]$$
$$\approx 283[mW]$$

As shown in the above equation, the loss of constant current driver will increase in proportion to the voltage difference between the LED driving voltage V^+ and ΣLED Vf.
It should set the LED operating Voltage (V^+) and output current (I_{LED}) with consideration of P_D.



The device power dissipation must be below the power dissipation rate of the device package including thermal derating to ensure correct operation.

(*1) Mounted on glass epoxy board based on EIA/JEDEC.
(76.2×114.3×1.6mm: 2Layers FR-4)
(*2) Mounted on glass epoxy board based on EIA/JEDEC.
(76.2×114.3×1.6mm: 4Layers FR-4),
Internal Cu area: 74.2×74.2mm

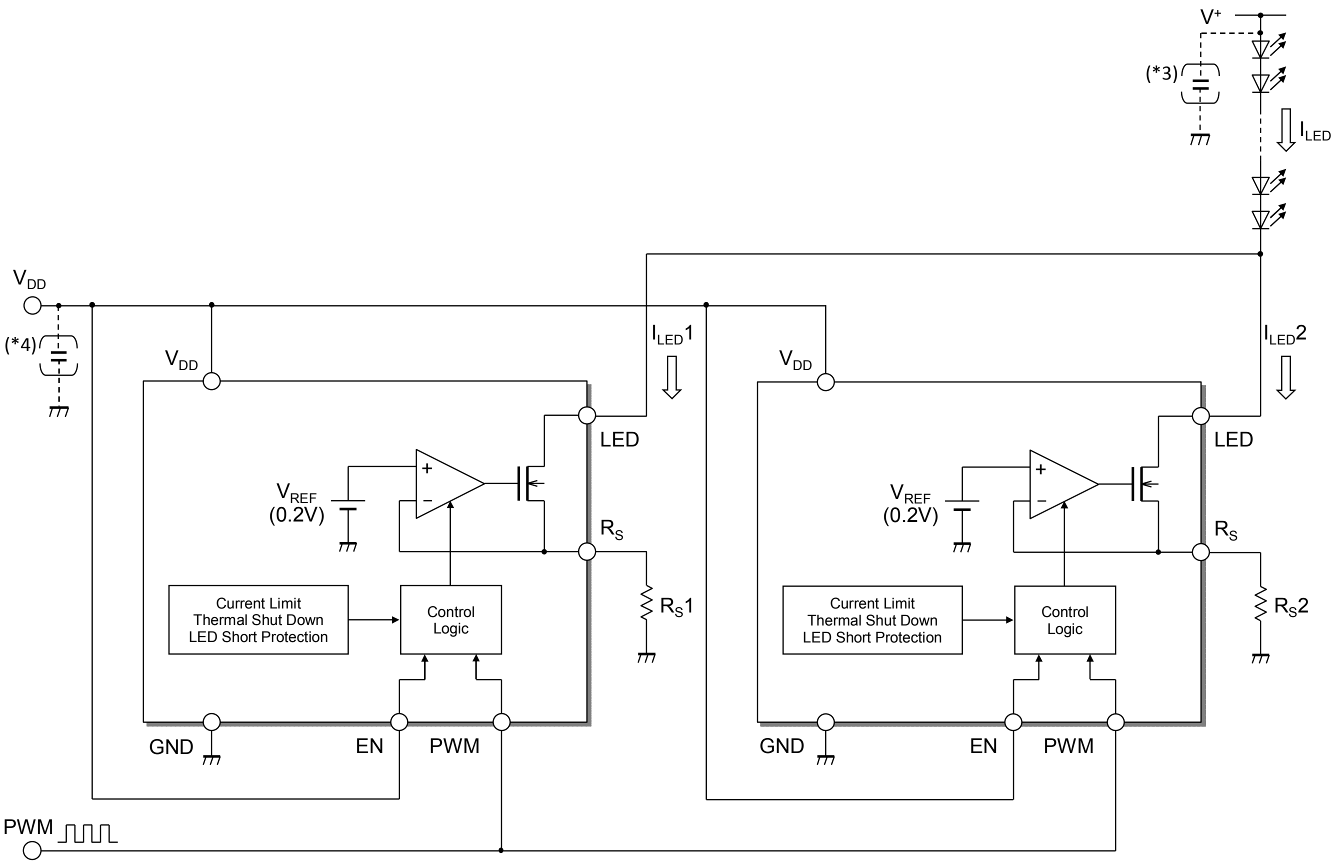
Application Manual

■ Parallel Drive of NJW4615A

For applications that require more than 100mA, it can correspond by parallel connecting two or more NJW4615A.
The LED current becomes sum of LED current of each NJW4615A.
Each device accepts different set current.

I_{LED} [A] = $I_{LED}1 + I_{LED}2$ = 0.2 / R_S1 [Ω] + 0.2 / R_S2 [Ω]

(e.g. I_{LED} = 150 [mA] setting: R_S1 = 4[Ω], R_S2 = 2 [Ω])



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