PT1505

White LED Driver & PMU for Portable Applications

GENERAL DESCRIPTION

The PT1505 is an integrated power management unit and white LED driver for small handheld portable applications. It contains a single-cell Lithium Ion battery charger, a synchronous step-down DC-DC converter, 2 Low Dropout Regulators and a step-up DC-DC converter designed for driving up to 8 white LEDs in series. It allows charging from both wall adapter and USB port. When charging from wall adapter, the PT1505 increases the charging current automatically.

The battery charger is a highly integrated charging management device targeted at space limited portable applications. It offers an integrated MOSFET and current sensor, reverse blocking protection, high accuracy current and voltage regulation, and charge termination. It charges a battery in three phases: trickle charging, constant current and constant voltage. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. The thermal feedback regulates the charging current to limit the chip temperature during high power operation or high ambient temperature to maximize the charge rate without risk of overheating. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The PT1502 automatically terminates the charge cycle when the charge current drops to 1/10 the programmed value after the final float voltage is reached. The PT1502 automatically re-starts the charge if the battery voltage falls below an internal threshold.

The step-down converter is a high efficiency monolithic current mode synchronous buck regulator with a constant operation frequency. A main switch and a synchronous switch are integrated in PT1502, the device has high efficiency and no external Schottky diode needed. 100% duty cycle provides low dropout operation, extending battery life in portable systems. Automatic burst mode operation at light loads provides high efficiency. Internal 1.5MHz switching frequency allowing the use of small surface mounts inductors and capacitors. The output voltage can be adjusted by external resistors.

The two low-dropout voltage regulators are designed for portable and wireless applications. It can provide better than 60dB PSRR at 1kHz. The output current can be up to 300mA. One regulator's output voltage is fixed at 3.0V, and the other one is adjusted to 2.5V, 2.8V, 3.0V, 3.3V by two control pins.

The white LED step-up DC-DC converter is ideal for driving light emitting diodes (LEDs) whose light intensity is proportional to the current passing through them, not the voltage across their terminals, as it directly regulates output current A single external resistor sets LED current between 5mA and 20mA, which can then be easily adjusted using either a DC voltage or a pulse width modulated (PWM) signal. Its low 104mV feedback voltage reduces power loss and improves efficiency. The OV pin monitors the output voltage and turns off the converter if an over-voltage condition is present due to an open circuit condition.

FEATURES

- Integrated switch for USB/AC Adapter supply
- 220uA quiescent supply current(includes step-down DC-DC converters , two low dropout regulators and step-up DC-DC converter)
- Integrated single-cell lithium ion battery charger
  - Auto thermal regulated
  - Charging current up to 800mA
  - Charging current adjusted by external resistor
- Integrated step-down DC-DC converter
  - Output voltage adjusted by external resistor
  - Output current up to 600mA
  - 1.5M Hz fixed switching frequency
  - Over-current and over-temperature protection
- Integrated two low dropout regulators
  - LDO1: output voltage 3.0V，up to 300mA output current
  - LDO2: output voltage optional for 2.5V/2.8V/3.0V/3.3V，up to 300mA output current
  - PSRR: 60dB@1k Hz
  - Over-current and over-temperature protection
- Integrated white LED step-up DC-DC converter
  - Drives up to 8 series white LEDs
  - Up to 87% Efficiency
  - 1.25MHz Fixed Switching Frequency
  - Low 104mV Feedback Voltage
  - Open Load Shutdown
  - Soft Start/PWM Dimming
- QFN28（5X5）package
- RoHS compliant

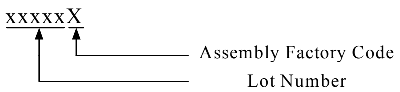
APPLICATIONS

- MP3/4
- PDAs
- GSM/CDMA mobile phone
- Portable media players
- Digital Cameras
- Small LCD Displays

ORDERING INFORMATION

PACKAGE	TEMPERATURE RANGE	ORDERING PART NUMBER	TRANSPORT MEDIA	MARKING
QFN28	-40 °C to 85 °C	PT1505EQFN	Tape and Reel	PT1505 xxxxxX

Note:



TYPICAL APPLICATION CIRCUIT

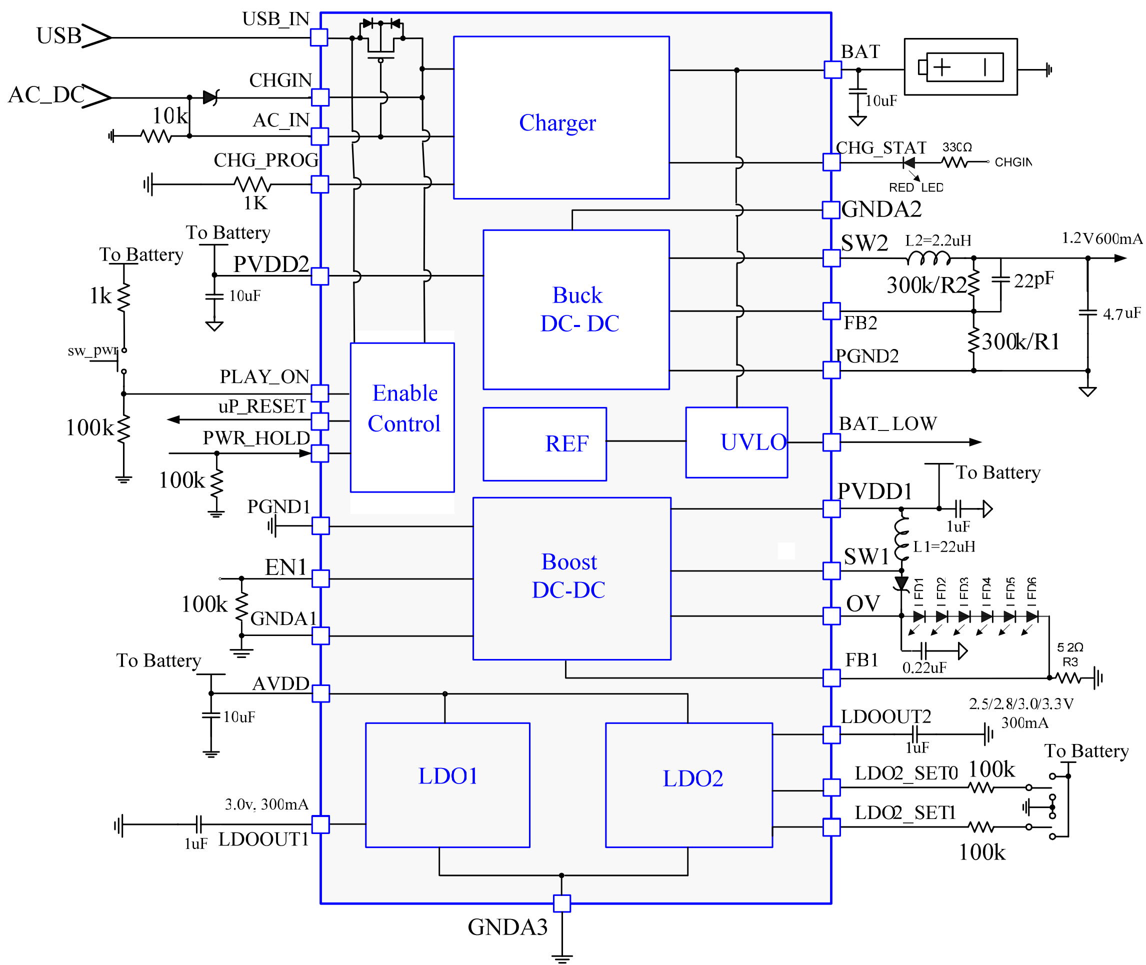


Figure1. Typical application circuit 1 of PT1505 (MCU controls EN1 pin)

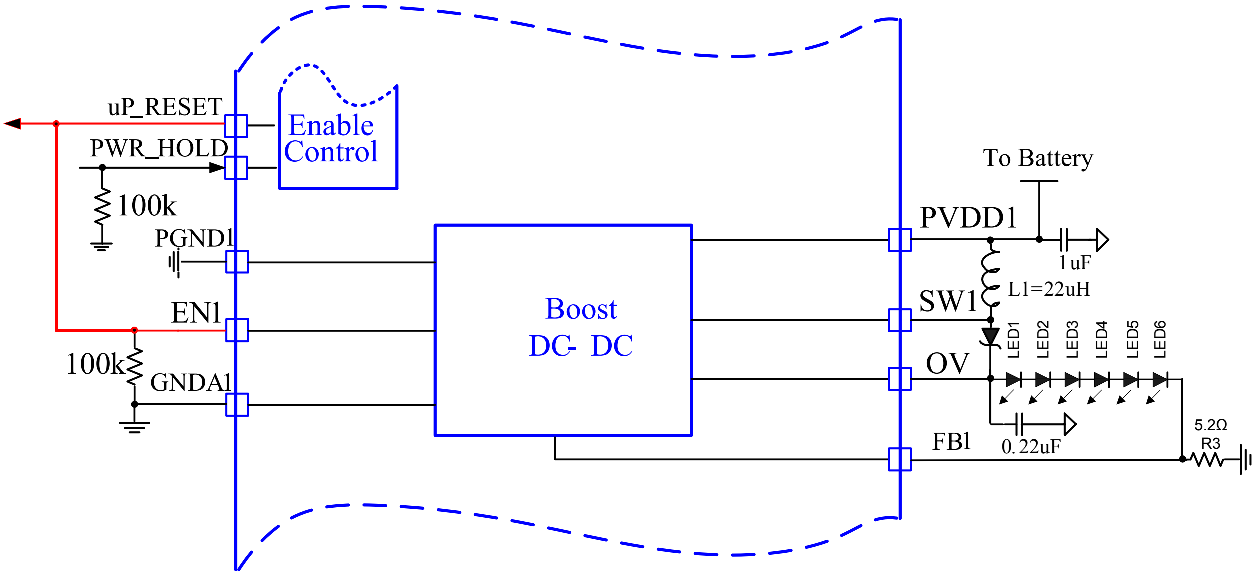
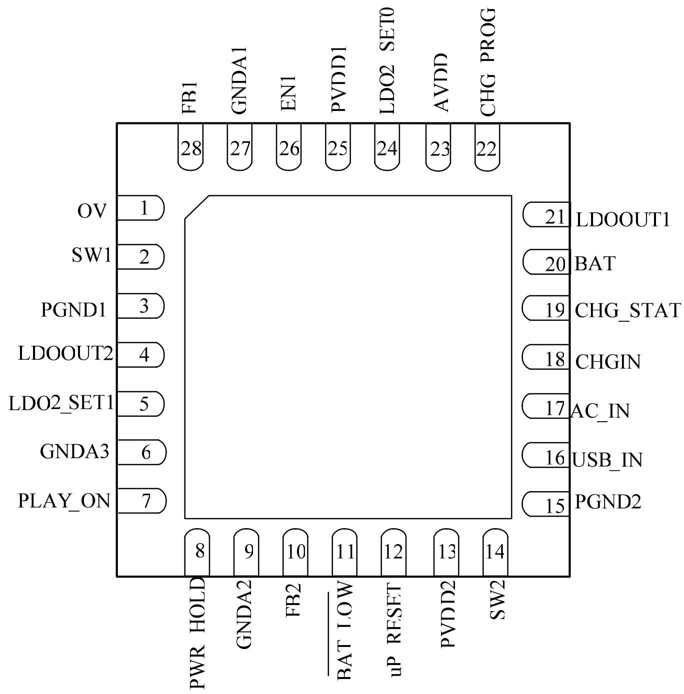


Figure2. Typical application circuit 2 of PT1505 (up_reset controls EN1 pin)

PIN ASSIGNMENT



PIN DESCRIPTION

PIN No.	PIN NAMES	PIN DESCRIPTION
1	OV	Over Voltage Input for LED step-up DC-DC converter.
2	SW1	Switch port for LED step-up DC-DC converter
3	PGND1	Power Ground for LED step-up DC-DC converter
4	LDOOUT2	LDO2 output
5	LDO2_SET1	LDO2 output voltage setting bit，MSB
6	GNDA3	Analog Ground
7	PLAY_ON	System start up signal for Battery
8	PWR_HOLD	feedback Chip enabled signal from CPU
9	GNDA2	Analog Ground for step-down DC-DC converter
10	FB2	Feedback port for step-down DC-DC converter
11	BAT_LOW	Battery voltage lower than 3.3V signal
12	uP_RESET	CPU RESET signal
13	PVDD2	supply port for step-down DC-DC converter
14	SW2	Switch port for step-down DC-DC converter
15	PGND2	Power Ground for step-down DC-DC converter
16	USB_IN	USB supply
17	AC_IN	Indicator for AC Adapter connected
18	CHGIN	AC Adapter input
19	CHG_STAT	Charging state indicator
20	BAT	Battery input
21	LDOOUT1	LDO1 output
22	CHG_PROG	Charging current setting pin, connects resistor to GNDA3
23	AVDD	Analog supply
24	LDO2_SET0	LDO2 output voltage setting bit，LSB
25	PVDD1	supply port for LED step-up DC-DC converter
26	EN1	Enable pin for LED step-up DC-DC converter
27	GNDA1	Analog Ground for LED step-up DC-DC converter
28	FB1	Feedback port for LED step-up DC-DC converter

ABSOLOUTE MAXIMUM RATING (Note1)

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	Input supply voltage: USB_IN， CHGIN， AVDD， PVDD1,PVDD2	– 0.3 ~ 6	V
V_{IO}	Input/Output signal: PLAY_ON，PWR_HOLD，uP_RESET，BAT_LOW，LDO2_SET0，LDO2_SET1，BUCKFB，LDO1OUT，LDO2OUT，CHG_PROG，SW2, EN1, AC_IN	– 0.3 ~ V_{IN}	V
VSW1	Voltage at SW1 Pin	-0.5～35	V
T_J	Junction Temperature	-40~125	°C
T_{STG}	Storage Temperature Range	– 65 ~ 150	°C
T_{SOLDER}	Lead Temperature (Soldering, 10 sec)	260	°C

RECOMMENDED OPERATING RANGE(Note2)

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	Input supply voltage: USB_IN，CHGIN	4.25 ~ 5.5	V
V_{IN2}	Input supply voltage: AVDD，PVDD1, PVDD2	3.5 ~ 5.5	V
T_{OPER}	Operating Temperature Range	– 40 ~ 85	°C
θ_{JA}	Thermal Resister	50	°C/W

Note1: Absolute Maximum Ratings are those values beyond which the life of the device maybe impaired.
Note2: Recommended operating Range indicates conditions for which the device is functional, but does not guarantee specific performance limits.

ELECTRICAL CHARACTERISTICS

（V_{BAT}=3.6V，T_A=25℃, unless otherwise specified）

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
I_Q	Bat supply quiescent current	CHGIN/USB_IN floating，Boost/BUCK/LDO1/LDO2 no load		220	650	µA
I_{SHDN}	Bat supply Shut down current	CHGIN/USB_IN floating，PLAY_ON=GNDA3, PWR_HOLD=GNDA3		1.2	6	µA
V_{IL}	Maximum Low Input Level at PLAY_ON, PWR_HOLD	AVDD = 3.0 to 5.5V			0.4	V
V_{IH}	Minimum High Input Level at PLAY_ON, PWR_HOLD	AVDD = 3.0 to 5.5V	1.5			V
V_{LBAT}	Battery voltage Undervoltage lockout threshold	VBAT high to low	3.135	3.3	3.465	V
T_{LBAT}	Battery voltage Undervoltage lockout comparator filter time			1		ms
$V_{LBATHYS}$	Battery voltage Undervoltage lockout hysteresis			100		mV

ELECTRICAL CHARACTERISTICS (continued)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
TSD	Thermal shutdown Temperature			160		°C
	Thermal shutdown Hysteresis			20		°C
Charger Characteristics						
SYMBOL	**PARAMETER**	**CONDITIONS**	**MIN**	**TYP**	**MAX**	**UNITS**
V_{CHG}	Input Charging Supply Voltage		4.25		5.5	V
V_{BAT_REG}	Regulated Output Voltage	I_{CH_CC} = 50mA, R_{PROG} =5K	4.158	4.2	4.242	V
I_{CH_CC}	Const current mode Charging current	R_{PROG} =1K, USB mode	445	470	495	mA
		R_{PROG} =1K, Adapter mode		750		mA
I_{TRIKL}	Trickle Charge Current	$V_{BAT} < V_{TRIKL}$		$I_{CH\_CC}/10$		mA
V_{TRIKL}	Trickle Charge Threshold Voltage	V_{BAT} from low to high		2.9		V
V_{TRHYS}	Trickle Charge Hysteresis Voltage			80		mV
V_{UV}	Under voltage Lockout Threshold	V_{CHGIN} from high to low		3.8		V
V_{UVHYS}	Under voltage Lockout Hysteresis			200		mV
I_{TERM}	Charging termination current			ICH_CC/10		mA
V_{PROG}	CHG_PROG pin voltage	Const current mode		1.0		V
ΔV_{RECHG}	Recharge Battery Threshold Voltage	VBAT_REG - VCHG		150		mV
T_{LIM}	Junction Temperature in Constant Temperature Mode			120		℃
T_{RECHG}	Recharge Comparator Filter Time	VBAT from high to low		2		ms
I_{PROG}	PROG Pin Pull-Up Current			3		µA
DC-DC step down converter Characteristics						
SYMBOL	**PARAMETER**	**CONDITIONS**	**MIN**	**TYP**	**MAX**	**UNITS**
V_{FB}	Regulated Feedback Voltage		0.588	0.600	0.612	V
ΔV_{OUT}	Line Regulation	PVDD = 3.5V to 5.5V		0.04	0.4	%/V
I_{LIMIT}	Peak Inductor Current			1		A
$V_{LOADREG}$	Load Regulation			0.5		%
F_{OSC}	Oscillator Frequency		1.2	1.5	1.8	MHz
R_{PFET}	RDS(ON) of P-Channel FET	I_{LX} = 100mA		0.4	0.8	Ω

ELECTRICAL CHARACTERISTICS (continued)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
R_{NFET}	RDS(ON) of N-Channel FET	$I_{LX} = -100mA$		0.35	0.7	Ω
LED DC-DC step up converter Characteristics						
SYMBOL	**PARAMETER**	**CONDITIONS**	**MIN**	**TYP**	**MAX**	**UNITS**
V_{EN1_H}	EN1 Minimum High Level		1.5			V
V_{EN1_L}	EN1 Maximum Low Level				0.4	V
V_{EN1HYS}	EN1 Hysteresis			90		mV
	EN1 Input Bias Current	V_{SW-ON} =0V, 5V			1	µA
V_{FB}	FB Pin Voltage		89	104	119	mV
Fsw	Switching Frequency		1.0	1.25	1.5	MHz
D_{max}	Maximum Duty Cycle	V_{FB}=0V	85	90		%
R_{ON}	SW On Resistance (Note 3)			0.5		Ω
I_{LIMIT}	SW Current Limit			400		mA
I_{LEAK}	SW Leakage Current	Vsw＝5V		0.01	1	µA
V_{OV}	Open Circuit Shutdown Threshold	V_{OV} Rising		30		V
tss	Soft Start Time (Note 1)	V_{IN} Power On		160		µS
Low Dropout Regulator Characteristics						
SYMBOL	**PARAMETER**	**CONDITIONS**	**MIN**	**TYP**	**MAX**	**UNITS**
V_{LDO1}	Output voltage 1		2.94	3.0	3.06	V
V_{LDO2}	Output voltage 2	LDO2_SET0=Low, LDO2_SET1=Low	2.45	2.5	2.55	V
		LDO2_SET0=High, LDO2_SET1=Low	2.744	2.8	2.856	
		LDO2_SET0=Low, LDO2_SET1=High	2.94	3.0	3.06	
		LDO2_SET0=High, LDO2_SET1=High	3.234	3.3	3.366	
ΔVOUT	Line Regulation Error	AVDD=($V_{LDO(nom)}$ + 0.5V) to 5.5V		0.1	0.5	%/V
	Load Regulation Error	I_{LDO_OUT} = 1mA to 150 mA		15	50	mV
I_{OUTMAX}	Peak Output Current	$V_{LDO} \geq V_{LDO(nom)} - 2\%$		300		mA

ELECTRICAL CHARACTERISTICS (continued)

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
PSRR	Power Supply Rejection Ratio	AVDD $=V_{LDO(nom)}+1.0V$	f=1k Hz	I_{OUT} = 50mA		60		dB
				I_{OUT} = 150mA		60		
			f=10kHz	I_{OUT} = 50mA		55		
				I_{OUT} = 150mA		55		
V_{DIFF}	Dropout Voltage	I_{LDO_OUT} = 50mA				50	90	mV
		I_{LDO_OUT} = 100mA				100	180	mV
I_{SC}	Output Short Current Limit	Output Grounded				500		mA
$\Delta V_{LDO\_OUT}/V_{OUT}$	V_{OUT} Temperature Characteristics	Temperature = -40 to 125°C				100		ppm/°C

SIMPLIFIED BLOCK DIAGRAM

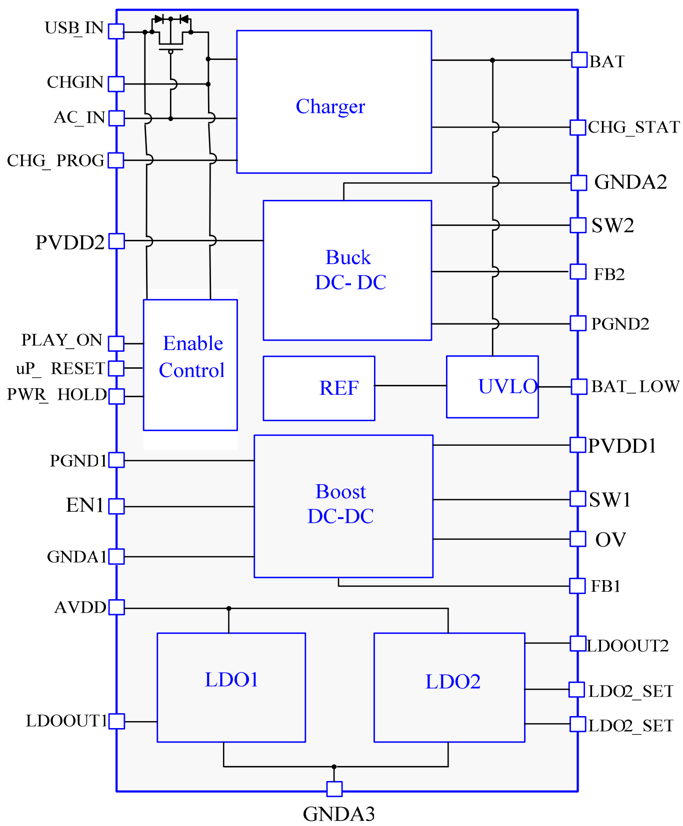


Figure3. Simplified block diagram of PT1505

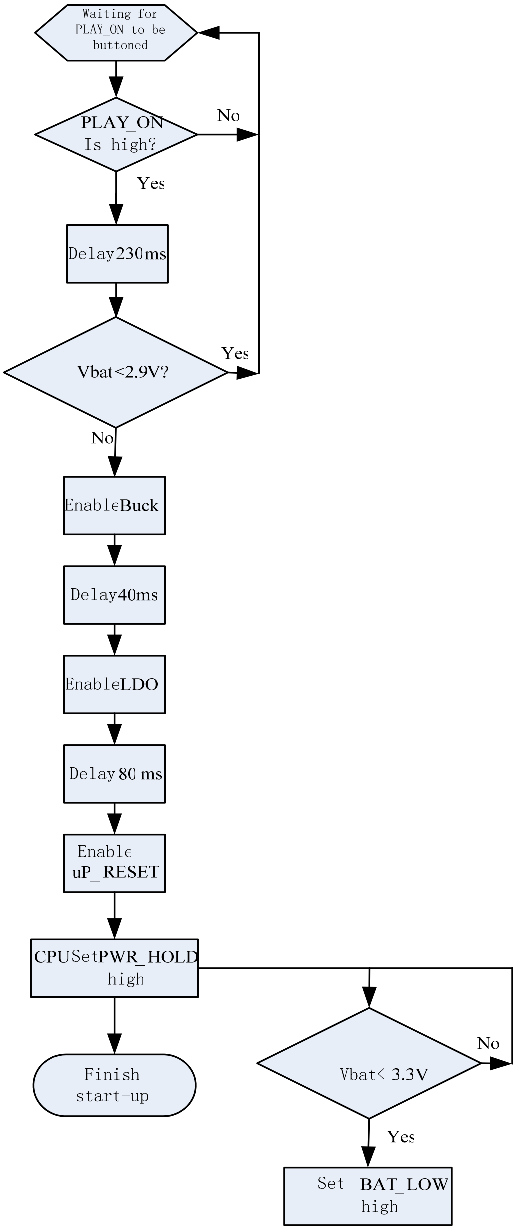
OPERATION DESCRIPTION

Power up sequency:

The uP_RESET signal will reset the CPU. And the PWR_HOLD contains the PMU in normal working status.

When the PLAY_ON button is hold up to high level for several hundred milliseconds， PMU will be ready to start. First, to start the Buck, then delay 40 milliseconds, to start the LDO, and after 80 milliseconds, the uP_RESET turns on to high level.

Start up sequence by external button：



Power Down Description：

When button the PLAY_ON in working status, this action will be checked by CPU and it shuts up inner blocks and sends low level to PWR_HOLD. When the PLAY_ON is loosened the PLAY_ON becomes low, and PMU will power down.

Bat Low Voltage Detection：

When in working status, the voltage of Bat pin lowers than 3.3V, then PT1502 puts the BAT_LOW pin to high level. This signal will be sent to CPU.

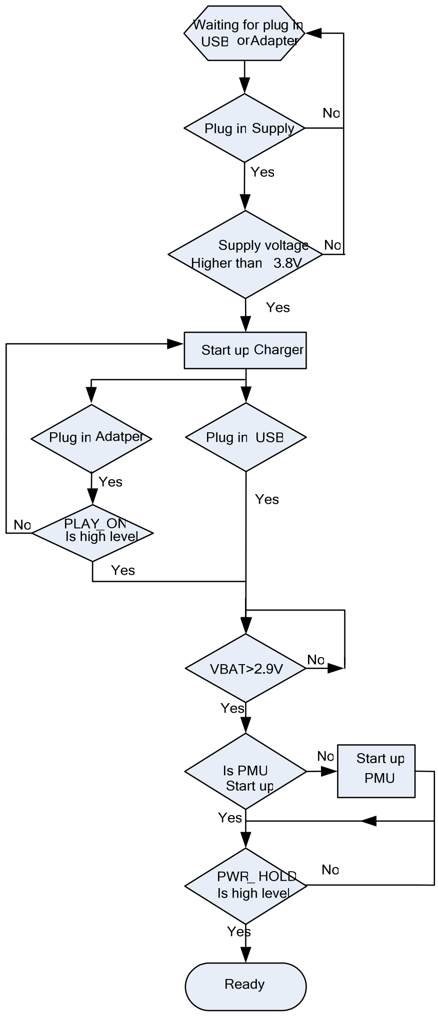
Adapter and USB plug in：

When USB or Adapter is plugged in, the PT1502 would detect whether the supply is higher than 3.8V. If the supply voltage is lower than 3.8V, the charger stops to charge.

And if the Battery voltage is lower than 2.9V, PMU doesn’t start up. And it will charge the battery until it over the 2.9V.

When the battery is absent, the PT1502 will stabilize the BAT pin voltage to 4.2V.

Sequence of plugging in the USB or Adapter：



Battery Charger

The PT1502 includes a linear Li-ion battery charger with thermal regulation. With the internal 0.6 ohms MOSFET, the minimum charging supply voltage can be less than 4.25V. One external 1% precision resistor is required to set the charging current value. When the voltage at the CHGIN pin rises above the UVLO threshold, the normal charging cycle begins. If the battery voltage is less than 2.9V, the device will operate in a trickle charging mode. The charging current in the trickle charging mode is $1/10^{th}$ of the programmed value, which effectively protects the battery from damage and prolongs its lifetime. When the voltage at the BAT pin rises above 2.9V, the charger enters the constant-current mode in which case the charging current equals to the programmed value. Once the voltage at the BAT pin reaches 4.2V, the charger goes into the constant voltage mode where the charging current decreases. Once the charging current drops to $1/10^{th}$ the programmed value, the charging cycle ends.

After a charge cycle is complete and the charging operation is terminated, the PT1502 keeps monitoring the BAT voltage. It will recharge the battery as soon as the BAT voltage drops below 4.05V. The PT1502 includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When the PROG pin is floating, the charger goes into the shutdown mode.

BUCK

The PT1502 includes a high efficiency current mode synchronous buck regulator with a constant operation frequency. Its internal integrated MOSFETs achieve high efficiency. Ultra low output voltages are easily available with the 0.6V feedback reference voltage. Internal fixed 1.5MHz switching frequency allowing the use of small surface mount inductors and capacitors. The 2.7V to 5.5V input voltage range and 600mA output current make the BUCK ideally suited for single Li-Ion battery-powered applications.

Current Mode PWM Control Loop

Slope compensated current mode PWM control and cycle-by-cycle current limit provides stable operation and excellent line and load regulation. During normal operation, the internal top power MOSFET is turned on each cycle when the rising edge of the oscillator sets the RS latch, and turned off when rising edge of the PWM comparator resets the RS latch. While the top MOSFET is off, the bottom MOSFET is turned on until either the inductor current starts to reverse or the beginning of the next clock cycle. The internal comparator controls output transient overshoots is smaller than 8% by turning the main MOSFET off until the fault is removed.

Skip-Cycles Mode Operation

At light loads, the BUCK enters skip-cycle mode automatically. In this mode, the inductor current may reach zero or reverse on each cycle. The PWM control loop will automatically skip cycles to maintain output regulation. The bottom MOSFET is turned off by the current reversal comparator, and the switch voltage will ring. This is discontinuous mode operation, and is normal behavior for the switching regulator.

Low-Dropout Operation

When the input voltage deceases to the value of output voltage, the control loop remains the main MOSFET on until it reaches 100% duty cycle. The output voltage then is the input voltage minus the voltage drop across the main switch and the inductor. Caution must be exercised to ensure the heat dissipated not to exceed the maximum junction temperature of the IC because the RDSON of the main MOSFET increases and the efficiency of the converter decrease.

LDO

The block of Voltage Reference provides the reference voltage of the LDO.

The op-amp block is used as the error amplifier of the LDO by comparing the reference with the output feedback voltages. Its output controls the gate of a large PMOS pass element and hereby adjusts the output voltage.

The Current Limit block senses the LDO output current and limits the output current from being too high. This is mostly a short circuit protection feature.

White LED step-up converter

It is a constant frequency, peak current mode Boost regulator to regulate the series string of white LEDs. After power up on the PVDD1 pin, if the voltage at EN1 pin reaches more than 1.5V, this converter will starting to work. At the start of each oscillator cycle, control logic turns on a power switch. The signal at the non-inverting input of the PWM comparator is proportional to the switch current, summed together with a portion of an oscillator ramp. When this signal reaches the level set by the output of error amplifier, the PWM comparator resets the latch in the control logic and turns off the power switch. In this manner, error amplifier sets the correct peak current level to keep the LED current in regulation. If the feedback voltage starts to drop, the output of the error amplifier increases. This result in more current to flow through power switch, hence increasing the power delivered to the output. The converter's driving capability is listed as follows:

PVDD1	I_{LED}=15mA	I_{LED}=20mA
3.0V	6 x LED	5 x LED
3.6V	8 x LED	8 x LED

APPLICATION INFORMATION

Battery Charger

Adjusting Charging Current

The charging current is programmed using 1% precision resistor from PROG pin to ground. When USB supply the PT1505, the charging current and the programming resistor are calculated using the following equations:

$R_{PROG}=470V/I_{CHG}$, $I_{CHG}=470V/R_{PROG}$

When Adapter alone or both Adapter and USB supply the PT1505, the charging current and the programming resistor are calculated using the following equations:

$R_{PROG}=750V/I_{CHG}$, $I_{CHG}=750V/R_{PROG}$

Thermal limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120℃. This feature protects the PT1505 from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the PT1505.

The conditions that cause the PT1505 to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET—this is calculated to be approximately:

$PD = (V_{CHGIN} – V_{BAT}) \cdot I_{BAT}$

Where PD is the power dissipated

V_{CHGIN} is the input supply voltage

V_{BAT} is the battery voltage

I_{BAT} is the charge current.

The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$T_A = 120℃ – PD \cdot \theta_{JA}$

$T_A = 120℃ – (V_{CHGIN} – V_{BAT}) \cdot I_{BAT} \cdot \theta_{JA}$

Reducing the voltage drop across the internal MOSFET can significantly decrease the power dissipation in the IC. This has the effect of increasing the current delivered to the battery during thermal regulation. One method is by dissipating some of the power through an external component, such as a resistor or diode. By dropping voltage across a resistor in series with a 5V wall adapter, the on-chip power dissipation can be decreased, thus increasing the thermally regulated charge current.

Under Voltage Lockout (UVLO)

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until CHGIN rises above the under voltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if CHGIN falls to within 30mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until V_{CHGIN} rises 100mV above the battery voltage.

Stability Considerations

The constant-voltage mode feedback loop is stable without an output capacitor provided a battery is connected to the charger output. With no battery present, an output capacitor is recommended to reduce ripple voltage. In constant current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with the programming resistor value as high as 20k. However, additional capacitance on this node reduces the maximum allowed program resistor. The pole frequency at the PROG pin should be kept above 100kHz.

BUCK

Setting the Output Voltage

The output voltage is set by an external resister divider according to the following formula:

$$V_{OUT} = 0.6V \times \left(1 + \frac{R2}{R1}\right)$$

Inductor Selection

For most applications, the PT1505 operates well with inductors of 1uH to 4.7uH. Low inductance values are physically smaller but require fast switching, which results in efficiency loss. The inductor value can be calculated from following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Table 1 list some typical surface mount inductors that adapt to PT1505 applications

Part #	L (μH)	Max DCR (mΩ)	Rated D.C. Current (A)	Size WxLxH (mm)
Sumida CR43	1.4 2.2 3.3 4.7	56.2 71.2 86.2 108.7	2.52 1.75 1.44 1.15	4.5x4.0x3.5
Sumida CDRH4D18	1.5 2.2 3.3 4.7	 75 110 162	 1.32 1.04 0.84	4.7x4.7x2.0
Toko D312C	1.5 2.2 3.3 4.7	120 140 180 240	1.29 1.14 0.98 0.79	3.6x3.6x1.2

Table 1. Typical Surface Mount Inductors

Input and Output Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. To prevent large voltage transients, a low ESR input capacitor sized for the maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$I_{RMS} \approx I_{OMAX} \times \frac{\left[V_{OUT}(V_{IN} - V_{OUT})\right]^{1/2}}{V_{IN}}$$

Ceramic capacitor with X5R or C7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 4.7uF ceramic capacitor for most applications is sufficient.

The output capacitor is required to obtain small output voltage ripple and ensure regulation loop stability. Typically, once the ESR requirement for COUT has been met, the RMS current generally far exceeds the ripple current requirement. The output ripple △VOUT is determined by:

$$\Delta V_{OUT} \approx \Delta I_L \times (ESR + \frac{1}{8 f C_{OUT}})$$

Where f is the operating frequency, COUT is the output capacitor and △IL is the ripple current of inductor current.

Ceramic capacitors with X5R or C7R dielectrics are recommended due to their low ESR and high current rating. A 10uF ceramic capacitor for most applications is recommended for low output voltage ripple and good loop stability.

LDO

Input Capacitor

An input capacitor of $\geq 1.0\mu F$ is required between the AVDD and GND pin. This capacitor must be located within 1cm distance from AVDD pin and connected to a clear ground. A ceramic capacitor is recommended although a good quality tantalum or film may be used at the input. However, a tantalum capacitor can suffer catastrophic failures due to surge current when connected to a low impedance power supply (such as a battery or a very large capacitor).

There is no requirement for the ESR on the input capacitor, but the tolerance and temperature coefficient must be considered in order to ensure the capacitor work within the operation range over the full range of temperature and operating conditions.

Output Capacitor

In applications, it is important to select the output capacitor to keep the PT1505 in stable operation. The output capacitor must meet all the requirements specified in the following recommended capacitor table over all conditions in applications. The minimum capacitance for stability and correct operation is 0.6μF. The capacitance tolerance should be ±30% or better over the operation temperature range. The recommended capacitor type is X7R to meet the full device temperature specification.

Recommended Output Capacitor (C_{OUT})

	TYP	MIN	MAX	Unit
Capacitance	1.0	0.6	10	μF
ESR		0	400	mΩ

The capacitor application conditions also include DC-bias, frequency and temperature. Unstable operation will result if the capacitance drops below minimum specified value.

The LDO is designed to work with very small ceramic output capacitors. A 1.0μF capacitor (X7R type) with ESR type between 0 and 400mΩ is suitable in the PT1502 applications. X5R capacitors may be used but have a narrow temperature range. With these and other capacitor types (Y5V, Z6U) that may be used, selection relies on the range of operating conditions and temperature range for a specified application.
It may also be possible to use tantalum or film capacitors at the output, but these are not as good for reasons of size and cost.

It is also recommended that the output capacitor be located within 1cm from the output pin and return to a clean ground wire.

NO-LOAD Stability
The LDO will remain stable and in regulation with no external load. This is especially important in CMOS RAM keep-alive applications.

LDO Output voltage setting:

LDO2_SET0	LDO2_SET1	LDO2OUT
Low	Low	2.5V
High	Low	2.8V
Low	High	3.0V
High	High	3.3V

The table of voltage of LDO2 setting

The voltage of LDO1is fixed at 3.0V。

The voltage of LDO2 can be adjusted to 2.5V，2.8V，3.0V，3.3V by setting LDO2_SET0 and LDO2_SET1.

White LED step-up converter

Inductor Selection
For most of the applications of white LED step-up converter subsystem of PT1505, it is recommended to use an inductor of 22uH. Although small size is one of the major factors in selecting an inductor, the smaller and thinner inductors give higher core losses at 1.25MHz and DRC, resulting in lower efficiencies. The following table provides a list of recommended inductors:

Part Number	DCR（Ω）	Current Rating （mA）	Manufacture
LQH3C220	0.71	250	MURATA
CDRH3D16-220	0.53	350	SUMIDA
LB2012B220M	1.7	75	TAIYO YUDEN
LEM2520-220	5.5	125	TAIYO YUDEN
EJPC220KF	4.0	160	PANASONIC

Capacitor Selection
The small size of ceramic capacitors makes them ideal for the white LED step-up converter subsystem of PT1505 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 1μF input capacitor and a 0.22 μF output capacitor are sufficient for most PT1505 applications.

Diode Selection
Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for the white LED step-up converter subsystem of PT1505 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (C_T or C_D) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1.25MHz switching frequency of the white LED step-up converter subsystem of PT1505. A Schottky diode rated at 100mA to 200mA is

sufficient for most white LED step-up converter subsystem of PT1505 applications. Some recommended Schottky diodes are listed in the following table:

Part Number	Forward Current (mA)	Voltage Drop (V)	Diode CAP (Pf)	Manu facture
CMDSH-3	100	0.58@100mA	7.0@10V	Central
CMDSH2-3	200	0.49@200mA	15@10v	Central
BAT54	200	0.53@100mA	10@25v	Zetex

LED Current Control

The LED current is controlled by the feedback resistor. The feedback reference is 104mV. The LED current is 104mV/R3 In order to have accurate LED current, precision resistors are preferred (1% is recommended). The formula and table for R_3 selection are shown below:

$$R_3 = 104mV/I_{LED}$$

I_{LED}（mA）	R_3 Value（Ω）
5	20.8
10	10.4
15	6.93
20	5.2

Open Circuit Protection

Open circuit protection will shut off the white LED step-up converter subsystem of PT1505 if the voltage at the OV pin goes too high when the OV pin is tied to the output. In some cases an LED may fail, which will result in the feedback voltage always being zero. The white LED step-up converter subsystem will then switch at its maximum duty cycle boosting the output voltage higher and higher. By connecting the OV pin to the top of the LED string the white LED step-up converter subsystem of PT1505 checks this condition and if the output ever exceeds 30V, the white LED step-up converter subsystem of PT1505 will shut down. The part will not switch again until the power is recycled.

Dimming Control

There are three different types of dimming control circuits:

1. Using a DC Voltage

For some applications, the preferred method of brightness control is a variable DC voltage to adjust the LED current. The dimming control using a DC voltage is shown in Figure 4. As the DC voltage increases, the voltage drop on R4 increases and the voltage drop on R3 decreases. Thus, the LED current decreases. The selection of R4 and R5 will make the current from the variable DC source much smaller than the LED current and much larger than the FB pin bias current.

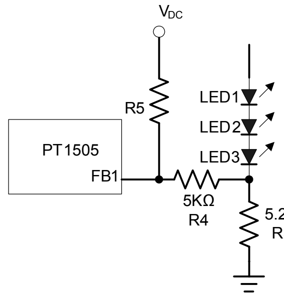


Figure4. Dimming Control Using a DC Voltage

2. Using a PWM Signal to EN Pin

With the PWM signal applied to the EN1 pin, the white LED step-up converter subsystem of PT1505 is turned on or off by the PWM signal. The LEDs operate at either zero or full current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle will turn off the white LED step-up converter subsystem of PT1505 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The typical frequency range of the PWM signal should be 1 kHz or less due to the soft start function.

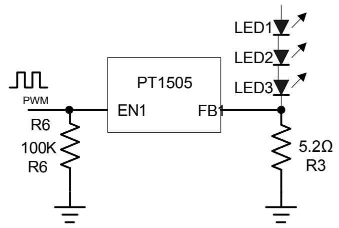


Figure5. Dimming Control Using a PWM Signal

3. Using a Filtered PWM Signal

The filtered PWM signal can be considered as an adjustable DC voltage. It can be used to replace the variable DC voltage source in dimming control. The circuit is shown in Figure 6.

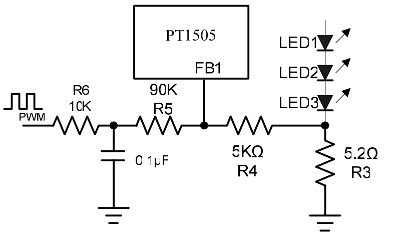


Figure6. Dimming Control Using a Filtered PWM Signal Start-up and Inrush Current

The white LED step-up converter subsystem of PT1505 has internal soft start to limit the amount of current through PVDD1 pin at startup and to also limit the amount of overshoot on the SW1 pin. The soft start is realized by gradually increasing the current limit during start-up. The current limit is increased by a third every 60μS giving a total soft start time of around 180μS.

EN1 Control

However, other than dimming applications, we recommend two methods concerning to controlling the white LEDs driver subsystem enable signal, that is the EN1 pin. One method is to use a Microcontroller Unit (MCU) to control this pin (figure 1), the other is connecting the EN1 pin to the up_reset pin (Figure 2) to let the PMU subsystem powered up firstly (when the PMU subsystem powered up completely, the up_reset signal will become logic high, see later) and then utilize the up_reset signal to enable the white LED driver subsystem. It will ensure the PT1505 operate more swimmingly using above two methods.

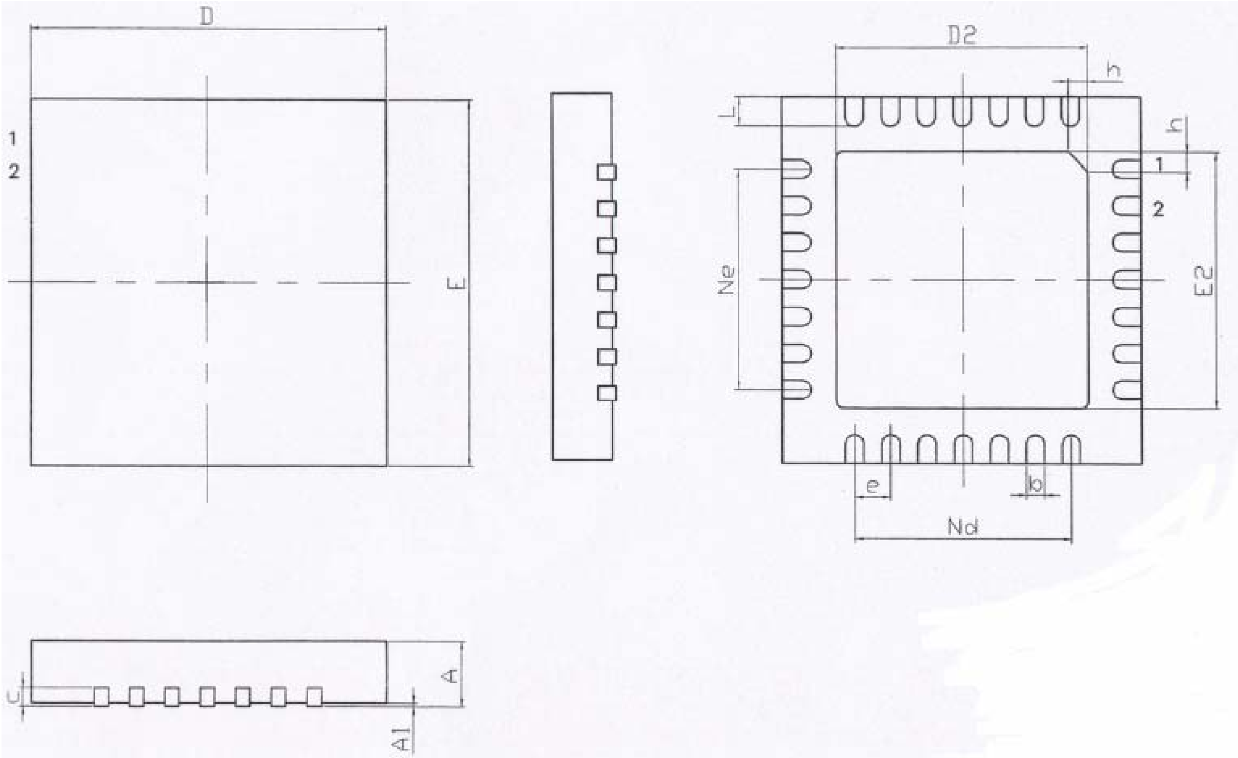
Layout Guideline

When laying out the PC board, the following layout guideline should be followed to ensure proper operation of the PT1505:

1. The power traces, including GND traces, the SW1, SW2 traces and the PVDD1, PVDD2 trace should be kept short, direct and wide to allow large current flow. The L1, L2 connection to the corresponding SW1, SW2 pins should be as short as possible. Use several via pads when routing between layers.
2. The input capacitors should be connected as close as possible to CHGIN and PGND to get good power filtering.
3. Keep the switching node SW1, SW2 away from the corresponding sensitive FB1, FB2 node.
4. The feedback trace for the BUCK should be separate from any power trace and connected as closely as possible to the load point. Sensing along a high current load trace will degrade DC load regulation.
5. SW1, SW2 and the corresponding output capacitors should be connected as close as possible and there should not be any signal lines under the inductor.
6. The resistance of the trace from the load return to the PGND2 should be kept to a minimum. This will help to minimize any error in DC regulation due to differences in the potential of the internal signal ground and the power ground.

PACKAGE INFORMATION

QFN28(5*5)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.01	0.05
b	0.18	0.25	0.30
c	0.18	0.20	0.25
D	4.90	5.00	5.10
D2	3.50REF		
e	0.50BSC		
Ne	3.00BSC		
Nd	3.00BSC		
E	4.90	5.00	5.10
E2	3.50REF		
L	0.35	0.40	0.45
h	0.30	0.35	0.40
L/F 载体尺寸（MIL）	150*150		