

160mA Single channel LED Driver

Features

- Up to 160mA single channel constant current regulator
- Current set by an external resistor
- 1.6V ~ 16V wide supply voltage range supports self-power structure in lighting application
- Minimum 0.4V (80mA) dropout voltage
- Fast current rising and falling
- -40°C ~ 85°C operating temperature
- Less than ±3% Chip to Chip current skew
- Less than 1%/V load (or line) regulation
- Normal mode 160°C half power / 115°C recovery thermal protect
- Cascade-able for higher voltage drop applications

Product Description

NU510 is a medium power linear current regulation component that can be easily used in various LED lighting applications. It is equipped the excellent feature of good load/line regulation capability, minimized chip current skew, stable output current in high power or load voltage fluctuating environment that can be used in wide area of LED lighting source to maintain the uniformity of light intensity . NU510 also can be used in the digital PWM controlled circuit to achieve more precise current adjusting in gray level applications.

A special cascade mode is also provided by NU510. In high power supply voltage and low LED load dropout voltage application, two or more NU510 can be connected in series to share redundant high voltage. With the exclusive voltage sharing technology of NUMEN tech., the extra redundant voltage that exceeds the preset threshold voltage (Viboost) can be shared by next NU510.

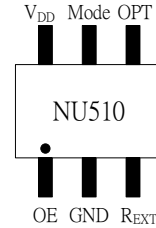
With the feature of wide power supply range design and ultra-low I_{DD} consumption, the NU510 supports the self-powered structure in LED lighting applications. In this structure, the NU510 no need to be provided a dedicate power circuit even the system power voltage is much higher than the maximum operation voltage of NU510. The V_{DD} power can be gotten from the proper position in LED series of system.

Applications

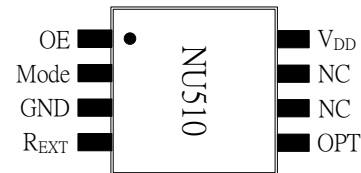
- General LED lighting
- Decoration lighting for architecture
- LED torch / flash light
- RGB lighting
- RGB display / indicator

Package Type

- SOT 23-6 (pin out compatible with NU501)
(Part No. : NU510ST)



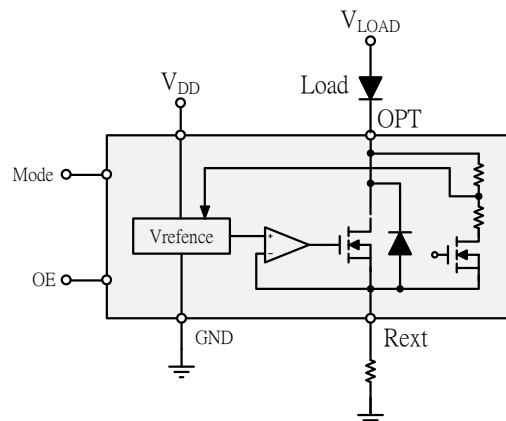
- MSOP 8 / SOP 8
(MSOP 8 Part No. : NU510MS)
(SOP 8 Part No. : NU510SO)



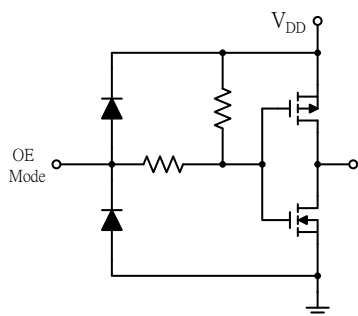
Terminal Description

| Pin name | Function |
|------------------|---------------------------------|
| V _{DD} | Power supply |
| OPT | Current sink |
| R _{EXT} | Current setting Resistor |
| OE | Output enable |
| Mode | Cascade / Normal mode selection |
| GND | Ground |

Block Diagram



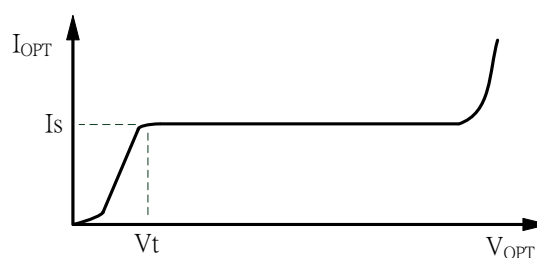
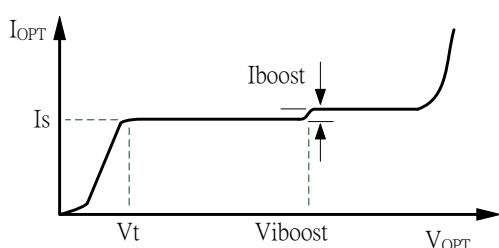
Equivalent Circuits for Inputs



Ideal IV characteristic

Mode pin = Logic high (default, cascade mode)

Mode pin = Logic low (normal mode)



| Mode | Mode Pin | Current boost | Leakage (Max.) |
|--------------|------------|----------------|----------------|
| Cascade mode | Logic high | +8%~+12%* IOPT | 5uA |
| Normal mode | Logic low | - | 0.5uA |

Maximum Ratings (T = 25°C)

| Characteristic | Symbol | Rating | Unit | |
|--------------------------------------|-------------------------------------|------------------------|------|-------|
| Supply voltage | V _{DD} | 0 ~ 20 | V | |
| Input voltage (Digital I/O) | V _{OE} , V _{MODE} | -0.2 ~ V _{DD} | V | |
| Output voltage | V _{OPT} | -0.2 ~ 20 | V | |
| Output current | I _{PN} | 0 ~ 200 | mA | |
| Power Dissipation (Ta=25°C) | P _D MAX | SOT 236 | 0.4 | W |
| | | MSOP 8 | 0.7 | |
| | | SOP 8 | 1 | |
| Thermal Resistance (On PCB, Ta=25°C) | R _{TH(j-a)} | SOT 236 | 400 | °C /W |
| | | MSOP 8 | 240 | |
| | | SOP 8 | 100 | |
| Operating temperature | T _{OPR} | -40~+85 | °C | |
| Storage temperature | T _{STG} | -55~+150 | °C | |

Electrical Characteristics and Recommended Operating Conditions

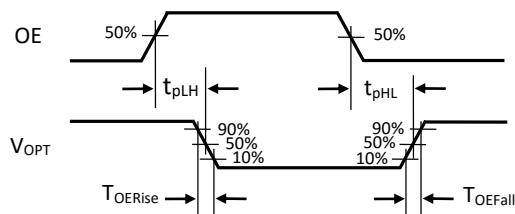
| Characteristic | Symbol | Condition | Min. | Typ. | Max. | Unit | |
|--|----------------------|---|------------------------|------|---------------------|----------------------|----|
| Supply voltage | V _{DD} | Room Temp. V _{OPT} = 1V | 1.5 | 1.6 | 16 | V | |
| Output voltage | V _{OPT} | PD ≤ PD _{RMP} | - | - | 17 | V | |
| Supply current | I _{DD} | V _{DD} ≤ 13V | 40 | 80 | 150 | uA | |
| | | V _{DD} ≤ 16V | - | - | 2 | mA | |
| Minimum dropout voltage | V _{OPT} | V _{DD} ≥ 3V | I _S ≤ 20mA | 0.25 | 0.3 | 0.4 | V |
| | | | I _S ≤ 60mA | 0.3 | 0.4 | 0.5 | |
| | | | I _S ≤ 100mA | 0.4 | 0.5 | 0.6 | |
| | | | I _S ≤ 160mA | 0.6 | 0.7 | 0.8 | |
| Output current | I _{OPT} | PD ≤ PD _{RMP} | - | - | 160 | mA | |
| Recommended Maximum Operating Power Dissipation | PD _{RMP} | (T _a = 25°C) | SOT 236 | - | - | 0.25 | W |
| | | | MSOP8 | - | - | 0.45 | |
| | | | SOP8 | - | - | 0.65 | |
| Leakage | I _{Leakage} | V _{DD} > 3V, V _{OPT} = 10V | Mode = high | 1 | - | 5 | uA |
| | | | Mode = low | - | - | 0.5 | |
| Line regulation | %/V _{DD} | 13V > V _{DD} > 1.6V | - | - | ±1 | %/V | |
| Load regulation | %/V _P | 8V > V _{OPT} > 0.4V, Mode = low | - | - | ±1 | %/V | |
| Thermal regulation | %/10°C | V _{DD} = V _P = 3V | - | - | ±0.5 | %/10°C | |
| Input voltage | V _{IH} | V _{DD} ≥ 5V | 3.2 | - | - | V | |
| | | V _{DD} < 5V | 0.7*V _{DD} | - | - | V | |
| | V _{IL} | V _{DD} ≥ 5V | - | - | 2 | V | |
| | | V _{DD} < 5V | - | - | 0.3*V _{DD} | V | |
| Half power temperature (Normal mode only) | T _{half} | $I_{OPT} \cong \frac{I_{NORMAL}}{2}$ | - | 160 | - | °C | |
| Half power recovery temperature (Normal mode only) | T _{recov} | I _{OPT} recover to I _{NORMAL} | - | 115 | - | | |
| Current boost voltage | V _{iboost} | Mode = high | 7 | 8 | 9 | V | |
| Current boost | I _{boost} | Mode = high | 8 | 10 | 12 | % * I _{OPT} | |
| Chip current skew | I _{skew} | V _{DD} = V _P = 3V | - | 2 | 3 | % | |

Switching Characteristics (T = 25°C)

| Characteristic | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---------------------|--|------|------|------|------|
| Propagation Delay Time (OE from "L" to "H") | t _{pLH} | V _{DD} =4V, V _{OPT} =1V, I _{OPT} =120mA, OE= 0V → 4V | 140 | 200 | 260 | nS |
| Output current rising time (OE from "L" to "H") | t _{OErise} | V _{DD} =4V, V _{OPT} =1V, I _{OPT} =120mA, OE= 0V → 4V | 30 | 40 | 60 | nS |
| Propagation Delay Time (OE from "H" to "L") | t _{pHL} | V _{DD} =4V, V _{OPT} =1V, I _{OPT} =120mA, OE= 4V → 0V | 260 | 320 | 380 | nS |

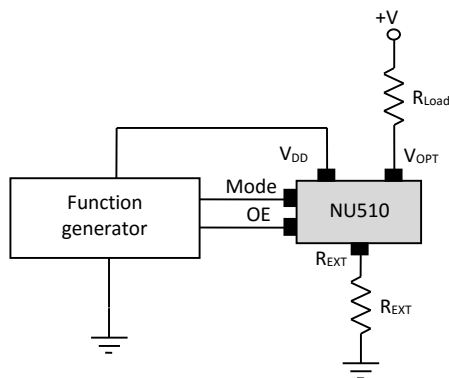
| Characteristic | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|--------------|---|------|------|------|------|
| Output current falling time (OE from "H" to "L") | t_{OEFall} | $V_{DD}=4V, V_{OPT}=1V,$ $I_{OPT}=120mA, OE=4V \rightarrow 0V$ | 30 | 50 | 80 | nS |

Timing Waveform



OE timing diagram

Test Circuit



Output Current Setting

The output current of NU510 is set by an external resistor (R_{EXT}). The output current can be figured out by following equation.

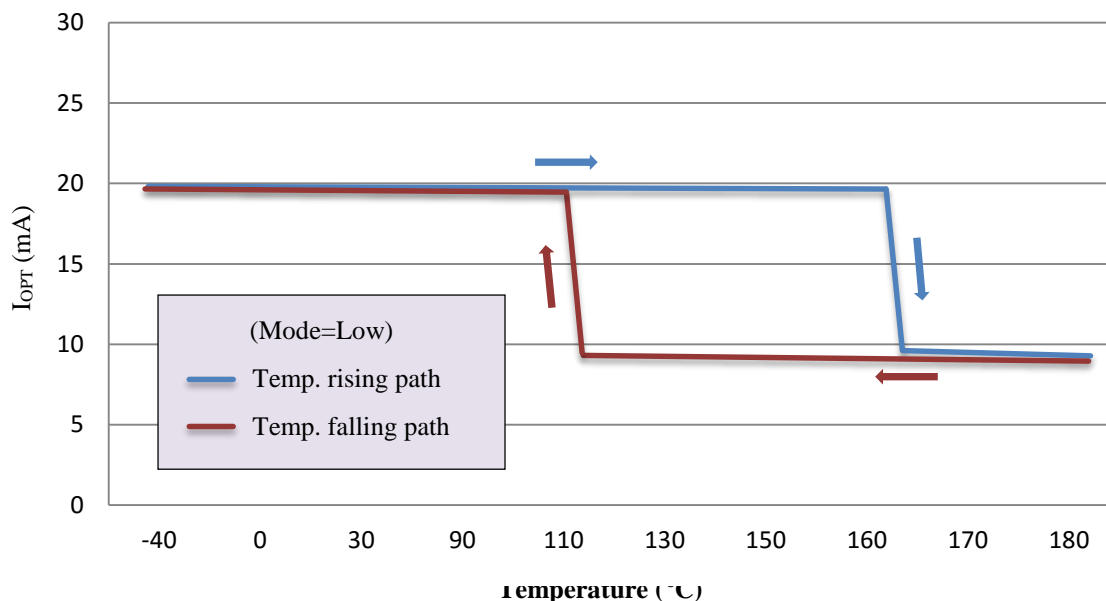
$$I_{out} \cong \frac{0.195V}{R_{EXT} + 0.07\Omega}$$

Thermal protection

When NU510 is working at normal mode (**mode pin voltage low**) and junction temperature is more than half power temperature (~160°C), the output current of NU510 will decrease about 50% to lower down the power dissipation on chip. This lower power state will be recovered when the junction temperature is lower than recovery temperature (~115°C).

Note: There is no half power thermal protection function while NU510 is working at cascade mode.

I_{OPT} vs. Temperature

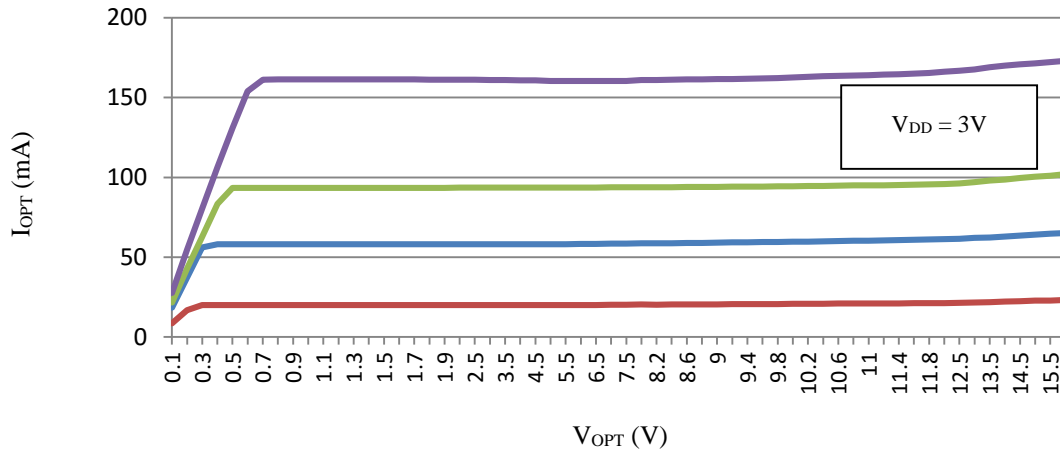


Power Dissipation and Recommended I_{OPT} - V_{OPT} Table

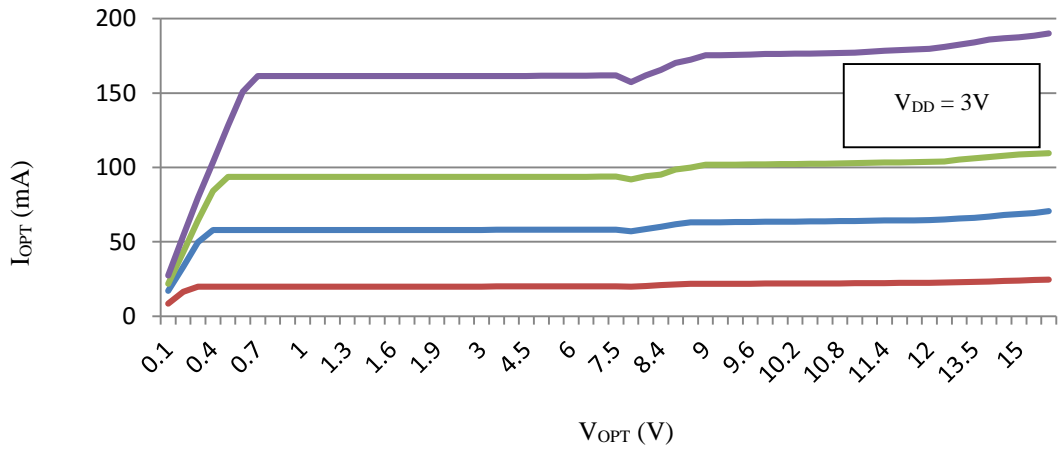
| Package I _{OPT} (mA) | SOT23-6 | | MSOP8 | | SOP8 | |
|----------------------------------|----------------------------------|------------------------------|----------------------------------|------------------------------|----------------------------------|------------------------------|
| | V _{OPT} (<) Recommended | V _{OPT} (<) Maximum | V _{OPT} (<) Recommended | V _{OPT} (<) Maximum | V _{OPT} (<) Recommended | V _{OPT} (<) Maximum |
| 20 | 12.5 | 20 | 17 | 20 | 17 | 20 |
| 40 | 6.3 | 10 | 11.2 | 17.5 | 16.2 | 20 |
| 60 | 4.2 | 6.6 | 7.5 | 11.6 | 10.8 | 16.6 |
| 80 | 3.1 | 5 | 5.6 | 8.7 | 8.1 | 12.5 |
| 100 | 2.5 | 4 | 4.5 | 7 | 6.5 | 10 |
| 120 | 2.1 | 3.3 | 3.7 | 5.8 | 5.4 | 8.3 |
| 140 | 1.8 | 2.8 | 3.2 | 5 | 4.6 | 7.1 |
| 160 | 1.5 | 2.5 | 2.8 | 4.3 | 4 | 6.2 |

Output I/V Curve

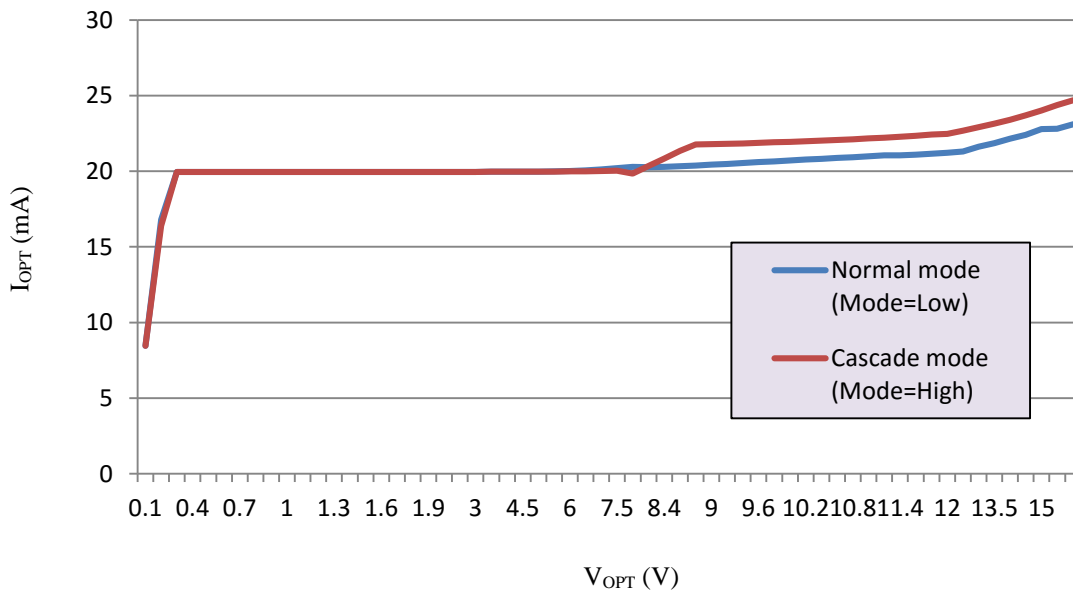
Normal mode output I/V curve



Cascade mode output I/V curve

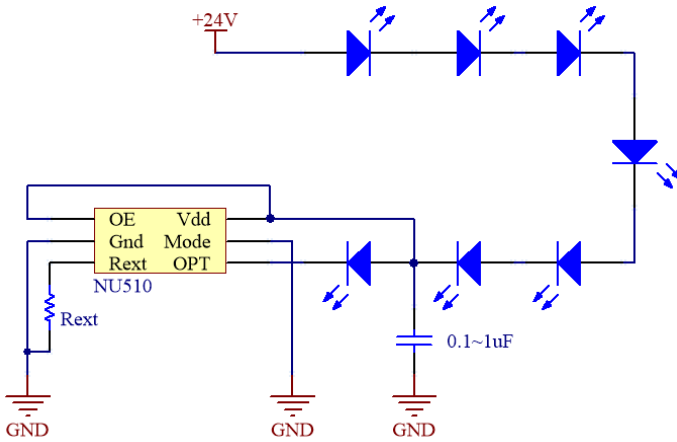


Output difference between cascade mode and normal mode

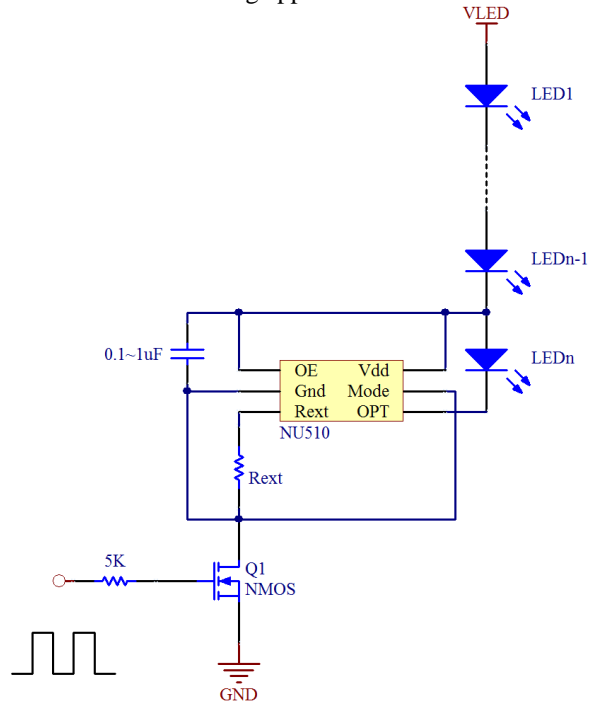


Typical Application Circuit

- 24v General lighting

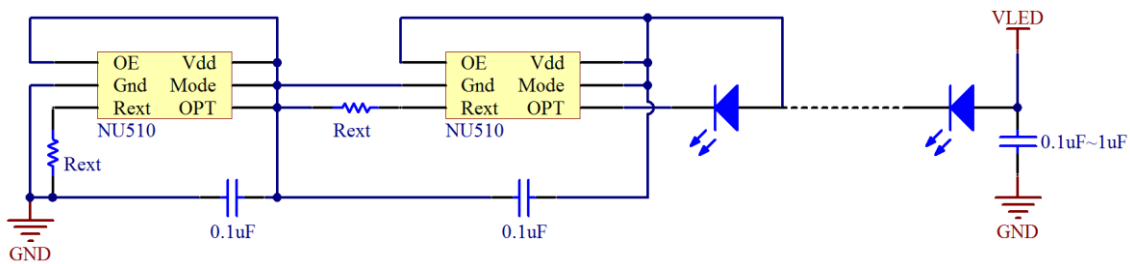


- PWM dimming application



Note: Generally, The capacitance of V_{DD} capacitor when self-power structure is used is about the same as LED typical current. For example, if the typical current of LED is 100mA, the capacitance is about 100nF. The capacitance can be adjusted according to the requirement of real applications.

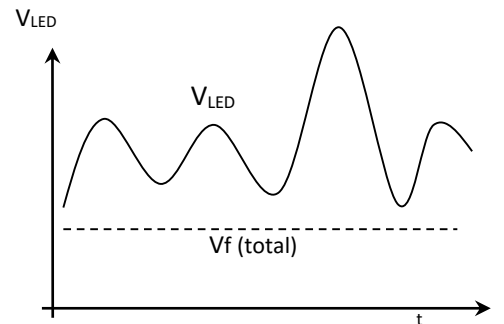
- Cascade application



By cascade mode, two or more NU510 in series can absorb higher voltage variation in lighting system. Each NU510 can share about 8 volts redundant. The total voltage variation range that system can work is calculated by following equation.

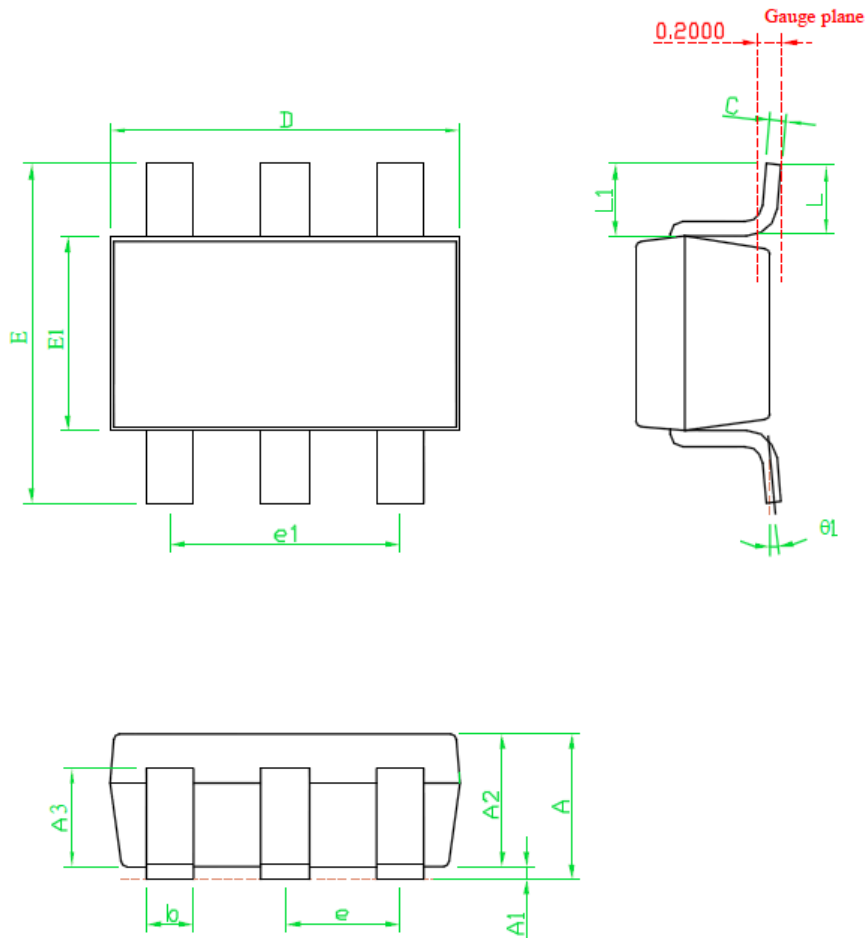
$$V_{LED(max)} \doteq 8 * N_{(NU510)} + V_{f(total)}$$

Where $V_{LED(max)}$ is the system power voltage, $N_{(NU510)}$ is the number of NU510 and $V_{f(total)}$ is the total forward voltage of all LEDs.



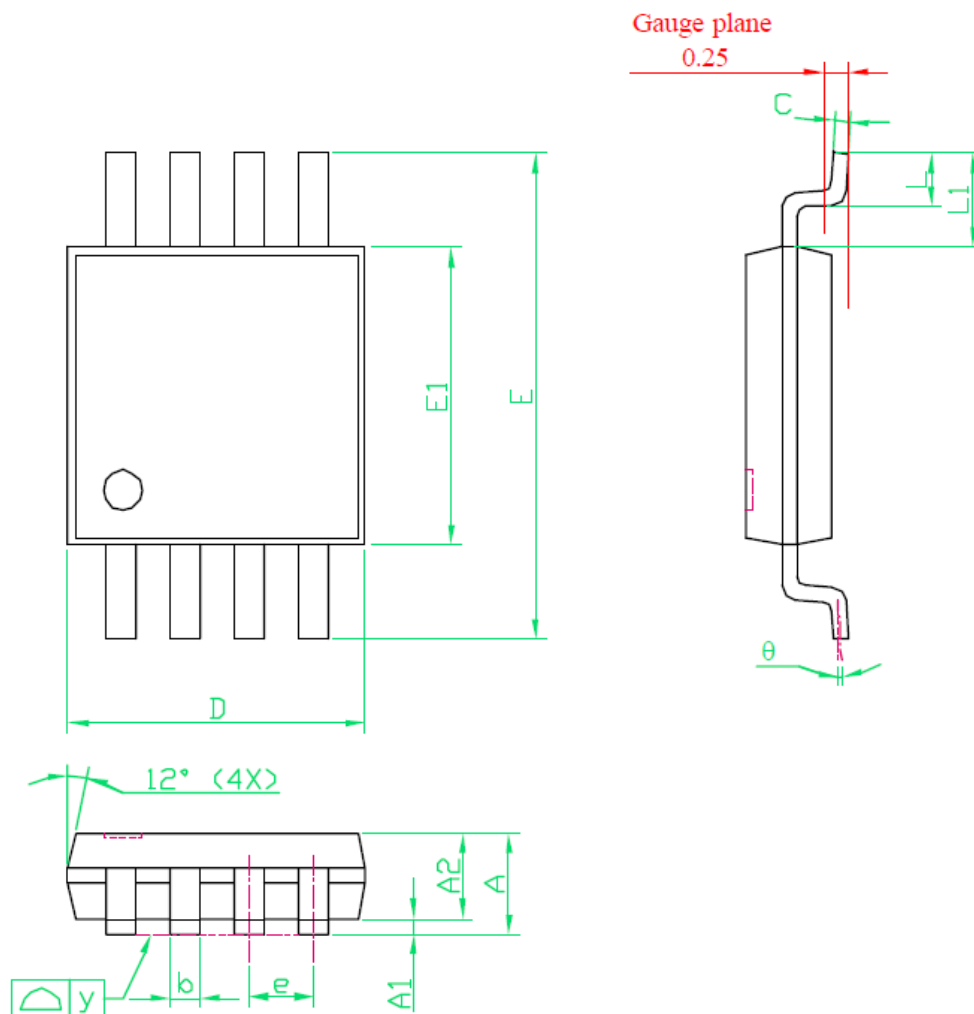
Package Dimensions

- SOT23-6



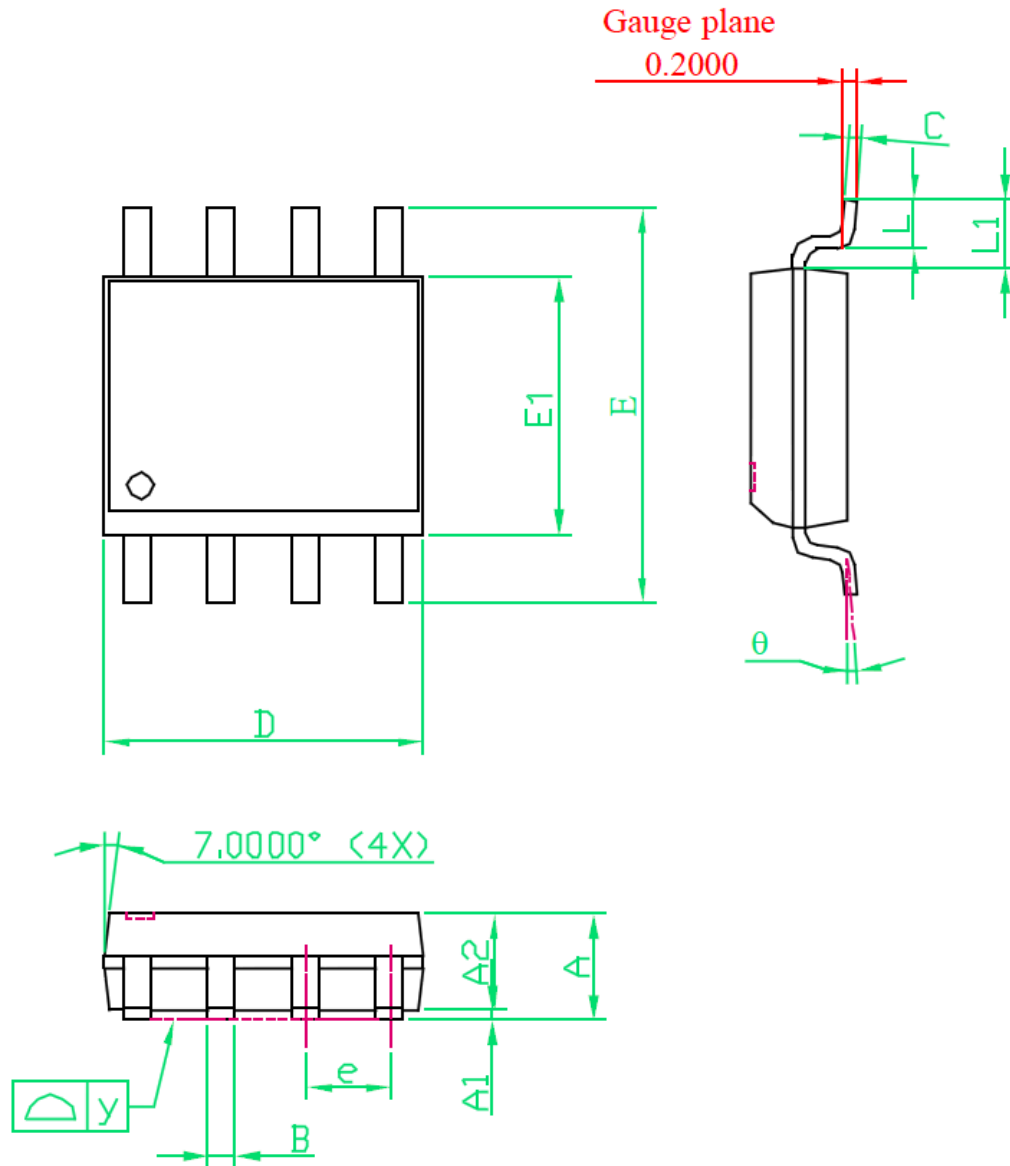
| SYMBOLS | DIMENSIONS IN MILLIMETERS | | |
|---------|---------------------------|-----------|------|
| | MIN | NOM | MAX |
| A | 1.00 | 1.10 | 1.40 |
| A1 | 0.00 | --- | 0.10 |
| A2 | 1.00 | 1.10 | 1.30 |
| A3 | 0.70 | 0.80 | 0.90 |
| b | 0.35 | 0.40 | 0.50 |
| C | 0.10 | 0.15 | 0.25 |
| D | 2.70 | 2.90 | 3.10 |
| E1 | 1.40 | 1.60 | 1.80 |
| e1 | --- | 1.90(TYP) | --- |
| E | 2.60 | 2.80 | 3.00 |
| L | 0.37 | --- | --- |
| θ1 | 1° | 5° | 9° |
| e | --- | 0.95(TYP) | --- |
| L1 | 0.5 | 0.6 | 0.7 |

- MSOP-8



| SYMBOLS | DIMENSIONS IN MILLIMETER | | |
|----------|--------------------------|---------|------|
| | MIN | NOM | MAX |
| A | --- | --- | 1.10 |
| A1 | 0.00 | --- | 0.10 |
| A2 | 0.75 | 0.85 | 0.95 |
| b | 0.22 | 0.30 | 0.38 |
| C | 0.13 | 0.15 | 0.23 |
| D | --- | 3.00BSC | --- |
| E | --- | 4.90BSC | --- |
| E1 | --- | 3.00BSC | --- |
| e | --- | 0.65BSC | --- |
| L | 0.40 | 0.53 | 0.66 |
| y | --- | --- | 0.10 |
| θ | 0° | --- | 6° |
| L1 | 0.85 | 0.95 | 1.05 |

- SOP-8



| SYMBOLS | DIMENSIONS IN MILLIMETER | | | DIMENSIONS IN INCH | | |
|----------|--------------------------|------|------|--------------------|-------|-------|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 1.35 | 1.60 | 1.75 | 0.053 | 0.063 | 0.069 |
| A1 | 0.10 | --- | 0.25 | 0.004 | --- | 0.010 |
| A2 | --- | 1.45 | --- | --- | 0.057 | --- |
| B | 0.33 | --- | 0.51 | 0.013 | --- | 0.020 |
| C | 0.19 | --- | 0.25 | 0.007 | --- | 0.010 |
| D | 4.80 | --- | 5.00 | 0.189 | --- | 0.197 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.153 | 0.157 |
| e | --- | 1.27 | --- | --- | 0.050 | --- |
| E | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| L | 0.40 | --- | 1.27 | 0.016 | --- | 0.050 |
| y | --- | --- | 0.10 | --- | --- | 0.004 |
| θ | 0° | --- | 8° | 0° | --- | 8° |
| L1 | 0.95 | 1.05 | 1.15 | 0.037 | 0.041 | 0.045 |

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