# MP1521

## High Efficiency White LED Driver

Monolithic Power Systems

## General Description

The MP1521 is a constant-current Boost Regulator. This IC has three individual current-sensing feedbacks, which are ideal for driving multiple strings of series connected LEDs. The OLS pin is designed for detecting loose or open LED connections.

The IC uses a peak current, constant minimum off-time architecture. The feedback pins measure voltage across sense resistors in series with the LED strings. When supplying a bias current of 20mA, the voltage drop across the sense resistor is only 0.4V to minimize power loss. Either a DC voltage or a PWM signal at the BRT/PWM input can control the LED brightness.

The MP1521 has an on board power MOSFET switch that is protected by current limit, open load shutdown, thermal shutdown, and under voltage lockout.

## Features

- On Board Power MOSFET
- Drive 9 White LEDs from 2.7V Input
- Drive 15 White LEDs from 5V Input
- Up to 90% Efficiency
- Over 80mA Output Current Capacity
- Open Load Shutdown
- Low Current Sensing Feedback Voltage
- Up to 3 String Current Sensing Feedback
- Analog and Digital PWM Brightness Control
- UVLO, Thermal Shutdown
- Soft Start
- Internal Current Limit
- Available in Compact MSOP10 and Tiny **3 mm x 3 mm** QFN16 Package
- **Evaluation Boards Available**

## Applications

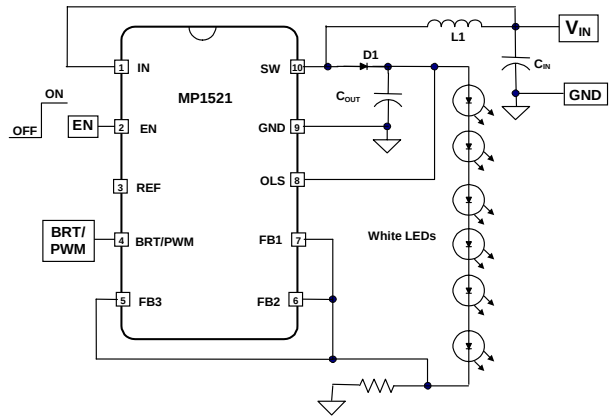
- Handheld Computers, Cell phones, PDAs, Digital and Video Cameras, Small LCD Displays
- Li Ion and NiMH Battery Applications

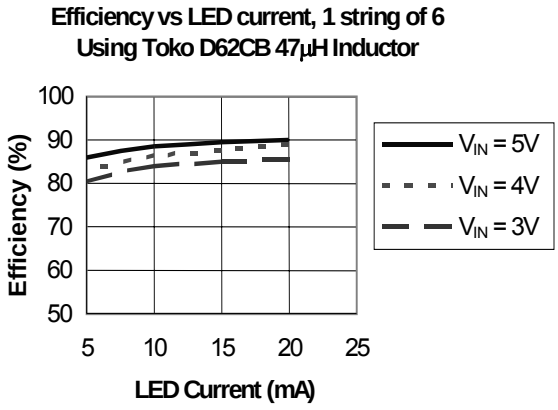
## Ordering Information

| Part Number * | Package | Temperature |
|---|---|---|
| MP1521EK | MSOP10 | -20° to +85°C |
| MP1521EQ | QFN16 (3x3) | -20° to +85°C |
| EV0005 | MP1521EK Evaluation Board | |
| EV0021 | MP1521EQ Evaluation Board | |

* For Tape & Reel, add suffix –Z (i.e., MP1521EK–Z)
For Lead Free, add suffix –LF (i.e., MP1521EK–LF–Z)

## Typical Application Circuit (One String of Six (6) LEDs)



## Absolute Maximum Ratings

| | |
|---|---|
| Supply Voltage ($V_{IN}$) | 28V |
| Switch Voltage to GND | -0.5V to 28V |
| $V_{EN}$, $V_{REF}$, $V_{BRT}$, $V_{FB1}$, $V_{FB2}$, $V_{FB3}$ | –0.3V to 6V |
| Storage Temperature | -55°C to +150°C |

## Recommended Operating Conditions

| | |
|---|---|
| Supply Voltage ($V_{IN}$) | 2.7V to 25V |
| Operating Temperature | -20°C to +85°C |
| Switch Voltage to GND | -0.5V to 25V |

## Package Thermal Characteristics

| | |
|---|---|
| Thermal Resistance, $\Theta_{JA}$ (MSOP10) | 150°C/W |
| Thermal Resistance, $\Theta_{JA}$ (QFN16) | 60°C/W |

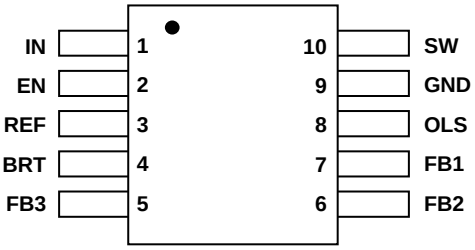
## Electrical Characteristics ($V_{IN}$ = 5.0V, $T_A$ = 25°C unless specified otherwise)

| Parameters | Symbol | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Supply Current (shutdown) | $I_{IN\ (OFF)}$ | $V_{EN}$<0.4V | | 1 | 3 | μA |
| Supply Current (quiescent) | $I_{IN\ (ON)}$ | $V_{EN}$ >1.5V, $V_{BRT}$=0V, $V_{FB}$=0V | | 550 | 700 | μA |
| Minimum Off Time, normal operation | $t_{OFF\ (NORMAL)}$ | $V_{EN}$ >1.5V, $V_{BRT}$ =0.6V $V_{FB}$ =0 | 400 | 500 | 700 | nS |
| Minimum Off Time, start-up (Note 1) | $t_{OFF\ (START)}$ | $V_{EN}$ >1.5V, $V_{BRT}$ =0.6V, $V_{FB}$ =0V | 1.5 | | 2.4 | μS |
| **UVLO** | | | | | | |
| Under Voltage Lockout | | $V_{IN\ RISING}$ | 2.1 | | 2.6 | V |
| | | $V_{IN\ FALLING}$ | 1.9 | | 2.4 | V |
| **Enable** | | | | | | |
| Threshold | | | 0.8 | 1.0 | 2.0 | V |
| Hysterisis | | | | 60 | | mV |
| Leakage Current | | $V_{EN}$=3V | | | 1 | μA |
| **Open Load Shutdown** | | | | | | |
| Threshold | | Measured at OLS Pin | 26 | | 29 | V |
| Leakage Current | | $V_{OLS}$=15V | | | 1 | μA |
| | | $V_{OLS}$=25V | | 45 | 70 | μA |
| **Reference** | | | | | | |
| Output Voltage | | $I_{REF}$=0A | 1.20 | 1.235 | 1.27 | V |
| Load Regulation | | $I_{REF}$=0 to 100μA | | 2.5 | 5 | mV |
| Line Regulation | | $V_{IN}$ =3 to 15V, $I_{REF}$=0A | | 2.5 | 5 | mV |
| **Feedback Comparator** | | | | | | |
| Threshold | | $V_{BRT}$ =1.2V | 380 | 400 | 420 | mV |
| Hysterisis (Note 2) | | $V_{BRT}$ =1.2V | | 30 | | mV |
| FB Input Bias Current | | $V_{FB}$=0.2V | -150 | -50 | 0 | nA |
| **PWM Mode** | | | | | | |
| Output-Off Threshold | | | 0.18 | | 0.26 | V |
| BRT Input Bias | | $V_{BRT}$=0.6V | -100 | -30 | 0 | nA |
| BRT Full Scale Threshold (Note 3) | | | | | 1.2 | V |
| **Output Switch** | | | | | | |
| Switch On Resistance (Note 2) | $R_{ON}$ | $V_{IN}$=5.0V | | 0.5 | 0.6 | Ω |
| Switch Current Limit | | | 300 | 400 | | mA |
| Leakage Current | | $V_{SW}$=25V | | | 5 | μA |
| Thermal Shutdown (Note 2) | | | | 160 | | °C |

Notes:
1) First 64 pulses after EN switches high.
2) Guaranteed by design.
3) The output current is off when BRT is driven below the output-off threshold and full-scale when driven above the full-scale threshold. To PWM the output drive BRT above and below these thresholds.

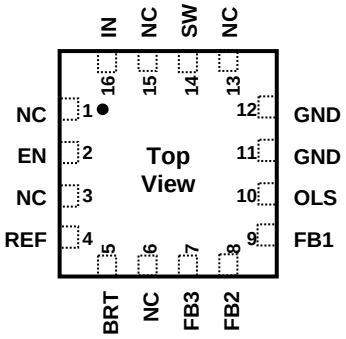
## Pin Description

**MSOP10**




**Part Marking: MP1521EK**

**QFN16**

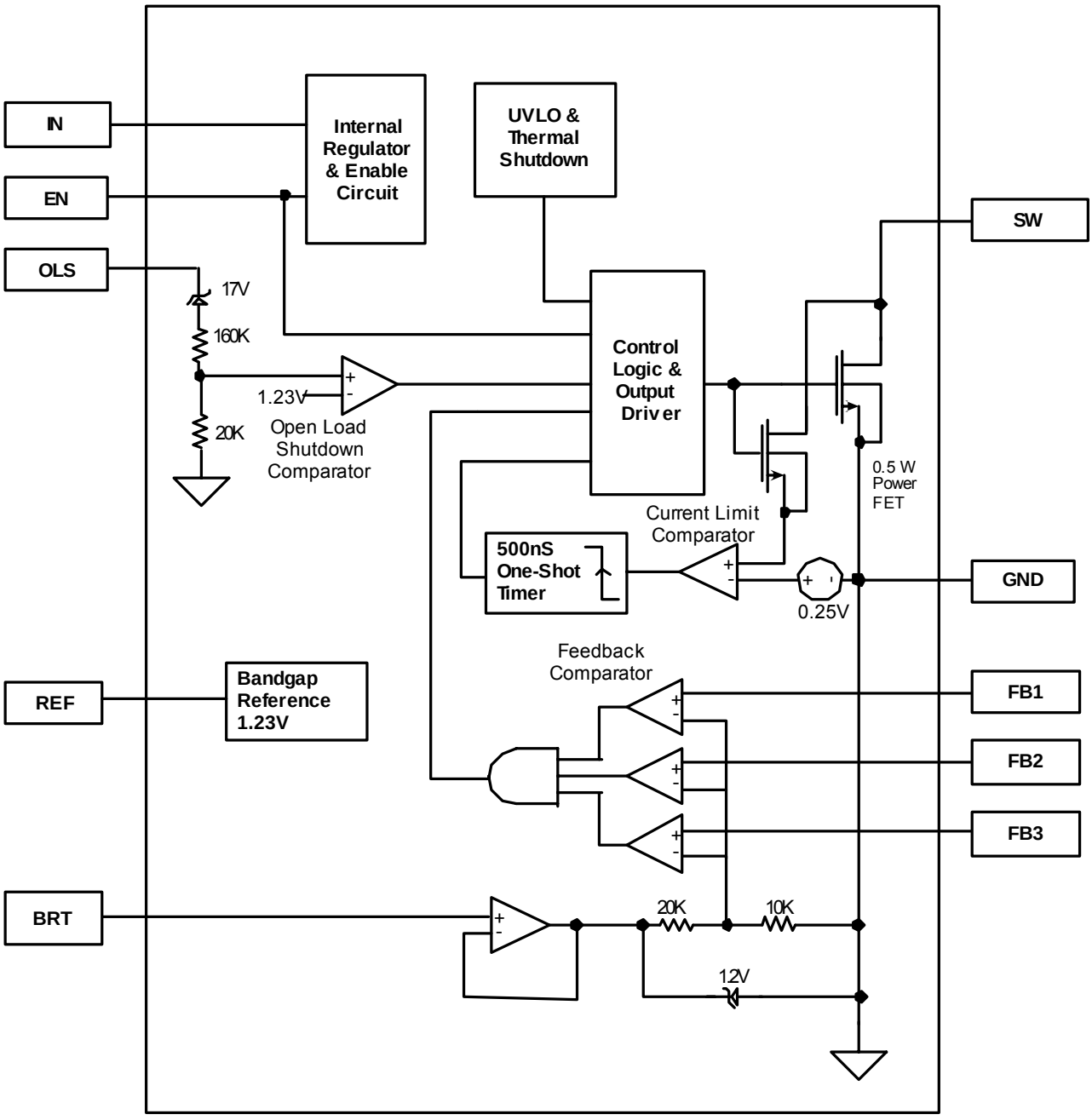



**Part Marking: A1xx**

### Table 1: MP1521 MSOP10 and QFN16 Pin Assignments

| MSOP Pin # | QFN Pin# | Pin Name | Pin Function |
|---|---|---|---|
| 1 | 16 | IN | Input supply pin. It can be connected to the regulator's input supply, or to the output for boot-strapped operation (boot-strapped operation is required for $V_{IN}$ of less than 3V). |
| 2 | 2 | EN | Regulator On/Off control input. Logic high ($V_{EN}$>1V) turns on IC, logic low puts it into low current shutdown mode. Place a 100KΩ resistor in series with EN if it is connected to a voltage greater than 10V. |
| 3 | 4 | REF | 1.23V reference used for setting the analog control voltage at BRT input. This reference can supply up to 200μA to an external load. **Do not** connect any bypass capacitors to this pin. It is internally compensated. |
| 4 | 5 | BRT | Analog or PWM input for controlling LED brightness. When used in analog mode, apply a DC voltage of 0.3 to 1.2V. This input voltage is attenuated by 1/3 to set the voltage across sense resistors at FB1, FB2, and FB3. Maximum brightness (20mA) occurs with 1.2V applied. To control brightness in PWM mode, apply a PWM square wave with a minimum voltage less the 0.18V and a maximum greater than 1.2V. When a voltage less than 0.18V is applied to this pin, the output switch is turned off. The regulator operates at maximum brightness when more than 1.2V is applied. The frequency of the PWM signal must be between 100 to 400 Hz. |
| 5<br>6<br>7 | 7<br>8<br>9 | FB3<br>FB2<br>FB1 | Feedback input for measuring voltage across current-sense resistor that is in series with LED string. Unused feedback pins must be connected to any used feedback pin. |
| 8 | 10 | OLS | Open Load Shutdown pin senses regulator output voltage to protect IC during open load operation. When this pin's voltage exceeds 28V, the output switch is shut off. The output switch remains off until the IC is reset by cycling the enable pin (EN) or input supply (IN) pin. |
| 9 | 11, 12 | GND | Signal and power ground. Connect directly to ground plane. |
| 10 | 14 | SW | Output switch pin, power DMOS low-side switch. |
| - | 1, 3, 6, 13, 15 | N/C | No Connect |

**Figure 2: MP1521 Functional Block Diagram**



## Functional Description

### Operation

The MP1521 utilizes a constant off-time control scheme (Refer to the Block Diagram). For maximum brightness, the BRT pin is biased at or above 1.2V. Its voltage is routed through the unity gain buffer whose the output of is clamped at 1.2V. A 20K/10K divider from the Buffer to the non-inverting input of the Feedback comparator divides the BRT voltage by three to set the current sense threshold. If any of the feedback pins FB1, FB2, or FB3 is lower than this threshold the Power FET is turned on. The Power MOSFET and inductor current increases until the current limit comparator trips at 0.5A turning off the MOSFET for 500ns. At the end of 500ns if any of the Feedback pins are still lower than the current sense threshold. The Power FET is again turned on. This cycle repeats itself until all three of the feedback pins exceed the threshold.

### Analog Brightness Adjust

Analog Brightness Adjust is accomplished by applying a voltage between 0.26V to 1.2V on the BRT pin. The 1.23V REF output can be used to bias a potentiometer whose wiper drives the BRT pin.

### PWM/ Brightness Adjust

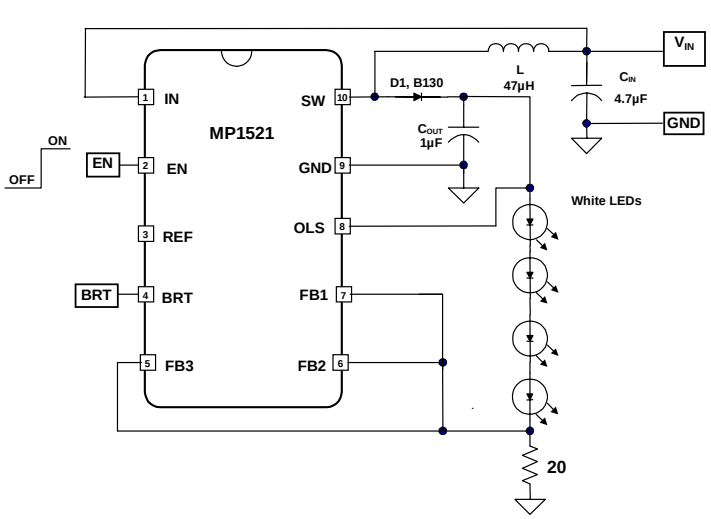
PWM Brightness Adjust is accomplished by driving the BRT pin with a square wave whose low voltage is below 0.2V and whose high voltage is greater than 1.2V. A voltage below 0.2V forces the Power MOSFET off. A voltage greater than 1.2V will cause all three feedback pins to regulate at or above 0.4V

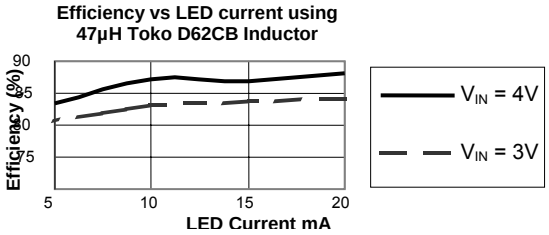
### Open Load Shut-Off

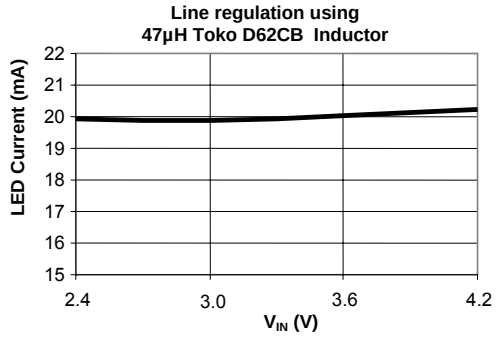
Open Load Shut-Off is implemented by connecting the OLS pin to $V_{OUT}$. In the fault condition where the connection to the LED's is open, $V_{OUT}$ will rise up, as all the feedback pins are absent of voltage. Once $V_{OUT}$ exceeds 28V, the part will cease operation until the EN pin is cycled off and on. To disable the open load shut-off feature, connect the OLS pin to GND.

## Application Circuits

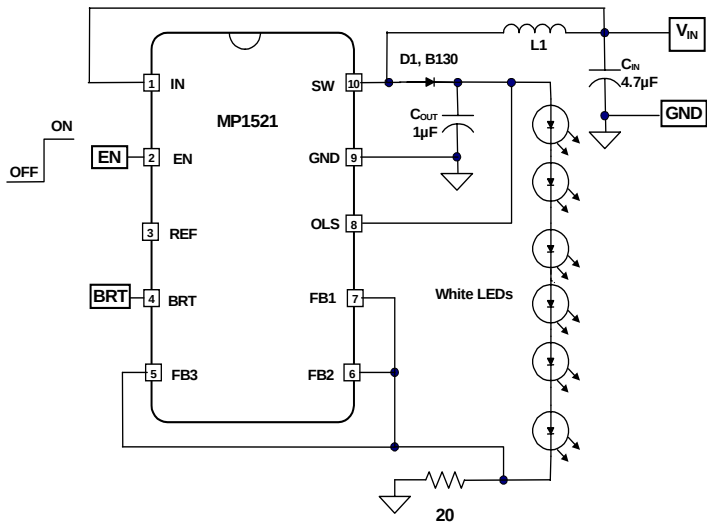
### Figure 3: One String of Four (4) LEDs

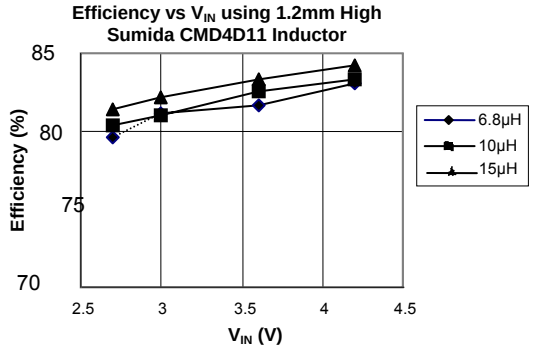


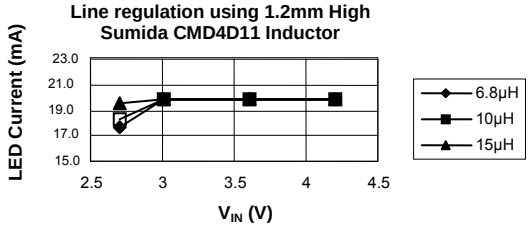




### Figure 4: One String of Six (6) LEDs (Low inductor height for portables)

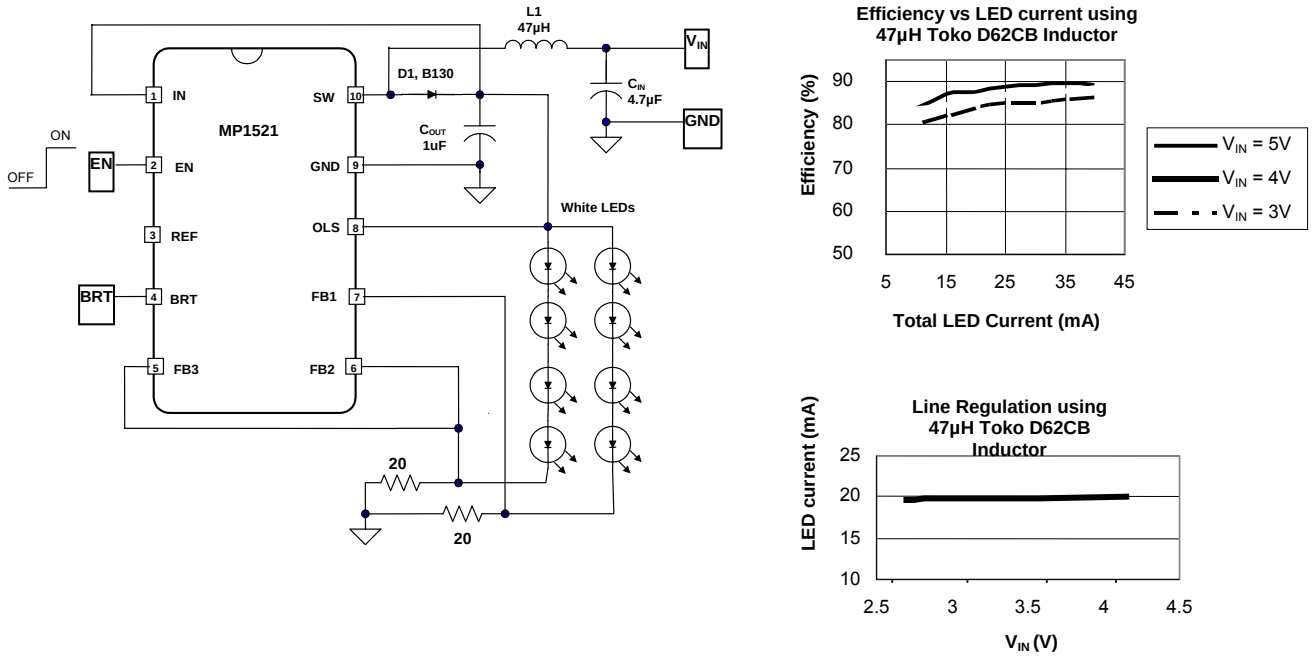


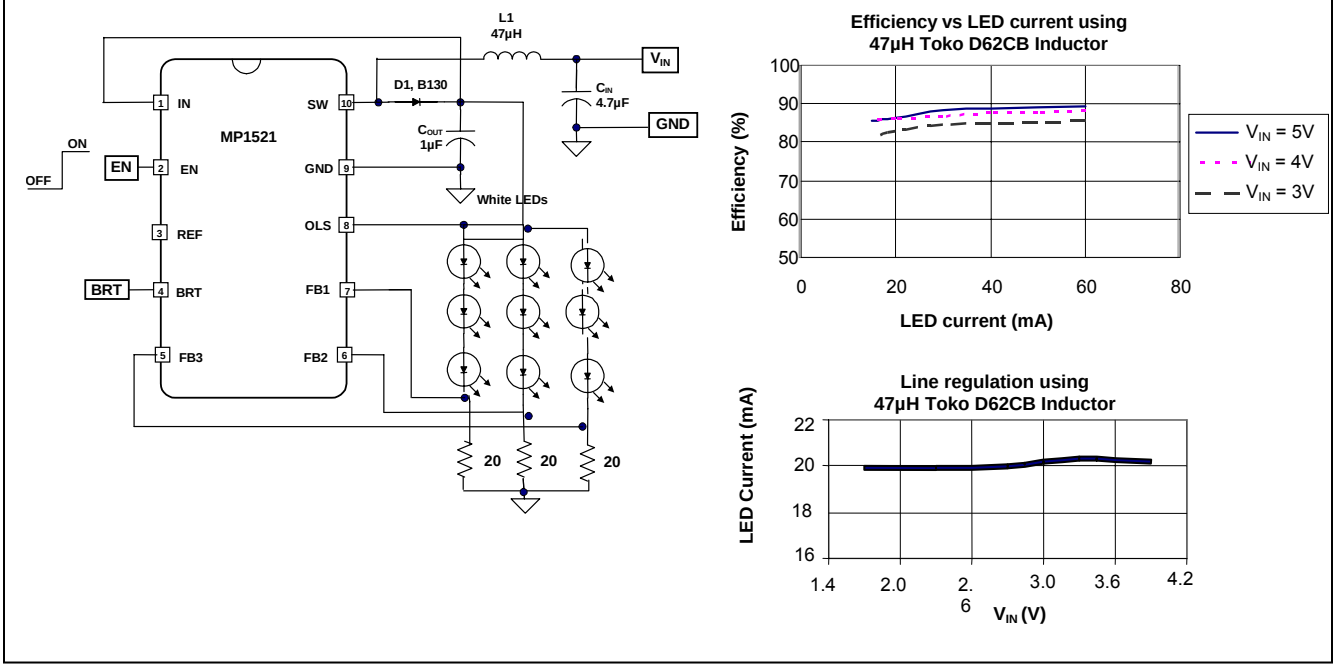



## Application Circuits Continued

### Figure 5: Two Strings of Four (4) LEDs or Eight (8) LEDs Total

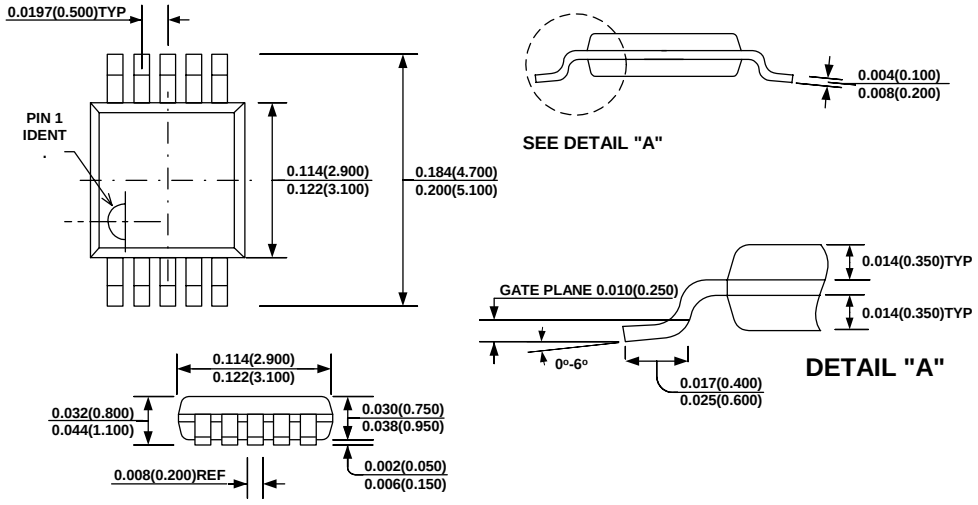



### Figure 6: Three Strings of Three (3) LEDs or Nine (9) LEDs Total



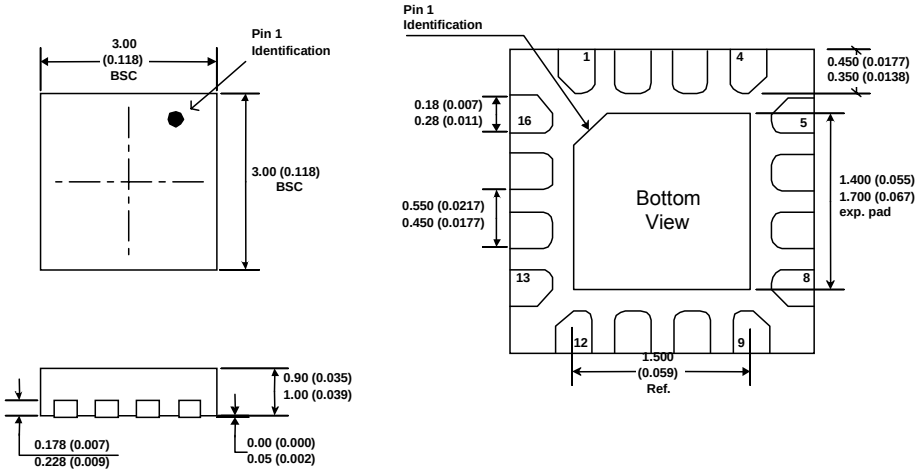
## Package Information

### MSOP10




NOTE:
1) Control dimension is in inches. Dimension in bracket is millimeters.

### QFN16 (3 x 3)




NOTE:
1) Control dimension is in millimeters. Dimension in bracket is inch.

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