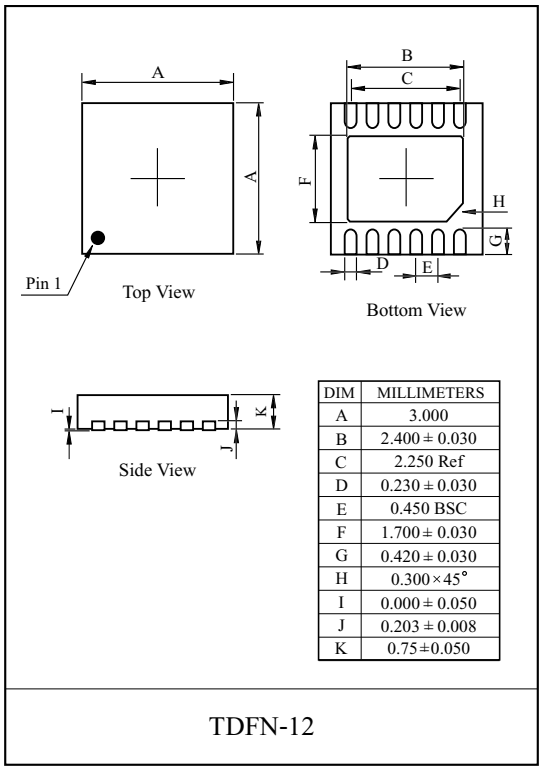
1X/1. 5X Fractional Charge Pump for White LED Driver with Dimming Control.

The KAC3303DN is low noise constant frequency charge pump DC/DC converter specially designed to drive up to four white LEDs with constant current from Li-ion cell. Dual (1x/1.5x) Modes and low dropout voltage of LED driver maximize efficiency for the white LED application over full Li-ion battery input range. Various kinds of protection circuits protect your system from every undesirable output condition.

The LED current is set by either the single wire serial interface or PWM. Various kinds of protection circuits keep your system from undesirable conditions.



DIM	MILLIMETERS
A	3.000
B	2.400 ± 0.030
C	2.250 Ref
D	0.230 ± 0.030
E	0.450 BSC
F	1.700 ± 0.030
G	0.420 ± 0.030
H	0.300×45°
I	0.000 ± 0.050
J	0.203 ± 0.008
K	0.75±0.050

TDFN-12

Not recommended for new design

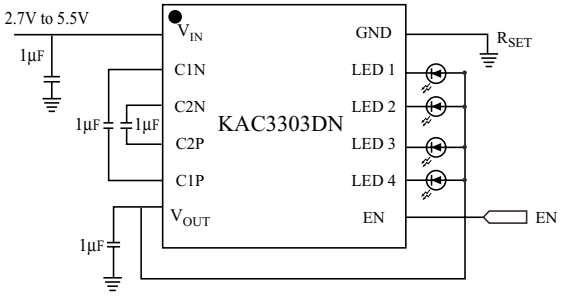
Features

- 1x/1.5x dual charge pump modes with auto detection.
- Excellent Power Efficiency. (more than 92% of P_{MAX})
- LED current matching of ±2%.
- Power-down current below 1 μA.(max.)
- Drives up to 4 LED s
- Up to 20mA/LED current capability. [V_{IN} > 3.1V]
- Up to 15mA/LED current capability. [V_{IN} > 2.7V]
- Strong to ESD. [MM:>200V, HBM:>2000V]
- Low input ripple and EMI.
- PWM or single wire serial interface dimming control.
- 2.7V to 5.5V input voltage range.
- Output over-voltage protection.
- Thermal shutdown protection.
- Output over-current protection.
- Soft start limits Inrush current.
- Automatic soft-start protects IC from output short.
- 1MHz switching frequency.
- Small TDFN-12 Package [3×3㎟]
- Drive-up to 100mA with shorted 4 LED terminals.

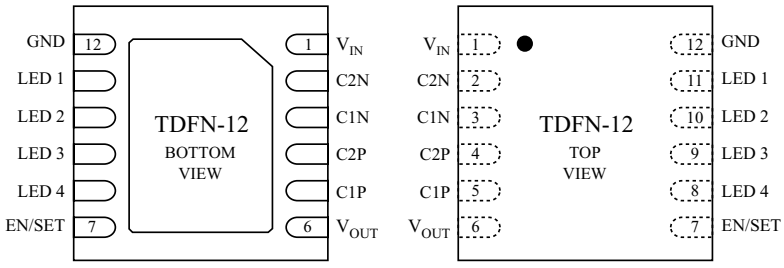
Applications

- Cellular phones, Smart Phones, PDA, Digital Cameras, Camcorders.
- MP3 player and other handheld devices with color displays operating circuit.

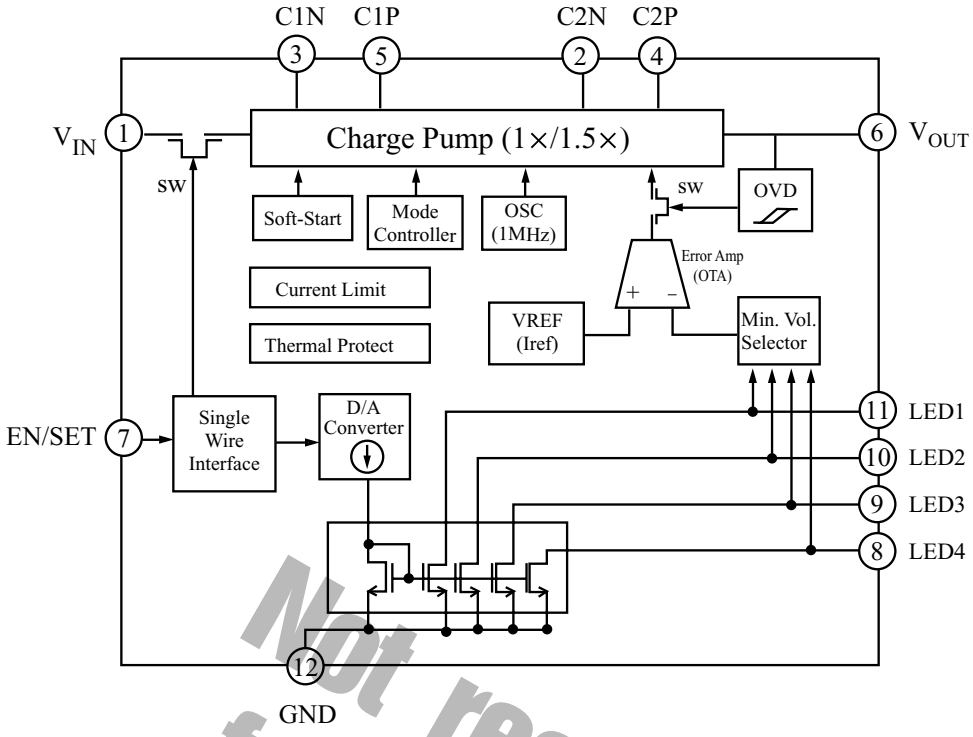
Typical operating Circuit



Pin Configuration



Block Diagram



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Pin Descriptions

Pin	Name	Function
1	V_{IN}	Power Supply Voltage Input
2	C2N	Negative terminal of switched capacitor 2
3	C1N	Negative terminal of switched capacitor 1
4	C2P	Positive terminal of switched capacitor 2
5	C1P	Positive terminal of switched capacitor 1
6	V_{OUT}	Charge pump output
7	EN/SET	Chip enable input. (Shutdown at Low state) Single Wire Interface & PWM Dimming Control
8	D4	Sinking current input for LED 4
9	D3	Sinking current input for LED 3
10	D2	Sinking current input for LED 2
11	D1	Sinking current input for LED 1
12	GND	Ground

Maximum Ratings

Characteristics	Symbol	Rating	Units
Input Supply Voltage	V_{IN}	-0.3 to +6.0	V
Input Pin	DIM, EN	-0.3 to (V_{IN}+0.2)	V
Maximum Power Dissipation. (@Ta=25℃)	P_D	2.25	W
Thermal Resistance	θ_{JA}	55.5	℃/W
Operating Ambient	Ta	-40 to + 85	℃
Junction Temperature	T_j	-40 to + 150	℃
Storage Temperature	T_{stg}	-55 to + 150	℃
Lead Temperature	T_{LEAD}	300	℃

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Electrical Characteristics (Ta=-40 to 85℃, 2.7V< V_{IN} < 5.5V, C_1=C_2=1.0μF. unless otherwise noted.) (note 1)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Supply Voltage	V_{IN}	-	2.7	-	5.5	V
Maximum LED sink current	I_{LED}	V_{IN}>2.7V	-	15	-	mA
		V_{IN}>3.1V	-	20	-	mA
Quiescent current	I_Q	No output load	-	1.0	2.0	mA
Power-down Current	I_{PD}	V_{EN}=Low	-	0.1	1	μA
I_{LED} Accuracy	I_{LED_ACC}	2mA<I_{LED} <20mA	-	±3	-	%
I_{LED} Matching between any other I_{LED}	I_{LED_MAT} (Note 2)	I_{LED}= 16.7mA	-	±2	-	%
LED regulation Voltage	V_{LED}	-	75	120	-	mV
Oscillator Frequency	F_{OSC}	2.5V<V_{IN}<5.5V	0.7	1	1.3	MHz
Maximum Output Current	I_{OUT}	V_{IN}>3.1V, V_{OUT}≥3.8V	80	100	-	mA
		V_{IN}>2.7V, V_{OUT}≥3.5V	60	80	-	mA
Input Current Limit	I_{LIMIT}	Short Condition in V_{OUT} Without Softstart. (Note 2)	-	280	600	mA
Thermal Shutdown Threshold	T_{SD}	40℃ Hysteresis	-	150	-	℃
Over-Voltage Protect	V_{OVP}	-	-	5.5	6.0	V
Hysteresis of V_{OVP}	V_{HTY_OVP}	-	-	0.4	-	V
Enable Logic High	V_{EN_H}	-	1.6	-	-	V
Enable Logic Low	V_{EN_L}	-	-	-	0.4	V

Note 1) Specifications to -40℃ are guaranteed by design and not production tested.

Note 2) This is occurred when Pin of LED is shorted to GND, or there are ohmic short V_{OUT} to GND

Application Information

- **Output Regulation**

KAC3303DN maintains constant LED brightness even at very low battery voltage. For example, at 2.7V of the battery voltage KAC3303DN can maintain constant LED bright above 15mA. For better efficiency KAC3303DN will be kept in 1x mode unless lowest voltage of the LED1~LED4 goes under the 75mV. Constant switching frequency & optimized duty make low input and output ripple at the 1.5x mode. Of course, KAC3303DN has almost no output ripple at the 1x mode.

- **Shutdown (Enable=Low)**

When voltage of the ENABLE pin goes under 0.4V, KAC3303DN enter the shutdown mode where input current go to zero and there are no current between output capacitors and transfer capacitor.

- **Soft-Start**

KAC3303DN has its original soft-start function to limit inrush current at turn on. KAC3303DN charges transfer capacitors and output capacitor with a constant input current until output voltage goes to the value of ($1.4 \times V_{IN}$). If output voltage reached the value of ($1.4 \times V_{IN}$) or over-voltage protection circuit is activated, LED current start to flow. But input current remains to zero until output voltage goes down to usual output operating voltage from the discharge of LED current. At the every turn on the ENABLE and output voltage less than 25% of the input voltage, soft-start sequence is introduced for the safety.

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- **Short protection (various short mode)**

1) Short V_{OUT} pin to GND pin: If output is shorted to ground, output current is limited by the soft-start which is repeated until V_{OUT} remains under 25% of V_{IN}.
2) Short LED pin to GND pin: If this occurs at the soft-start-mode or shutdown state, KAC3303DN stays at soft-start-mode. Else this is done during operating, the output current is limited by the current-limit-circuitry.
3) Short V_{OUT} pin to LED pin(shorted LED) : There are no change but shorted LED doesn t work.

- **Open protection**

If more than one LED is opened, output voltage is limited by over-voltage-protect circuitry. But, other LEDs work continuously without change of the brightness.

- **Current limit**

There could be variable short mode in the backlight system. For example, V_{OUT} pin to GND or LED pin to GND or short of LEDs, etc. In these case, large current could be flow at the output pin. KAC3303DN are protected by the" thermal shutdown circuitry, but external elements might be damaged without" current limit circuitry. Current limit" circuitry set you to ease to design safely.

- **Over-voltage protection**

When a LED pin shorted to the ground or LED is opened itself, voltage of the LED terminal could be almost 0V without any concerning to the other conditions. In this case, output voltage might be raised over IC s maximum ratings. And, then IC may be destroyed KAC3303DN maintains over voltage protection circuitry for the prohibiting output voltage over the maximum ratings.

- **Thermal shutdown**

KAC3303DN includes a thermal shutdown circuit which makes IC shutdown at 150℃(typ.) and recover after IC cools by approximately 40℃.

· Input Ripple

For LED drive IC s in mobile system, input ripple is more important than output ripple, because there are many other components which have input supply terminal from battery instead of the output terminal. KAC3303DN has very excellent input ripple characteristics which is depends on the supply s impendence. You can get better input ripple characteristics, by minimizing resistance from battery to the V_{IN} pin.

· Unused LED

When driving fewer than four LEDs, connect any unused LED pin to V_{IN}. This makes the corresponding LED driver disable, then there is no current consumption through unused LED pin, so KAC3303DN maintains its efficiency.

· Flash or Large Current Drive up to 100mA.

KAC3303DN can be used Flash Driver when shorting pins of 4 LEDs, Be careful that current setting should be set not for the I_{LED} but for I_{FLASH} ($=I_{LED}\times 4$).

· LED Current Control & Dimming

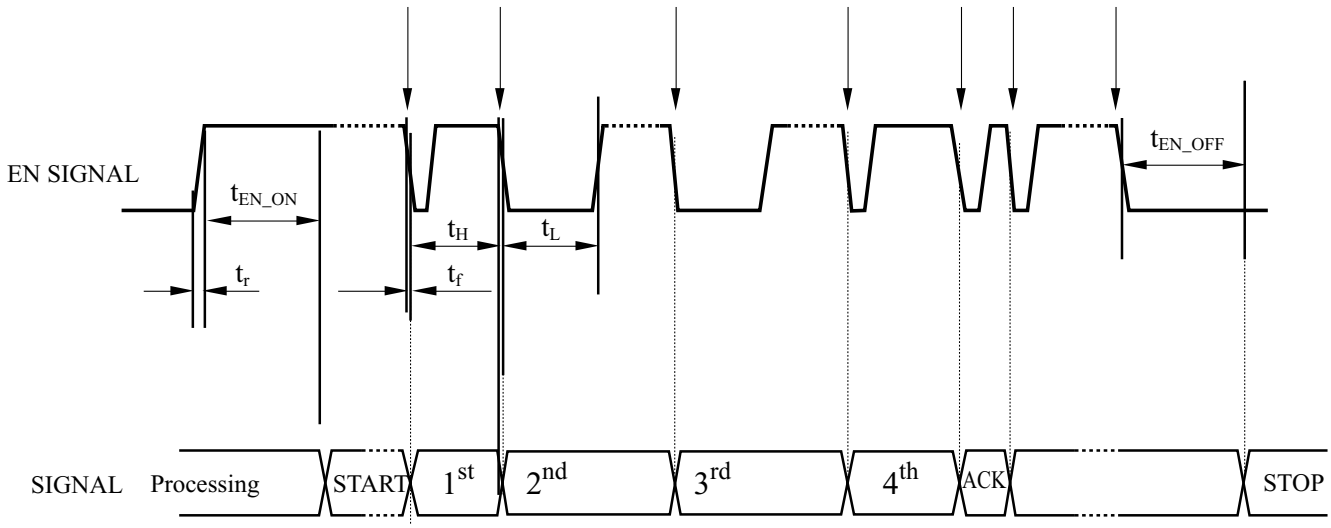
KAC3303DN don t need to external R_{SET} terminal for the LED Current control. You can easily setting LED current with Single Serial Interface through Enable terminal. See next pages for the Single Serial Interface.

· LED Current Control

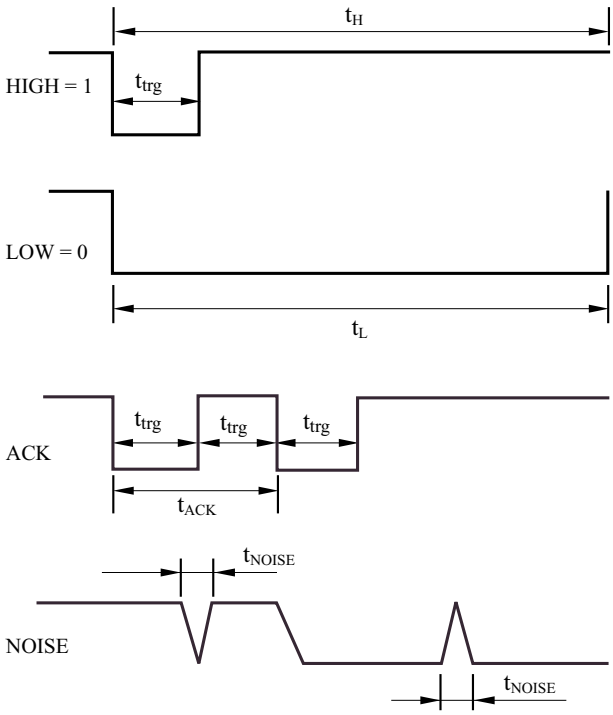
KAC3303DN support PWM dimming which could be used when your application can not make singe serial interfacing signal from micom. You can control LED current under the 16.7mA which is initial LED current setting value when IC is enabled. But, please be careful to determine PWM frequency, between 100Hz and 1kHz, not to noise (sound) occurred from ceramic capacitors.

Not recommended for new design

Single Serial Interface

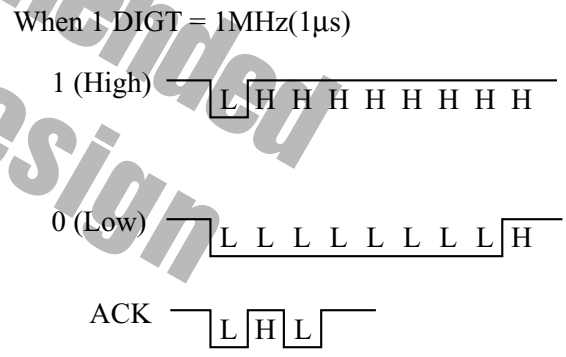


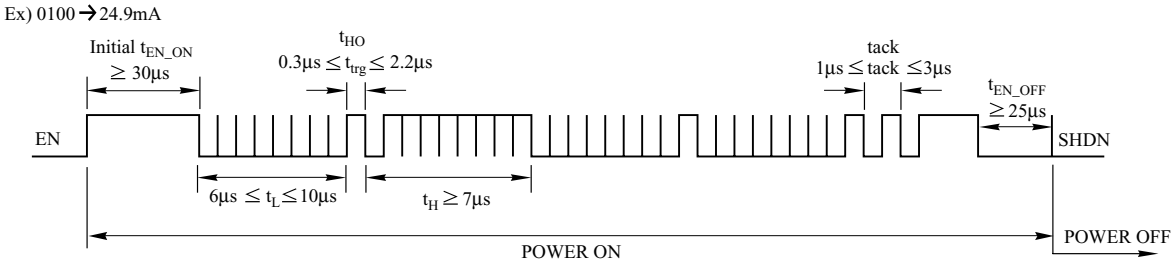
Parameter	Symbol	Conditions	Min	Typ	Max	Units
Digital input voltage	V_{IL}	-	-	-	0.4	V
	V_{IH}	-	1.6	-	-	V
Digital input Current	I_{EN}	-	-0.2	-	0.2	μA
Start Time	t_{EN_ON}	-	30	-	-	μS
Stop Time	t_{EN_OFF}	-	25	-	-	μS
EN High Time	t_H	-	7	-	-	μS
EN Low Time	t_L	-	6	8	10	μS
ACK Time	t_{ACK}	-	1.0	1.5	3.0	μS
Rising Time	t_r	-	-	-	100	nS
Falling Time	t_f	-	-	-	100	nS
Pulse Width	t_{trg}	-	0.3	1	2.2	μS
Filtered Noise Width	t_{noise}	-	-	-	0.1	μS

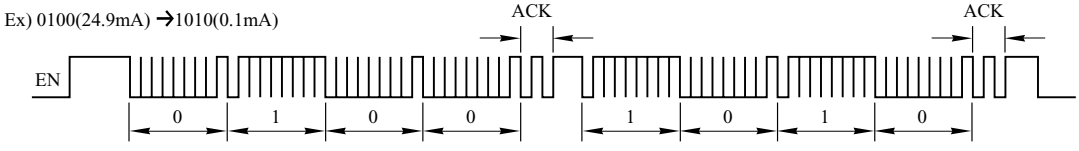


I_{LED}[mA]	B3	B2	B1	B0	Decimal
0.1	1	0	1	0	10
0.5	1	0	1	1	11
2.8	1	0	0	0	8
3.2	1	0	0	1	9
8.4	1	1	1	0	14
8.8	1	1	1	1	15
11.4	1	1	0	0	12
11.8	1	1	0	1	13
13.9	0	0	1	0	2
14.3	0	0	1	1	3
16.7	0	0	0	0	0
17.1	0	0	0	1	1
22.2	0	1	1	0	6
22.6	0	1	1	1	7
24.9	0	1	0	0	4
25.3	0	1	0	1	5

Not recommended for new design

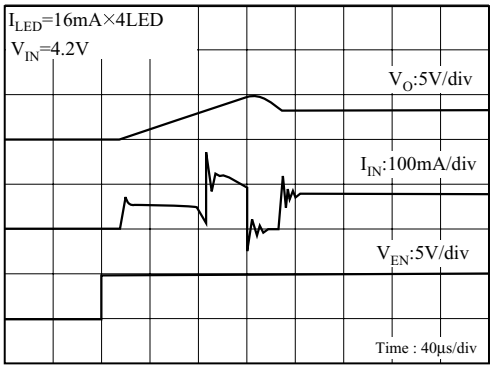




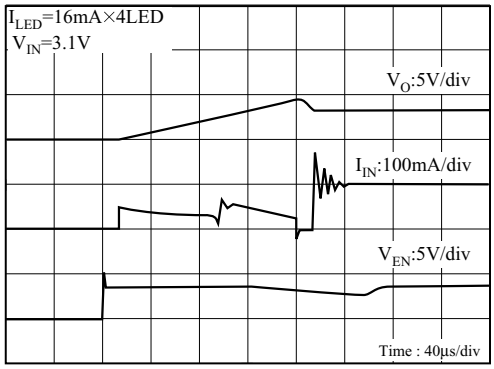


Typical Opering Characteristics

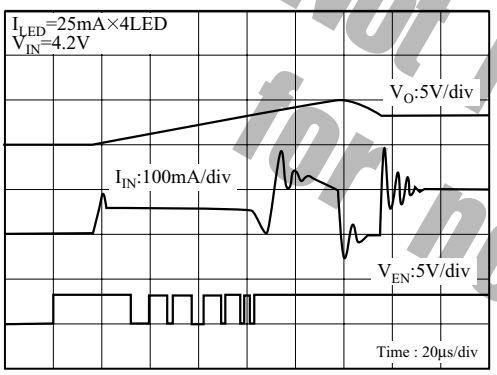
StartUP From Discharged Output (1)



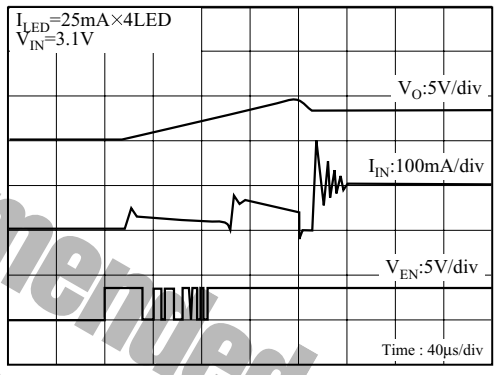
StartUP From Discharged Output (2)



StartUP From Discharged Output (3)

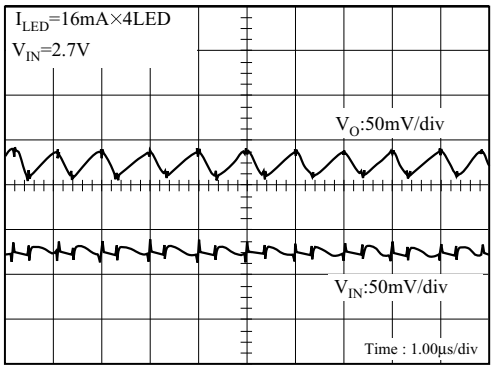


StartUP From Discharged Output (4)

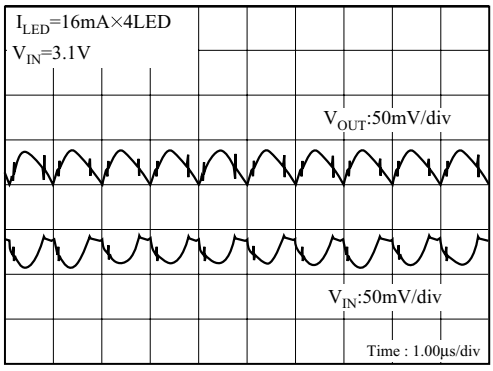


Not recommended for new design

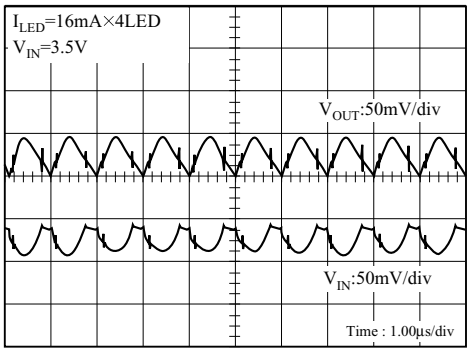
Typical Operating Wave Form in ×1.5 Mode (1)



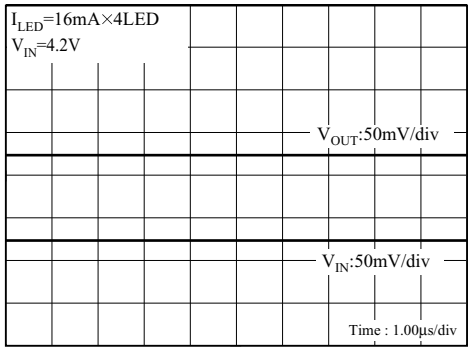
Typical Operating Wave Form in ×1.5 Mode (2)



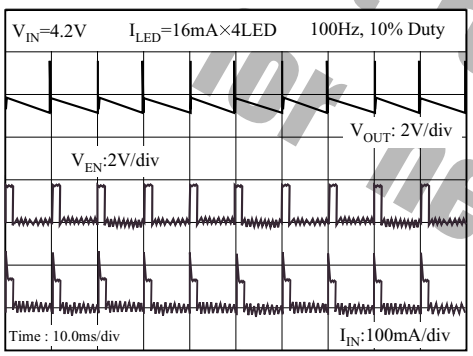
Typical Operating Wave Form in ×1.5 Mode (3)



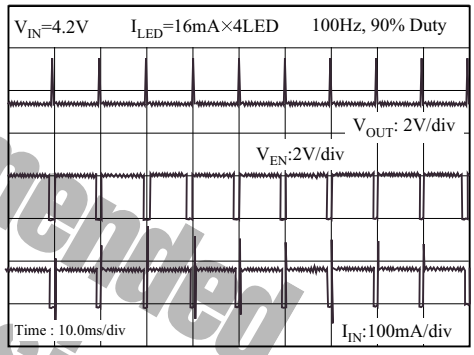
Typical Operating Wave Form in×1 Mode



PWM Dimming without serial interface (1)



PWM Dimming without serial interface (2)



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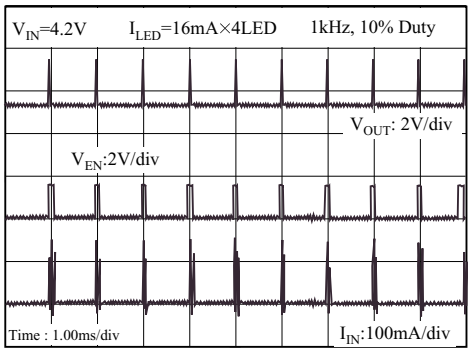
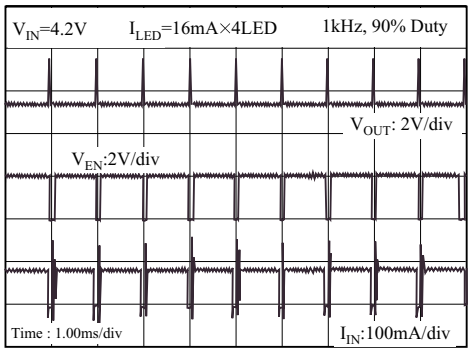
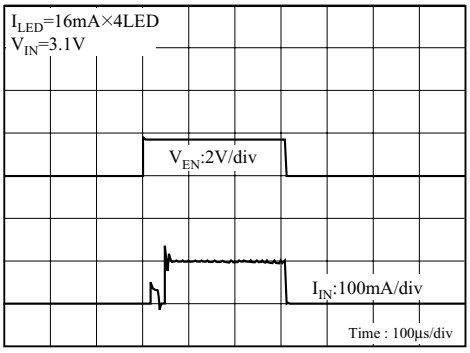
PWM Dimming without serial interface (3)



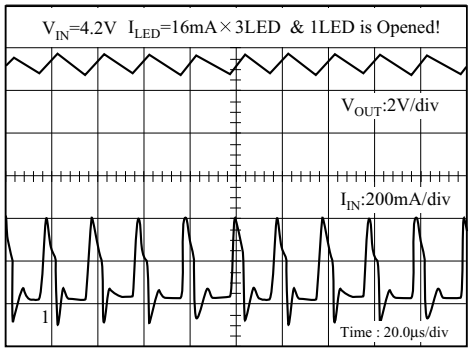
PWM Dimming without serial interface (4)



Start & Shutdown Response



OVP When LED Open



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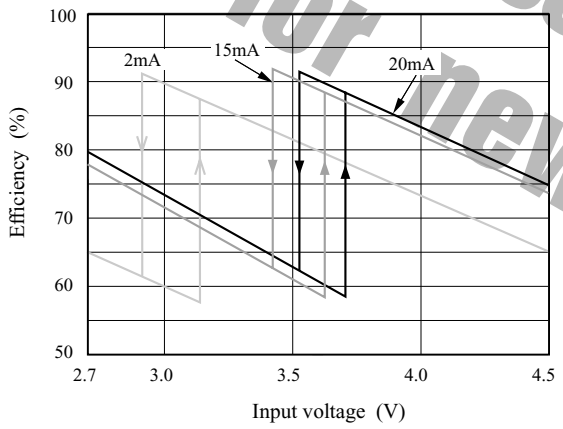
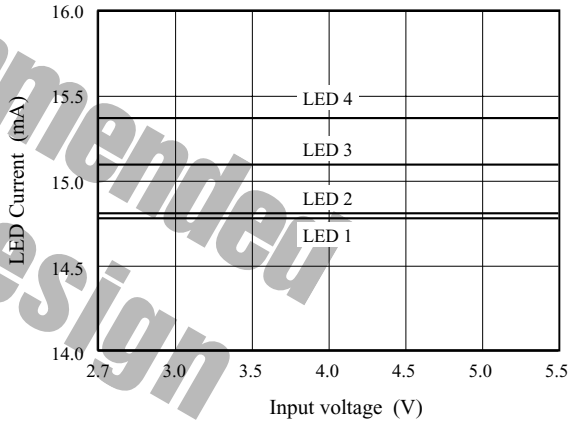
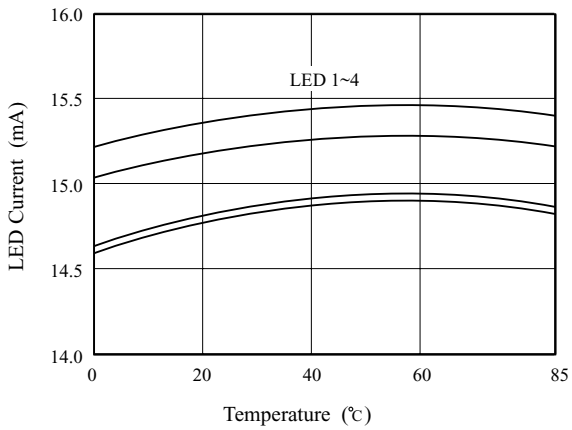
Efficiency vs. Supply Voltage



LED Current vs. Supply Voltage



LED Current vs. Temperature



Quiesecent current vs Temperature