TAIWAN SEMICONDUCTOR

RoHS COMPLIANCE

TS19371

Boost (Step-up) WLED Driver with OVP

SOT-26



Pin Definition:

1. SW	6. VIN
2. GND	5. OVP
3. FB	4. CTRL

SOP-8



Pin Definition:

1. VIN	8. SW
2. GND	7. GND
3. GND	6. GND
4. CTRL	5. FB

General Description

The TS19371 is a step-up DC/DC converter specifically designed to drive white LEDs with a constant current. The device can drive up to 126 LEDs (9S14P) from a 12V supply. The output capacitor can be as small as 4.7µF, saving space versus alternative solutions. A low 95mV feedback voltage minimizes power loss for better efficiency. Additional feature include over output voltage limiting (SOT-26 package) when LEDs are disconnected. The TS19371 switches at a fixed frequency of 1.2MHz, allowing the use of tiny, low profile inductors and capacitors to minimize footprint and cost in space consideration applications for cellular phone backlighting or other hand held equipment.

Features

- Inherently Matched LED Current
- High Efficiency: 89% Typical
- Drives Up to 9 LEDs Series @ Vin 9~15V
- Drives Up to 126 LEDs (9S14P) @ Vin 12~15V
- Drives Up to 6 (1W) LEDs Series @ Vin 12V
- Over Output Voltage Protection 30V (SOT-26)
- Fast 1.2MHz Switching Frequency
- Requires Only 4.7µF Output Capacitor
- PWM dimming control 1KHz to 10KHz
- Analog dimming control

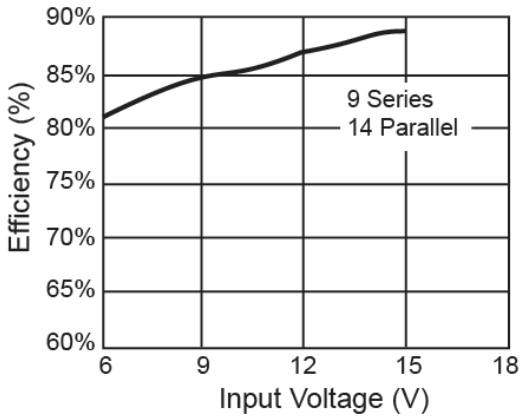
Application

- Cellular Phones
- Portable Electronics Devices PDA, GPS
- LCD Display Module
- White LED Backlighting
- MR-16 lighting

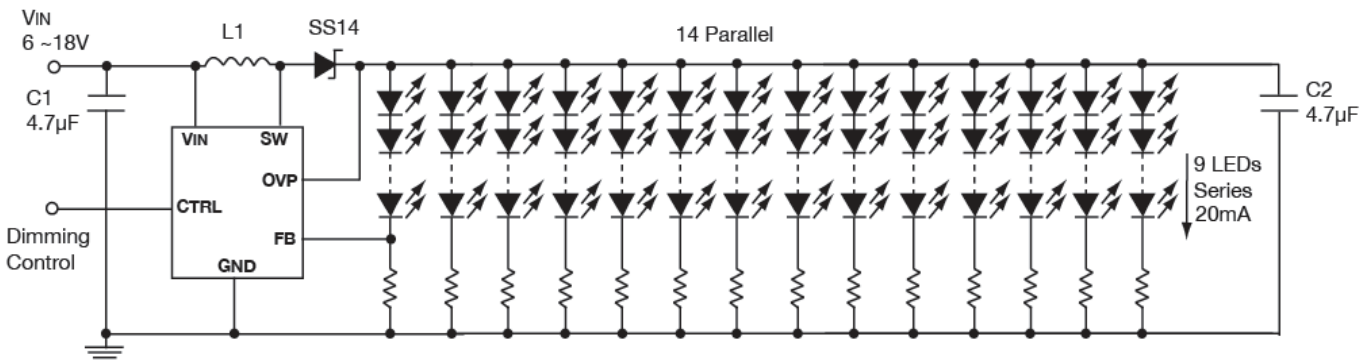
Ordering Information

Part No.	Package	Packing
TS19371CX6 RF	SOT-26	3Kpcs / 7” Reel
TS19371CS RL	SOP-8	2.5Kpcs / 13” Reel

Input Voltage vs. Efficiency



Typical Application Circuit



Absolute Maximum Rating

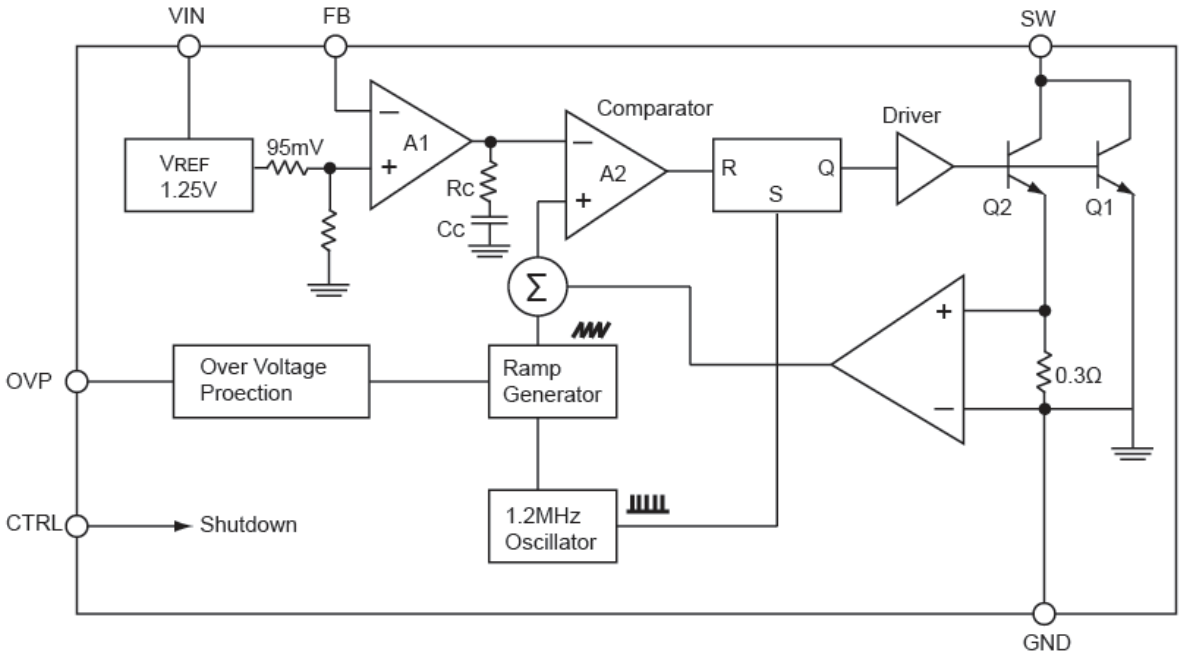
Parameter	Symbol	Limit	Unit
Input Voltage	V_{IN}	20	V
Supply Voltage (Recommended)	V_{IN}	2.5 ~ 18	V
FB Voltage	V_{FB}	10	V
SW Voltage	V_{SW}	36	V
CTRL Voltage	V_{CTRL}	10	V
Ambient Temperature Range	T_A	-40 to +85	°C
Junction Temperature Range	T_J	-40 to +125	°C

Electrical Specifications (Ta = 25°C, V_{IN}= V_{CTRL}=3V, C_{IN}=1uF, C_{OUT}=0.22uF unless otherwise noted)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Input Voltage Range	V_{IN}		2.5	--	18	V
Feedback Voltage	V_{FB}	I_{SW}=180mA, Vin=5V	80	95	110	mV
FB Pin Bias Current	I_B		10	45	100	nA
Supply Current	I_Q		--	2.1	3.0	mA
		CTRL = 0V	--	0.1	1.0	uA
Switching Frequency	F_{RSW}		0.8	1.2	1.6	MHz
Switch Current Limit	I_{CL}		--	650	--	mA
Maximum Duty Cycle	D_{TMX}		85	90	--	%
Switch V_{CESAT}	V_{SAT}	At I_{SW} = 250mA	--	350	--	mV
Switch Leakage Current	I_{LKG}	V_{SW} = 5V	--	0.01	5	μA
Voltage Enable Control	V_{CTL}	High	1.5	--	--	V
		Low	--	--	0.4	V
CTRL Pin Bias Current	I_{CTL}	Ctrl = 2V	--	65	--	μA
Over Voltage Protection	OVP		--	30	--	V
Thermal Resistance - Junction to Ambient	$R\Theta_{JA}$	SOT-26	--	220	--	℃/W
		SOP-8 (Note 1)	--	70	--	

Note 1: Surface mounted on 1” x 1” FR4 board
Note 2: Absolute maximum ratings are limits beyond which damage to the device may occur.
Note 3: The maximum allowable power dissipation is a function of maximum function temperature, TJ(max), the junction to ambient thermal resistance, θJA, and the ambient temperature. The maximum allowable, power dissipation at any ambient temperature is calculated using: PD(MAX)= [TJ(max)-TA]/θJA . Exceeding the maximum allowable power dissipation will cause excessive die temperature. All limits at temperature extremes are guaranteed via correlation using standard statistical methods

Functional Block



Pin Description

Pin (SOT-26)	Pin (SOP-8)	Function	Description
1	8	SW	Switching Pin. This is the collector of the internal NPN power switch. Connect to inductor and diode. Minimize the metal trace area connected to this pin to reduce EMI.
2	2,3,6,7	Ground	Ground Pin. Connect directly to local ground plane.
3	5	FB	Feedback Pin. Reference voltage is 95mV. Connect LEDs and a resistor at this pin. LED current is determined by the resistance and CTRL voltage.
4	4	CTRL	Shutdown Pin and Dimming Control Pin. VCTRL > 1.8V generates full-scale LED current VCTRL < 0.4V chip is off Switching from 04V to 2.0V, PWM duty cycle controls the LED current
5		OVP	Over Voltage Protection, 30V
6	1	VIN	Input Supply Pin. Bypass this pin with a capacitor as close to the device as possible

Application Information

Operation

The TS19371 uses a constant frequency, current mode control scheme to provide excellent line and load regulation. Operation can be best understood by referring to the block diagram. At the start of each oscillator cycle, the RS latch is set, which turns on the power switch Q1. A voltage proportional to the switch current is added to a stabilizing ramp and the resulting sum is fed into the positive terminal of the PWM comparator A2. When this voltage exceeds the level at the negative input of A2, the RS latch is reset turning off the power switch. The level at the negative input of A2 is set by the error amplifier A1, and is simply an amplified version of the difference between the feedback voltage and the reference voltage of 95mV. In this manner, the error amplifier sets the correct peak current level to keep the output in regulation. If the error amplifier's output increases, more current is delivered to the output; if it decreases, less current is delivered.

Soft Start and Current Limit

The internal soft start circuit minimizes the inrush current during turning on TS19371. The Typical switch current is limited to about 650mA by the chip.

Over Voltage Protection

The TS19371 has design an internal latched off open-circuit protection circuit, the additional sense pin to detect the voltage when the LEDs are disconnected from the circuit or fail open, the TS19371 will shutdown until input condition changes to bring it out of the shutdown mode.

Inductor Selection

A 10uH inductor is recommended for most TS19371 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at 1.2MHz and low DCR (copper wire resistance).

Diode Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for TS19371 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode while the diode capacitance (CT or CD) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1.2MHz switching frequency of the TS19371. A Schottky diode rated at 1000mA is sufficient for most TS19371 applications.

Capacitor Selection

The small size of ceramic capacitors makes them ideal for TS19371 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 4.7µF input capacitor and a 4.7µF output capacitor are sufficient for most TS19371 applications

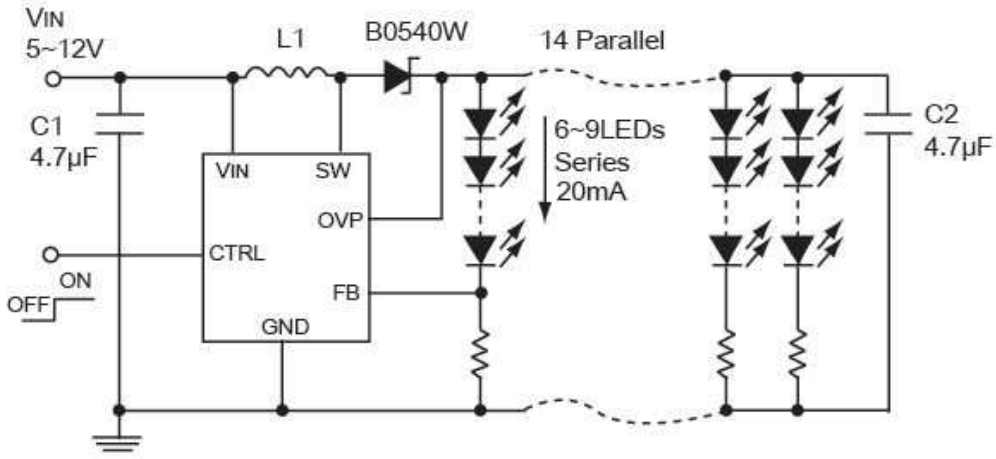
LED Current Control

The LED current is controlled by the feedback resistor (R1). The feedback reference is 95mV. The LED current is 95mV/R1. The formula and table 3 for R1 selection are shown below. $R1=95mV/I_{LED}$

ILED (mA)	R1(Ω)
5	19.1
10	9.53
12	7.87
15	6.34
20	4.75

Application Information (Continue)

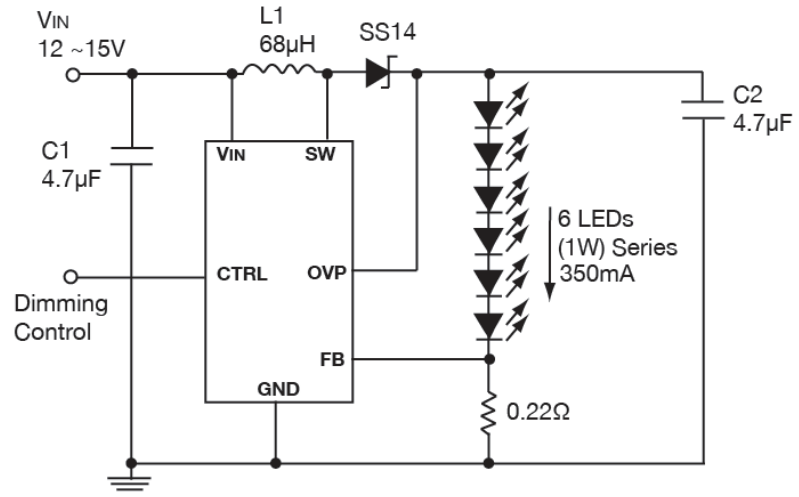
TS19371CX6 Typical Application Circuit



Reference Design Information

VIN Range (V)	VLED. (V)	L (uH)	LED (Series)	LED (Parallel)	Current (Series/mA)	Resistor (Ω)	Efficiency (%)
5	19.8	22	6pcs	14	20	4.75	81.2
9	29.7	33	9pcs	14	20	4.75	83.6
12	29.7	47	9pcs	14	20	4.75	87.2
15	29.7	68	9pcs	14	20	4.75	88.4

TS19371CX6 Typical Application Circuit for 1W x 6pcs LEDs

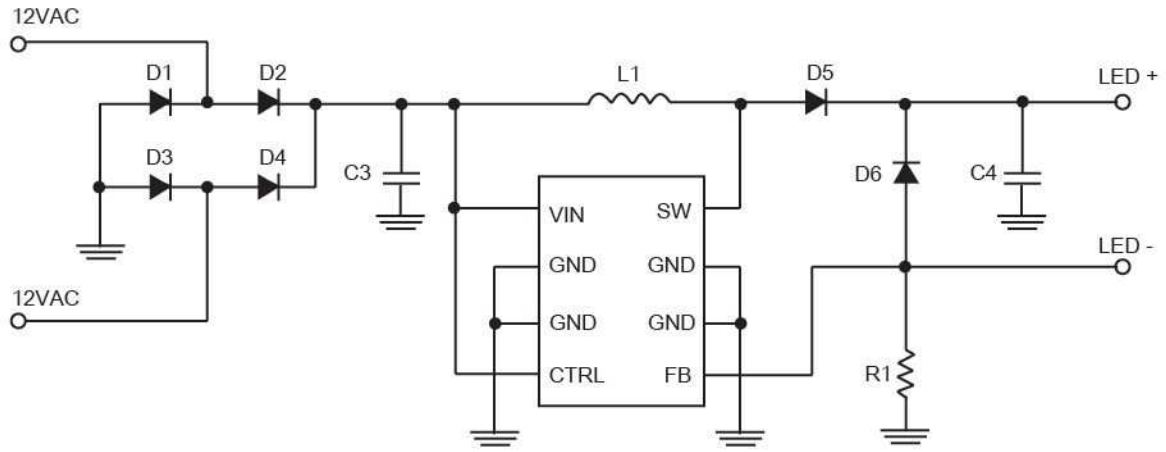


Reference Design Information

VIN Range (V)	VLED. (V)	L (uH)	1W LED (Series)	Current (mA)	Resistor (Ω)	Efficiency (%)
12~15	19.8	68	6pcs	350	0.22	88

Application Information (Continue)

TS19371CS Typical Application Circuit for 1W x 5pcs LEDs



Reference Design Information

VIN Range (VAC)	VLED. (V)	L (uH)	1W LED (Series)	Current (mA)	Resistor (Ω)	Efficiency (%)
12	16.5	22	5pcs	300	0.33	85

Bill of Material

No.	Reference	Part number	Quantity	Manufacture
1	C3,C4	4.7uF/16V/ 1206	2	Generic
2	D1,D2,D3,D4,D5	SS24L	5	TSC
3	D6	ZD24V	1	TSC
4	L1	22uH	1	Generic
5	R1	0.33 /1206	1	Generic
6	U1	TS19371CS	1	TSC

Application Information (Continue)

LED Dimming Control

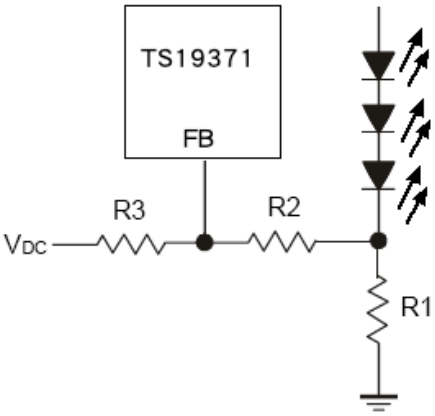
There are some different types of dimming control circuits:

1. Using a PWM Signal to SHDN Pin

With the PWM signal applied to the SHDN pin, the TS19371 is turned on or off by the PWM signal. The LEDs operate at either zero or full current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle will turn off the TS19371 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The typical frequency range of the PWM signal is 1kHz to 10kHz.

The magnitude of the PWM signal should be higher than the minimum SHDN voltage high.

For some applications, the preferred method of brightness control is a variable DC voltage to adjust the LED current. The dimming control using a DC voltage is shown in below figure. As the DC voltage increases, the voltage drop on R2 increases and the voltage drop on R1 decreases. Thus, the LED current decreases. The selection of R2 and R3 will make the current from the variable DC source much smaller than the LED current and much larger than the FB pin bias current. For VDC range from 0V to 2V, the selection of resistors in Figure 4 gives dimming control of LED current from 0mA to 20mA.

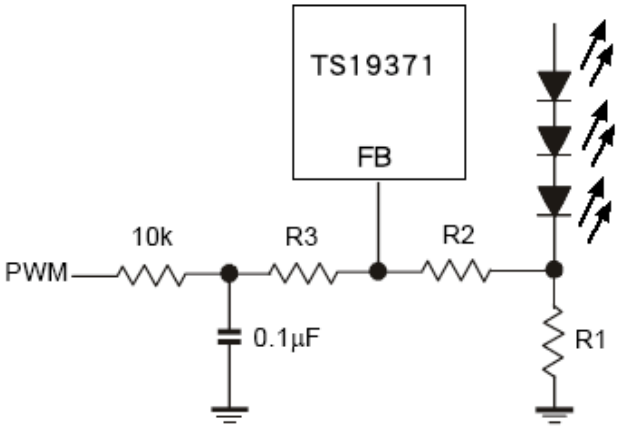


Dimming Control using a DC Voltage

VDC(V)	VFB	Iout(mA)
2	0	0
1.8	2.2	0.43
1.6	9.2	1.8
1.4	19.6	3.6
1.2	31.1	6
1	43.4	8.5
0.8	63	12.3
0.6	74	14.5
0.4	86.4	16.9
0.2	96.9	19
0	102	20

2. Using a Filtered PWM Signal

The filtered PWM signal can be considered as an adjustable DC voltage. It can be used to replace the variable DC voltage source in dimming control. The circuit is shown as follow:



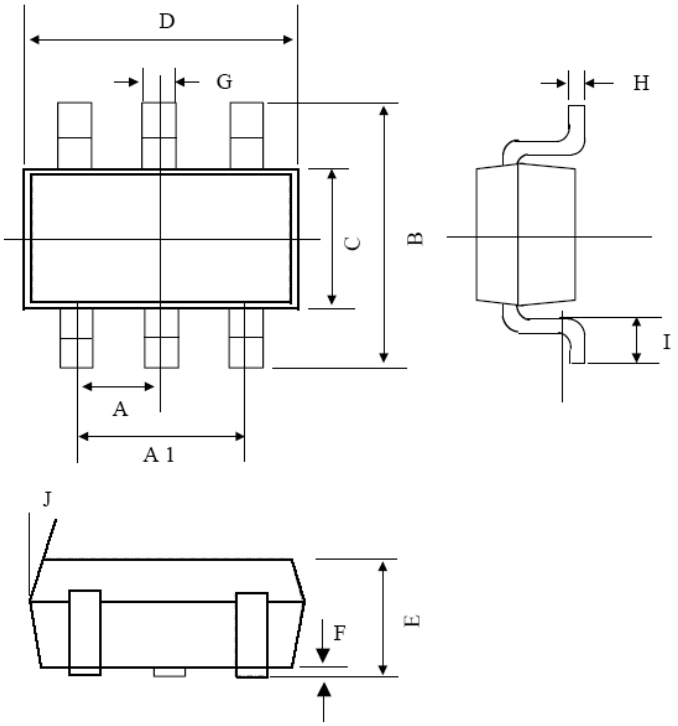
Dimming Control using a Filtered PWM Signal

Duty	Iout (mA)
0%	20
20%	17.4
30%	15
40%	12.4
50%	10
60%	8
70%	6.4
80%	4.07
100%	0
PWM : 2V ; 1KHz ; Vin=3.6V	

3. Using Control pin for dimming

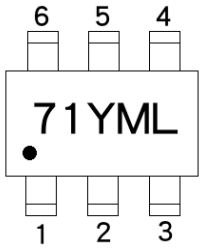
The PWM signal can be considered as TTL signal to control pin to change the power on/off time.

SOT-26 Mechanical Drawing



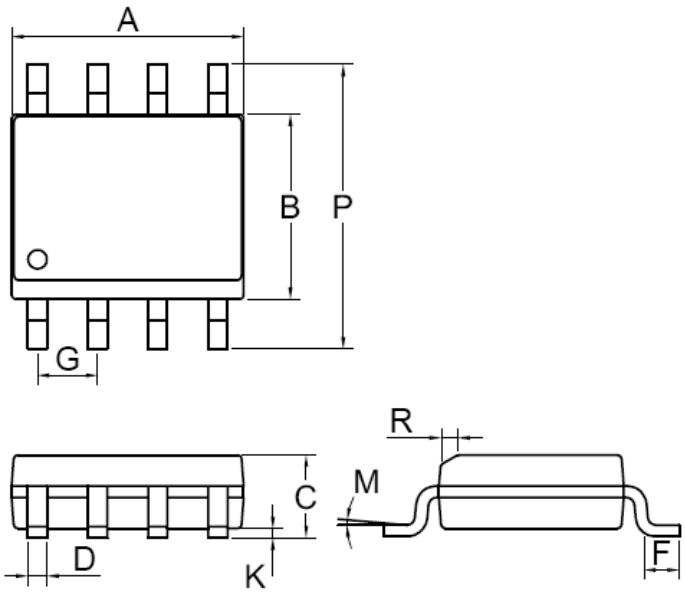
SOT-26 DIMENSION						
DIM	MILLIMETERS			INCHES		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.95 BSC			0.0374 BSC		
A1	1.9 BSC			0.0748 BSC		
B	2.60	2.80	3.00	0.102	0.110	0.118
C	1.40	1.50	1.70	0.055	0.059	0.066
D	2.80	2.90	3.10	0.110	0.114	0.122
E	1.00	1.10	1.20	0.039	0.043	0.047
F	0.00	--	0.10	0.00		0.003
G	0.35	0.40	0.50	0.013	0.015	0.019
H	0.10	0.15	0.20	0.003	0.005	0.007
I	0.30	--	0.60	0.011	--	0.023
J	5º	--	10º	5º	--	10º

Marking Diagram



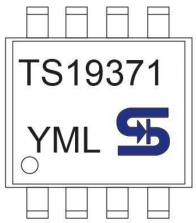
71 = Device Code
Y = Year Code
M = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apl, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
L = Lot Code

SOP-8 Mechanical Drawing



SOP-8 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX.
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27BSC		0.05BSC	
K	0.10	0.25	0.004	0.009
M	0º	7º	0º	7º
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

Marking Diagram



Y = Year Code
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