



## Medium Power Lighting LED Driver

# NU510

### 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.

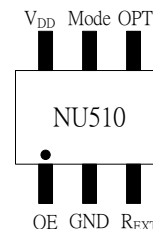
With the feature of wide power supply range design and ultra-low  $I_{DD}$  consumption, the NU510 supports the self-powered structure in LED lighting applications. In this structure, the NU510 no need to be provided a dedicate power circuit even the system power voltage is much higher than the maximum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



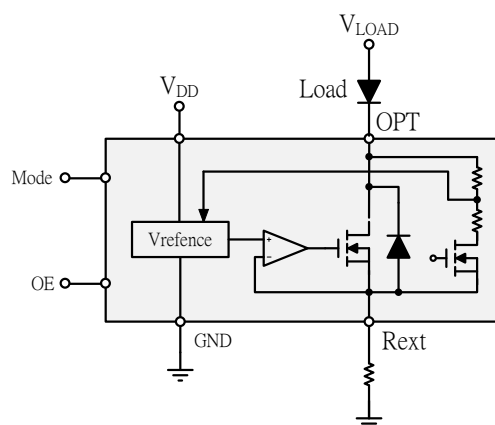
- MSOP 8 / SOP 8  
(MSOP 8 Part No. : NU510MS)  
(SOP 8 Part No. : NU510SO)



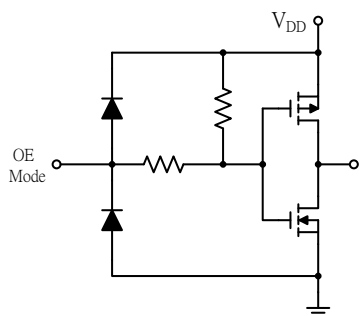
#### Terminal Description

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
Thermal pad	Ground potential

#### Block Diagram



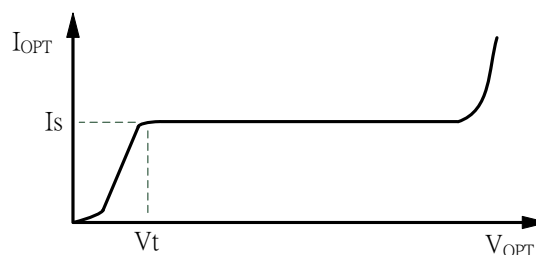
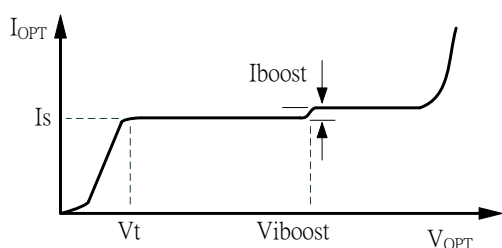
**Equivalent Circuits for Inputs**



**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 <sub>DD</sub>	0 ~ 20	V	
Input voltage (Digital I/O)	V <sub>OE</sub> , V <sub>MODE</sub>	-0.2 ~ V <sub>DD</sub>	V	
Output voltage	V <sub>OPT</sub>	-0.2 ~ 20	V	
Output current	I <sub>PN</sub>	0 ~ 200	mA	
Power Dissipation (Ta=25°C)	P <sub>DMAX</sub>	SOT 236	0.4	W
		MSOP 8	0.7	
		SOP 8	1	
Thermal Resistance (On PCB, Ta=25°C)	R <sub>TH(j-a)</sub>	SOT 236	400	°C /W
		MSOP 8	240	
		SOP 8	100	
Operating temperature	T <sub>OPR</sub>	-40~+85	°C	
Storage temperature	T <sub>STG</sub>	-55~+150	°C	

## Electrical Characteristics and Recommended Operating Conditions

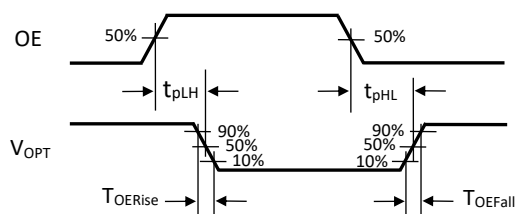
Characteristic	Symbol	Condition	Min.	Typ.	Max.	Unit	
Supply voltage	V <sub>DD</sub>	Room Temp. V <sub>OPT</sub> = 1V	1.5	1.6	16	V	
Supply voltage rising and falling speed *1	V <sub>DDspd</sub>	V <sub>DD</sub> ≤ 5V	0.05	-	-	μs	
		V <sub>DD</sub> > 5V	5	-	-		
Output voltage	V <sub>OPT</sub>	PD ≤ PD <sub>RMP</sub>	-	-	17	V	
Supply current	I <sub>DD</sub>	V <sub>DD</sub> ≤ 13V	40	80	150	μA	
		V <sub>DD</sub> ≤ 16V	-	-	2	mA	
Minimum dropout voltage	V <sub>OPT</sub>	V <sub>DD</sub> ≥ 3V	I <sub>S</sub> ≤ 20mA	0.25	0.3	0.4	V
			I <sub>S</sub> ≤ 60mA	0.3	0.4	0.5	
			I <sub>S</sub> ≤ 100mA	0.4	0.5	0.6	
			I <sub>S</sub> ≤ 160mA	0.6	0.7	0.8	
Output current	I <sub>OPT</sub>	PD ≤ PD <sub>RMP</sub>	-	-	160	mA	
Recommended Maximum Operating Power Dissipation	PD <sub>RMP</sub>	(Ta=25°C)	SOT 236	-	-	0.25	W
			MSOP8	-	-	0.45	
			SOP8	-	-	0.65	
Leakage	I <sub>Leakage</sub>	V <sub>DD</sub> > 3V, V <sub>OPT</sub> = 10V	Mode = high	1	-	5	μA
			Mode = low	-	-	0.5	
Line regulation	%/V <sub>DD</sub>	13V > V <sub>DD</sub> > 1.6V	-	-	±1	%/V	
Load regulation	%/V <sub>P</sub>	8V > V <sub>OPT</sub> > 0.4V, Mode = low	-	-	±1	%/V	
Thermal regulation	%/10°C	V <sub>DD</sub> = V <sub>P</sub> = 3V	-	-	±0.5	%/10°C	
Input voltage	V <sub>IH</sub>	V <sub>DD</sub> ≥ 5V	3.2	-	-	V	
		V <sub>DD</sub> < 5V	0.7*V <sub>DD</sub>	-	-	V	
	V <sub>IL</sub>	V <sub>DD</sub> ≥ 5V	-	-	2	V	
		V <sub>DD</sub> < 5V	-	-	0.3*V <sub>DD</sub>	V	
Half power temperature (Normal mode only)	T <sub>half</sub>	$I_{OPT} \cong \frac{I_{NORMAL}}{2}$	-	160	-	°C	
Half power recovery temperature (Normal mode only)	T <sub>recov</sub>	I <sub>OPT</sub> recover to I <sub>NORMAL</sub>	-	115	-		
Current boost voltage	V <sub>iboot</sub>	Mode = high	7	8	9	V	
Current boost	I <sub>boost</sub>	Mode = high	8	10	12	% * I <sub>OPT</sub>	
Chip current skew	I <sub>skew</sub>	V <sub>DD</sub> = V <sub>P</sub> = 3V	-	2	3	%	

\*1 For the stable reason, the rising and falling speed of supply voltage (V<sub>DD</sub>) on NU510 should be slower when higher V<sub>DD</sub> than 5V is adopted for V<sub>DD</sub> dimming application. Fast and high V<sub>DD</sub> transition will bring the timing of output current instable. Please refer to typical application circuit in this specification for proper using.

**Switching Characteristics (T = 25°C)**

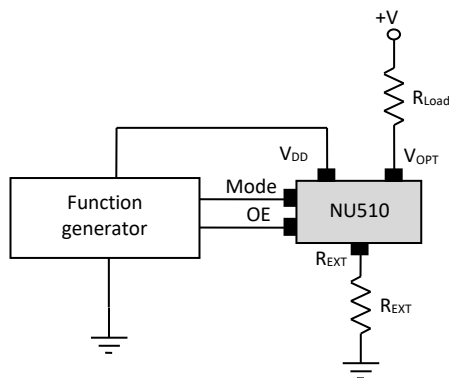
Characteristic	Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time (OE from "L" to "H")	$t_{pLH}$	$V_{DD}=4V, V_{OPT}=1V,$ $I_{OPT}=120mA, OE= 0V \rightarrow 4V$	140	200	260	nS
Output current rising time (OE from "L" to "H")	$t_{OERise}$	$V_{DD}=4V, V_{OPT}=1V,$ $I_{OPT}=120mA, OE= 0V \rightarrow 4V$	30	40	60	nS
Propagation Delay Time (OE from "H" to "L")	$t_{pHL}$	$V_{DD}=4V, V_{OPT}=1V,$ $I_{OPT}=120mA, OE= 4V \rightarrow 0V$	260	320	380	nS
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.

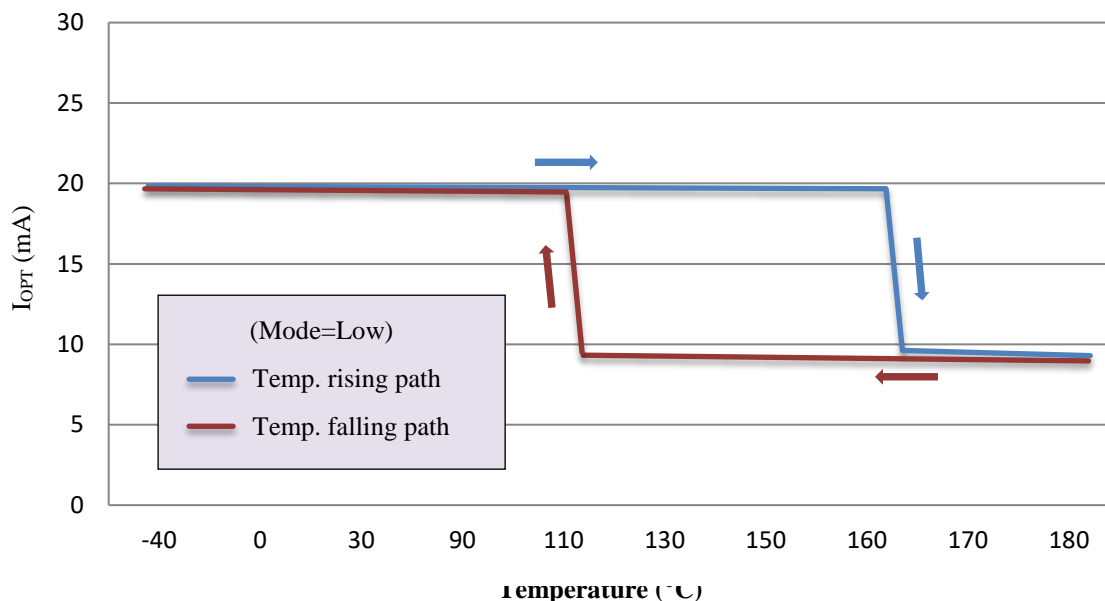
$$I_{out} \cong \frac{0.195V}{R_{EXT} + 0.07\Omega}$$

### 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<sub>OPT</sub> vs. Temperature

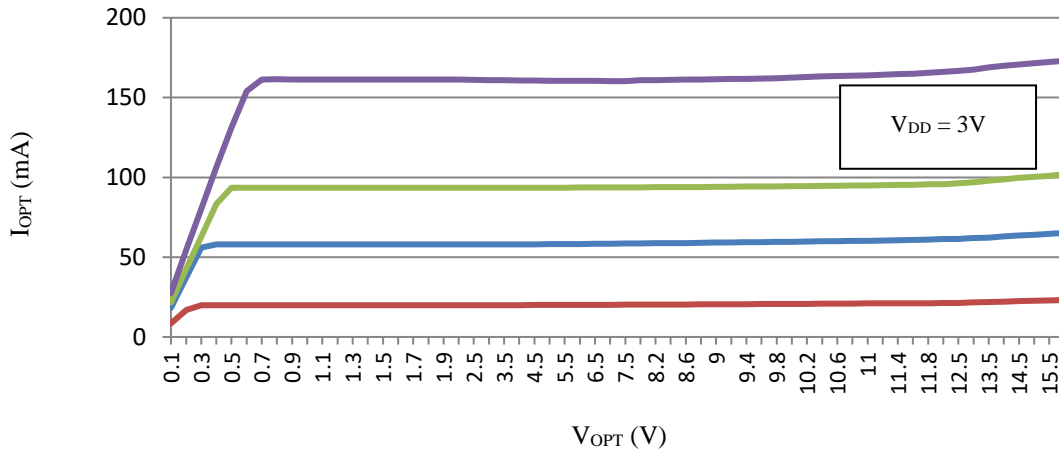


### Power Dissipation and Recommended I<sub>OPT</sub> - V<sub>OPT</sub> Table

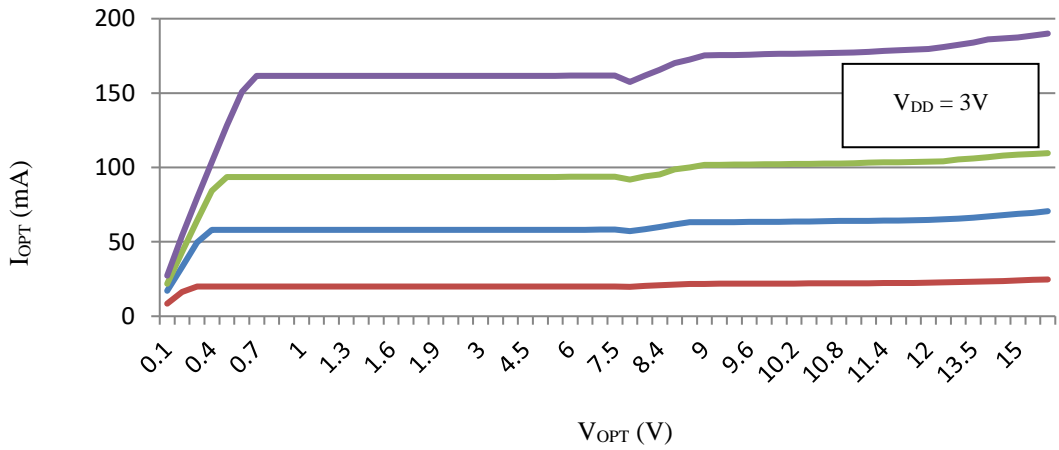
Package I <sub>OPT</sub> (mA)	SOT23-6		MSOP8		SOP8	
	V <sub>OPT</sub> (<) Recommended	V <sub>OPT</sub> (<) Maximum	V <sub>OPT</sub> (<) Recommended	V <sub>OPT</sub> (<) Maximum	V <sub>OPT</sub> (<) Recommended	V <sub>OPT</sub> (<) Maximum
20	12.5	20	17	20	17	20
40	6.3	10	11.2	17.5	16.2	20
60	4.2	6.6	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

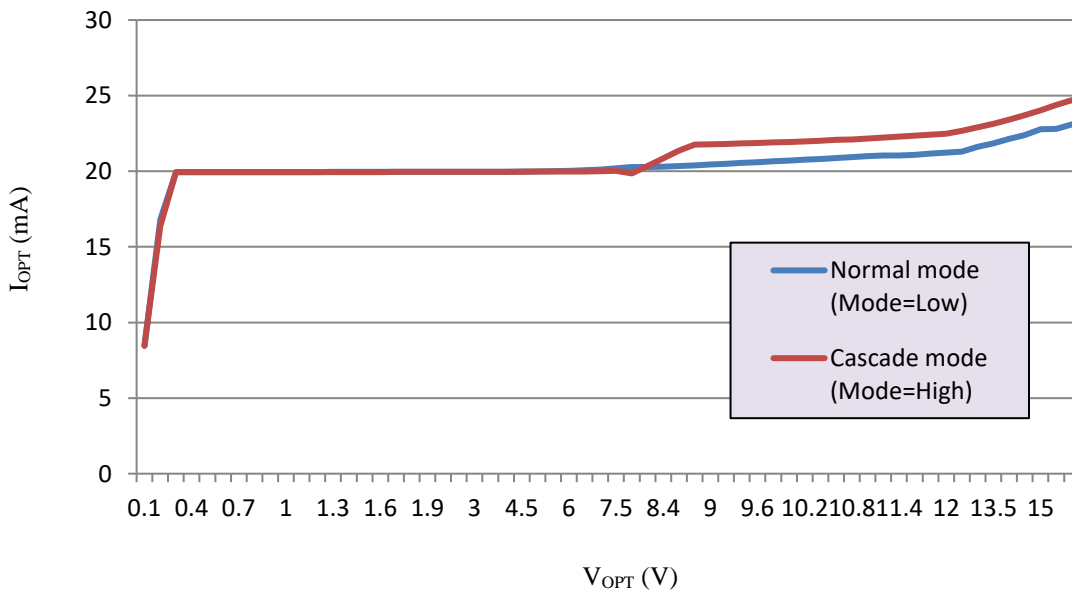
Normal mode output I/V curve



Cascade mode output I/V curve

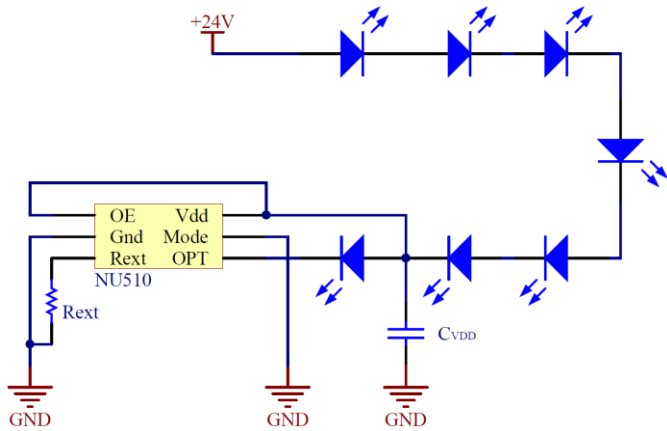


Output difference between cascade mode and normal mode

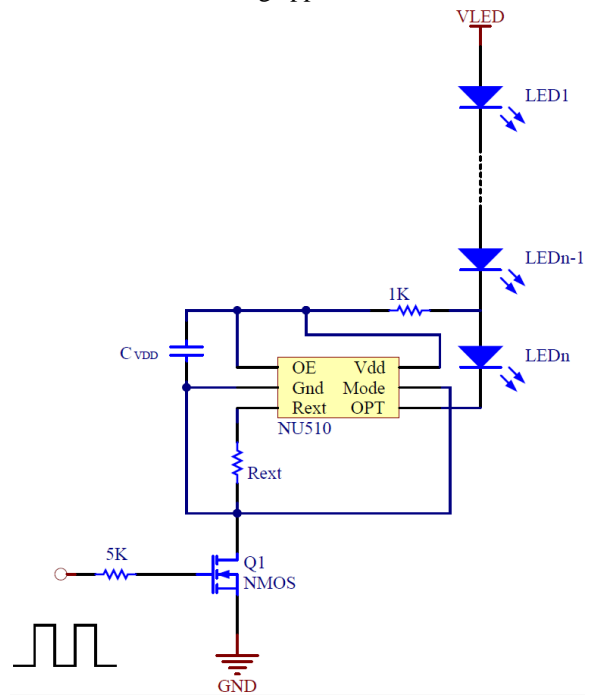


Typical Application Circuit

- 24v General lighting

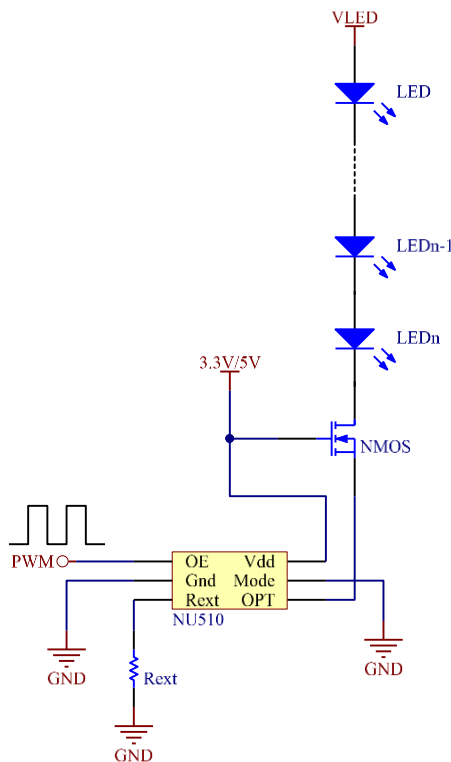


- PWM dimming application

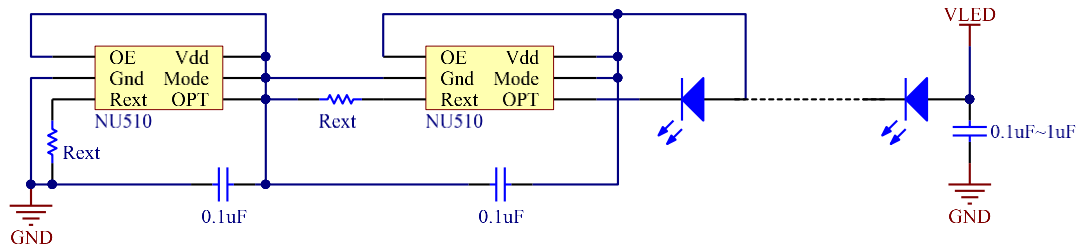


**Note:** Generally, The capacitance of  $C_{VDD}$  capacitor when self-power structure is used can be related with LED typical current. For example, if the typical current of LED is 160mA, the capacitance is about 160nF. The capacitance can be adjusted according to the requirement of real applications.

- High VLED voltage PWM dimming application



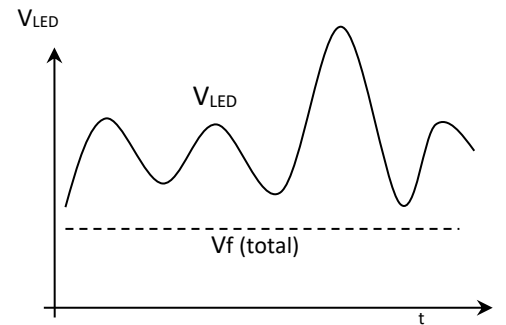
● Cascade application



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.

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

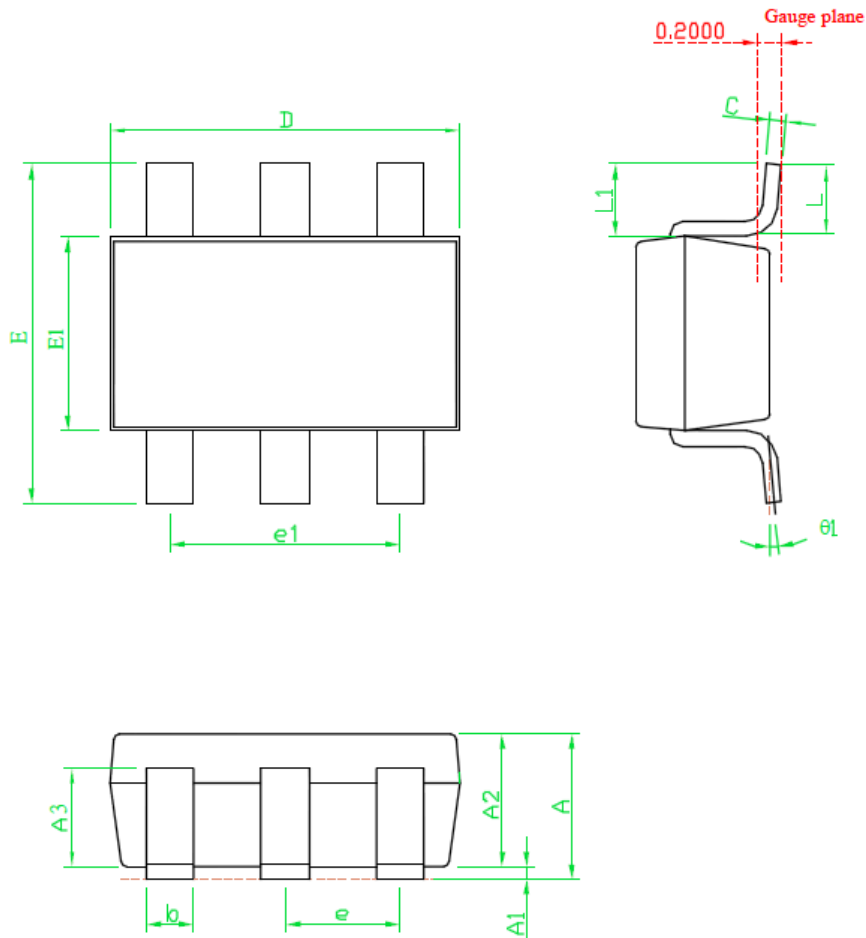
Where  $V_{LED(max)}$  is the system power voltage,  $N_{(NU510)}$  is the number of NU510 and  $V_{f(total)}$  is the total forward voltage of all LEDs.





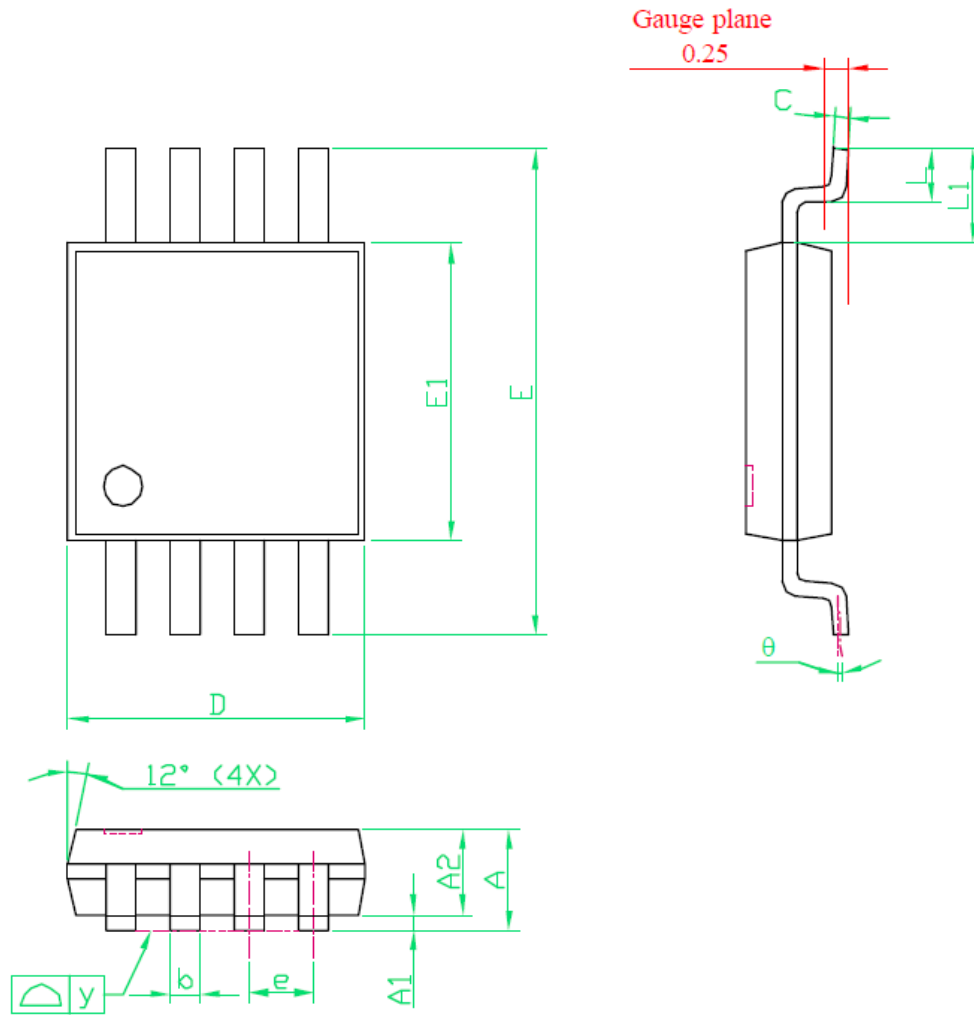
Package Dimensions

- SOT23-6



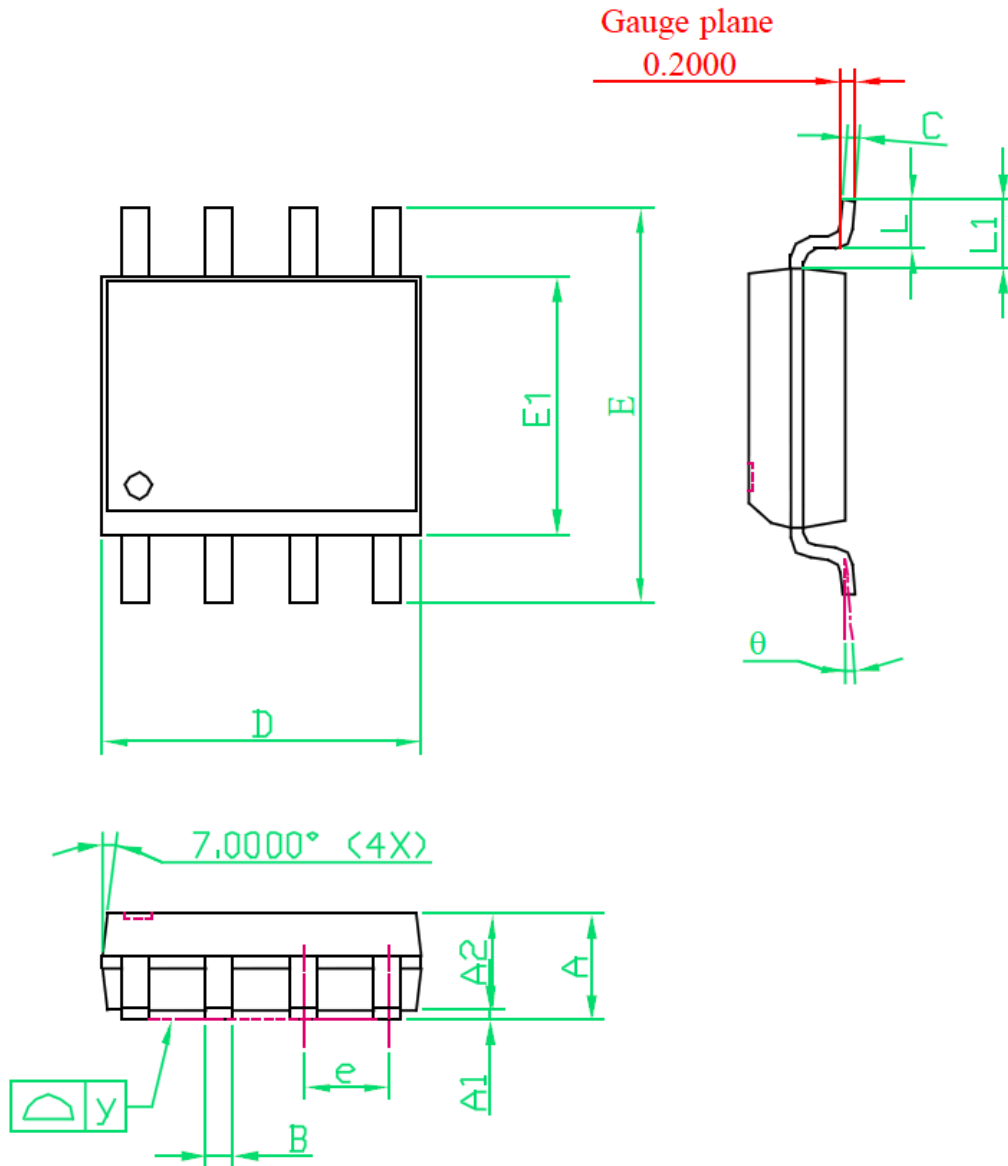
SYMBOLS	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	1.00	1.10	1.40
A1	0.00	---	0.10
A2	1.00	1.10	1.30
A3	0.70	0.80	0.90
b	0.35	0.40	0.50
C	0.10	0.15	0.25
D	2.70	2.90	3.10
E1	1.40	1.60	1.80
e1	---	1.90(TYP)	---
E	2.60	2.80	3.00
L	0.37	---	---
$\theta 1$	1°	5°	9°
e	---	0.95(TYP)	---
L1	0.5	0.6	0.7

- 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
$\theta$	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
$\theta$	0°	---	8°	0°	---	8°
L1	0.95	1.05	1.15	0.037	0.041	0.045

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