Techcode®

DATASHEET

# High Efficiency 1.2MHz Step Up Regulator TD8213

## General Description

The TD8213 is the high power and high efficiency boost converter with an integrated 30V FET ideal for LCD panel backlighting applications. 30V output voltage allows for 8 high-power LEDs in series, and 3.5A inductor current limit allows for more LED strings connected in parallel. The low 0.5V feedback voltage offers higher efficiency in WLED driver applications. The wide input range from 2.7V to 21V made TD8213 a perfect solution for various applications such as LCD monitor and portable devices. The OVP pin monitors the output voltage to protect IC during open load and FB pin short circuit operations. The TD8213 provides the ALS pin to simplify the interface to an ambient light sensor for automatic dimming. The TD8213 is available in the thermally enhanced DFN-10 lead 3mmx3mm package.

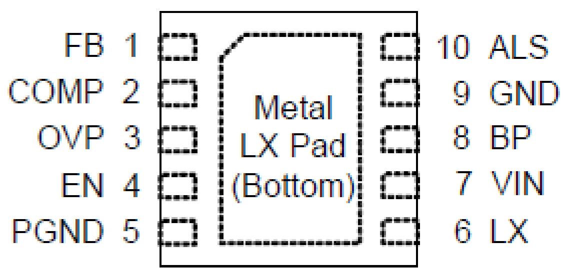
## Features

- Wide Input Voltage Range from 2.7V to 21V
- High Current-Limit up to 3.5A
- 0.5V Reference Voltage with ±3% System Accuracy
- 50mΩ Integrated N-FET
- Fixed 1.2MHz Switching Frequency
- High Efficiency up to 95%
- Open-LED Protection
- Under-Voltage Lockout Protection
- ALS Control Input Pin
- Over-Temperature Protection
- Low Shutdown Current: <1mA
- 3mmx3mm DFN-10 Package
- Lead Free and Green Devices Available

## Applications

- Display Backlighting
- Automotive
- LCD Monitors
- Notebook Displays
- Portable Displays

## Pin Assignments

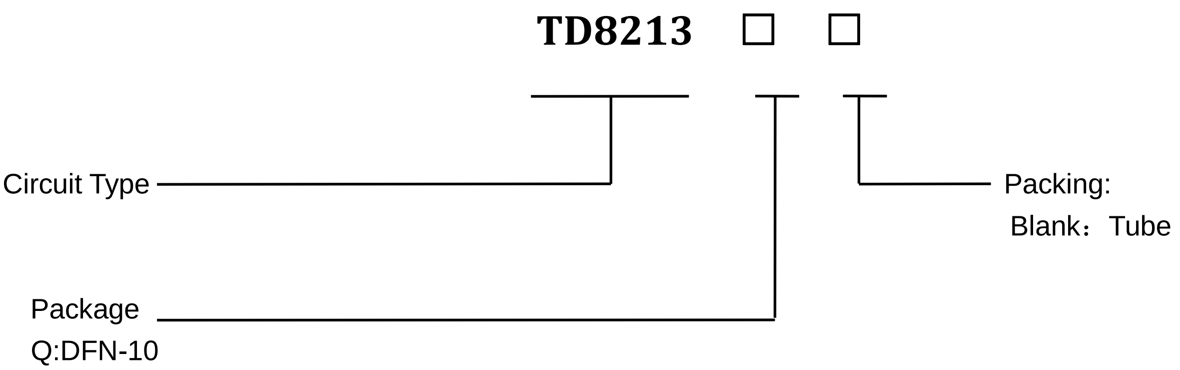



DFN3x3-10
(Top View)

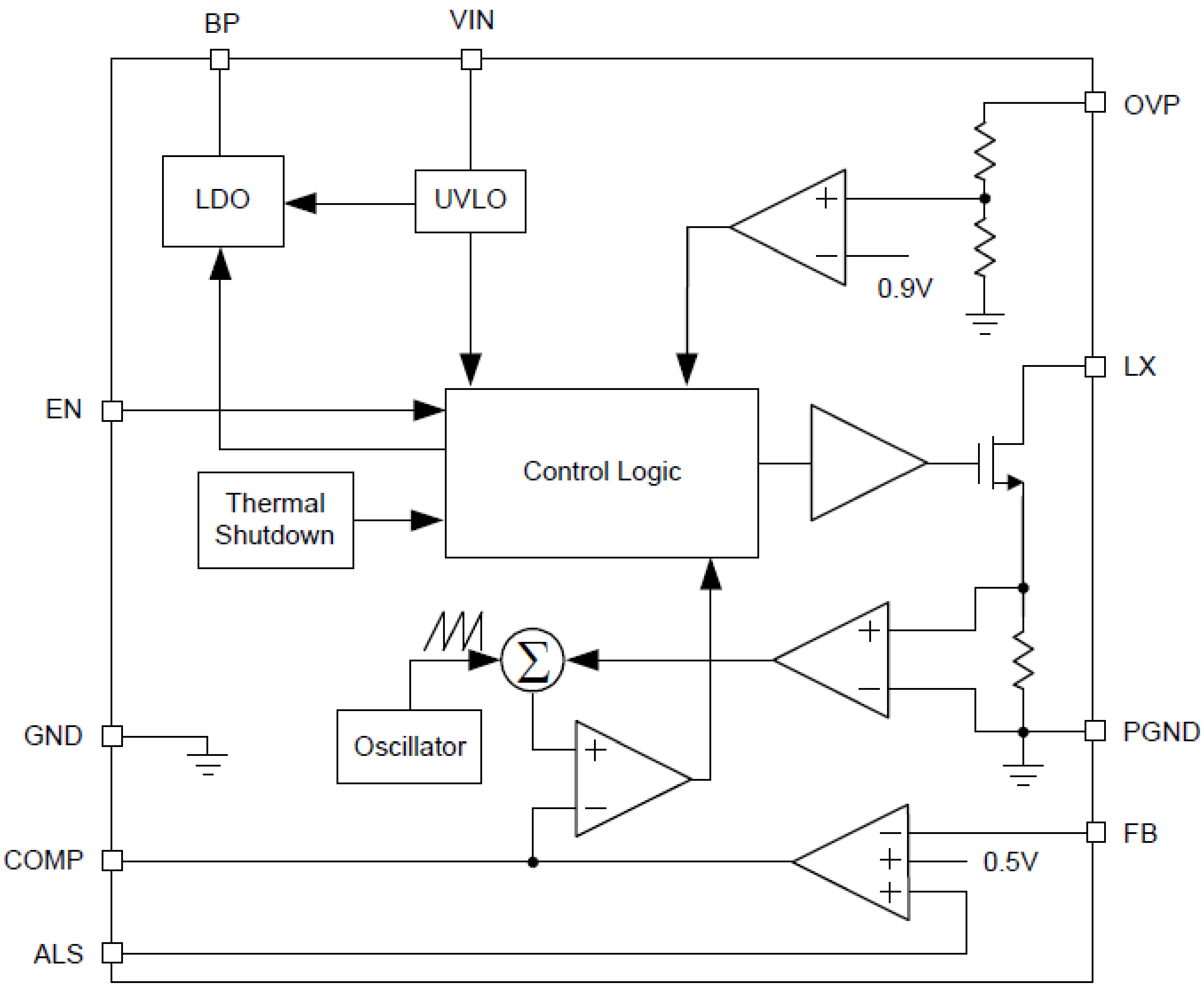
## Pin Description

| PIN | | FUNCTION |
|---|---|---|
| NO. | NAME | |
| 1 | FB | Regulator Feedback Pin. Connect a current sense resistor to GND to set the LED current. |
| 2 | COMP | Error Amplifier Output. Connect a 0.22μF capacitor for compensation and soft-start. When EN is pulled low, an internal switch will discharge the COMP voltage to 0V. |
| 3 | OVP | Output Over Voltage Monitor Pin. Tie to VOUT for OVP function. |
| 4 | EN | Enable Input Pin. Pull EN above 2.4V to enable the device; pull EN below 0.4V to disable the device. The EN pin cannot be left floating. |
| 5 | PGND | Power Ground. Source of the internal N-channel power MOSFET. |
| 6 | LX | Internal Power MOSFET Drain. |
| 7 | VIN | Supply Voltage Input. |
| 8 | BP | Output of The Internal 5V Regulator. Connect a 1μF bypass capacitor to GND. Do not apply an external load to BP. |
| 9 | GND | Signal Ground. |
| 10 | ALS | Ambient Light Sensor Input. Allow the light sensor to control the FB voltage for LED dimming. If the ALS function is not used, tie the ALS pin to BP pin. |

## Ordering Information



## Functional Block Diagram




**Functional Block Diagram of TD8213**

## Absolute Maximum Ratings

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| VIN | VIN pin to GND | -0.3 to 30 | V |
| VLX | LX pin to PGND | -0.3 to 30 | V |
| VOVP | OVP pin to GND | -0.3 to 30 | V |
| VBP | BP pin to GND | -0.3 to 6 | V |
| VEN | EN pin to GND | -0.3 to 30 | V |
| VALS | ALS pin to GND | -0.3 to 6 | V |
| | PGND to GND | -0.3 to 0.3 | V |
| TJ | Maximum Junction Temperature | 150 | ℃ |
| TSTG | Storage Temperature Range | -65 to 150 | ℃ |
| TL | Maximum Lead Soldering Temperature, 10 Seconds | 260 | ℃ |

## Recommended Operating Conditions

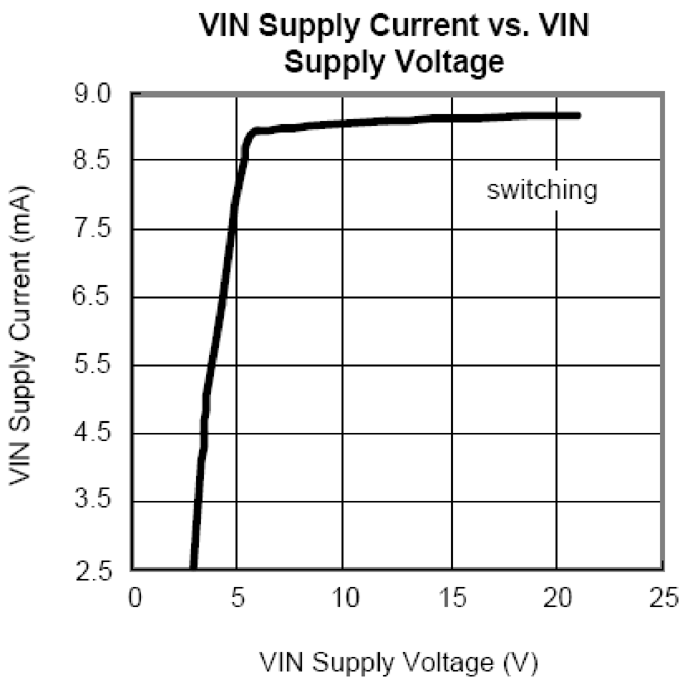
| Symbol | Parameter | Typical Value | Unit |
|---|---|---|---|
| VIN | VIN Supply Voltage, (VIN=BP) | 2.7 to 5.5 | V |
| | VIN Supply Voltage, (BP is open) | 3.7 to 21V | V |
| VOUT | Output Voltage | up to 30 | V |
| TJ | Operating Ambient Temperature | -40 to 85 | ℃ |
| TA | Operating Junction Temperature | -40 to 125 | ℃ |

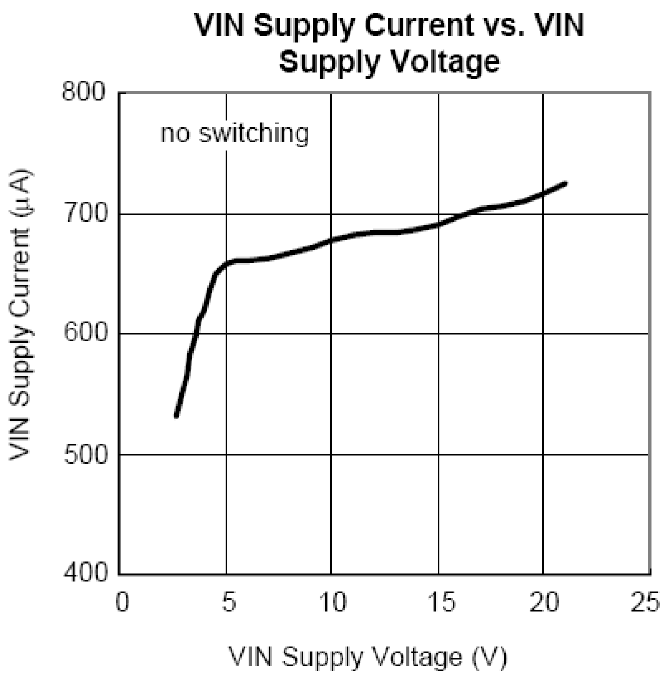
## Electrical Characteristics

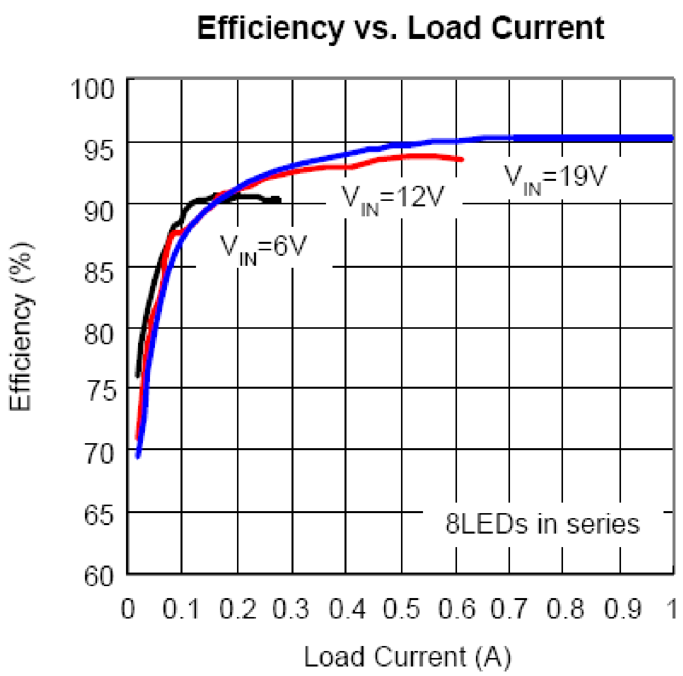
The following specifications apply for $V_{IN}$ =6V $T_A$=25 °C, unless specified otherwise.

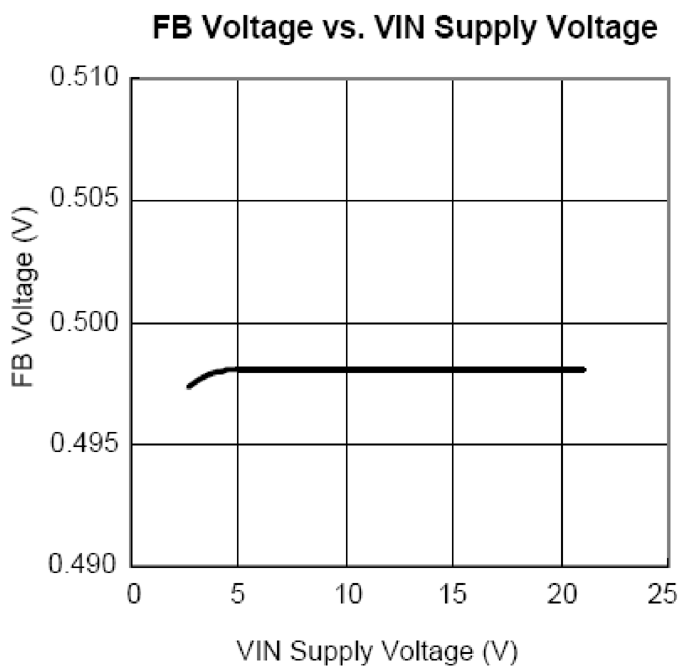
| Symbol | Parameter | Test Conditions | TD8213 Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **INPUT SUPPLY CURRENT AND UVLO** | | | | | | |
| | BP Under Voltage Lockout Threshold | $V_{IN}$ rising | 2.4 | 2.5 | 2.6 | V |
| | UVLO Hysteresis | | - | 100 | - | mV |
| $I_{VIN}$ | VIN Supply Current | EN=5V, switching | - | 9 | 15 | mA |
| | | EN=0V | - | - | 1 | uA |
| **ERROR AMPLIFIER** | | | | | | |
| gm | Error Amplifier Transconductance | | - | 350 | - | uA/V |
| $I_{COMP}$ | COMP Output Current | sourcing and sinking, $V_{COMP}$=1.5V | - | 50 | - | uA |
| $V_{FB}$ | FB Voltage | | 485 | 500 | 515 | mV |
| | Minimum FB Voltage | $V_{ALS}$=0.3V | 188 | 200 | 212 | mV |
| $I_{FB}$ | FB Input Bias Current | | - | - | 1 | uA |
| | FB Line Regulation | $V_{IN}$=2.7V to 21V | - | 0.02 | 0.04 | %/V |
| **INTERNAL POWER SWITCH** | | | | | | |
| | Power Switch Current-Limit | | 2.5 | 3.5 | 4.5 | A |
| $R_{DS(ON)}$ | Power Switch On Resistance | | - | 50 | 100 | mΩ |
| | LX Leakage Current | $V_{LX}$=30V | - | - | 1 | uA |
| $F_{SW}$ | Switching Frequency | | 0.9 | 1.2 | 1.5 | MHz |
| $D_{MAX}$ | LX Maximum Duty Cycle | | 92 | 95 | 98 | % |
| **ALS** | | | | | | |
| | ALS Ratio | $V_{ALS}$=1V, $V_{ALS}/V_{FB}$ | 2.9 | 3 | 3.1 | V/V |
| | ALS Pin Leakage | $V_{ALS}$=5V | - | - | 1 | uA |
| **OUTPUT OVER-VOLTAGE PROTECTION** | | | | | | |
| | Over-Voltage Threshold | | 30 | 32 | 34 | V |
| | OVP Hysteresis | | 2 | 3 | 4 | V |
| | OVP Leakage Current | | - | - | 30 | uA |
| **CONTROL LOGIC PIN** | | | | | | |
| | EN High-Level Input Voltage | | 2.4 | - | - | V |
| | EN Low-Level Input Voltage | | - | - | 0.4 | V |
| | EN Leakage Current | $V_{EN}$=21V | - | - | 1 | uA |
| **THERMAL SHUTDOWN** | | | | | | |
| | Thermal Shutdown Threshold | | - | 150 | - | ℃ |
| | Thermal Shutdown Hysteresis | | - | 50 | - | ℃ |

## Typical Operating Characteristics



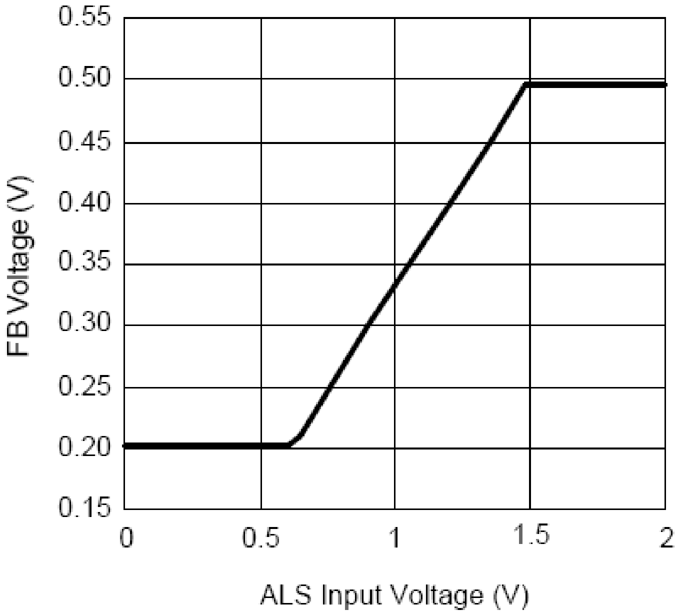



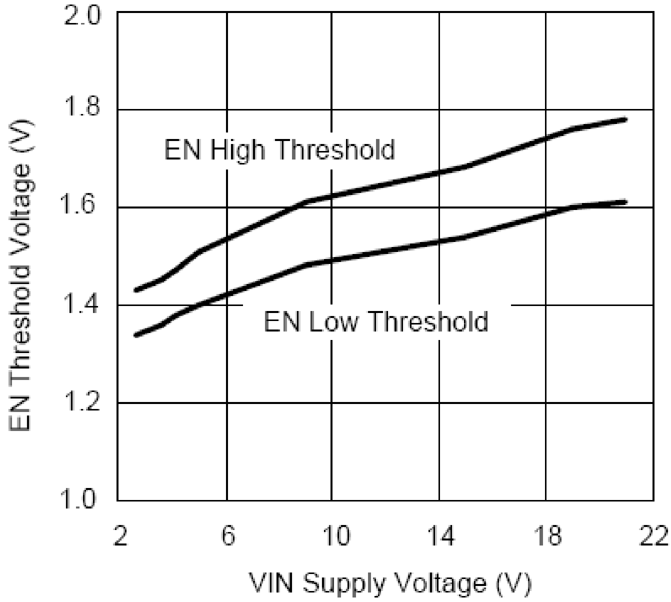



## Typical Operating Characteristics(Cont.)

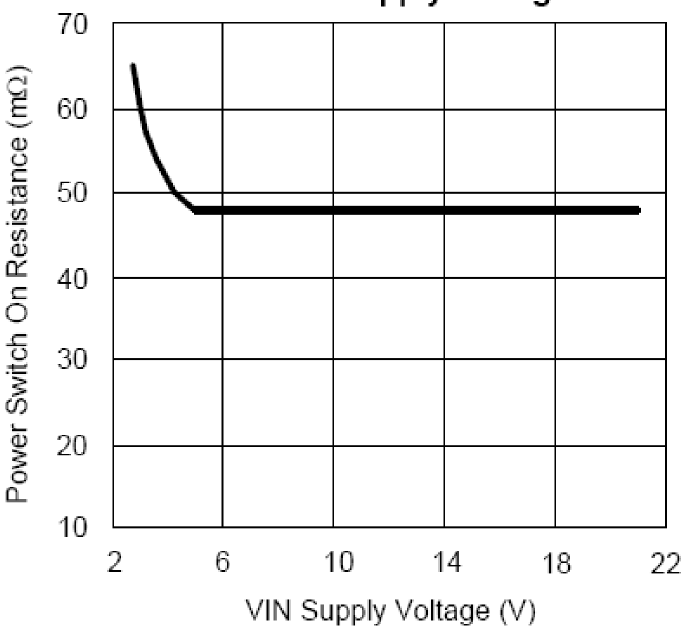
FB Voltage vs. ALS Input Voltage



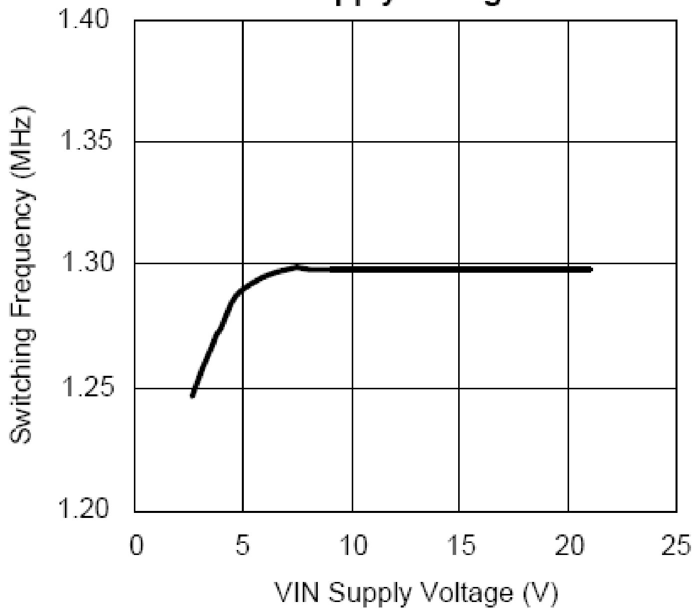

EN Threshold Voltage vs. VIN Supply Voltage



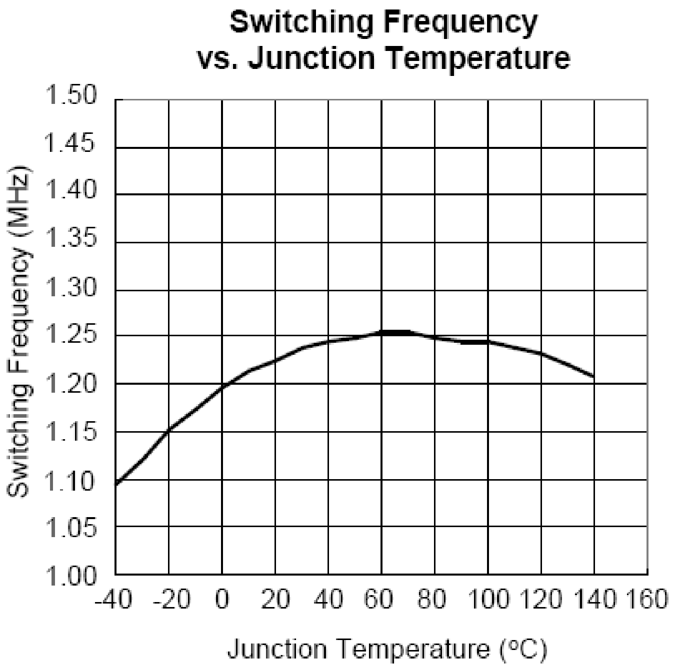

Power Switching On Resistance vs. VIN Supply Voltage

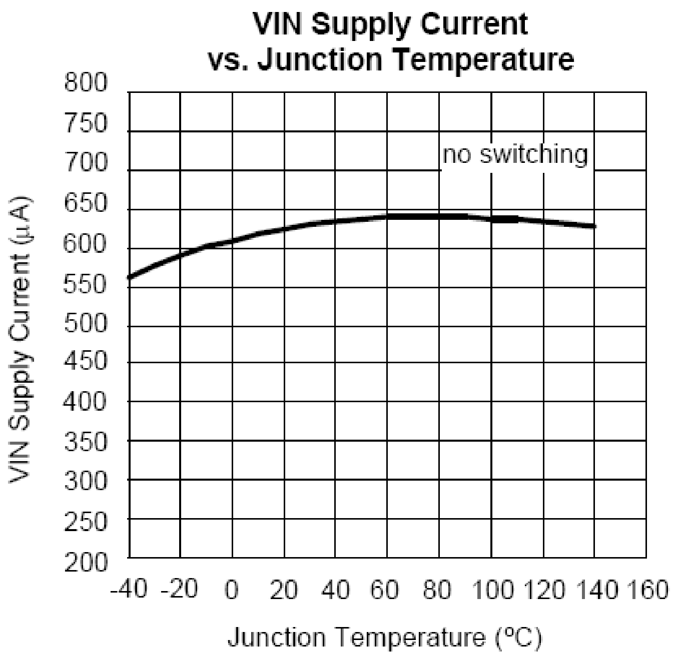


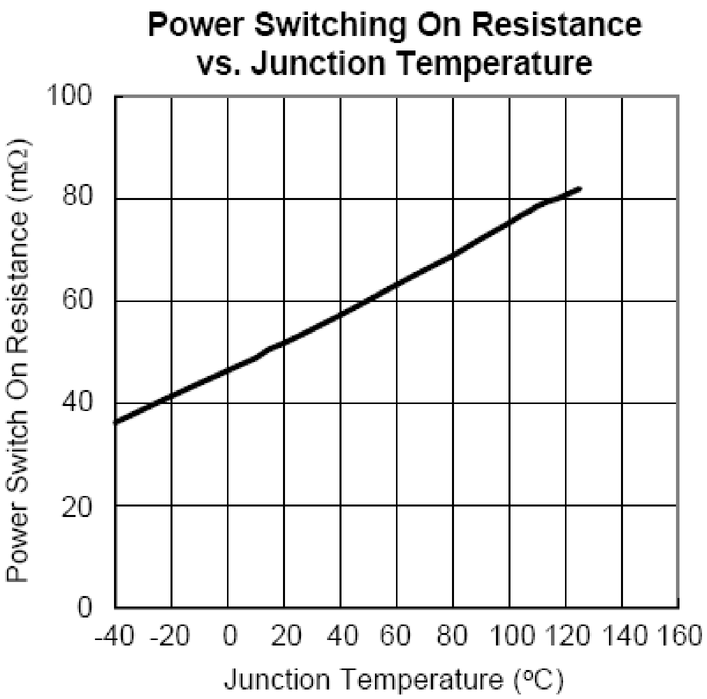

Switching Frequency vs. VIN Supply Voltage

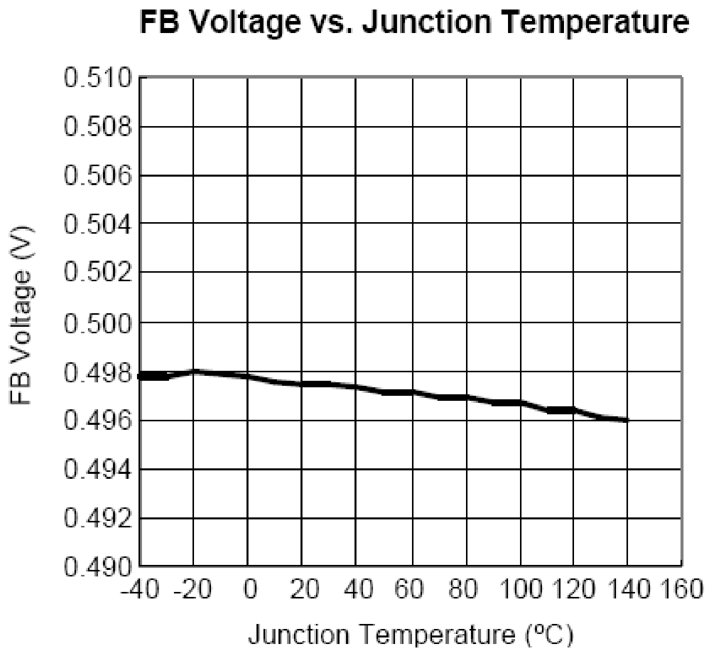


## Typical Operating Characteristics(Cont.)



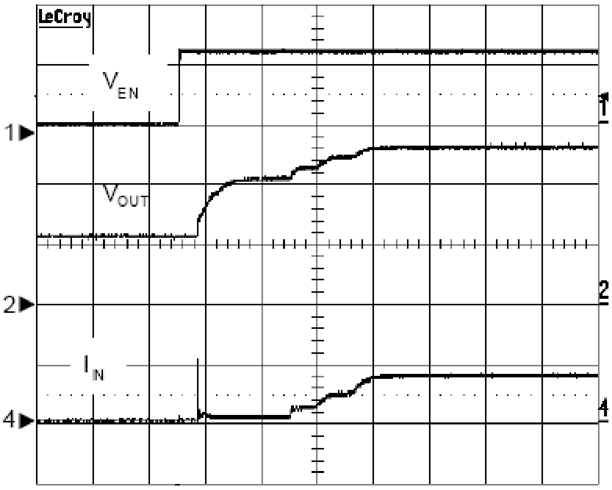



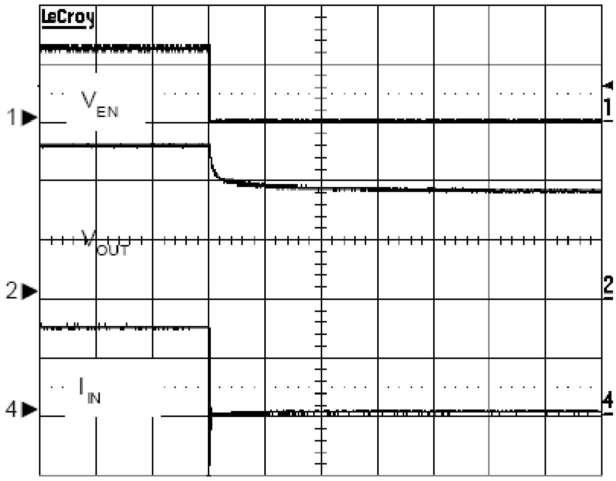
## Operating Waveforms

**Start-up**



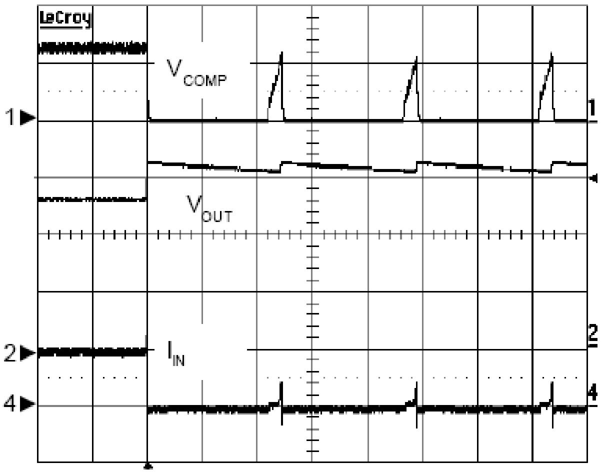

$V_{IN}$=12V, L=10μH, $C_{COMP}$=0.22μF
CH1: $V_{EN}$, 10V/div, DC
CH2: $V_{OUT}$, 10V/div, DC
CH4: $I_{IN}$, 500mA/div, DC
TIME: 1ms/div

**Shutdown**



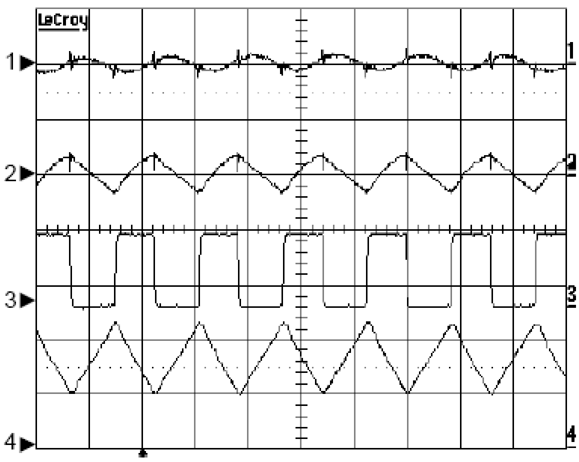

$V_{IN}$=12V, L=10μH, $C_{COMP}$=0.22μF
CH1: $V_{EN}$, 10V/div, DC
CH2: $V_{OUT}$, 10V/div, DC
CH4: $I_{IN}$, 500mA/div, DC
TIME: 10ms/div

**Over-Voltage Protection**




Output is open
CH1: $V_{COMP}$, 0.5V/div, DC
CH2: $V_{OUT}$, 10V/div, DC
CH4: $I_{IN}$, 100mA/div, DC
TIME: 10ms/div

**Switching Waveforms**




$V_{IN}$=12V, L=10μH, $C_{COMP}$=160mA
CH1: $V_{IN}$, 50mV/div, AC
CH2: $V_{OUT}$, 200mV/div, AC
CH3: $V_{LX}$, 20V/div, DC
CH4: $I_L$, 200mA/div, DC
TIME: 0.5μs/div

## Typical Application Circuit

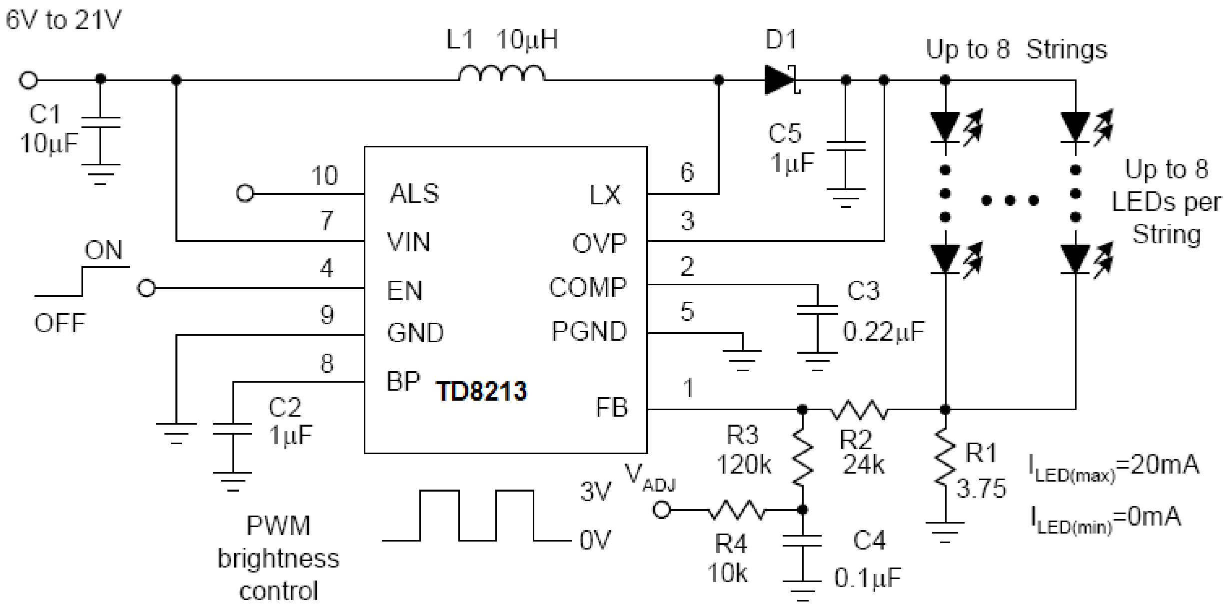



Figure1. Analog Dimming with PWM Voltage

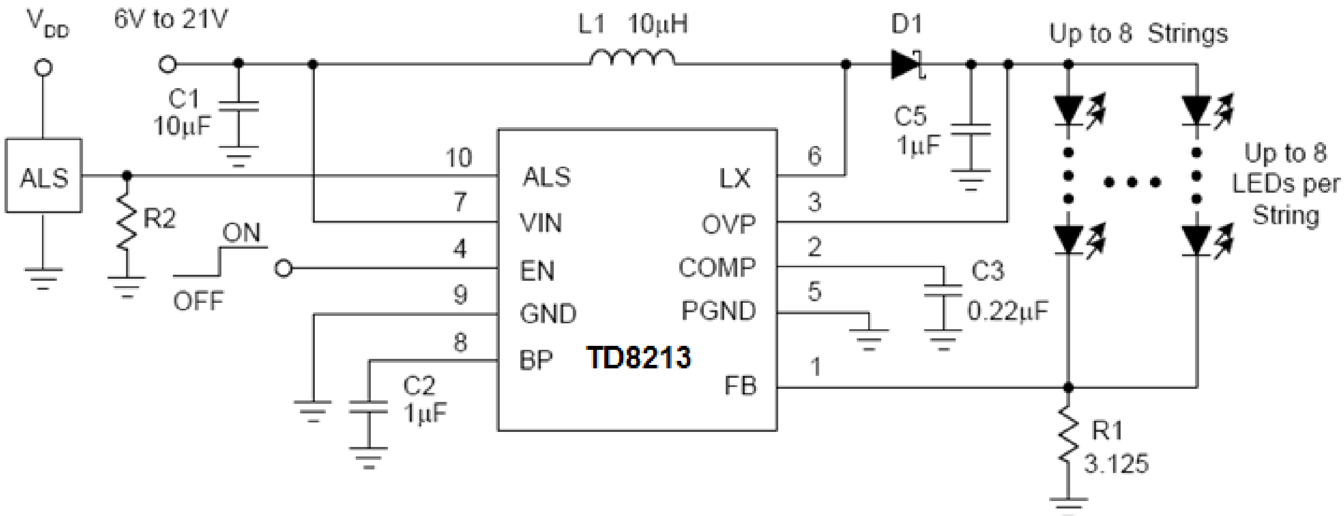



Figure2. Analog Dimming with External ALS Voltage

## Typical Application Circuit(Cont.)

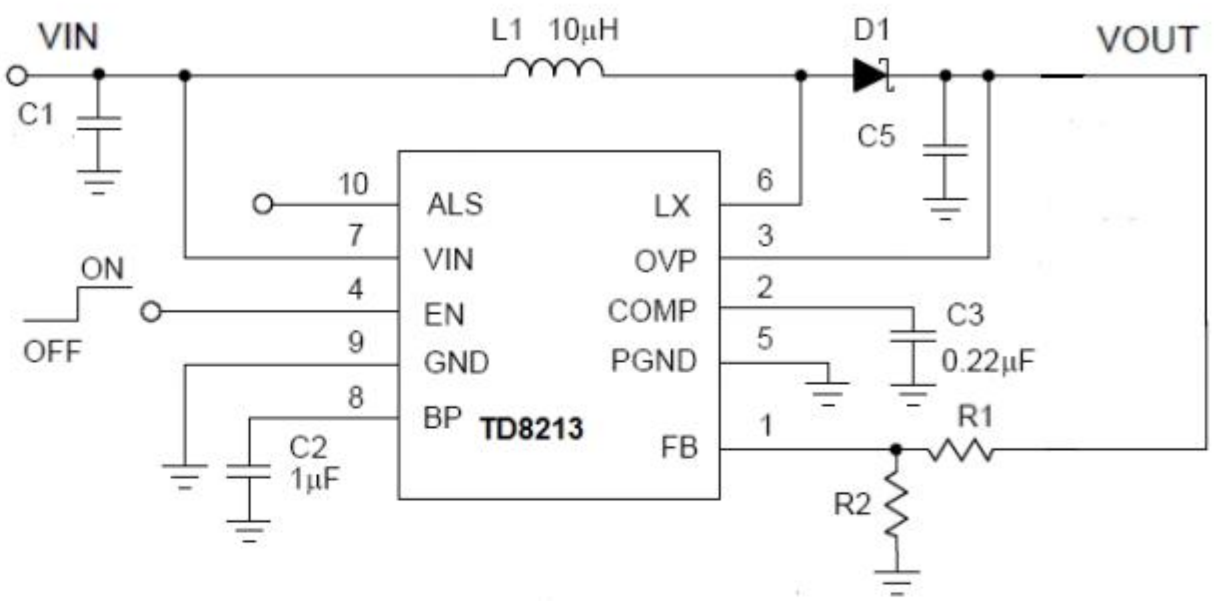



Figure 3 General Boost Converter Application

| Designation | Supplier | Part Number | Specification | Wedsite |
|---|---|---|---|---|
| L1 | GOTREND | GTSD53 | 10uH, 1.33A | www.gotrend.com.tw |
| C1 | Murata | GRM31CR61E106K | X5R, 25V, 10uF | www.murata.com |
| C2 | Murata | GRM155R61A105K | X5R, 10V, 1u F | www.murata.com |
| C3 | Murata | GRM155R60J224KE01 | X5R, 6.3V. 0.22uF | www.murata.com |
| C5 | Murata | GRM21BR71H105KA12 | X7R, 50V, 1u F | www.murata.com |
| D1 | Zowie | MSCD104 | 1.0A, 40V | www.zowie.com.tw |

## Function Description

**Output Over-Voltage Protection**

If the FB pin is shortened to the ground or an LED fails open circuit, output voltage in BOOST mode can increase to potentially damaging voltages. An optional over-voltage protection circuit can be enabled by connection of the OVP pin to the output voltage. The device will stop switching if the output voltage exceeds OVP high threshold and re-start when the output voltage falls below OVP low threshold. During sustained OVP fault conditions, $V_{OUT}$ will saw-tooth between the upper and lower threshold voltages at a frequency determined by the magnitude of current available to discharge the output capacitor. Note that the OVP pin must be connected to output voltage for OVP function.

**Ambient Light Sensor Interface**

The TD8213 provides the ALS pin to simplify the interface to an ambient light sensor. The ambient light sensor detects the ambient light and yields a current which is related to the illuminance. Connect a load resistor from the current output of ambient light sensor to ground to provide an output voltage to ALS pin. The ALS voltage will be divided by an internal divider circuit, and the divided ALS voltage will replace the internal reference voltage.The LED current can be calculated by the following equation:

$$I_{LED} = \frac{1}{3} \times \frac{V_{ALS}}{R1}$$

Note that the maximum FB voltage is set to 0.5V, and minimum FB voltage is set to 0.2V. If the divided ALS voltage is over 0.5V or less 0.2V, the LED current is limited at:

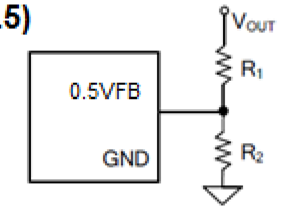
$$I_{LED(MAX)} = \frac{0.5V}{R1} \qquad I_{LED(MIN)} = \frac{0.2V}{R1}$$

where R1 is the resistor from FB to GND.

**Feedback resistor dividers R1 and R2**:

Choose R1 and R2 to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both R1 and R2. A value of between 10k and 1M is recommended for both resistors. If R1=200k is chosen, then R2 can be calculated to be:

$$R2=R1*0.5/(Vout-0.5)$$




**Enable/Disable**

Pull the EN above 2V to enable the device and pull EN pin below 0.4V to disable the device. In shutdown mode, the internal control circuits are turned off, the quiescent current is below 1μA.

**Thermal Shutdown**

When the junction temperature exceeds 150°C, the internal thermal sensor circuit will disable the device and allow the device to cool down. When the device's junction temperature cools by 50°C, the internal thermal sense circuit will enable the device, resulting in a pulsed output during continuous thermal protection. Thermal protection is designed to protect the IC in the event of over temperature conditions. For normal operation, the junction temperature cannot exceed $T_J$=+125 °C.

**Internal 5V LDO**

The TD8213 provides an internal 5V LDO for the control circuitry, and the output of the internal LDO is BP pin. In normal operation, connect a 1μF or greater capacitor to GND is recommended. The internal LDO cannot supply any more current than is required to operate the TD8213. Therefore, do not apply any external load to BP pin. In applications, where the $V_{IN}$ is less than 5.5V, BP should be tied to VIN through a 10Ω resistor.

## Application Information

**Connecting More LED Strings**

The TD8213 can drive 8 LED strings in parallel and up to 8 LEDs per string ($V_F$<3.5V). Each string must have the same number of LEDs. In the applications that have the same total number of LEDs, more strings and less LEDs in series are more efficiency than less strings and more LEDs in series.

**Brightness Control**

The method for dimming the LEDs is to apply a PWM voltage through an RC filter into the FB pin.

The RC filter is used to convert the PWM voltage into an analog voltage. The values of the R and C depend upon the frequency of the PWM voltage and the amount of allowable ripple voltage on FB pin. The LED current is proportional to the PWM duty cycle. 0 % duty delivers maximum LED current and 100% duty delivers minimum LED current. The values of R1 and R2 are calculated by the following equations:

$$R2 = \frac{V_{FB} \times (I_{LED(max)} \times R3 + V_{ADJ(low)} - I_{LED(min)} \times R3 - V_{ADJ(high)})}{V_{ADJ(high)} \times I_{LED(max)} + V_{FB} \times I_{LED(min)} - V_{ADJ(low)} \times I_{LED(min)} - V_{FB} \times I_{LED(max)}}$$

$$R1 = \frac{V_{FB} \times (1 + \frac{R2}{R3}) - \frac{R2}{R3} \times V_{ADJ(low)}}{I_{LED(max)}}$$

where:

$I_{LED(max)}$ is the maximum LED current

$I_{LED(min)}$ is the minimum LED current

$V_{ADJ(high)}$ is the maximum PWM voltage level

$V_{ADJ(low)}$ is the minimum PWM voltage level

$V_{FB}$ is the FB pin Voltage

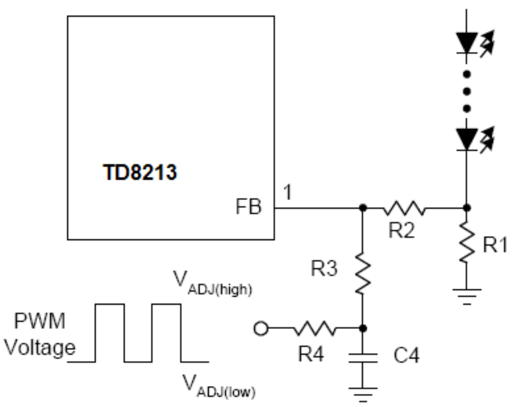



Figure 3. Dimming with the PWM Voltage

**Inductor Selection**

A larger value of inductor will reduce the peak inductor current, resulting in smaller input ripple current, higher efficiency and reducing stress on the internal MOSFET. However, the larger value of inductor has a large dimension, lower saturation current, and higher series resistance.

A good rule for determining the inductance is to allow the peak-to-peak ripple current to be approximately 30% to 50% of the maximum input current. Calculate the required inductance value by the equation:

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

$$\Delta I_L = (30\% - 50\%) \times I_{IN}$$

$$I_{IN} = \frac{V_{OUT} \times I_{LOAD}}{V_{IN} \times \eta}$$

It is necessary to choose an inductor that ensures the inductor saturation current rating to exceed the peak inductor current for the application.

To make sure that the peak inductor current is below the current-limit 2.5A. Calculating the peak inductor current by the following equation:

$$I_{PEAK} = I_{IN} + 0.5 \times \Delta I_L$$

$$I_{PEAK} = \frac{V_{OUT} \times I_{LOAD}}{V_{IN} \times \eta} + \frac{(V_{OUT} - V_{IN}) \times V_{IN}}{2 \times L \times F_{SW} \times V_{OUT}}$$

where

$\eta$ is the efficiency

**Schottky Diode Selection**

A fast recovery time and low forward voltage Schottky diode is necessary for optimum efficiency. Ensure that the diode's average and peak current rating exceed the average output current and peak inductor current. In addition, the diode's reverse voltage must exceed output voltage.

**Capacitor Selection**

An input capacitor is required to supply the ripple current to the inductor and stabilize the input voltage. Larger input capacitor values and lower ESR provide smaller input voltage ripple and noise. The typical value for input capacitor is 2.2µF to 10µF.

## Application Information(Cont.)

**Capacitor Selection (Cont.)**

The output capacitor with typical value 1µF to 10µF is required to maintain the output voltage. The COMP capacitor with typical value 0.22µF to 1µF stabilizes the converter and controls the soft-start.

To ensure the voltage rating of input and output capacitors is greater than the maximum input and output voltage. It is recommended using the ceramic capacitors with X5R, X7R, or better dielectrics for stable operation over the entire operating temperature range.

**Layout Consideration**

The correct PCB layout is important for all switching converters. If the layout is not carefully done, the regulator could show stability problems as well as EMI problems. Figure. 4 illustrates the layout guidelines; the bold lines indicate these traces that must be short and wide. The capacitors, the diode, and the inductor should be as close to the IC as possible. Keep traces short, direct, and wide. Keep the LX node away from FB and COMP pins. The trace from diode to the LEDs may be longer. The ground return of input capacitor and output capacitor should be tied close to PGND. Use the different ground planes for signal ground and power ground to minimize the effects of ground noise. Connect these ground nodes at any place close to one of the ground pins of the IC. The resistor from FB to GND should be close to the FB pin as possible. The metal plate of the bottom must be soldered to the PCB and connected to LX node and the LX plane on the backside through several thermal vias to improve heat dissipation.

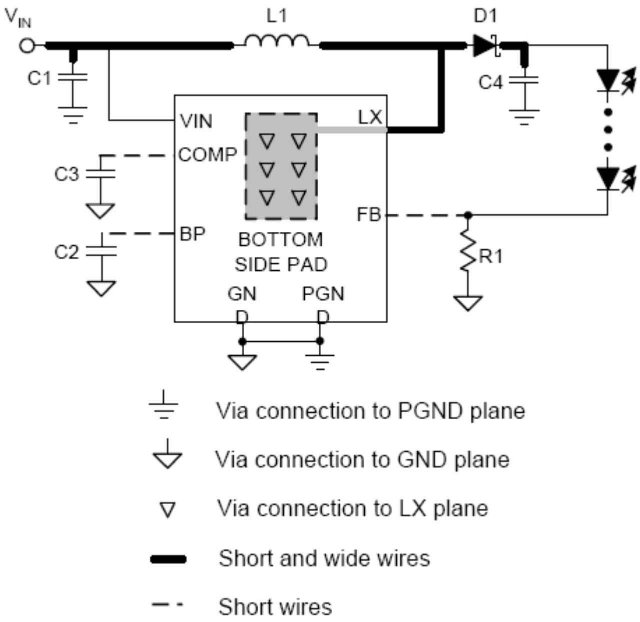
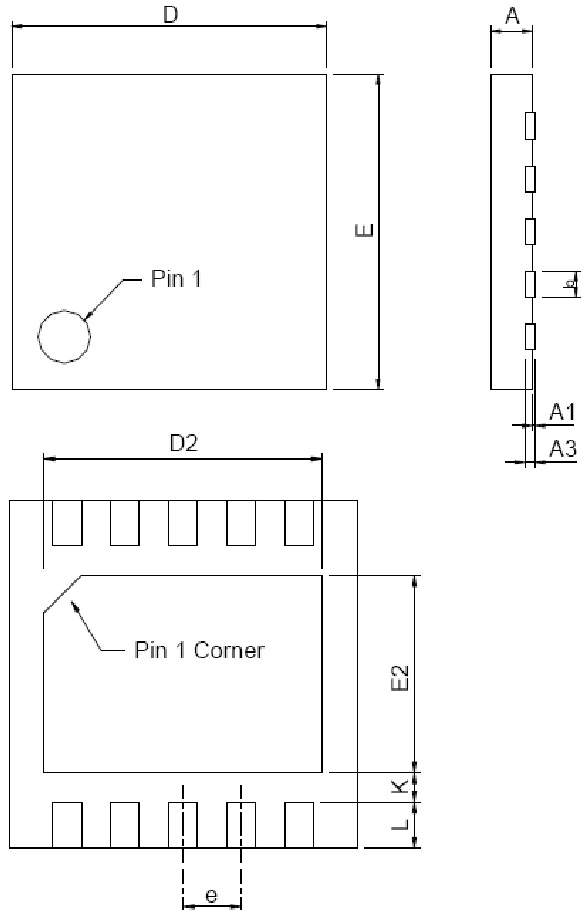



Figure 4. Layouy Guidelines

## Package Information

DFN3x3-10




| SYMBOL | DFN3x3-10 | | | |
|---|---|---|---|---|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | 0.80 | 1.00 | 0.031 | 0.039 |
| A1 | 0.00 | 0.05 | 0.000 | 0.002 |
| A3 | 0.20 REF | | 0.008 REF | |
| b | 0.18 | 0.30 | 0.007 | 0.012 |
| D | 2.90 | 3.10 | 0.114 | 0.122 |
| D2 | 2.20 | 2.70 | 0.087 | 0.106 |
| E | 2.90 | 3.10 | 0.114 | 0.122 |
| E2 | 1.40 | 1.75 | 0.055 | 0.069 |
| e | 0.50 BSC | | 0.020 BSC | |
| L | 0.30 | 0.50 | 0.012 | 0.020 |
| K | 0.20 | | 0.008 | |

Note : 1. Followed from JEDEC MO-229 VEED-5.

Design Notes