4 Channel High Current Balance LED Driver

General Description

The uP6034 consists of a high efficiency boost converter and four current balance controllers. It supports 4-channel LED string designed for LED backlight unit. The current matching function provides LED backlight unit with better brightness uniformity. The uP6034 can optimize LED output voltage for getting better boost converter efficiency.

The uP6034 has a wide input supply voltage from 4.5V to 33V, adjustable LED current from 20mA to 160mA for each strings, adjustable switching frequency from 100kHz to 1MHz by external resistor and supports external PWM dimming from 100Hz to 20kHz.

The uP6034 includes over voltage protection, cycle by cycle current limit and over temperature protection. It supports LED open string, LED short and light bar short protection. Output shorted circuit to ground and open Schottky diode detection to prevent Power MOS damage.

Features

- **4.5V to 33V Input Voltage Range**
- **Support to 4-channel LED String**
- **100kHz to 1MHz Adjustable Switching Frequency**
- **100Hz to 20kHz PWM Dimming**
- **20 to 160mA Adjustable LED Channel Current**
- **Status Output**
- **Output Short Circuit and Open Schottky Diode Protection**
- **LED Short Protection**
- **LED Open String Protection**
- **Adjustable Over Voltage Protection**
- **Over Temperature Protection**
- **Over Current Protection**

Applications

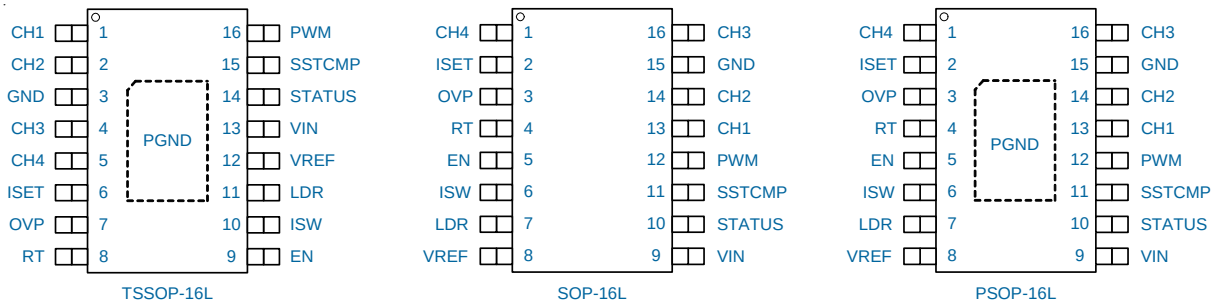
- **Monitor LED Backlight**
- **TV LED Backlight**

Ordering Information

Order Number	Package	Top Marking	Remark
uP6034PTUD	TSSOP-16L	uP6034P	With Exposed PAD
uP6034PSAD	SOP-16L	uP6034P	--
uP6034PSUD	PSOP-16L	uP6034P	With Exposed PAD

Note:
(1) Please check the sample/production availability with uPI representatives.
(2) uPI products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

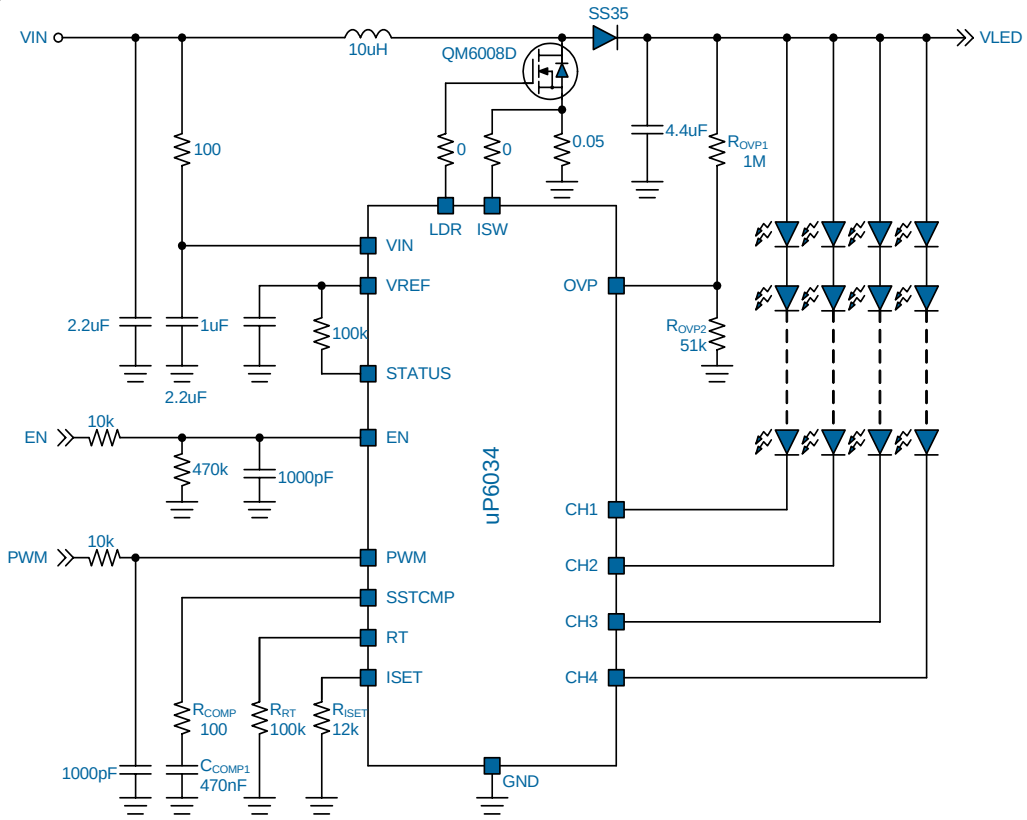
Pin Configuration



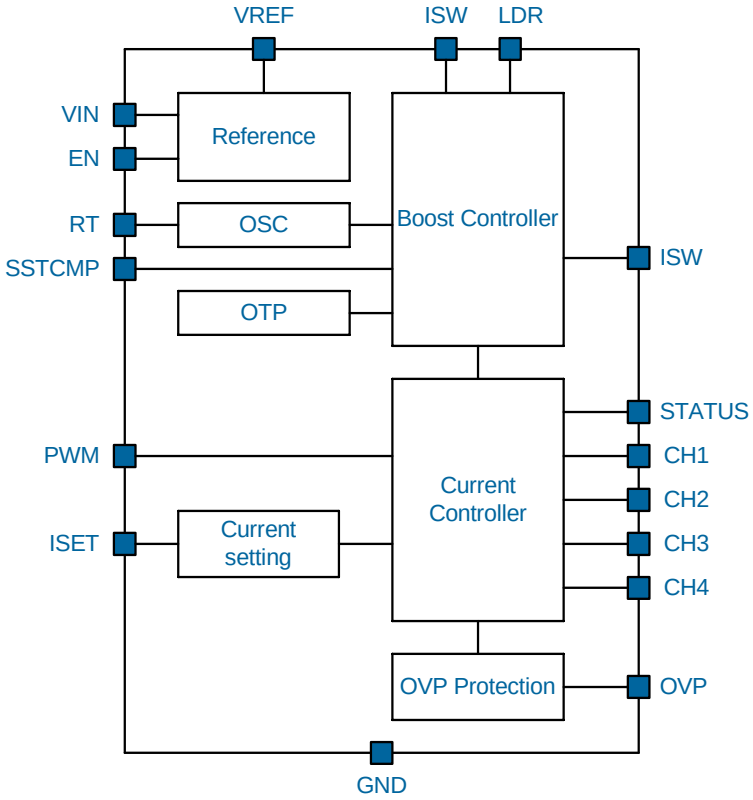
Functional Pin Description

Pin No. PTUD	Pin No. PSAD	Pin No. PSUD	Pin Name	Pin Function
1	13	13	CH1	**LED Current Sense Input.** Leave the pin unconnected if not being used.
2	14	14	CH2	**LED Current Sense Input.** Leave the pin unconnected if not being used.
3	15	15	GND	**IC Ground.**
4	16	16	CH3	**LED Current Sense Input.** Leave the pin unconnected if not being used.
5	1	1	CH4	**LED Current Sense Input.** Leave the pin unconnected if not being used.
6	2	2	ISET	**LED Current Set Pin.** Connect a resistor to GND to set the LED strings current.
7	3	3	OVP	**Over Voltage Protection Sense Pin.**
8	4	4	RT	**Switching Frequency Set Pin.** This pin sets the switching frequency with a resistor ranging from 100kHz to 1MHz.
9	5	5	EN	**Enable Pin.** Active high. When low, the device is turned off.
10	6	6	ISW	**Power MOSFET Current Sense Pin.**
11	7	7	LDR	**Power MOSFET Gate Driver.**
12	8	8	VREF	**5V Output For External Circuits.**
13	9	9	VIN	**Input Supply Voltage Pin.**
14	10	10	STATUS	**LED Converter Operation Status Output.**
15	11	11	SSTCMP	**Soft Start And Control Loop Compensation.**
16	12	12	PWM	**PWM Dimming Control Input.**

Typical Application Circuit



Functional Block Diagram



Functional Description

The uP6034 is a 4-Channel LED current matching controller for LED TV backlight unit. It supports wide range input voltage from 4.5V to 33V. The LED current can adjust from 20mA to 160mA by external resistor. The switching frequency can adjust from 100kHz to 1MHz. It supports external PWM dimming frequency from 100Hz to 20kHz. The uP6034 has built-in over current protection, over voltage protection, over temperature protection, LED short protection, LED open string protection, output short circuits protection and Schottky Diode open protection.

Setting Switching Frequency

The uP6034 switching frequency is adjustable. The switching frequency can be adjusted by RT pin resistor R_{RT} to GND.

$$f_{OSC}(MHz) = \frac{50}{R_{RT}(k\Omega)}$$

Adjustable LED Current:

The LED current can be set by the following equation:

$$I_{LED}(mA) = \frac{1200}{R_{ISET}(k\Omega)}$$

R_{ISET} is the resistor between ISET pin and GND.

External PWM Dimming:

The uP6034 supports PWM dimming function. The uP6034 brightness control is determined by the signal on the PWM pin with a suggested PWM frequency range from 100Hz to 20kHz.

LED Short Protection:

If any string of CH1~CH4 voltage exceeds a threshold of approximately 8.5V during the normal operation, the corresponding string will be turned off and latched.

LED Open Protection:

If any string is open, the output voltage will boost up until the OVP pin voltage is approximately 2V threshold. The IC will ignore the open string and other strings will be in normal operation. If all strings are open and the OVP pin voltage reaches 2V threshold, the LDR will turn off and IC will shut down and latch.

Adjustable Over Voltage Protection:

The uP6034 has adjustable over voltage protection. The boost converter with an integrated over voltage protection prevents the components from exceeding the absolute maximum voltage rating. When the OVP reaches the threshold voltage, the boost converter turns the Power MOS switch off. The internal switch will be turned on again once the voltage at OVP pin drops below its threshold voltage. The over voltage protection set voltage is divided by R_{OVP1} and R_{OVP2} resistors.

$$OVP_{SET} = OVP_{TH} \times (1 + \frac{R_{OVP1}}{R_{OVP2}})$$

Over Current Protection:

The boost converter has over current protection to limit peak inductor current. It prevents large current damaging the inductor and diode. During the ON-time, when ISW pin reaches 0.54V, the LDR will turn off immediately. Actual current limit is always larger than the nominal value because of the internal circuit delay. Current limit is also affected by the input voltage, duty cycle, and inductor value.

Output Short Circuit/Schottky Diode Open Protection:

When OVP pin voltage is less than 0.1V threshold, LDR will turn off. It prevents the components from damage when output shorted to ground or Schottky diode open conditions.

Shut down Under Abnormal Condition:

When OVP pin voltage is greater than 3V, the IC will shut down and latch unless switching the EN to reset IC.

Status Ouput:

The STATUS will output a logic low if any of the below conditions exists:

1) Over voltage protection
2) LED short protection
3) Any string is open
4) Over temperature protection

Over Temperature Protection:

When the junction temperature exceeds 140°C, all the blocks will be turned off. Once the temperature cools down to approximately 110°C, IC will resumes normal operation.

Absolute Maximum Rating

(Note 1)

Supply Input Voltage to GND ---------- -0.3V to +40V
EN, PWM, OVP, STATUS, VREF to GND ---------- -0.3V to +7V
ISET, RT, SSTCMP, LDR to GND ---------- -0.3V to (VREF+0.3)V
CH1~CH4 to GND (No Switching) ---------- -0.3V to 60V
ISW to GND ---------- -0.3V to 50V
CH1~CH4 Current ---------- 200mA
Storage Temperature Range ---------- -65°C to +150°C
Junction Temperature ---------- 150°C
Lead Temperature (Soldering, 10 sec) ---------- 260°C
ESD Rating (Note 2)
- HBM (Human Body Mode) ---------- 2kV
- MM (Machine Mode) ---------- 200V

Thermal Information

Package Thermal Resistance (Note 3)
- TSSOP -16L (with Exposed PAD) θ_{JA} ---------- 38°C/W
- TSSOP -16L (with Exposed PAD) θ_{JC} ---------- 10°C/W
- SOP -16L θ_{JA} ---------- 110°C/W
- SOP -16L θ_{JC} ---------- 30°C/W
- PSOP -16L θ_{JA} ---------- 45°C/W
- PSOP -16L θ_{JC} ---------- 3°C/W

Power Dissipation, P_D @ T_A = 25°C
- TSSOP -16L (with Exposed PAD) ---------- 2.63W
- SOP -16L ---------- 0.91/W
- PSOP -16L ---------- 2.22/W

Recommended Operation Conditions

(Note 4)

Input Voltage ---------- 4.5V to +33V
EN, PWM, OVP, STATUS, VREF to GND ---------- 0V to +5.5V
ISET, RT, SSTCMP, LDR to GND ---------- 0V to VREF
CH1~CH4 LED Current ---------- 20mA to 160mA
PWM Frequency ---------- 100Hz to 20kHz
Switching Frequency ---------- 100kHz to 1MHz
Operating Junction Temperature Range ---------- -40°C to +125°C
Operating Ambient Temperature Range ---------- -40°C to +85°C

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

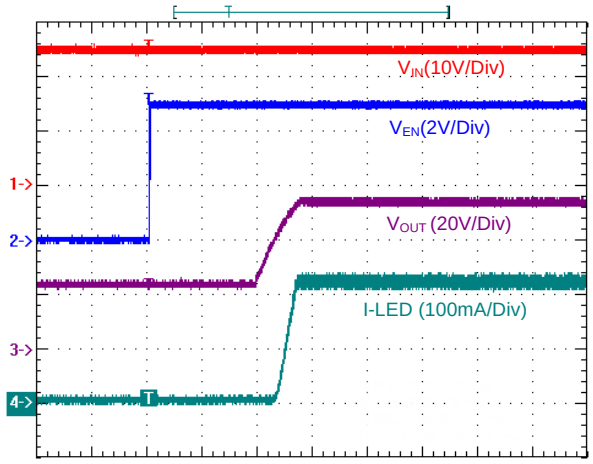
Electrical Characteristics

(V_{IN} = 24V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
VIN Operation Current	I_{OP}	EN = 5V, PWM = 5V	--	--	10	mA
VIN Shutdown Current	I_{SHDN}	EN = 0V, PWM = 0V	--	--	5	uA
VIN Standby Current	I_{STB}	EN = 5V, PWM = 0V	--	--	220	uA
Under Voltage Lockout Logic	V_{LCK}	$VREF_{LOCKOUT}$	--	3.6	--	V
Under Voltage Lockout Resume	V_{RSM}	$VREF_{RESEUME}$	--	4	--	V
VREF Reference Voltage	V_{REF}		4.85	5	5.15	V
VREF Output Current Capability	VV_{REF}		--	--	30	mA
Logic High Input Voltage(EN,PWM)	V_{IH}	VIN = 4.5V to 33V	2.4	--	--	V
Logic Low Input Voltage(EN, PWM)	V_{IL}	VIN = 4.5V to 33V	--	--	0.7	V
Switching Frequency	fosc	R_{RT} = 100kΩ	450	500	550	kHz
Minimum MOSFET ON Time	Tm_ON		20	50	80	ns
Minimum MOSFET OFF Time	Tm_OFF		40	80	120	ns
LDR Sink Resistance	R_{LDR_SK}		1	3.5	5	Ω
LDR Source Resistance	R_{LDR_SC}		1	5	9	Ω
N-Channel MOSFET Over Current Protection	V_{ISW}		0.48	0.54	0.6	V
Regulation LED Current per Channel	I_{SET}	R_{ISET} = 12kΩ	95	100	105	mA
LED Current Matching	I_{LEDM}		--	+/- 1.5	+/- 3	%
Over Voltage Protection Threshold	V_{OVP}		1.9	2.0	2.1	V
Shun Down Under Abnormal Condition	V_{OVP}		2.8	3	3.2	V
LED Short Protection Threshold	V_{SHT}	Ch1~CH4	7.8	8.5	9.2	V

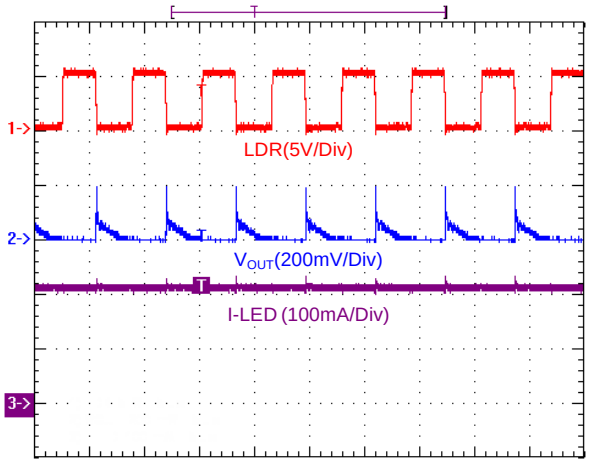
Typical Operation Characteristics

Power ON from EN



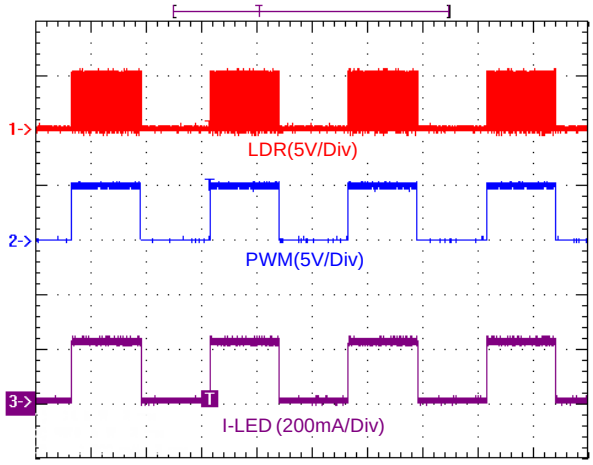
10ms/Div
18WLED, V_{IN} = 24V, I-LED = 240mA
(Per String =60mA)

VOUT Ripple



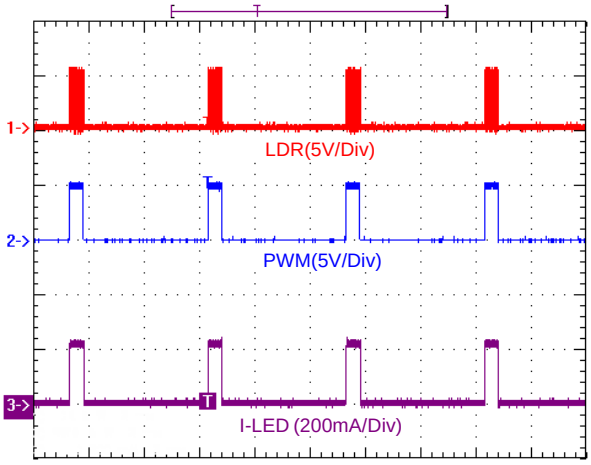
5us/Div
18WLED, V_{IN} = 24V, I-LED = 240mA
(Per String =60mA), C_{OUT} = 56uF

PWM Dimming Waveform



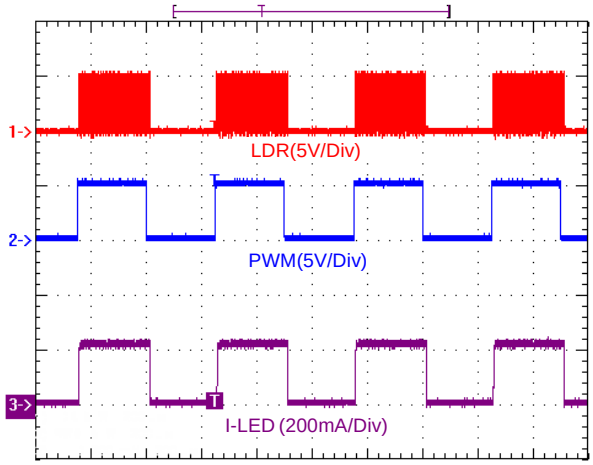
2ms/Div
18WLED, V_{IN} = 24V, I-LED = 240mA
(Per String =60mA), PWM = 200Hz. Duty = 50%

PWM Dimming Waveform



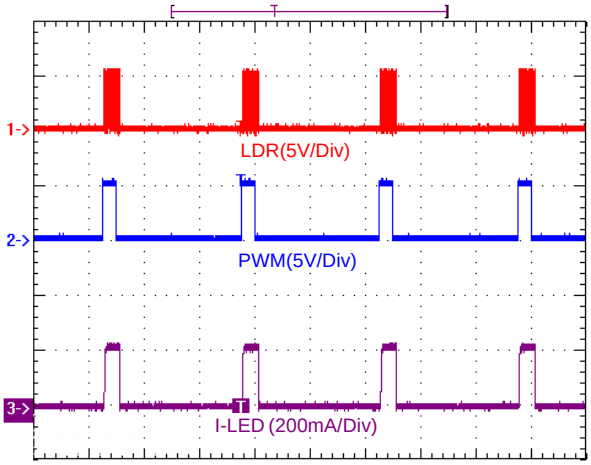
2ms/Div
18WLED, V_{IN} = 24V, I-LED = 240mA
(Per String =60mA), PWM = 200Hz. Duty = 10%

PWM Dimming Waveform



200us/Div
18WLED, V_{IN} = 24V, I-LED = 240mA
(Per String =60mA), PWM = 2KHz. Duty = 50%

PWM Dimming Waveform



200us/Div
18WLED, V_{IN} = 24V, I-LED = 240mA
(Per String =60mA), PWM = 2KHz. Duty = 10%

Application Information

Inductor Selection

Inductor selection should consider the inductor value, rated current, DCR, size, and cost. The main parameter for inductor selection is saturation current of the inductor which should be higher than the minimum switch current limit. The inductor should have low core loss at and low DCR for better efficiency.

Output Capacitor Selection

For the best output voltage filtering, the low ESR of output capacitor is recommended. The X5R, X7R ceramic capacitors are suitable for uP6034 applications. The output voltage ripple can be calculated as below:

$$\Delta V_{OUT} = \frac{I_{OUT}}{C_{OUT}}\left(\frac{1}{F_S} - \frac{I_P x L}{V_{OUT} + V_D - V_{IN}}\right) + I_P x ESR$$

I_{OUT}: load current

C_{OUT}: selected output capacitor

F_S: switching frequency

I_P: delta switching current

L: selected inductor value

V_D: rectifier diode forward voltage

ESR: output capacitor ESR value

Diode Selection

To achieve high efficiency, the Schottky diode with low forward voltage and fast reverse recovery time are the ideal choices for uP6034. The voltage rating should be higher than the maximum output voltage of the boost converter. The average forward current rating should be higher than the current limit of the boost converter.

Power MOS Selection

The Power MOS Vds voltage rating should be higher than the maximum output voltage of the boost converter. The Ids current rating should be higher than the current limit of the boost converter.

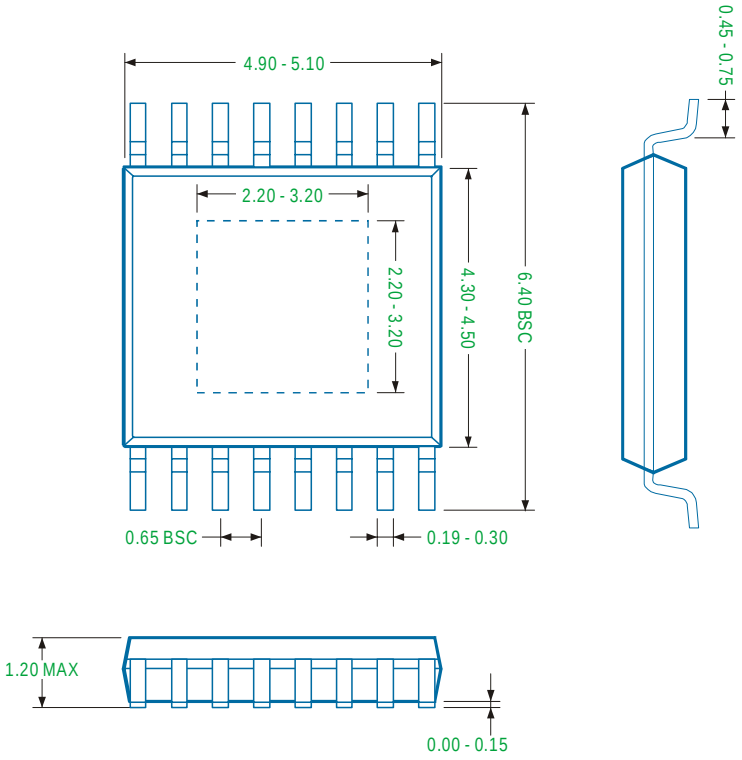
PCB Layout

For best performance of the uP6034, the following guidelines must be strictly followed.

1. Minimize the high-current and switching paths loop, made the trace width enough to avoid the EMI and stability problems. Keep input capacitor, inductor, LX-pin, Schottky diode and output capacitor placement be in the shortest area.
2. Avoid using vias in the high-current paths. If vias are unavoidable in the high-current paths, use many vias in parallel to reduce resistance and inductance.
3. Place the VIN and VREF pin bypass capacitors as close as possible to the uP6034. The ground of VIN capacitor should be connected directly to the GND that near the IC.
4. Minimize the length and maximize the width of the traces between the output capacitors and the load for best transient responses.
5. Place the output voltage divider resistors near the OVP pins. Keep the feedback resistors and trace far away from the high-current and switching loops to avoid the noise coupling.

Package Information

TSSOP - 16L with Exposed PAD

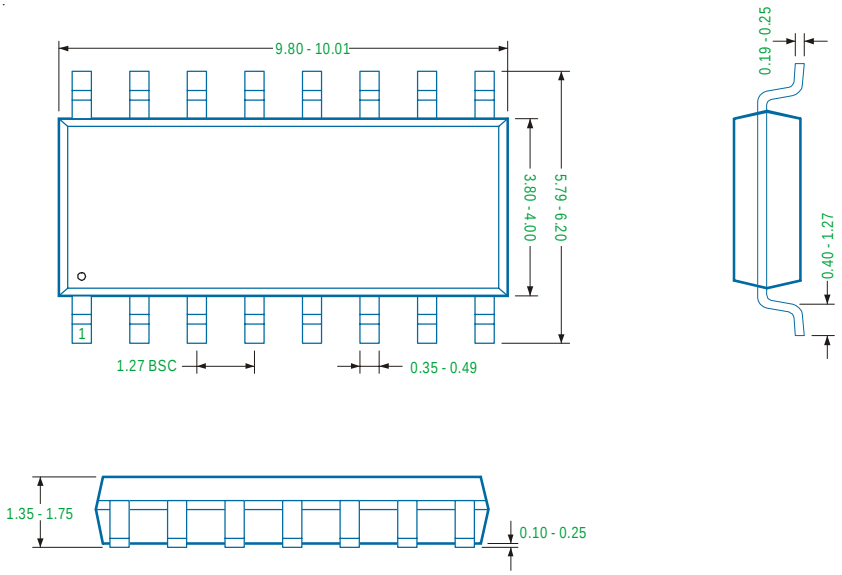


Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

Package Information

SOP - 16L



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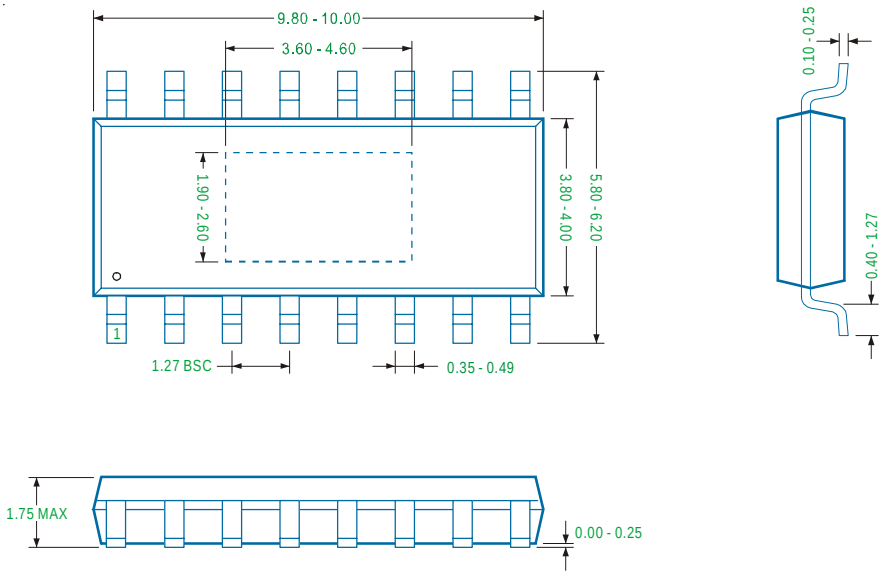
Package Information

PSOP - 16L



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