

### Step Up Type DC/DC Converter for White LED

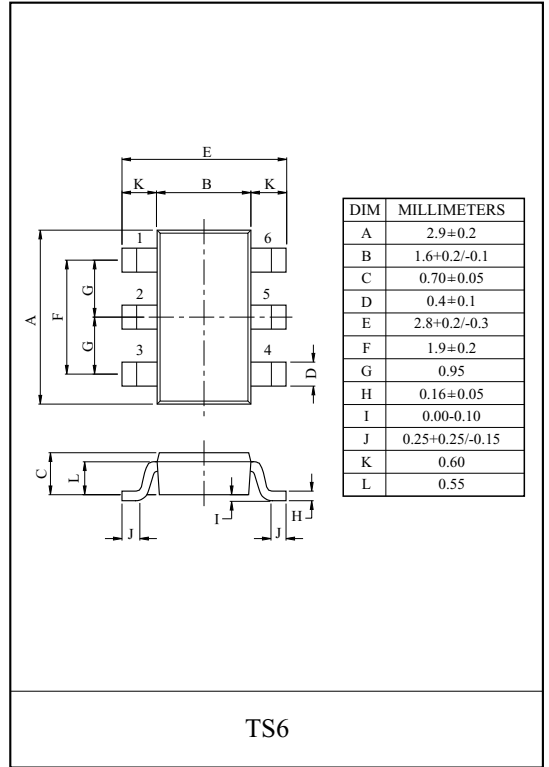
KAB3405T is a high efficient Step-Up Type DC/DC Converter specially designed for constant current drive of White LED. This IC can drive 2-10 white LEDs connected series using a Li-ion Battery. This IC contains N-ch MOS-FET Transistor for Coil-Switching, and LED Current ( $I_F$ ) is set with an external resistor.

#### Features

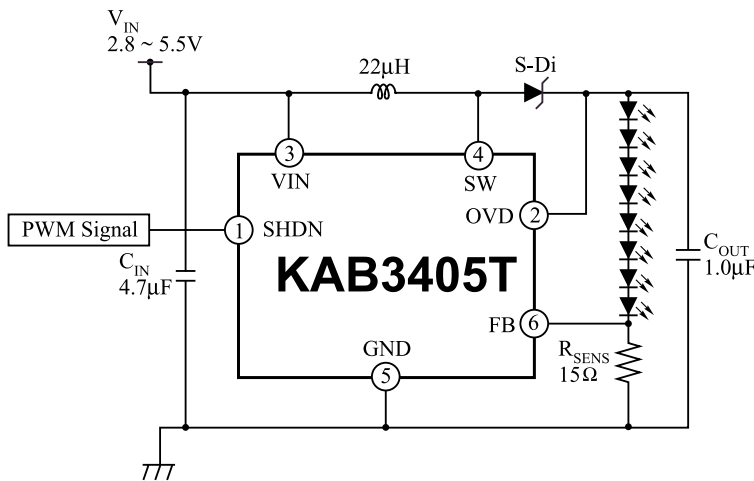
- Variable LED Current  $I_F$  is set with a external resistor  
: 20 mA (Typ.) @  $R_{SENS} = 15 \Omega$
- High Efficiency
- Output Over Voltage Shutdown
- Built in output over voltage protect circuit.
- Switching Frequency : 1.0 MHz (Typ.)

#### Applications

- Back light white LEDs in LCD of PDA, Cellular Phone
- Handy Terminal Equipment.

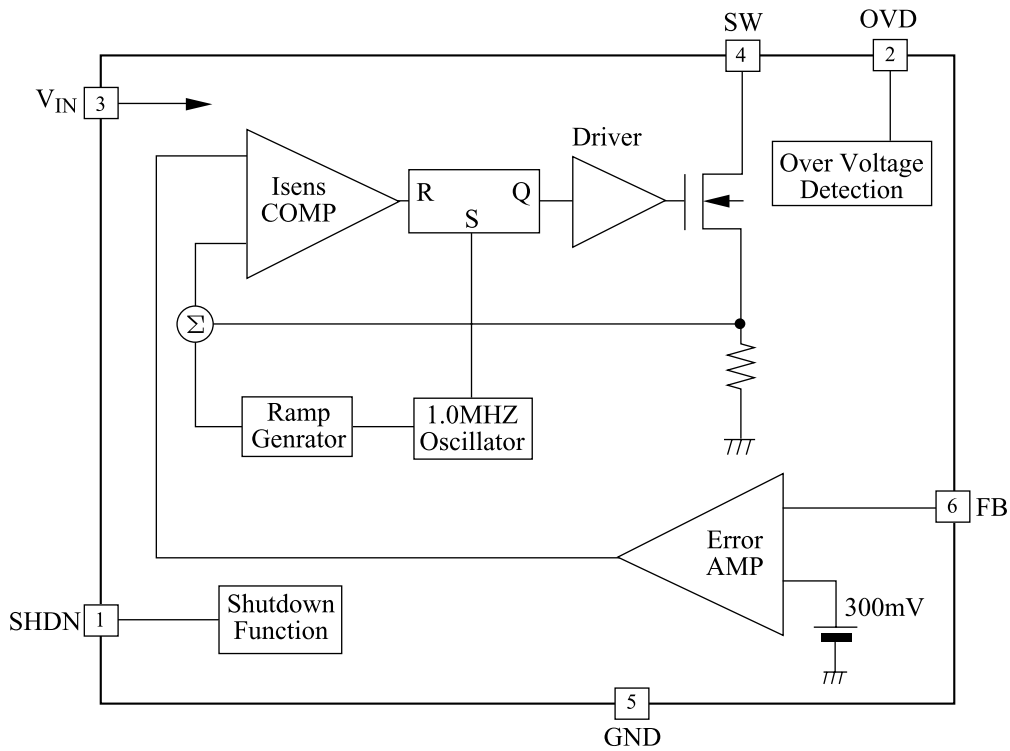


#### Basic Application Circuit



# KAB3405T

## Block Diagram



## Pin Function

Pin No.	Symbol	Function Description
1	SHDN	Voltage-Input Terminal for IC-Enable / Disable LED- $I_F$ . $I_F$ adjustment with PWM input signal is also available.
2	OVD	Over Voltage Detection Terminal. IC Switching Operation is disabled with detection over voltage. If the voltage returns to detection level or less, Operation is enabled again.
3	$V_{IN}$	Supply Voltage Input Terminal. ( 2.8V to 5.5V)
4	SW	Switch Terminal for DC/DC Converter. Nch MOSFET Built-In.
5	GND	Ground Terminal.
6	FB	LED $I_F$ Setting Resistor Connecting Terminal.

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## AUTE MAXIMUM RATINGS (Ta = 25° C if without notice)

Characteristics	Symbol	Ratings	Unit
Power Supply Voltage	V <sub>IN</sub>	-0.3 to +6.0	V
Input Voltage	V <sub>IN(SHDN)</sub>	-0.3 to +V <sub>IN</sub> + 0.3	V
Switching Terminal Voltage	V <sub>O(SW)</sub>	-0.3 to 40	V
Switching Terminal Current	I <sub>O(SW)</sub>	1500	mA
Power Dissipation	P <sub>D</sub>	0.41 (Device)	W
		0.47(on PCB)Caution 2	
Thermal Resistance	R <sub>th(j-a)</sub>	300(Device)	°C/W
		260(on PCB)	
Operation Temperature Range	T <sub>opr</sub>	-40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +150	°C
Maximum Junction Temperature	T <sub>j</sub>	150	°C

Caution 2: Power Dissipation must be calculated with subtraction of 3.8 mW/°C from Maximum Rating with every 1 °C if Topr is upper 25° C. (on PCB)

## ELECTRICAL CHARACTERISTICS (Ta = 25 °C, V<sub>IN</sub>=2.8V to 5.5V if without notice)

Characteristics	Symbol	Test Condition	Min	Typ	Max	Unit
Input Voltage Range	V <sub>IN</sub>	-	2.8	-	5.5	V
Operating Consumption Current	I <sub>N(ON)</sub>	V <sub>IN</sub> =3.6V, R <sub>SENS</sub> =15 Ω	-	0.6	0.9	mA
Quiescent Consumption Current	I <sub>N(OFF)</sub>	V <sub>IN</sub> =3.6V, V <sub>SHDN</sub> =0V	-	0.5	1.0	μA
SHDN Terminal 'H' Level Input Voltage	V <sub>SHDNH</sub>	-	1.3	-	V <sub>IN</sub>	V
SHDN Terminal 'L' Level Input Voltage	V <sub>SHDNL</sub>	-	0	-	0.4	V
SHDN Terminal Current	I <sub>SHDN</sub>	V <sub>IN</sub> =3.6V, V <sub>SHDN</sub> =3.6V or 0V	-	0	1.0	μA
Integrated MOS-Tr Switching requency	f <sub>OSC</sub>	V <sub>IN</sub> =3.6V, V <sub>SHDN</sub> =3.6V	0.77	1.0	1.43	MHz
Switching Terminal Leak Current	I <sub>OZ(SW)</sub>	-	-	0.5	1	μA
FB Terminal Feedback Voltage (V <sub>FB</sub> )	V <sub>FB</sub>	V <sub>IN</sub> =3.6V, R <sub>SENS</sub> =15 Ω, Ta=25° C, L=22μH	285	300	315	mV
		V <sub>IN</sub> =3.6V, R <sub>SENS</sub> =15 Ω, Ta=25° C, L=22μH	285	300	315	mV
FB Terminal Line Regulation	V <sub>FB</sub>	V <sub>IN</sub> =3.6V center V <sub>IN</sub> =3.0 to 5.0V	-5	-	5	%
FB Terminal Current	I <sub>FB</sub>	V <sub>IN</sub> =3.6V, V <sub>SHDN</sub> =3.6V, V <sub>FB</sub> =300mV	-	0.02	-	μA
OVD terminal Voltage	V <sub>OVD</sub>	-	36	38	39.5	V
OVD Terminal Leakage Current	I <sub>OVD</sub>	V <sub>OVD</sub> =30V	-	0.5	1	μA

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## Protection in LED opened condition

The operation with OVD terminal is available for the protection in case LED Circuit opened.  
When the voltage of OVD terminal is over 38V (typ.), Nch MOS switching operation is disabled in the IC. When the voltage of OVD terminal drops below 38V (typ.), Nch MOS switching operation becomes available again.

If load of LED is detached, Nch MOS switching operation is disabled with detection of boost circuit voltage and the IC is protected from unexpected over voltage.

## Setting of external Capacitor

In case not using PWM signal to SHDN terminal for brightness control, recommended values are

$$C_{IN} = \text{Over } 2.2 (\mu\text{F}), C_{OUT} = \text{Over } 1.0 (\mu\text{F})$$

In case with PWM signal to SHDN terminal for brightness control, recommended values are

$$C_{IN} = \text{Over } 4.7 (\mu\text{F}), C_{OUT} = \text{Under } 1.0 (\mu\text{F})$$

The recommended values of the capacitors depend on the control of brightness. For details, please see the item "Control of brightness" from the next page.)

These recommended values reduce fluctuation of input current to up accuracy of brightness.

<Please see after page-6>

The capacitor value must be considered for gain enough accuracy of brightness with reduction of noise from Input current changing.

## Setting of External Inductor Size

Please select the inductor size with referring this table corresponding to each number of LEDs.

Recommendation for the case that LED current  $I_F = 20 \text{ mA}$

LEDs	Indictor Size	Note
2 - 5	10 $\mu\text{H}$	LED current $I_F = 20 \text{ mA}$
Over 6	22 $\mu\text{H}$	

## Setting of $I_F$

Resistance connects between  $R_{SENS}$  pin and GND.

The average current is set by this  $R_{SENS}$  value and average current are obtained by the following equation.

$$I_F[\text{mA}] = \frac{300[\text{mV}]}{R_{SENS}[\Omega]}$$

Current Value error is within  $\pm 5\%$ .

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## Current Dimming Control

Recommended Brightness Control Circuits are 4 types.

### 1) Input PWM signal to SHDN terminal

$I_F$  can be adjusted with PWM signal by inputting it to SHDN terminal.

[Notice]

<<PWM signal frequency>>

- The recommended PWM signal frequency is from 100 Hz to 10 kHz. There is a possibility to arise the audible frequency in mounting to the board because it is within the auditory area.

<<Constant number of external condenser>>

- To reduce the fluctuation of input current and increase the accuracy of brightness, the values that  $C_{IN} = 4.7 (\mu F)$  or more,  $C_{OUT} = 1.0 (\mu F)$  or less are recommended.
- When the PWM signal is off, the time to drain  $C_{OUT}$  of charge depends on the constant number. And so, the actual value is little different from the theoretical value.

<<PWM input signal>>

- Set the amplitude of PWM signal within the range of SHDN terminal specification.

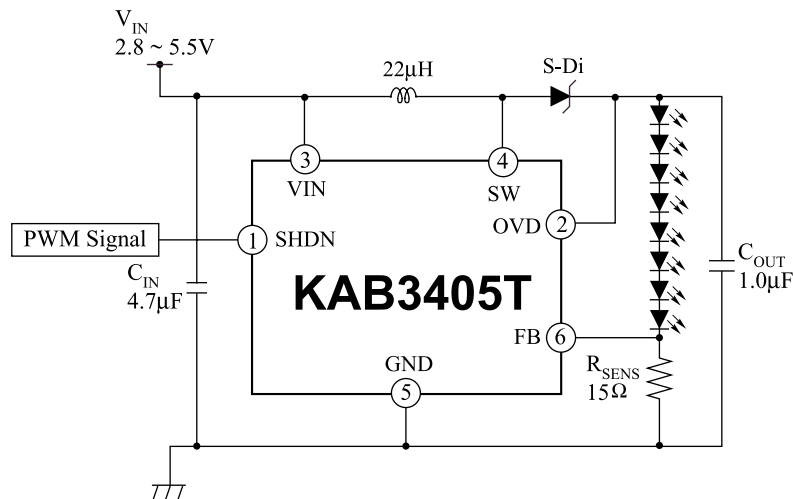
<<Rush current in inputting>>

- In case dimming by inputting the PWM signal to the SHDN terminal, this IC turns on and off repeatedly.  
And the rush current, which provides the charge to  $C_{OUT}$ , arises in turning on. Take care in selecting the condenser.

<<Current value in Control with PWM: Ideal Equation>>

$$I_F [\text{mA}] = \frac{300 [\text{mV}] \times \text{ON Duty} [\%]}{R_{\text{SENS}} [\Omega]}$$

<<Recommended application>>



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## 2) Input analog voltage to FB terminal

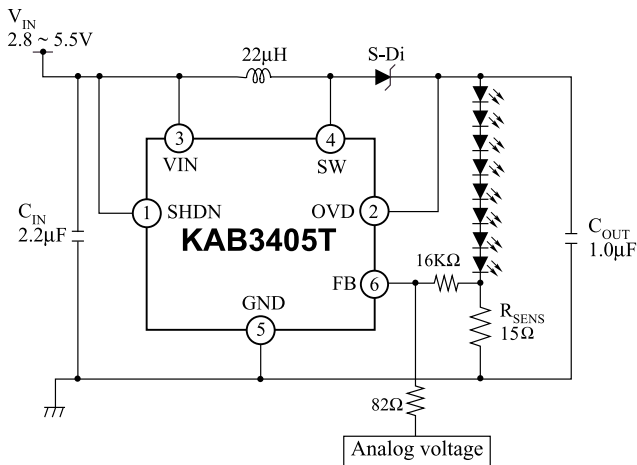
$I_F$  can be adjusted with Analog voltage input to FB terminal.

This method is without repeating IC ON/OFF, and no consider holding rash current.

### [Notice]

- LED current value goes over 100% of current set with  $R_{SENS}$ , if the input voltage is between 0 V to 300 mV(typ)

### <<Recommended application>>



## 3) Input PWM signal with filtering to FB terminal

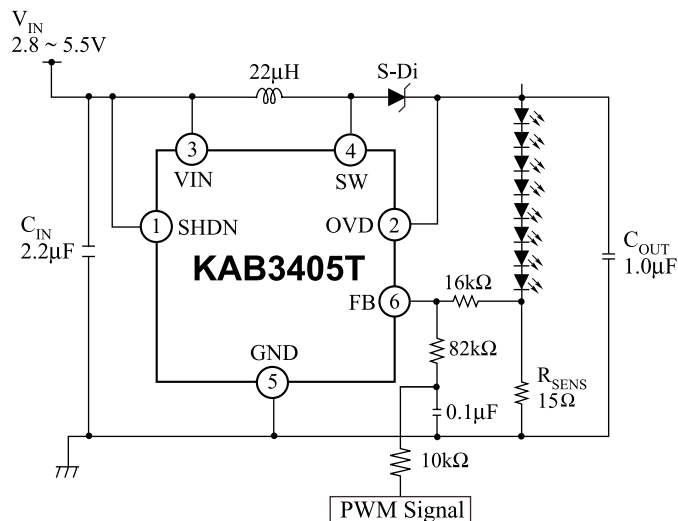
$I_F$  can be adjusted with filtering PWM signal using RC filter indicated in recommended circuit, because the PWM signal can be regard as analog voltage after filtering.

This method is without repeating IC ON/OFF, and no need to consider holding rash current.

### [Notice]

- LED current value goes over 100% of the current set with  $R_{SENS}$ , if the input voltage after filtering is between 0 V to 300 mV (typ).

### <<Recommended application>>



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## 4) Input Logic signal

$I_F$  can be adjusted with Logic signal input as indicated in recommended circuit.

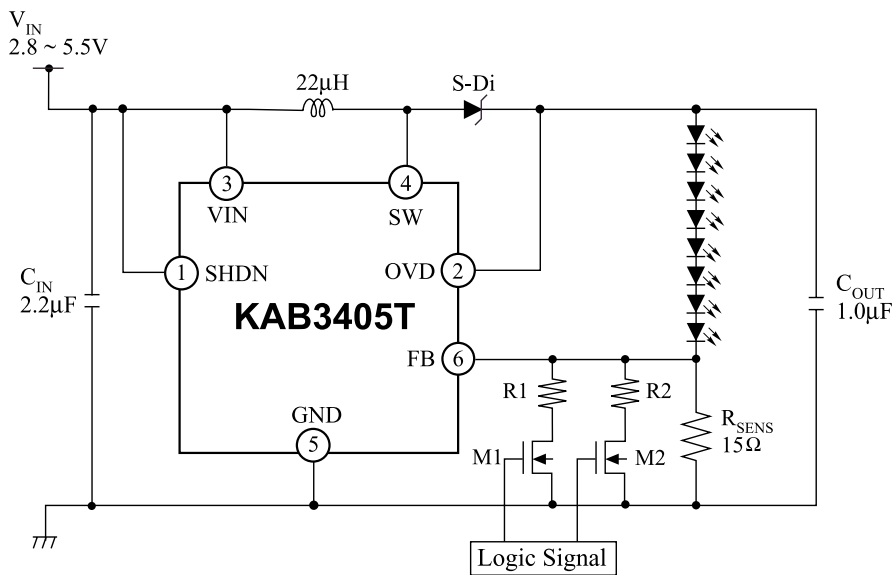
The resistor connected the ON-state Nch MOS Drain and  $R_{SENS}$  determines  $I_F$ .

Average of setting current  $I_o$  (mA) is next, approximately.

$I_F = (300 \text{ [mV]} / \text{Sum of resistor value [ } \Omega \text{ ]})$

$$I_F \text{ [mA]} = \frac{300 \text{ [mV]}}{\text{Sum of resistor value [ } \Omega \text{ ]}}$$

<<Recommended application>>



M1	M2	LED Current
OFF	OFF	$\frac{300 \text{ [mV]}}{R_{SENS} \text{ [ } \Omega \text{ ]}}$
ON	OFF	$300 \text{ [mV]} \times \frac{R_{SENS} \text{ [ } \Omega \text{ ]} R1 \text{ [ } \Omega \text{ ]}}{R_{SENS} \text{ [ } \Omega \text{ ]} + R1 \text{ [ } \Omega \text{ ]}}$
OFF	ON	$300 \text{ [mV]} \times \frac{R_{SENS} \text{ [ } \Omega \text{ ]} R2 \text{ [ } \Omega \text{ ]}}{R_{SENS} \text{ [ } \Omega \text{ ]} + R2 \text{ [ } \Omega \text{ ]}}$
ON	ON	$300 \text{ [mV]} \times \frac{R_{SENS} \text{ [ } \Omega \text{ ]} R1 \text{ [ } \Omega \text{ ]} R2 \text{ [ } \Omega \text{ ]}}{R_{SENS} \text{ [ } \Omega \text{ ]} R1 \text{ [ } \Omega \text{ ]} + R_{SENS} \text{ [ } \Omega \text{ ]} R2 \text{ [ } \Omega \text{ ]} + R1 \text{ [ } \Omega \text{ ]} R2 \text{ [ } \Omega \text{ ]}}$