

### GENERAL DESCRIPTION

PT4305 is a 1x/1.5x auto-adjust charge pump white LED driver with maximum 350mA load. Auto-adjust charge pump achieves high efficiency for Li-Ion battery supply. Few external components (two flying capacitors, two filter capacitors at VIN and VOUT, and one feedback resistor) make PT4305 ideally suited for mobility application.

The current through the LED can be pre-set by feedback resistor. And the LED can also be dimmed by PWM control signal. Built-in soft-start circuit prevents the inrush current from supply source during power on and 1x/1.5x mode change. Thermal shutdown and current limiter prevent PT4305 being damaged by the high-level current through it. Shutdown current less than 1uA makes the battery time longer. PT4305 is packaged with QFN-10, MSOP-10 and SOP-14, and it is also available with different feedback voltage references: 315mV, 236mV, 157mV, and 78mV.

### FEATURES

- 1x/1.5x auto-adjust charge pump
- 350mA maximum load current
- <10% feedback voltage reference error
- Dimming LED by PWM signal through EN/PWM pin
- Less than 1uA shutdown current
- Built-in soft-start and soft mode decision
- Less than 1uA shutdown current r
- Thermal shutdown n
- Shorted LED protection

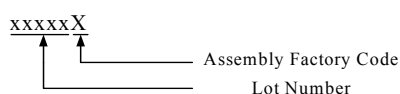
### APPLICATIONS

- Cell Phones
- Camera Flash Driver
- Small LCD Displays
- 1 Watt White LED Driver
- Handheld Computers and PDAs

### ORDERING INFORMATION

| PACKAGE | TEMPERTURE RANGE | FEEDBACK VOLTAGE | ORDERING PART NUMBER | TRANSPORT MEDIA             | MARKING          |
|---------|------------------|------------------|----------------------|-----------------------------|------------------|
| DFN-10  | -40 °C to 85 °C  | 315mV            | PT4305EQFN-315       | Tape and Reel<br>3000 units | PT4305<br>xxxxxX |
|         |                  | 236mV            | PT4305EQFN-236       |                             |                  |
|         |                  | 157mV            | PT4305EQFN-157       |                             |                  |
|         |                  | 78mV             | PT4305EQFN-78        |                             |                  |
| MSOP-10 | -40 °C to 85 °C  | 315mV            | PT4305EMSI-315       | Tape and Reel<br>3000 units | PT4305<br>xxxxxX |
|         |                  | 236mV            | PT4305EMSI-236       |                             |                  |
|         |                  | 157mV            | PT4305EMSI-157       |                             |                  |
|         |                  | 78mV             | PT4305EMSI-78        |                             |                  |
| SOP-14  | -40 °C to 85 °C  | 315mV            | PT4305ESON-315       | Tube<br>50 units            | PT4305<br>xxxxxX |
|         |                  | 236mV            | PT4305ESON-236       |                             |                  |
|         |                  | 157mV            | PT4305ESON-157       |                             |                  |
|         |                  | 78mV             | PT4305ESON-78        |                             |                  |

Note:



### TYPICAL APPLICATION CIRCUIT

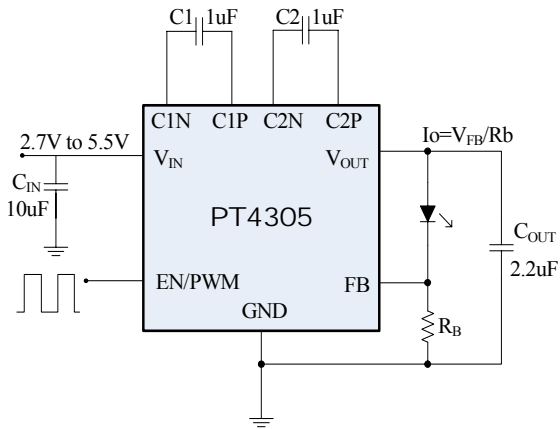


Figure 1. Li-Ion Driver for Flash LED

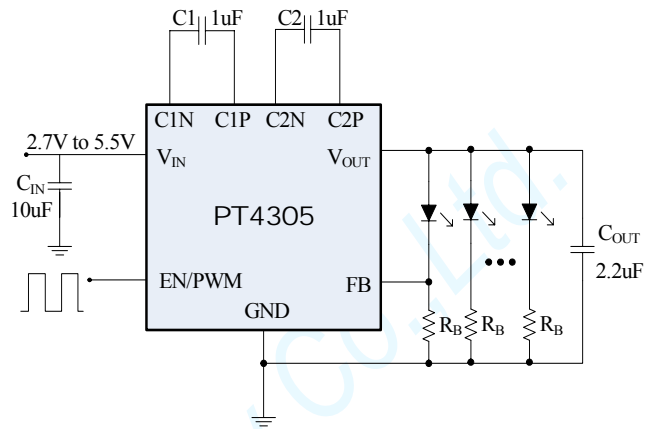
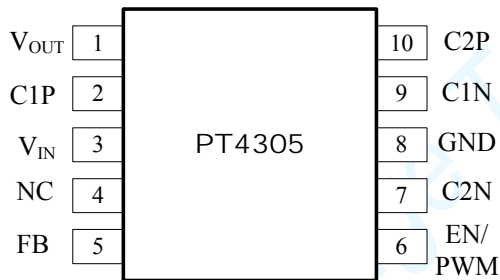
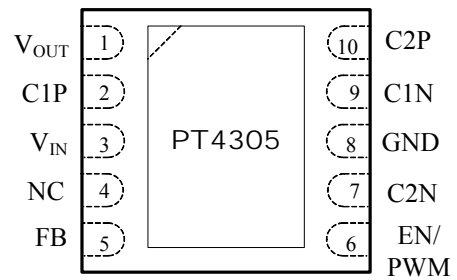


Figure 2. Li-Ion Driver for LCD Backlight

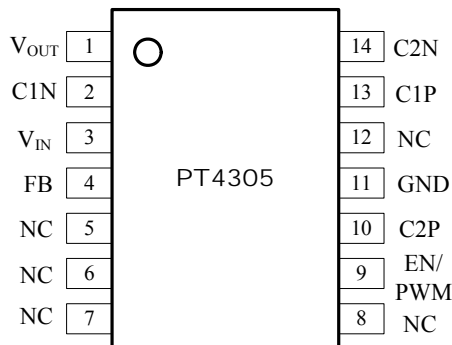
### PIN ASSIGNMENT



MSOP-10 Top View



DFN10 (3X3mm<sup>2</sup>) Top View



SOP-14 Top View

**PIN DESCRIPTIONS**

| MSOP-10/DFN-10<br>PIN No. | SOP-14<br>PIN No. | PIN<br>NAMES     | DESCRIPTION  |
|---------------------------|-------------------|------------------|--|
| 1                         | 1                 | V <sub>OUT</sub> | Output voltage source connecting to the 1uF ceramic capacitor's positive and LED's anodes.   |
| 2                         | 13                | C1P              | Positive terminal of fly capacitor 1   |
| 3                         | 3                 | V <sub>IN</sub>  | Power supply   |
| 4                         | 5,6,7,8,12        | NC               | Not connected  |
| 5                         | 4                 | FB               | Feedback pin for output current setting. LED currents are set by the resistor R <sub>B</sub> connected from the FB pin to ground. Do not short the FB pin to ground, its voltage is supposed to be 315mV, 236mV, 157mV, or 78mV. |
| 6                         | 9                 | EN/PWM           | Chip enable and LED current sink programming pin   |
| 7                         | 14                | C2N              | Negative terminal of fly capacitor 2   |
| 8                         | 11                | GND              | Ground   |
| 9                         | 2                 | C1N              | Negative terminal of fly capacitor 1   |
| 10                        | 10                | C2P              | Positive terminal of fly capacitor 2   |

**ABSOLUTE MAXIMUM RATINGS (Note 1)**

| SYMBOL              | ITEMS                                | VALUE                       | UNIT |
|---------------------|--------------------------------------|-----------------------------|------|
| V <sub>IN</sub>     | Input Voltage                        | -0.3 ~ 6                    | V    |
| V <sub>OUT</sub>    | Output Voltage                       | -0.3 ~ 6                    | V    |
| V <sub>EN/PWM</sub> | The voltage of EN/PWM                | -0.3 ~ V <sub>IN</sub> +0.3 | V    |
| P <sub>TR</sub>     | Thermal Resistance, θ <sub>JA</sub>  | DFN-10                      | 50   |
|                     |                                      | MSOP-10                     | 190  |
|                     |                                      | SOP-14                      | 105  |
| P <sub>DMAX</sub>   | Power Dissipation (Note 2)           | Internally Limited          | W    |
| T <sub>J</sub>      | Operation Junction Temperature Range | -40 ~ 150                   | °C   |
| T <sub>stg</sub>    | Storage Temperature                  | -55 ~ 150                   | °C   |
| T <sub>solder</sub> | Package Lead Soldering Temperature   | 260°C, 10s                  |      |
|                     | ESD Susceptibility (Note 3)          | 2                           | kV   |

**RECOMMENDED OPERATING RANGE (Note 4)**

| SYMBOL           | ITEMS                            | VALUE       | UNIT |
|------------------|----------------------------------|-------------|------|
| V <sub>IN</sub>  | V <sub>IN</sub> Supply Voltage   | +2.7 ~ +5.5 | V    |
| V <sub>LED</sub> | The LED Forward Voltage at 350mA | < 4         | V    |
| T <sub>OPT</sub> | Operating Temperature            | -40 ~ +85   | °C   |

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.

## 1x/1.5x Auto-Adjust Charge Pump One Channel White LED Driver for Flash

**Note 2:** The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{JMAX}$ ,  $\theta_{JA}$ , and the ambient temperature  $T_A$ . The maximum allowable power dissipation is  $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$  or the number given in Absolute Maximum Ratings, whichever is lower.

**Note 3:** Human body model, 100pF discharged through a 1.5k $\Omega$  resistor.

**Note 4:** Recommended operating Range indicates conditions for which the device is functional, but does not guarantee specific performance limits.

### ELECTRICAL CHARACTERISTICS (Note 5,6,7)

$V_{IN}=3.5V$ ,  $V_{FB}=315mV$ ,  $C1=C2=1\mu F$ ,  $C_{IN}=10\mu F$ ,  $C_{OUT}=2.2\mu F$  (Ceramic, ESR=0.03 $\Omega$ ),  $T_A=25^\circ C$ , unless specified otherwise.

| SYMBOL                        | ITEMS                                  | CONDITIONS  | MIN. | TYP. | MAX. | UNIT       |
|-------------------------------|--|---|------|------|------|------------|
| <b>Input Characteristics</b>  |  |   |      |      |      |            |
| $V_{IN}$                      | Input Voltage                          |   | 2.7  |      | 5.5  | V          |
| $I_{OFF}$                     | Operating Current (Shutdown)           | EN/PWM=0  |      |      | 1    | $\mu A$    |
| $I_q$                         | Operating Current (Quiescent)          | $V_{IN}=2.7V$ to 5.5V<br>100 $\mu A$ load Current |      | 0.5  | 3    | mA         |
| <b>Charge Pump</b>            |  |   |      |      |      |            |
| $F_{CLK}$                     | Switching Frequency                    |   | 0.8  | 1.2  | 1.5  | MHz        |
| $T_{SS}$                      | Soft-start time (Note 8)               |   |      | 250  |      | $\mu s$    |
| $V_{1.5-1}$                   | The Threshold of 1.5X $\rightarrow$ 1X | $V_{LED}=3.4V$ , $I_{LED}=300mA$                  |      | 4.1  |      | V          |
| $V_{1-1.5}$                   | The Threshold of 1X $\rightarrow$ 1.5X | $V_{LED}=3.4V$ , $I_{LED}=300mA$                  |      | 3.8  |      | V          |
| <b>Output Characteristics</b> |  |   |      |      |      |            |
| $I_{OUT}$                     | Maximum LED output current             | $3.4 < V_{IN} < 5.5$ , $V_{LED}=3.4V$             |      | 350  |      | mA         |
| $V_{Rip}$                     | $V_{OUT}$ Ripple                       | 1.5X Mode, $I_{OUT}=300mA$                        |      | 80   |      | mV         |
| $V_{FB}$                      | Feedback Voltage Reference             | 315mV Feedback Type                               | 283  | 315  | 347  | mV         |
|                               |  | 157mV Feedback Type                               | 141  | 157  | 173  |            |
| $I_{OLP}$                     | Over Load Protection Trigger Current   | Short $V_{OUT}$ to GND                            |      | 550  |      | mA         |
| $V_{ovp}$                     | Over output voltage protection         | $V_{IN}=4V$ , Open LED                            |      | 5.5  |      | V          |
| <b>Chip Enable</b>            |  |   |      |      |      |            |
| $V_{IL}$                      | EN/PWM Maximum Low Level Threshold     | $2.7V \leq V_{IN} \leq 5.5V$                      |      |      | 0.4  | V          |
| $V_{IH}$                      | EN/PWM Minimum High Level Threshold    | $2.7V \leq V_{IN} \leq 5.5V$                      | 1.6  |      |      | V          |
| <b>Thermal</b>                |  |   |      |      |      |            |
| $T_{SD}$                      | Thermal Shutdown Threshold             | Temperature rise                                  |      | 160  |      | $^\circ C$ |
| $T_{HY}$                      | Thermal Shutdown Hysteresis            |   |      | 10   |      | $^\circ C$ |

**Note 5:** Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the recommended operating Range. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

**Note 6:** Typical values are measured at 25°C and represent the parametric norm.

**Note 7:** Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

**Note 8:** Soft-start time is related to  $V_{IN}$  and  $V_{OUT}$ .

### SIMPLIFIED BLOCK DIAGRAM

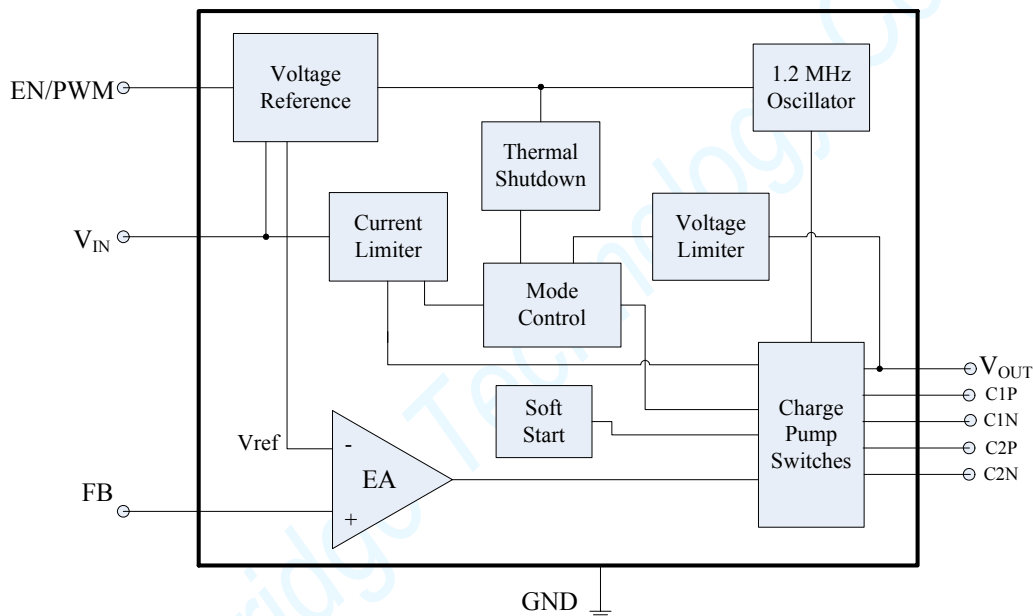


Figure 3. Simplified Block Diagram of PT4305

### OPERATION DESCRIPTION

PT4305 is a 1.5x/1x charge pump and can be used to drive white LED for flash. In 1x mode, it can achieve high efficiency for high input voltage. 1.5x charge pump guarantees the enough current through the LED for low level input voltage. The current through the LED can be pre-set by external resistor. That the LED is on or off can be controlled by EN/PWM terminal, so you can dim LED by PWM control signals.

- **Mode Decision**

PT4305 uses a 1.5x/1x charge pump. The switch between two modes is a smart process. PT4305 senses

the voltage at FB, the input and the output to select the charge pump mode in order to achieve the maximum efficiency. User intervention isn't needed to complete this process.

- **Soft Start**

Soft start circuit would be started at power on or mode switching process in order to reject the inrush current from  $V_{IN}$ . The circuit would increase the input current step by step during a long period. Soft start time is dependent on the input level, the output current and the LED forward voltage.

- **Over Load Protection**

PT4305 employs the over-load protection to avoid the high current from  $V_{IN}$ . PT4305 would decrease the input current to protect the chip and battery, whenever the input current rises above the threshold.

- **Over Voltage Protection**

PT4305 employs the over voltage protection circuit to

detect the output voltage in 1.5x mode. Whenever the output voltage level rises above the threshold in 1.5x mode, PT4305 would shutdown the charge pump until the output voltage falls below the threshold.

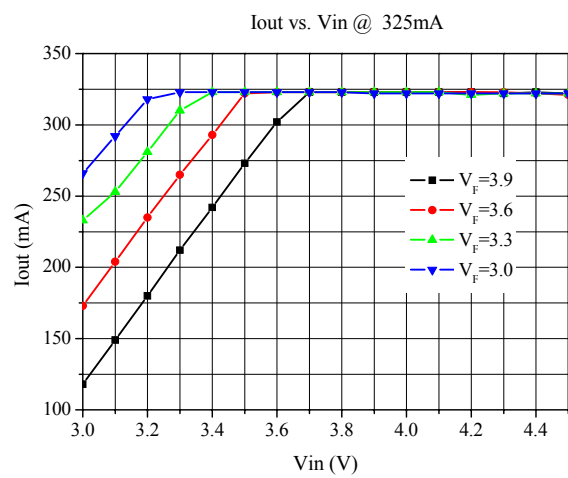
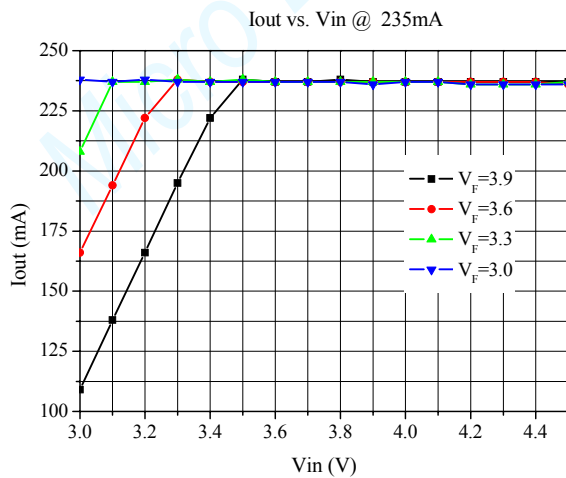
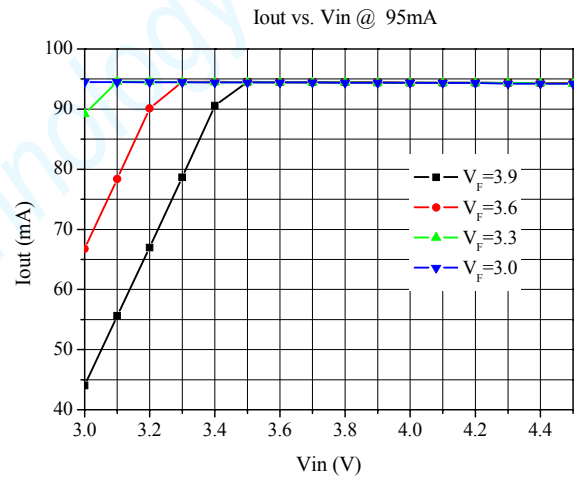
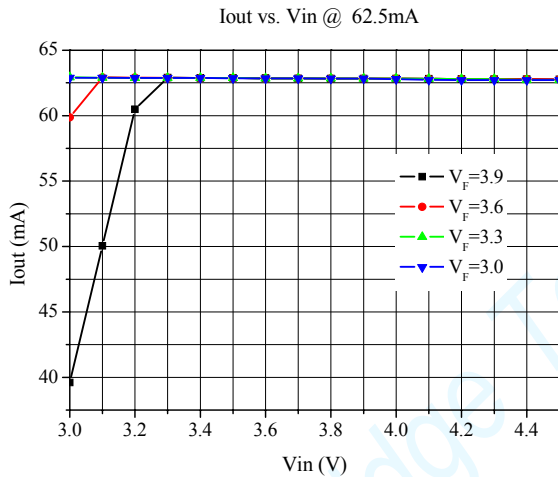
- **Thermal Shutdown**

When the chip temperature rises above the 160 °C, PT4305 would shutdown the charge pump to protect the chip from thermal damage.

### TYPICAL PERFORMANCE CHARACTERISTICS

Note: Typical characteristics are obtained in the following condition:

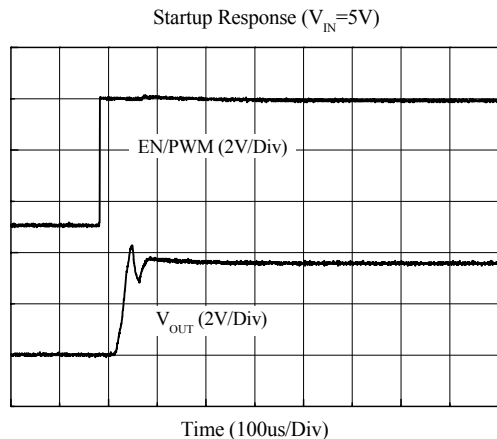
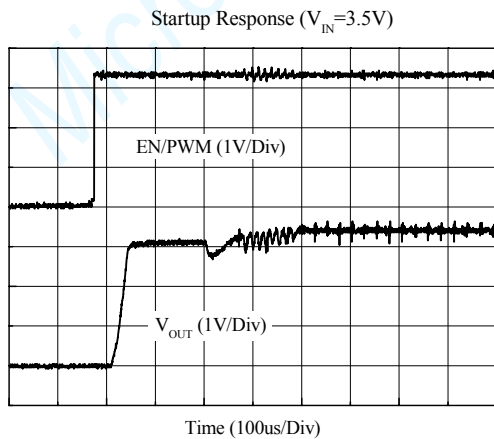
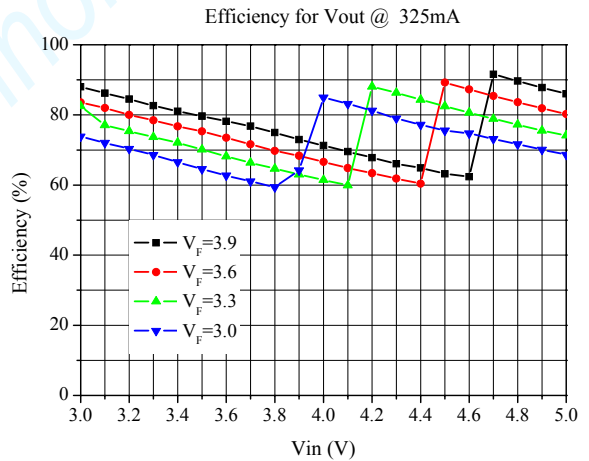
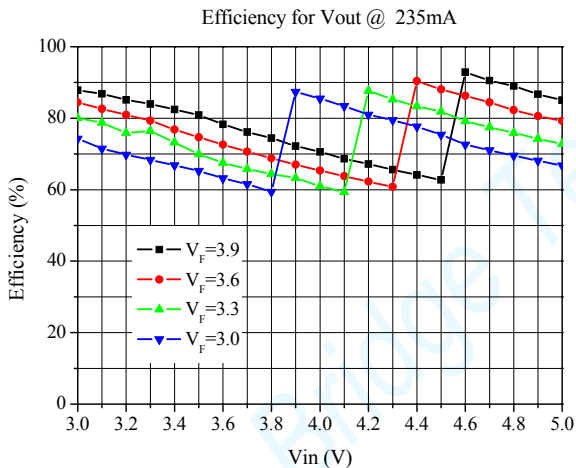
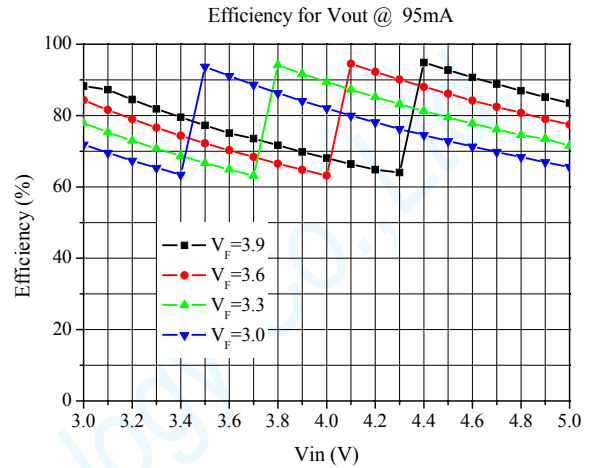
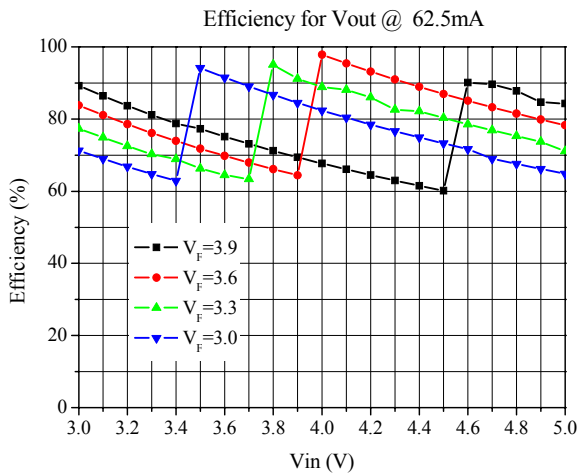
$C_1 = C_2 = 1\mu\text{F}$ ,  $C_{IN} = 10\mu\text{F}$ ,  $C_{OUT} = 2.2\mu\text{F}$  (Ceramic, ESR=0.03Ω),  $T_A = 25^\circ\text{C}$ , unless specified otherwise.



### TYPICAL PERFORMANCE CHARACTERISTICS

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### APPLICATION INFORMATION

- PCB Board Layout**

PT4305 is a high-frequency switched-capacitor converter. For best performance, place all of the components as close to IC as possible. Besides a solid ground plane is recommended on the bottom layer of the PCB, the ground should be connected  $C_{IN}$  and  $C_{OUT}$  together and as close to the IC as possible. Figure 4 shows the typical layout of PT4305's EVB board

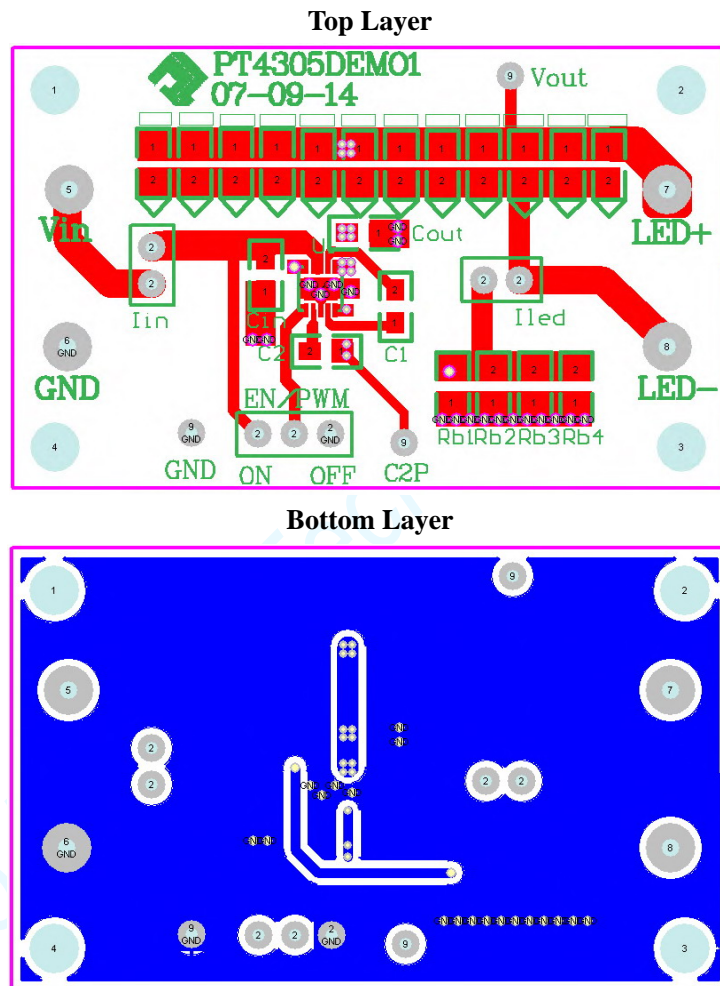


Figure 4. PT4305 EVB board

- Component Selection**

PT4305 can drive a white LED up to 350mA; the forward voltage of LED can range from 2.7V to 4.0V.

The selection of the four external capacitors  $C_{IN}$ ,  $C_1$ ,  $C_2$  and  $C_{OUT}$  is important because they will affect turn-on time, output ripple, and stability. Low ESR capacitor is recommended for low ripple value.

PT4305 can be set to a fixed LED current by a resistor  $R_B$  connected from FB to GND. The current flowing into LED can be calculated by the formula as below:

$$I_{LED} = V_{FB} (V) / R_B (\Omega)$$



## 1x/1.5x Auto-Adjust Charge Pump One Channel White LED Driver for Flash

| Manufacturer          | Part Number        | Capacitance/<br>Voltage | Capacitor<br>Size/Type/Thickness | ESR at<br>100KHz |
|-----------------------|--------------------|-------------------------|----------------------------------|------------------|
| TDK/www.tdk.com       | C1005X5R0J105M     | 1uF/6.3V                | 0402/X5R/0.5mm                   | 0.03Ω            |
|                       | C1608X5R0J225K     | 2.2uF/6.3V              | 0603/X5R/0.9mm                   | 0.02Ω            |
| Murata/www.murata.com | GRM155R60J105KE19B | 1uF/6.3V                | 0402/X5R/0.55mm                  | 0.03Ω            |
|                       | GRM188R61A225KE34B | 2.2uF/6.3V              | 0603/X5R/0.9mm                   | 0.02Ω            |

### ● Configuring as Cellphone Camera Flash Driver

PT4305 is capable of delivering up to 350mA current, which is competent to drive the most common LEDs in today's market.

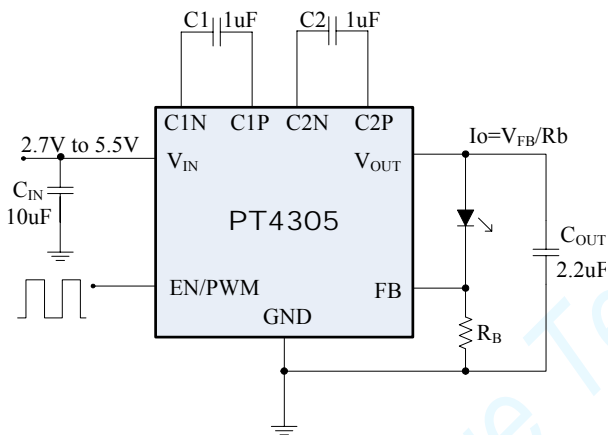


Figure 5. Camera Flash Driver

### ● Configuring as LCD Backlight

PT4305 is able to efficiently drive up to fifteen 20mA white LEDs in parallel and maintain a constant wide operating voltage range (2.7V to 5.5V).

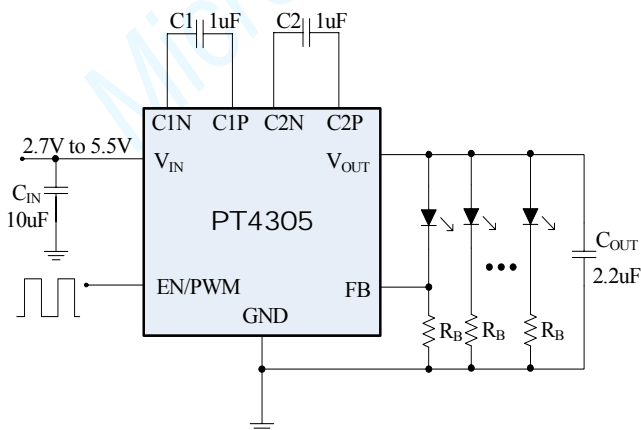


Figure 6. LCD Backlighting Driver

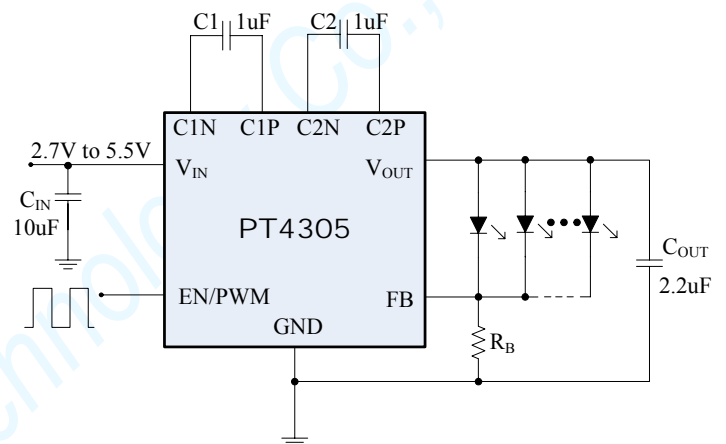


Figure 7. LCD Backlighting Driver

### ● Configuring as Camera Flash + Torch Drive

PT4305 can be configured as a flash/ torch LED driver which in some applications require constant torch current used for motion pictures (i.e. movie mode).

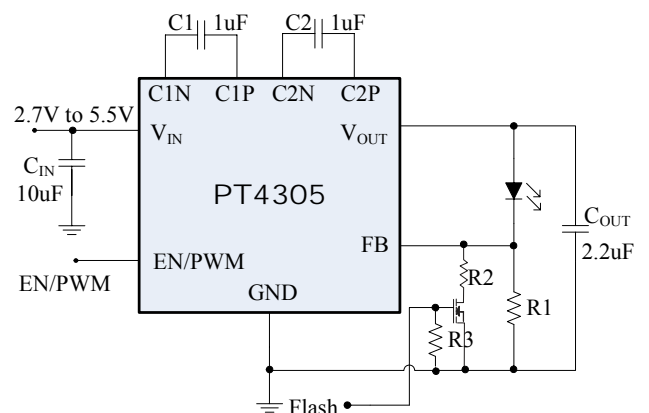
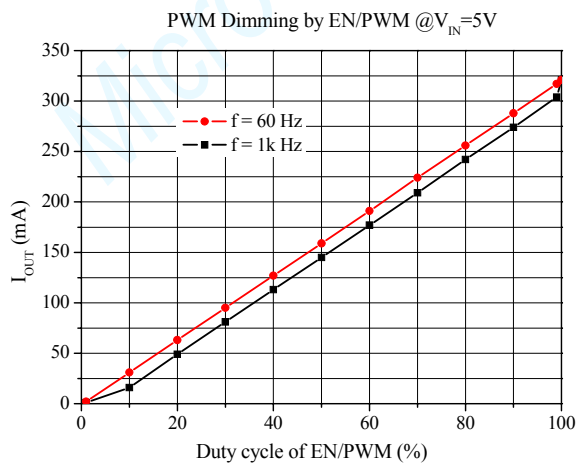
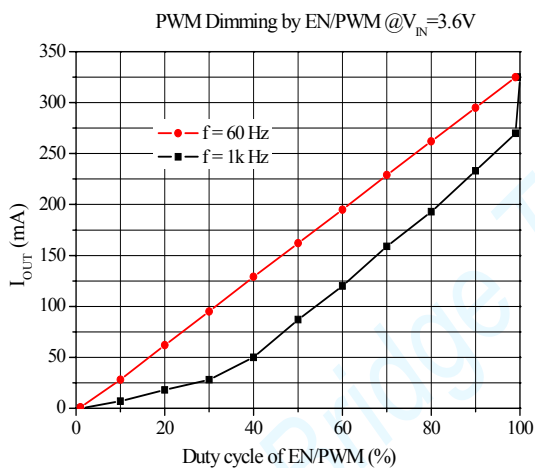


Figure 8. Flash/ Torch LED Driver

● **Brightness Control Using PWM**

Dimming control can be achieved by applying a PWM control signal to the EN/PWM pin. The brightness of the white LEDs is controlled by increasing and decreasing the duty cycle of the PWM signal. While operating frequency range is from 60 Hz to 1k Hz, the recommended maximum brightness frequency range is from 60 Hz to 200 Hz. A repetition rate of at least 60 Hz is required to prevent flicker. The following two figures plot the average output current versus duty cycle at different  $V_{IN}$  and PWM frequency. The soft start time will last longer at  $V_{IN}=3.6V$  than at  $V_{IN}=5V$ , so the average output current is smaller at  $V_{IN}=3.6V$ . When PWM frequency becomes large, this phenomenon become more evident.



● **Configuring as Voltage or Current Source**

Since  $V_{FB}$  is supposed to be 0.315V, you can get different  $V_{OUT}$  by choosing proper ratio of  $Rb1/Rb2$  as show below.  $V_{OUT}$  can range from 2.7V to 1.5 $V_{IN}$ . As a current source, LED driver is the best application case.

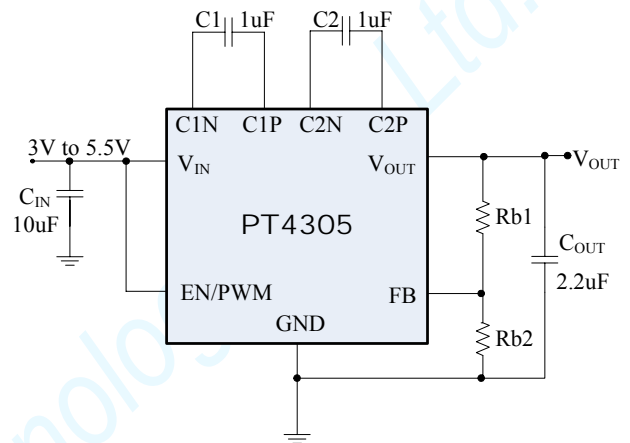
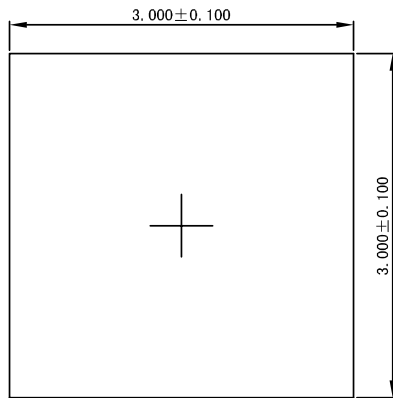


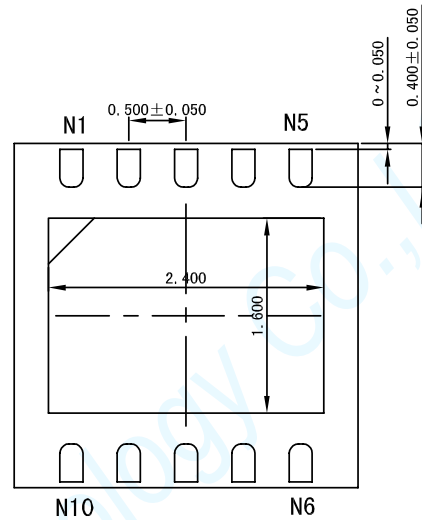
Figure 9. Voltage Source

### PACKAGE INFORMATION

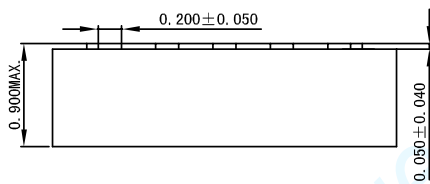
#### DFN-10(3mm×3mm)



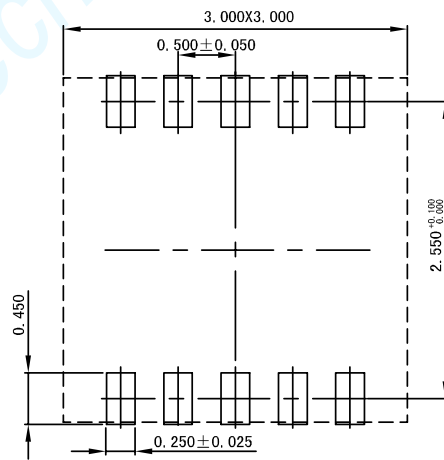
**Top View**



**Bottom View**



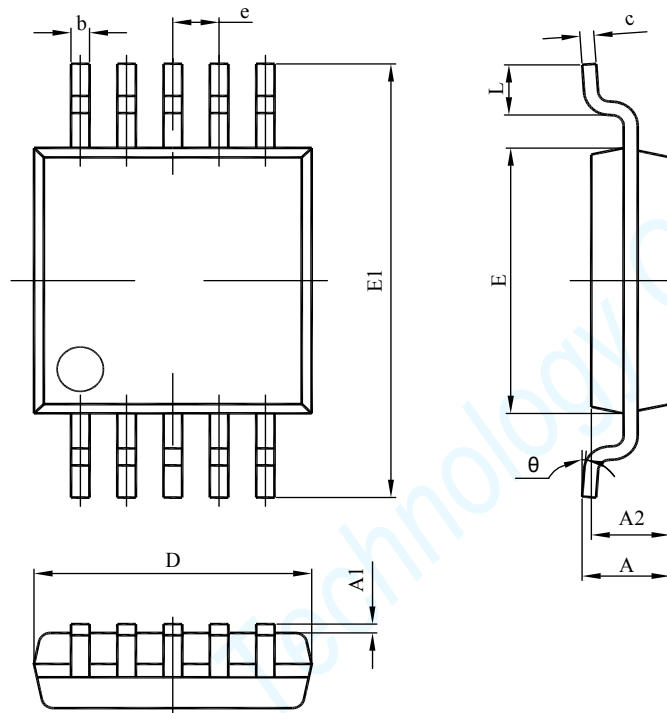
**Side View**



**(LAND PATTERN RECOMMENDATION)**

### PACKAGE INFORMATION

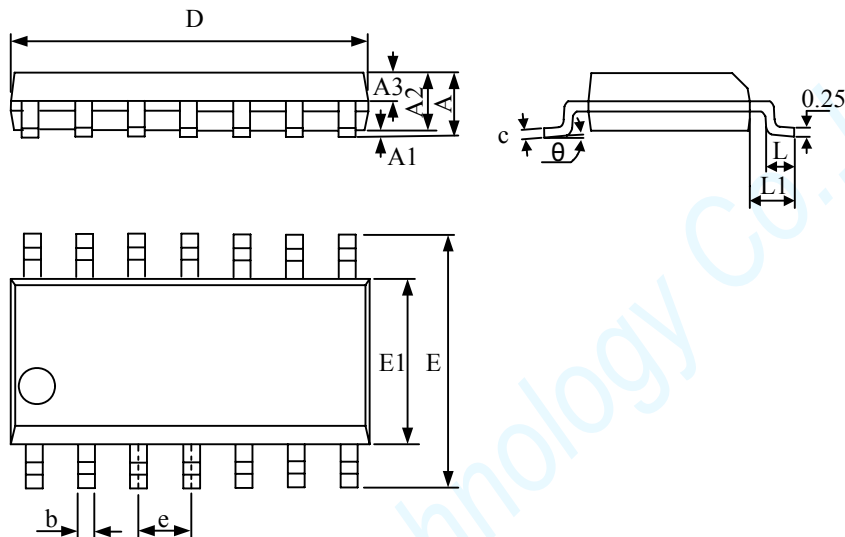
#### MSOP-10



| SYMBOL | MILLIMETER |       | INCHES      |       |
|--------|------------|-------|-------------|-------|
|        | MIN        | MAX   | MIN         | MAX   |
| A      | 0.820      | 1.100 | 0.032       | 0.043 |
| A1     | 0.020      | 0.150 | 0.001       | 0.006 |
| A2     | 0.750      | 0.950 | 0.030       | 0.037 |
| b      | 0.180      | 0.280 | 0.007       | 0.011 |
| c      | 0.090      | 0.230 | 0.004       | 0.009 |
| D      | 2.900      | 3.100 | 0.114       | 0.122 |
| e      | 0.50(BSC)  |       | 0.020 (BSC) |       |
| E      | 2.900      | 3.100 | 0.114       | 0.122 |
| E1     | 4.750      | 5.050 | 0.187       | 0.199 |
| L      | 0.400      | 0.800 | 0.016       | 0.031 |
| θ      | 0°         | 6°    | 0°          | 6°    |

### PACKAGE INFORMATION

#### SOP-14



| SYMBOL   | MILLIMETERS |      |      |
|----------|-------------|------|------|
|          | MIN         | NOM  | MAC  |
| A        | -           | -    | 1.77 |
| A1       | 0.08        | 0.18 | 0.28 |
| A2       | 1.20        | 1.40 | 1.60 |
| A3       | 0.55        | 0.65 | 0.75 |
| b        | 0.39        | -    | 0.48 |
| b1       | 0.38        | 0.41 | 0.43 |
| c        | 0.21        | -    | 0.26 |
| c1       | 0.19        | 0.20 | 0.21 |
| D        | 8.45        | 8.65 | 8.85 |
| E        | 5.80        | 6.00 | 6.20 |
| E1       | 3.70        | 3.90 | 4.10 |
| e        | 1.27BSC     |      |      |
| L        | 0.50        | 0.65 | 0.80 |
| L1       | 1.05BSC     |      |      |
| $\theta$ | 0           |      | 8°   |