PRELIMINARY

High Efficiency White LED Driver

■ GENERAL DESCRIPTION

The **NJU6048** is a high-efficiency white LED driver. It contains a high-efficiency step-up DC/DC converter and an output driver. The IC ensures a 18V maximum capacity which allows series connection of 4 white LEDs with a constant current so that the LED currents are identical for uniform brightness.

The high frequency of the step-up converter permits the use of small, low-profile inductors and capacitors to minimize the footprint in space-conscious applications. And additional features are a low operating voltage of 1.7V and the small package SOT-23 (MTP-5).

All of these benefits make the **NJU6048** suitable for the battery-powered portable applications such as a cellular phone, a camcorder, PDA, etc.

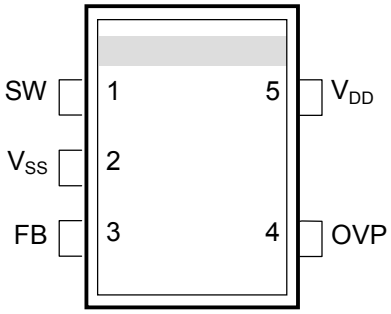
■ PACKAGE OUTLINE

NJU6048F

■ FEATURES

- Drives Up to 4White LEDs in Series
  I_{OUT} = 20mA(typical)
- Uses Small Inductor and Capacitors
- 1.7V to 6.5V Operating Voltage for Step-up Circuits (V_{DD})
- Low Switch R_{DS} (ON)
  V_{SW} = 18V, R_{DS}=0.8Ω (I_{SW}=150mA)
- OVP Function
- CMOS Technology
- Package : SOT-23 5 pin (MTP-5)

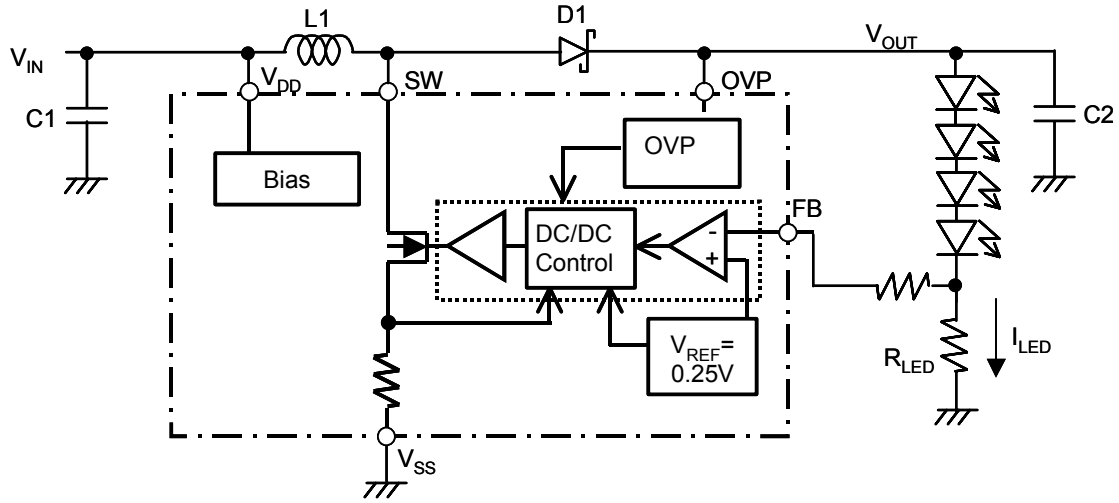
■ PIN CONFIGURATION (TOP VIEW)



■ PIN DESCRIPTIONS

No.	SYMBOL	TYPE	DESCRIPTION
1	SW	Input	Switch Terminal
2	V_{SS}	Power	Ground Terminal
3	FB	Input	Feedback Terminal
4	OVP	Input	Over Voltage protection Terminal
5	V_{DD}	Power	Power Supply terminal

■ BLOCK DIAGRAM



■ FUNCTIONAL DESCRIPTONS

(1) LED Current Control and Resistor R_{LED} Selection

The **NJU6048** incorporates the LED current control to regulate the LED current (I_{LED}), which is programmed by the feedback resistor (R_{LED}) connected between the FB and the V_{SS} terminals. Typically, the reference voltage V_{REF} is internally regulated to 0.25V and is used as the positive input of the built-in comparator. Formula (1) is used to choose the value of the R_{LED}, as shown below.

$$R_{LED} = \frac{V_{REF}}{I_{LED}} \qquad \text{--- Formula (1)}$$

V_{REF}=0.25 *(typical)*

The I_{LED} is the constant current programmed by the R_{LED}. When the feedback voltage on the FB terminal reaches above the reference voltage V_{REF} (i.e., I_{LED} is above the level programmed by R_{LED}), the output capacitor C2 delivers the I_{LED}. Once the feedback voltage drops below the reference voltage (i.e., I_{LED} drops below the level programmed by the R_{LED}), the MOS switch is turned on, then the current of the inductor L1 begins increasing. When the switch current reaches 250mA, the MOS switch is turned off, then the L1 delivers current to the output through the diode D1 as the inductor current drops. After that, the MOS switch is turned on again and the switch current increases up to 250mA. This switching cycle continues until the I_{LED} reaches the level programmed by the R_{LED}, then the I_{LED} current is maintained constant.

(2) Over Voltage Protection

OVP is designed to prevent the damage of internal NMOS switch in case the increased impedance of the LED load (including the LED opened). Once the device detects over voltage at the output, the internal NMOS switch is kept off until the output voltage drops below 14V.

(3) Inductor Selection

A 10uH inductor is recommended for most application. The selected inductor must have a saturation current that meets the maximum peak current of the converter. Another important inductor parameter is the DC resistance. The lower DC resistance the device has higher efficiency.

(4) Diode Selection

A Schottky diode with a low forward-voltage-drop and a fast switching-speed is ideal for the D1. And the D1 must have a rating greater than the output voltage and output current in the system.

(5) Capacitor Selection

A low ESR (Equivalent Series Resistance) capacitor should be used as the output capacitor C2 to minimize output ripples. A multi-layer ceramic capacitor is the best selection for the **NJU6048** application because of not only the low ESR but also small package. Application requires good line regulation ±1%(typ) should use output capacitor larger than 1uF. A ceramic capacitor is also recommended for the input decoupling-capacitor C1, and should be placed as close to the **NJU6048** as possible. A 4.7uF is sufficient for most applications.

■ ABSOLUTE MAXIMUMN RATINGS

Ta=25°C

PARAMETERS	SYMBOL	CONDITIONS	RATINGS	UNIT
V_{DD} Power Supply	V_{DD}		-0.3 to +7.0	V
OVP Terminal to GND	V_{OVP}		-0.3 to 18.0V	
SW Terminal Voltage	V_{SW}	SW terminal	-0.3 to +18.0	V
FB Terminal Voltage	V_{FB}	FB terminal	-0.3 to V_{DD}	V
Power Dissipation	PD	MTP-5	200	mW
Operating Temperature	T_{opr}		-40 to +85	°C
Storage Temperature	T_{stg}		-65 to +150	°C

Note1) All voltages are relative to V_{SS} = 0V reference.
Note2) Do not exceed the absolute maximum ratings, otherwise the stress may cause a permanent damage to the IC. It is also recommended that the IC be used in the range specified in the DC electrical characteristics, or the electrical stress may cause mulfunctions and impact on the reliability.

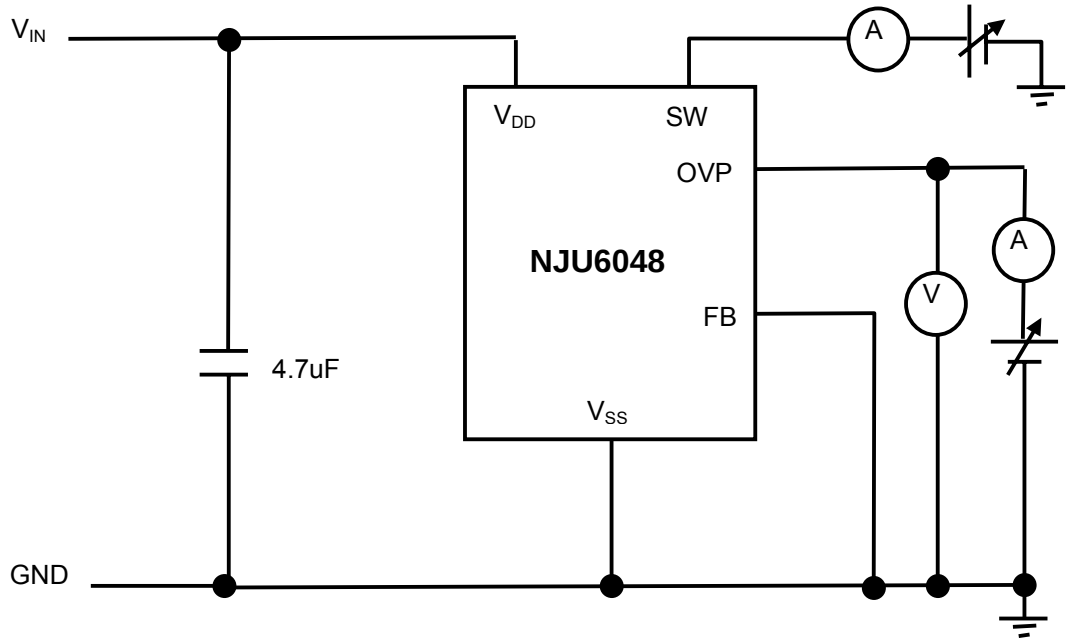
■ DC ELECTRICAL CHARACTERISTICS

(V_{DD}=3.6V, V_{SS}=0V, Ta=25°C)

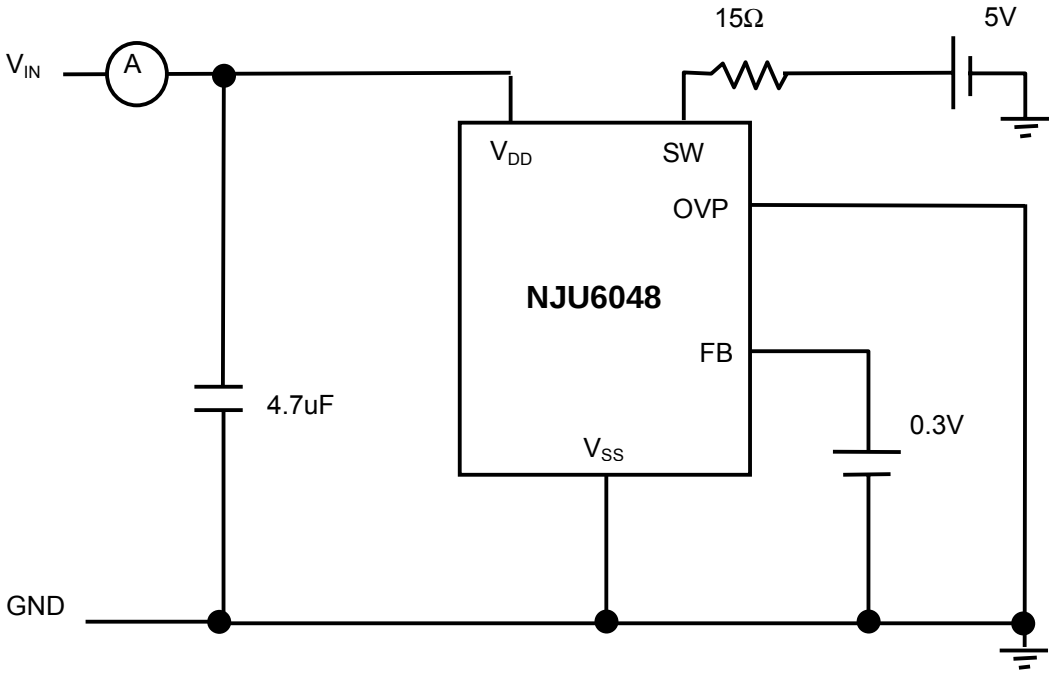
PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	Unit
V_{DD} Power Supply	V_{DD}		1.7		6.5	V
OVP Threshold	V_{OVPTH}	Trigger	15	16	17	V
		Release			14	V
OVP Pin Input Current	I_{OVPIC}	V_{OVP}=16V		10	15	μA
Quiescent Current	I_{STBY1}	V_{FB}=0.3V		50	80	μA
FB Comparator Trip point	V_{FBP}		242	250	258	mV
Switch Off Time	t_{OFF}	V_{FB} =0V		400		ns
Switch R_{DS}(ON)	R_{DS}	I_{SW}=150mA		0.8	1.2	Ω
Switch Current Limit	I_{CL}		200	250	300	mA
Switch Leakage Current	I_L	Switch Off, V_{SW}=18V		0.1	5.0	μA

- **TEST CIRCUITS**

OVP Threshold Voltage

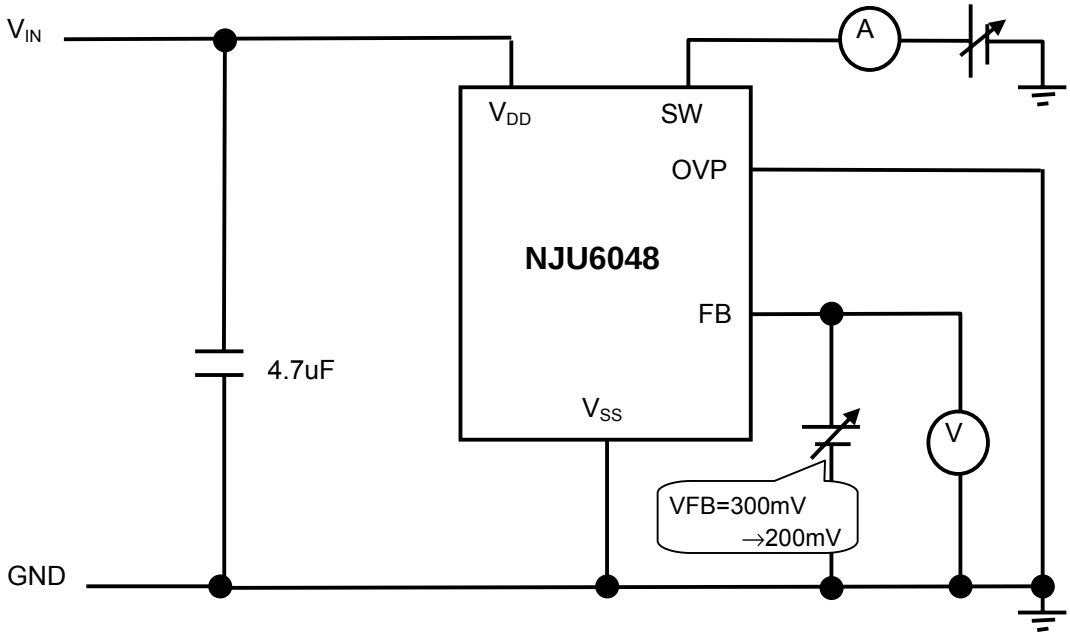


Quiescent Current

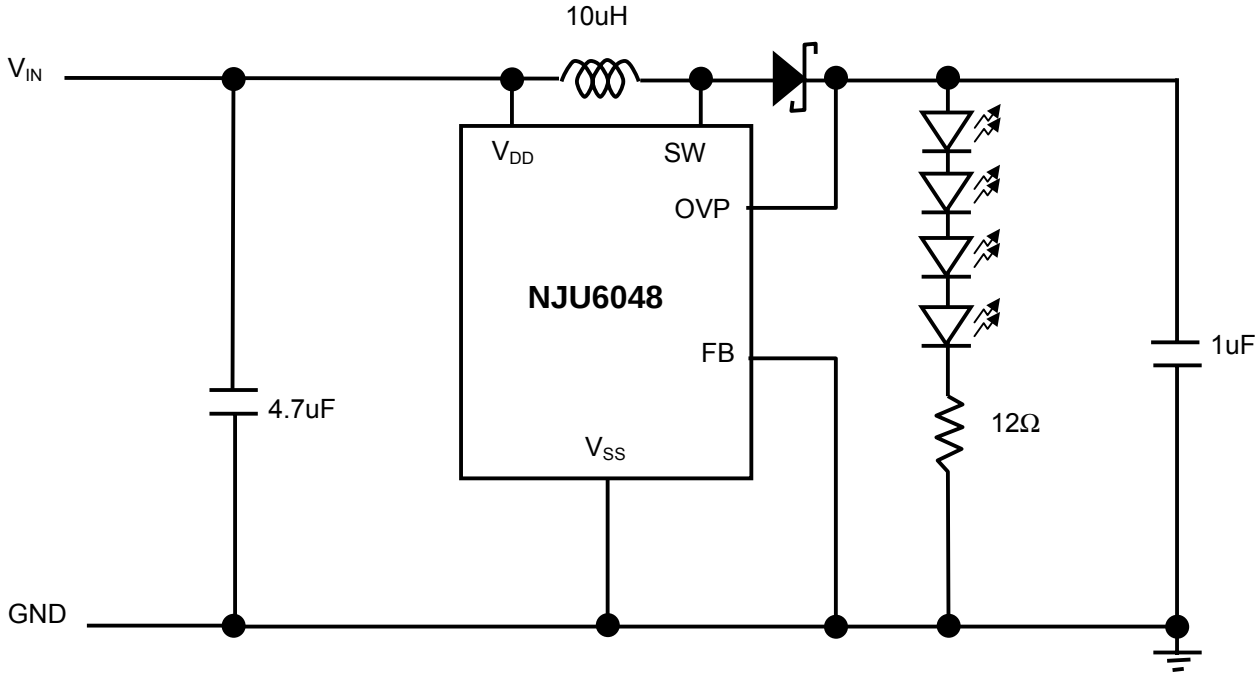


FB Comparator Trip point

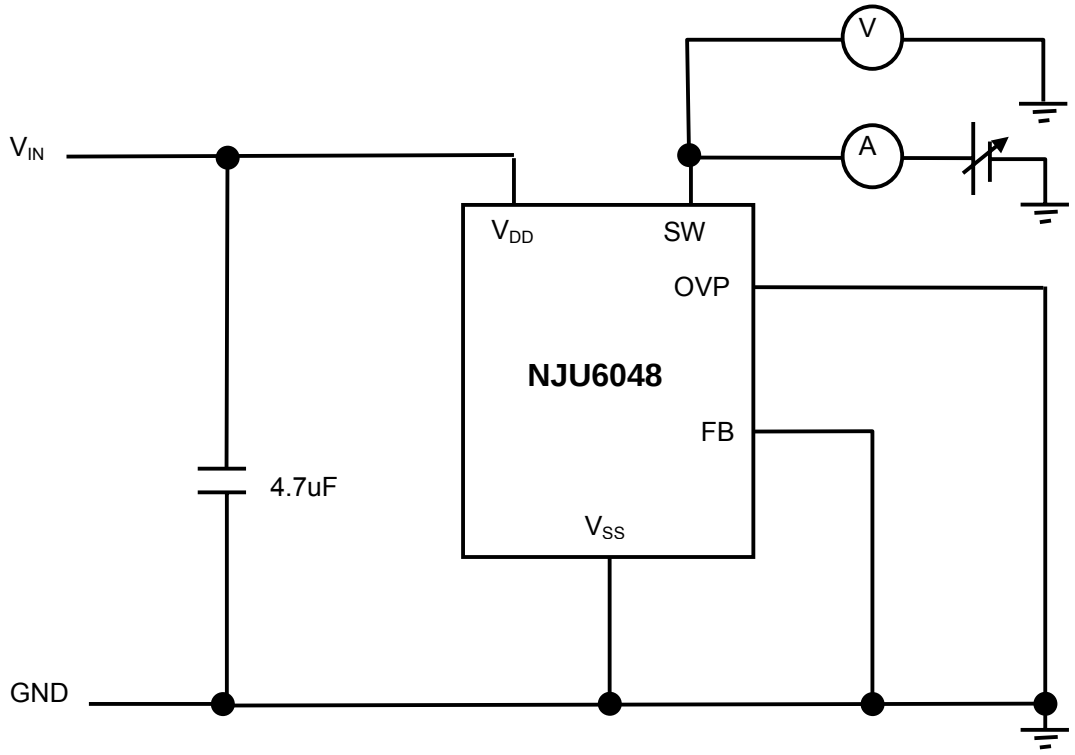
In stepping down V_{FB} from 300mV, V_{FBP} is the threshold voltage to begin switching operation.



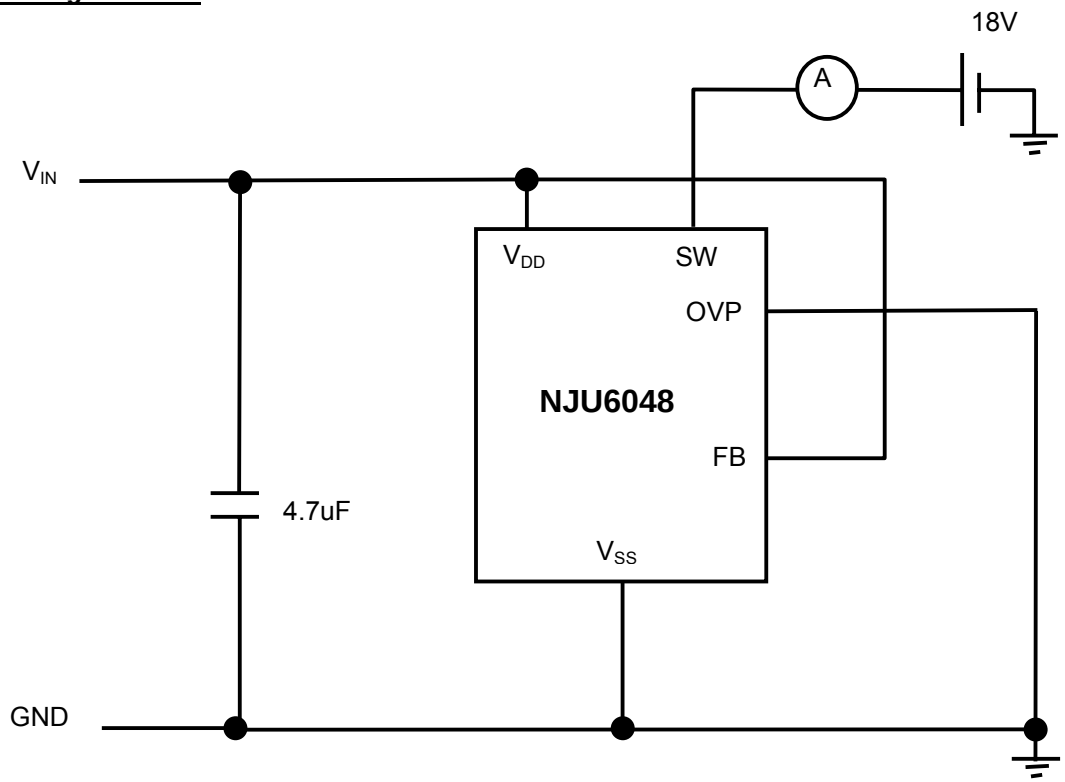
Switch Off Time



Switch Current Limit / Switch R_{DS}(ON)



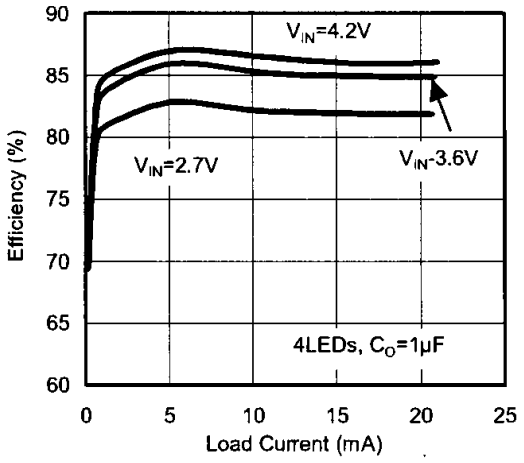
Switch Leakage Current



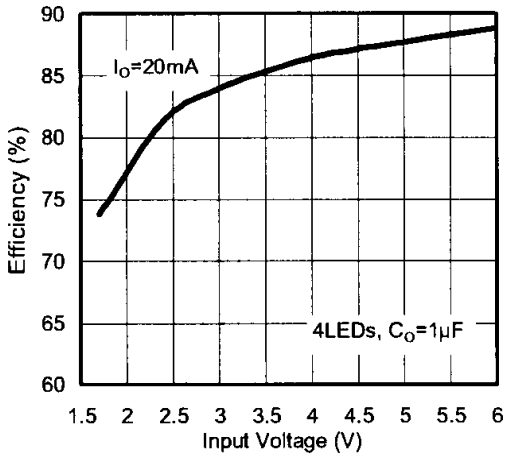
■ TYPICAL PERFORMANCE

(V_{DD}=3.6V, V_{SS}=0V, L=10µH, Ta=25°C)

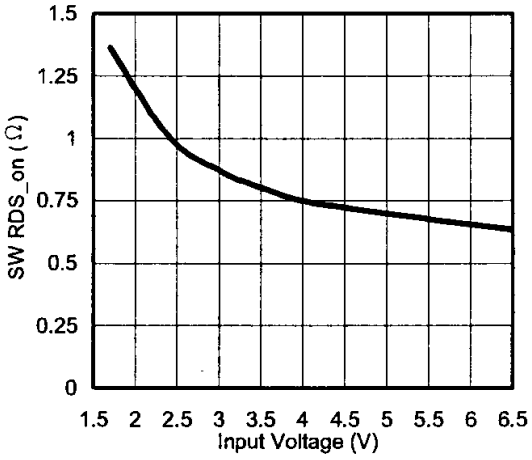
Efficiency vs. Output Current



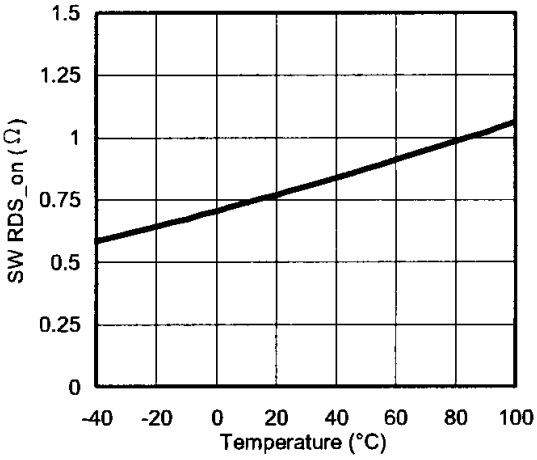
Efficiency vs. Input Voltage



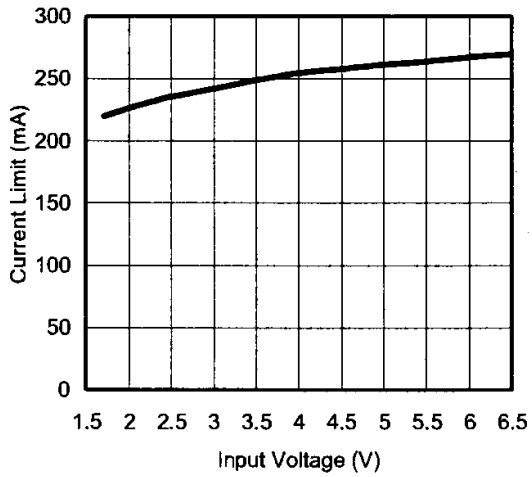
SW RDS_on vs. Input Voltage



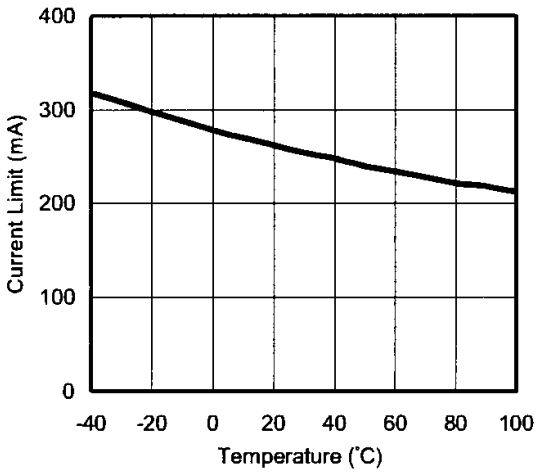
SW RDS_on vs. Temperature



Current Limit vs. Input Voltage

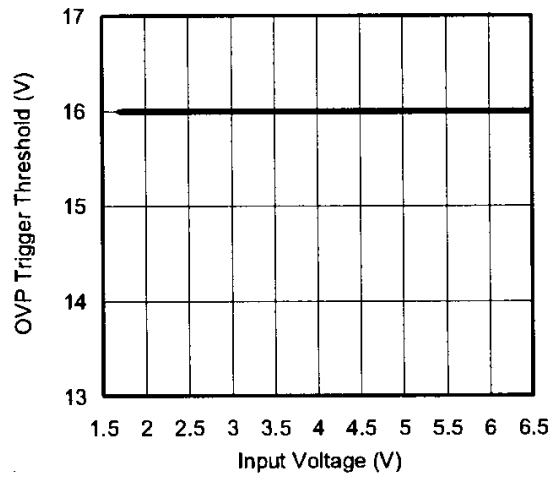


Current Limit vs. Temperature

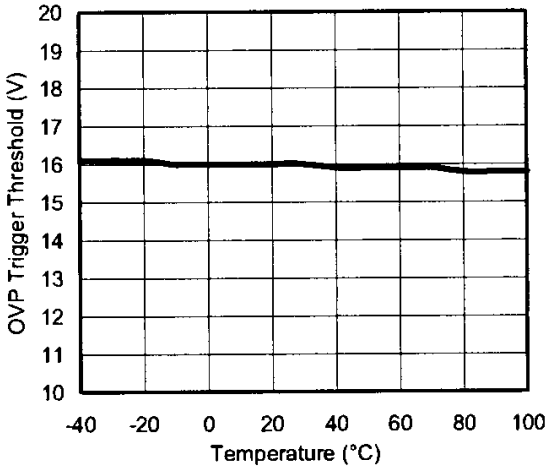


(V_{DD}=3.6V, V_{SS}=0V, L=10µH, Ta=25°C)

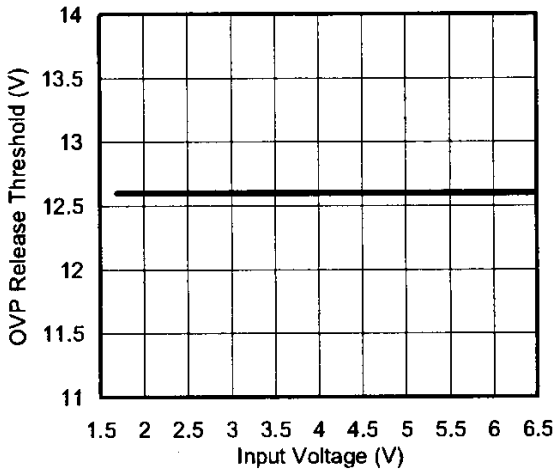
OVP Trigger Threshold vs. Input Voltage



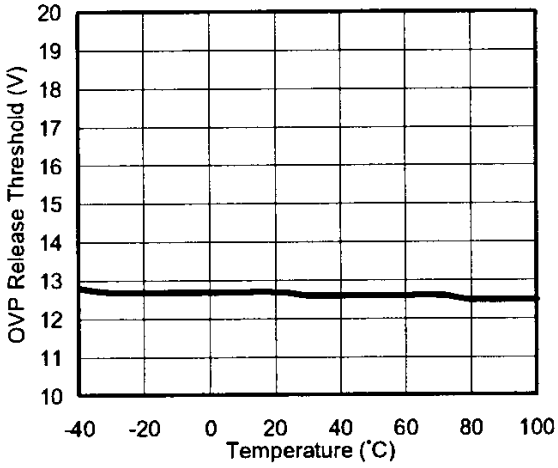
OVP Trigger Threshold vs. Temperature



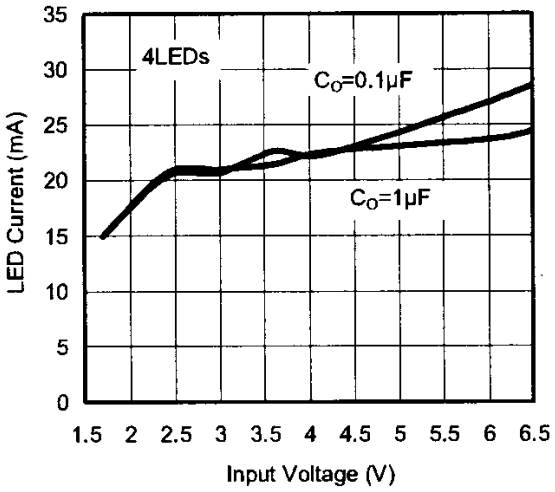
OVP Release Threshold vs. Input Voltage



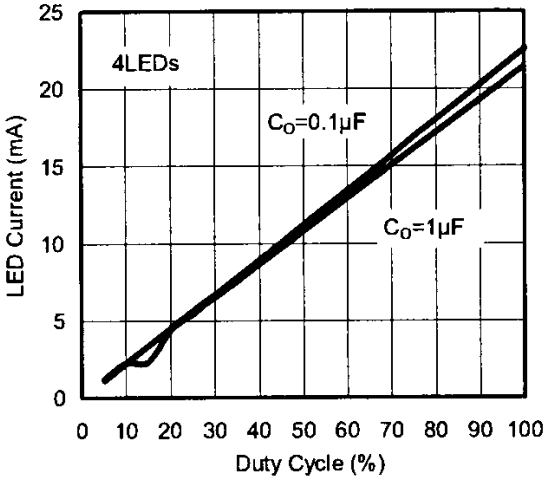
OVP Release Threshold vs. Temperature



LED Current vs. Input Voltage

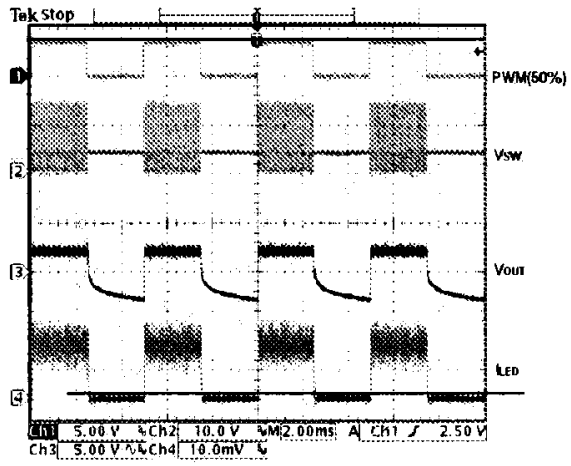


LED Current vs. Duty Cycle

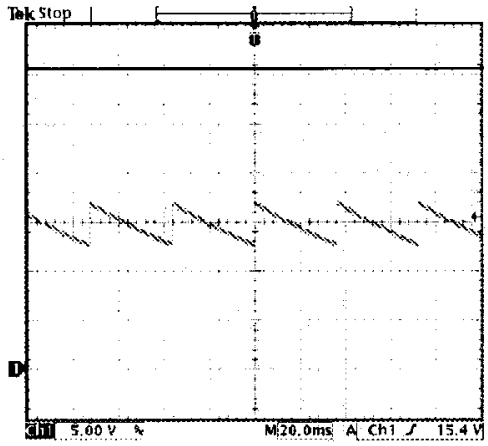


(V_{DD}=3.6V, V_{SS}=0V, L=10µH, Ta=25°C)

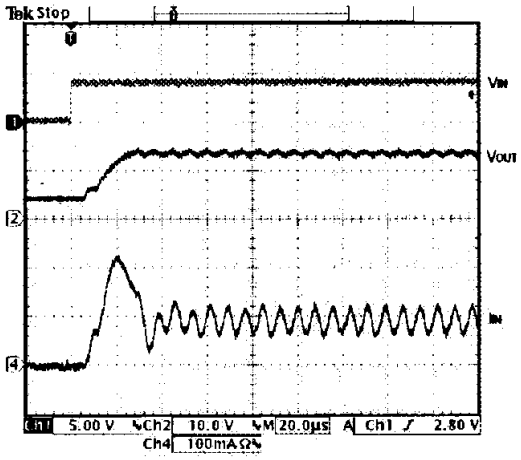
PWM Dimming



OVP Waveform

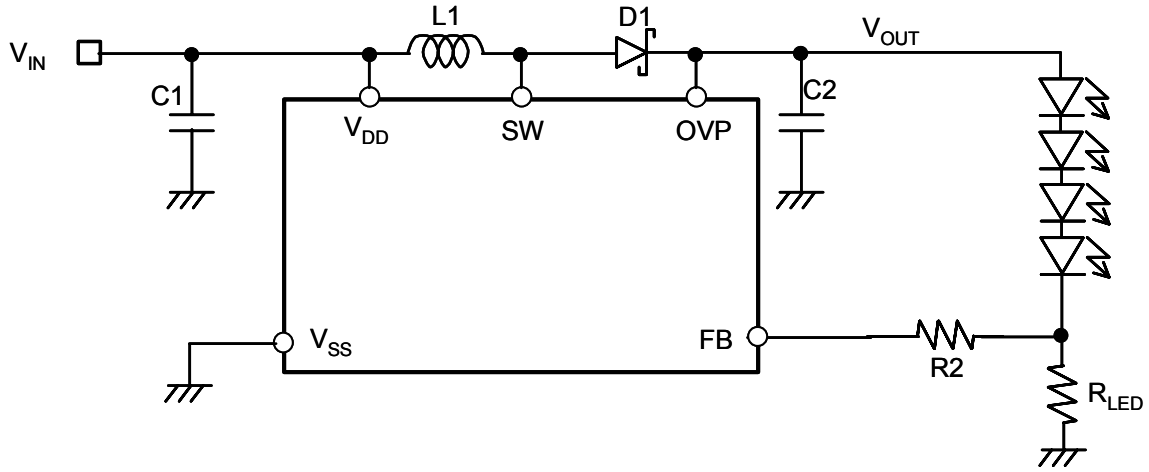


Inrush Current Waveform

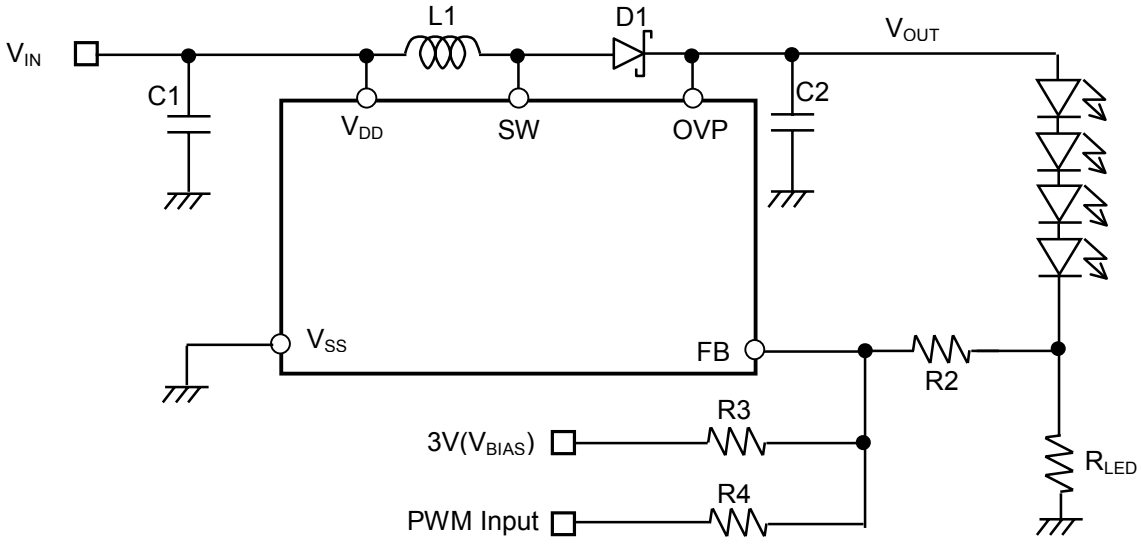


■ TYPICAL APPLICATION CIRCUITS

(1) 4 white LEDs



(2) 4 white LEDs & Dimming control by external PWM signal



Referential List of External Components

Component		Supplier / Parts Number	Qty	Value
IC1	LED Driver IC	NJRC / NJU6048	1	-
L1	Inductor	TDK / VLF3010AT-100MR49	1	10uH
D1	Schottky Diode	ROHM / RB160M-30	1	-
C1	Ceramic Capacitor	Taiyo Yuden / JMK107 BJ475MA	1	4.7uF/6.3V
C2	Ceramic Capacitor	Taiyo Yuden / TMK107 BJ105KA	1	1uF/25V
R_{LED}(R1)	Chip Resistor	Standard	1	5.1Ω
R2	Chip Resistor	Standard	1	15KΩ
R3	Chip Resistor	Standard	1	300KΩ
R4	Chip Resistor	Standard	1	430KΩ
LED1 to 4	White LED	Nichia / NSCW215T	4	-

MEMO