4 Channels 100mA x1/x1.5/x2 Charge Pump White LED Driver

General Description

The RP1364A is a 4 channel WLED driver with auto mode selection of x1, x1.5 and x2 mode with low dropout voltage in current sources. The RP1364A can power up to 4 white LEDs with regulated constant current for uniform intensity. Each channel (LED1 to LED4) can support up to 25mA. The part maintains highest efficiency by utilizing x1/x1.5/x2 fractional charge pump and low dropout current regulators. An internal 5-bit DAC is used for brightness control. Users can easily configure up to 16-step of LED current by enable pin.

The RP1364A is available in a WQFN-16L 3x3 package. Small 0.22uF capacitors can be used for fly capacitors. It provides the best backlighting solution with high efficiency and smallest board space for portable application.

Ordering Information

RP1364A□□

- Package Type
  QW : WQFN-16L 3x3 (Option 1)
- Operating Temperature Range
  G : Green (Halogen Free with Commercial Standard)

Note :

Richpower Green 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.

Marking Information

For marking information, contact our sales representative directly or through a Richpower distributor located in your area, otherwise visit our website for detail.

Features

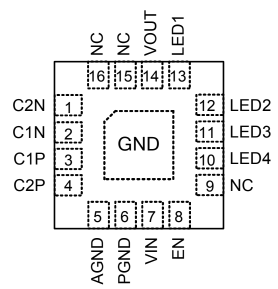
- **Efficiency Up to 93% Over Li-ion Battery Discharge**
- **Typical 85% Average Efficiency Over Li-ion Battery Discharge**
- **Support Up to 4 White LEDs**
- **Support Up to 25mA/Per Channel**
- **Support Up to 100mA Output Current**
- **Flexible 16-step Brightness Control**
- **60mV Typical Current Source Dropout**
- **1% Typical LED Current Accuracy**
- **0.7% Typical LED Current Matching**
- **Automatic x1/x1.5/x2 Charge Pump Mode Transition**
- **Low Input Noise and EMI Charge Pump**
- **5V Over Voltage Protection**
- **Power On/Mode Transition In-rush Protection**
- **1MHz Switching Frequency**
- **Typical 0.4uA Low Shutdown Current**
- **RoHS Compliant and Halogen Free**

Applications

- Camera Phone, Smart Phone
- White LED Backlighting

Pin Configurations

(TOP VIEW)

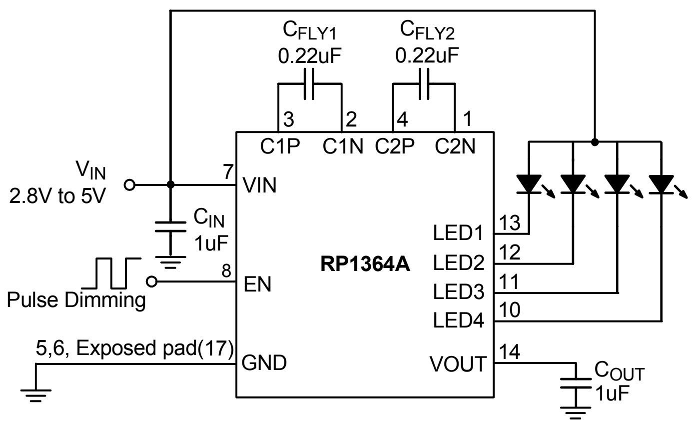


WQFN-16L 3x3

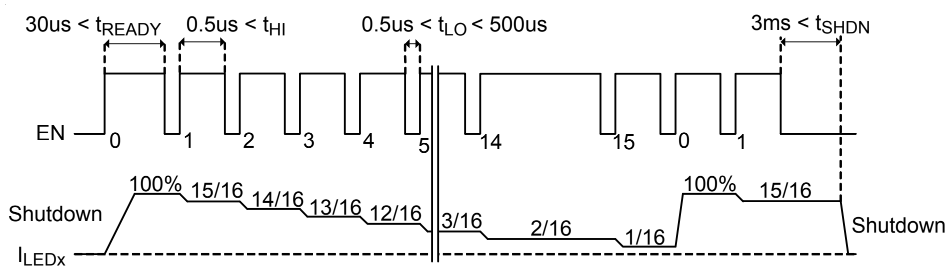
Functional Pin Description

Pin Number	Pin Name	Pin Function
1	C2N	Negative Terminal of Bucket Capacitor 2.
2	C1N	Negative Terminal of Bucket Capacitor 1.
3	C1P	Positive Terminal of Bucket Capacitor 1.
4	C2P	Positive Terminal of Bucket Capacitor 2.
5	AGND	Analog Ground.
6	PGND	Power Ground.
7	VIN	Power Input Voltage.
8	EN	Chip Enable (Active High), and connects to GPIO pin of MCU.
9, 15	NC	No Internal Connection.
10	LED 4	Current Sink for LED4. (If not in use, pin should be connected to VIN)
11	LED 3	Current Sink for LED3. (If not in use, pin should be connected to VIN)
12	LED 2	Current Sink for LED2. (If not in use, pin should be connected to VIN)
13	LED 1	Current Sink for LED1. (If not in use, pin should be connected to VIN)
14	VOUT	Output Voltage Source for LED1 to LED4.
16	NC	No Internal Connection.
Exposed Pad	GND	Exposed pad should be soldered to PCB board and connected to GND.

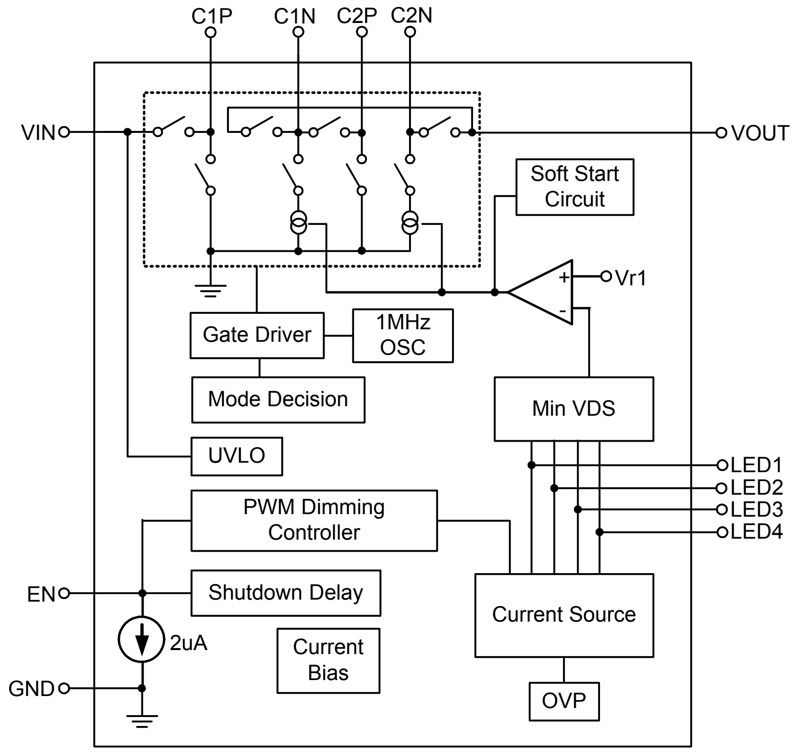
Typical Application Circuit



Timing Diagram (16-steps Pulse Dimming and Shutdown Delay)



Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, V_{IN} ---------- –0.3V to 5V
- Output Voltage, V_{OUT} ---------- –5V to 0.3V
- Power Dissipation, P_D @ $T_A = 25°C$
  WQFN-16L 3x3 ---------- 1.47W
- Package Thermal Resistance (Note 4)
  WQFN-16L 3x3, θ_{JA} ---------- 68°C/W
- Junction Temperature ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –40°C to 150°C
- ESD Susceptibility (Note 2)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 3)

- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 3.6V, V_F = 3.5V, C_{IN} = C_{OUT} = 1uF, C_{FLY1} = C_{FLY2} = 0.22uF, $I_{LED1\ to\ LED4}$ = 15mA, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Input Power Supply						
Input Supply Voltage	V_{IN}		2.8	–	4.5	V
Under-Voltage Lockout Threshold	V_{UVLO}	V_{IN} Rising	1.8	2	2.5	V
Under-Voltage Lockout Hysteresis	ΔV_{UVLO}		--	100	--	mV
Quiescent Current x1 Mode	I_Q	x1 Mode	--	1	2	mA
Shutdown Current	I_{SHDN}	V_{IN} = 5V	--	0.4	2	uA
LED Current						
I_{LEDx} Accuracy		I_{LEDx} = 25mA	–5	0	+5	%
Current Matching		I_{LEDx} = 25mA	–2	0	+2	%
Charge Pump						
Oscillator Frequency	f_{OSC}		--	1	--	MHz
Mode Decision						
x1 Mode to x2 Mode Transition Voltage (V_{IN} Falling)		I_{OUT} = 100mA, I_{LEDx} = 25mA.	--	3.6	3.8	V
Mode Transition Hystersis		I_{OUT} = 100mA, I_{LEDx} = 25mA.	--	200	--	mV
Protection Function						
OVP		V_{IN} – V_{OUT}	--	5	--	V
Dimming						
EN Low Time for Shutdown			3	–	--	ms
Dimming						
EN Time: Logic-Low Delay	T_{IL}		0.5	–	500	us
EN Time: Logic-High Delay	T_{IH}		0.5	–	--	us
EN Threshold: Logic-Low Voltage	V_{IL}		--	–	0.2	V
EN Threshold: Logic-High Voltage	V_{IH}		1	–	--	V
EN Pull Low Current	I_{EN}		--	2	--	uA

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 for extended periods may remain possibility to affect device reliability.

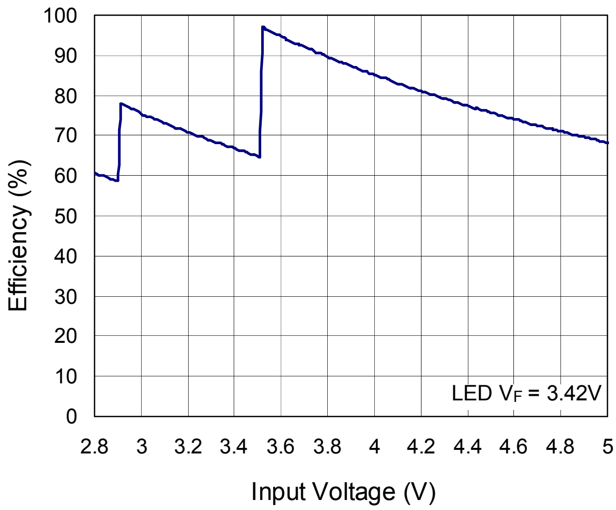
Note 2. Devices are ESD sensitive. Handling precaution is recommended.

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

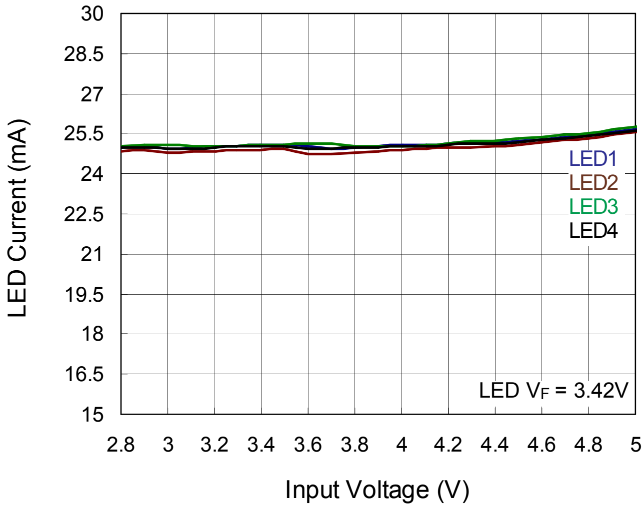
Note 4. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Typical Operating Characteristics

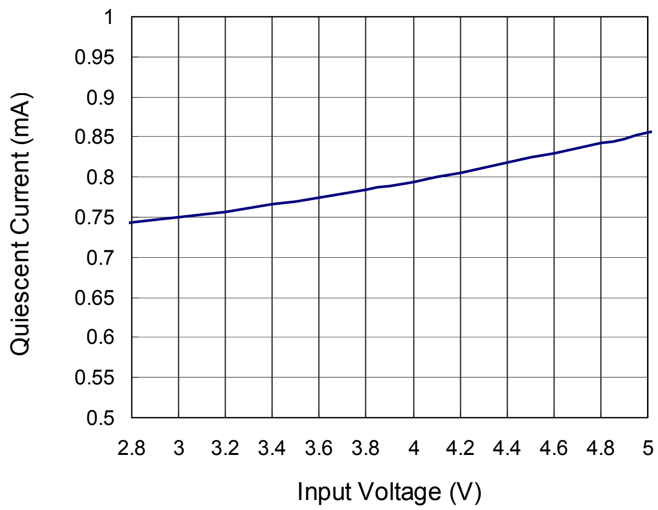
Efficiency vs. Input Voltage



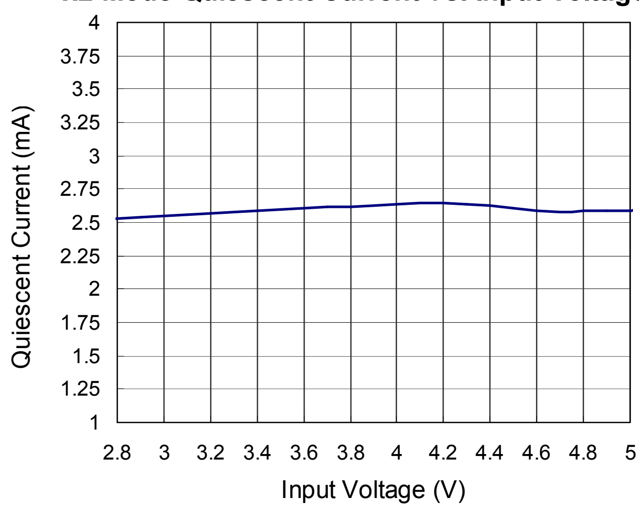
LED Current vs. Input Voltage



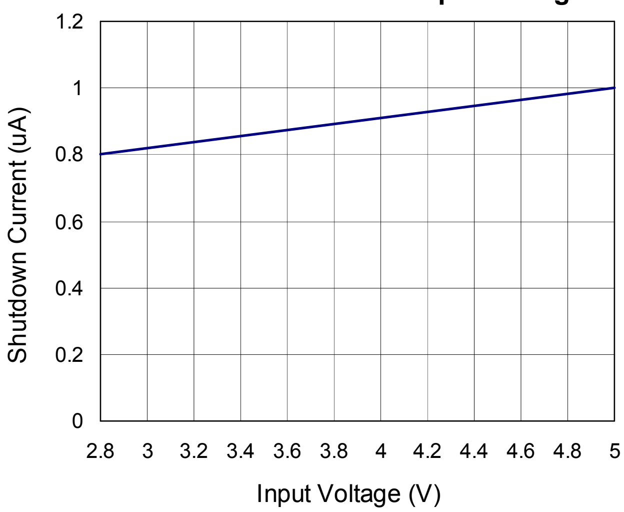
x1 Mode Quiescent Current vs. Input Voltage



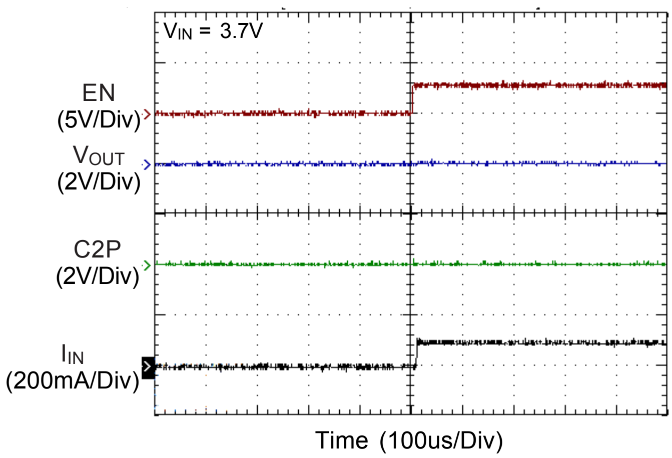
x2 Mode Quiescent Current vs. Input Voltage



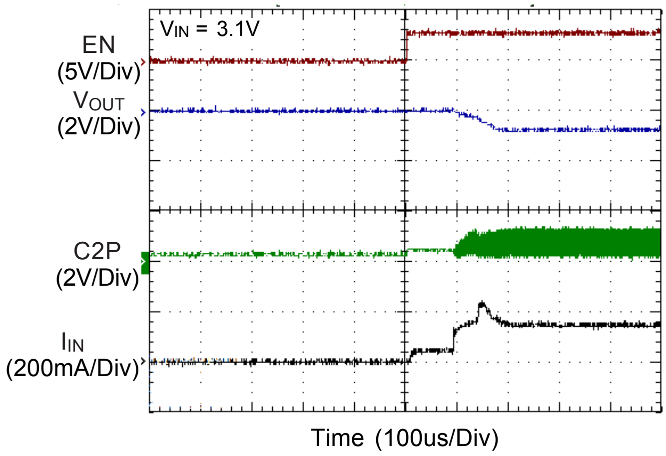
Shutdown Current vs. Input Voltage



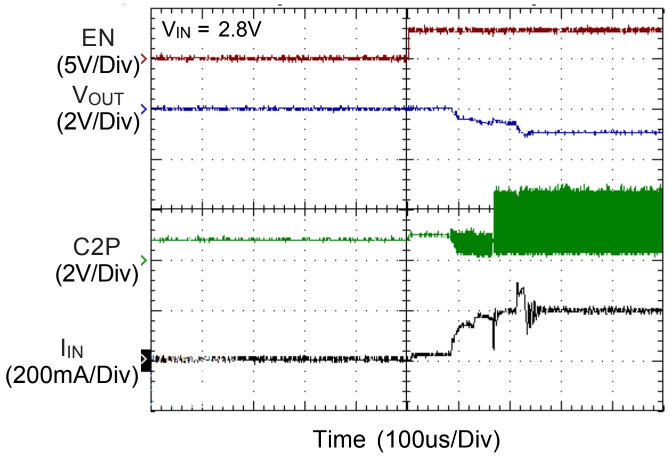
x1 Mode Inrush Current Response



x1.5 Mode Inrush Current Response



x2 Mode Inrush Current Response



Applications Information

The RP1364A uses a fractional switched capacitor charge pump to power up to four white LEDs with a programmable current for uniform intensity. The part integrates current sources and automatic mode selection charge pump. It maintains the high efficiency by utilizing an x1/x1.5/x2 fractional charge pump and current sources. The small equivalent x1 mode open loop resistance and ultra-low dropout voltage of current source extend the operating time of x1 mode and optimize the efficiency in white LED applications.

Input UVLO

The input operating voltage range of the LED driver is from 2.8V to 5V. An input capacitor at the VIN pin could reduce ripple voltage. It is recommended to use a ceramic 1uF or larger capacitance as the input capacitor. This RP1364A provides an under voltage lockout (UVLO) function to prevent it from unstable issue when startup. The UVLO threshold of input rising voltage is set at 2V typically with a hysteresis of 100mV.

Soft Start

The charge pump employs a soft-start feature to limit the inrush current. The soft-start circuit prevents the excessive inrush current and input voltage droop. The soft-start clamps the input current over a typical period of 50us.

Mode Decision

The RP1364A uses a smart mode selection method to decide the working mode for optimizing the efficiency. Mode decision circuit senses the output and LED voltage for up/down selection. The RP1364A automatically switches to x1.5 or x2 mode whenever the dropout condition is detected from the current source and returns to x1 mode whenever the dropout condition releases.

LED connection

The RP1364A supports up to 4 white LEDs. The 4 LEDs are connected from VIN to pin7, 8, 9, and 10 respectively. If the LED is not used, the LED pin should be connected to VIN directly.

Capacitor Selection

To get the better performance of the RP1364A, the selection of peripherally appropriate capacitor and value is very important. These capacitors determine some parameters such as input/output ripple voltage, power efficiency and maximum supply current by charge pump. To reduce the input and output ripple effectively, the low ESR ceramic capacitors are recommended. For LED driver applications, the input voltage ripple is more important than output ripple. Input ripple is controlled by input capacitor CIN, increasing the value of input capacitance can further reduce the ripple. Practically, the input voltage ripple depends on the power supply impedance. The flying capacitor CFLY1 and CFLY2 determine the supply current capability of the charge pump to influence the overall efficiency of the system. The lower value will improve efficiency. However, it will limit the LED's current at low input voltage. For 4 X25mA load over the entire input range of 2.8V to 5V, it is recommended to use a 1uF ceramic capacitor on the flying capacitor CFLY1 and CFLY2.

Brightness Control

The RP1364A implements a pulse dimming method to control the brightness of white LEDs. Users can easily configure the LED current by a serial pulse. The dimming of white LEDs' current can be achieved by applying a pulse signal to the EN pin. There are totally 16 steps of current could be set by users. The detail operation of brightness dimming is showed in the figure of " Timing Diagram" .

Thermal Considerations

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

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

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

For recommended operating conditions specification of RP1364A, The maximum junction temperature is 125°C. The junction to ambient thermal resistance θ_{JA} is layout dependent. For WQFN-16L 3x3 packages, the thermal resistance θ_{JA} is 165°C/W on the standard JEDEC 51-3 single layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by following formula :

$P_{D(MAX)}$ = (125°C − 25°C) / (165°C/W) = 0.606W for WQFN-12L 2x2 packages

The maximum power dissipation depends on operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance θ_{JA}. For RP1364A packages, the Figure 1 of derating curves allows the designer to see the effect of rising ambient temperature on the maximum power allowed.

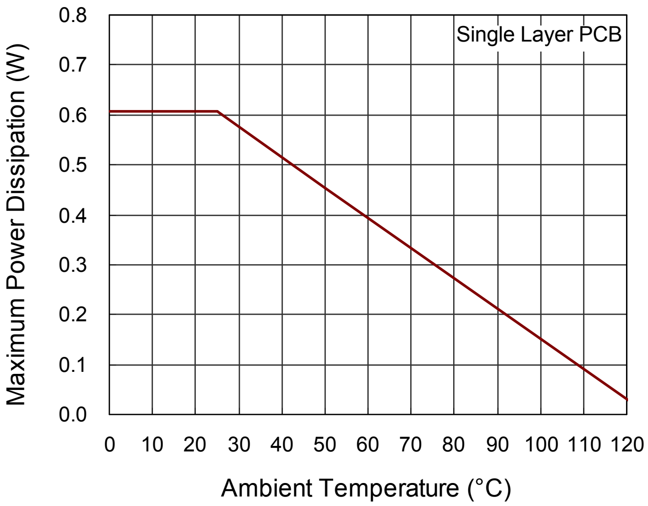


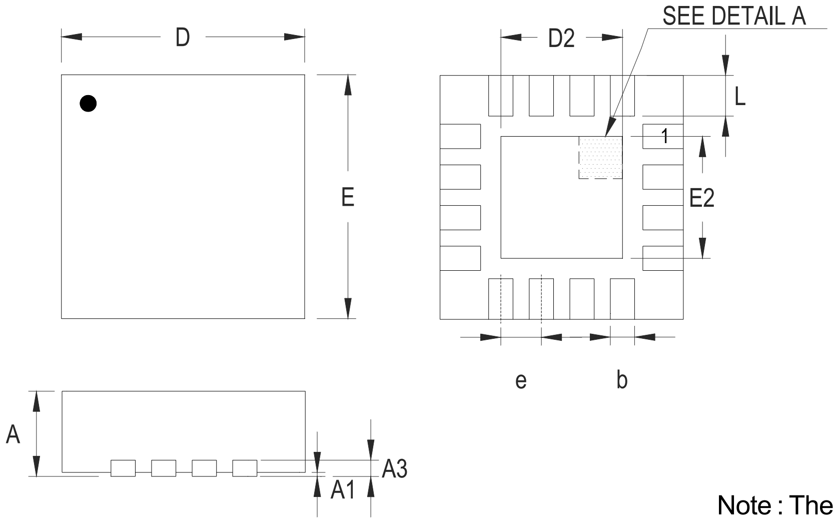
Figure 1. Derating Curves for RP1364A Packages

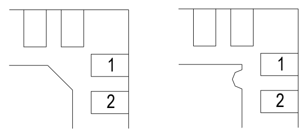
Layout Considerations

The RP1364A is a high-frequency switched-capacitor converter. Careful PCB layout is necessary. For best performance, place all peripheral components as close to the IC as possible. Place CIN, COUT, CFLY1, and CFLY2 near to VIN, VOUT, CP1, CN1, CP2, CN2, and GND pin respectively. A short connection is highly recommended. The following guidelines should be strictly followed when designing a PCB layout for the RP1364A.

- The exposed GND pad must be soldered to a large ground plane for heat sinking and noise prevention. The throughhole vias located at the exposed pad is connected to ground plane of internal layer.
- VIN traces should be wide enough to minimize inductance and handle the high currents. The trace running from battery to chip should be placed carefully and shielded strictly.
- Input and output capacitors must be placed close to the part. The connection between pins and capacitor pads should be copper traces without any through-hole via connection.
- The flying capacitors must be placed close to the part. The traces running from the pins to the capacitor pads should be as wide as possible. Long traces will also produce large noise radiation caused by the large dv/dt on these pins. Short trace is recommended.
- All the traces of LED and VIN running from pins to LCM module should be shielded and isolated by ground plane. The shielding prevents the interference of high frequency noise coupled from the charge pump.
- Output capacitor must be placed between GND and VOUT to reduce noise coupling from charge pump to LEDs.

Outline Dimension





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	1.300	1.750	0.051	0.069
E	2.950	3.050	0.116	0.120
E2	1.300	1.750	0.051	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

RICHPOWER MICROELECTRONICS CORP.

Headquarter

Room 2102, 1077 ZuChongZhi Road, Zhang Jiang
Hi-TechPark, Pudong New Area, Shanghai, China

Tel: (8621)50277077 Fax: (8621)50276966