

SANYO Semiconductors DATA SHEET

An ON Semiconductor Company

LV5026M — LED Driver IC

Overview

LV5026M is a High Voltage LED drive controller which drives LED current up to 3A with external MOSFET. LV5026M is realized very simple LED circuits with a few external parts. It corresponds to various wide dimming controls including the TRIAC dimming control.

Functions

- High Voltage LED Controller
- Various Dimming Control
- -TRIAC & Analog Input & PWM Input
- Soft Start function
- Built-in TRIAC stabilized function
- Built-in circuit of detection of overvoltage of CS pin.
- Selectable Switching frequency [50 kHz or 70 kHz, open: 50 kHz]
- Short Protection Circuit
- Selectable reference Voltage
 - -Internal 0.605V & External Input Voltage
- Low noise switching system
 - 5 stages skip mode Frequency
 - Soft driving

Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum Input voltage	V _{IN} max		-0.3 to 42	V
REF_OUT, REF_IN, RT, CS, PWM_D, ACS			-0.3 to 7	V
OUT1 pin	V _{OUT_} abs		-0.3 to 42	V
OUT2 pin	V _{OUT} 2_abs		-0.3 to 42	V
Allowable power dissipation	Pd max	With specified board*	1.0	W
Junction temperature	Tj		150	°C
Operating temperature	Topr		-30 to +125	°C
Storage temperature	Tstg		-40 to +150	°C

^{*}Specified board: 58.0×54.0×1.6mm (glass epoxy board)

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Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Input voltage	VIN		8.5 to 24	V

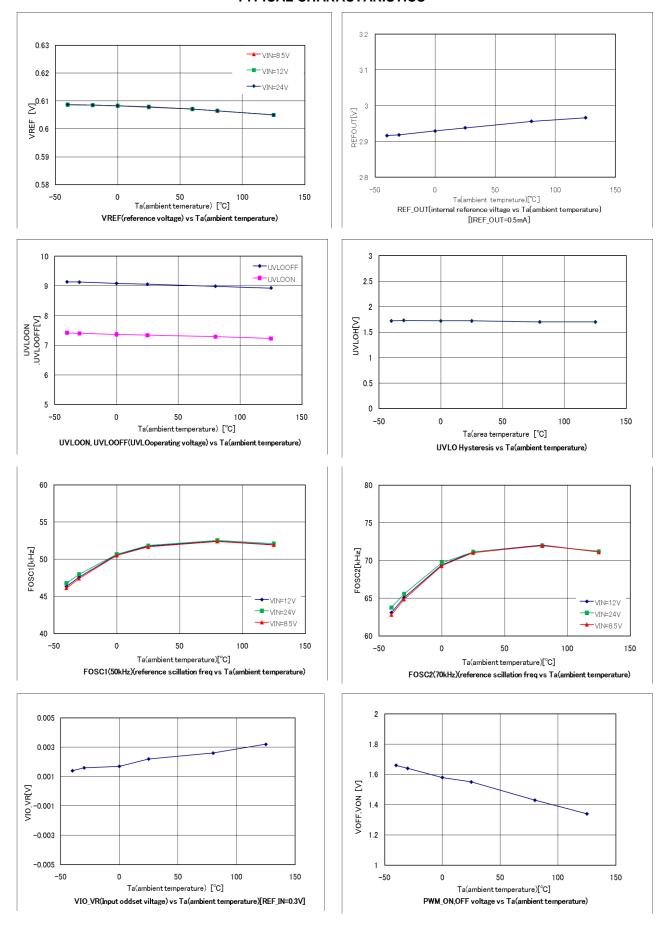
Electrical Characteristics at Ta = 25°C, V_{IN} = 1	12V, unless otherwise specified.
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Danasatan	0	O and Hitlands	Ratings			Lloit	
Parameter	Symbol	Conditions	min	typ	max	Unit	
Reference Voltage block							
Built-in Reference Voltage	VREF		0.585	0.605	0.625	V	
VREF V _{IN} line regulation	VREF_LN	V _{IN} = 8.5 to 24V		±0.5		%	
Reference Output Voltage	REFOUT	IREFOUT = 0.5mA		3.0		V	
- Maximum load	REFOUT_MA X		0.5			mA	
- equivalent output impedance	REFOUT_RO			10		Ω	
Under Voltage Lockout			<u> </u>				
Operation Start Input Voltage	UVLOON		8	9	10	V	
Operation Stop Input Voltage	UVLOOFF		6.3	7.3	8.3	V	
Hysteresis Voltage	UVLOH			1.7		V	
Oscillation	1	1	<u>. </u>	<u> </u>			
Frequency	FOSC1	RT = OPEN	40	50	60	kHz	
	FOSC2	RT=REF_OUT	55	70	85	kHz	
FOSC1 Switch voltage	Vosc1	_	2	-	5	V	
FOSC2 Switch voltage	V _{OSC} ²				0.5	V	
Maximum ON duty	MAXDuty			93		%	
Comparator	1		1			-	
Input offset Voltage	V _{IO} _VR			1	10	mV	
(Between CS and VREF)	10_***						
Input offset Voltage	V _{IO} _RI			1	10	mV	
(Between CS and REFOUT)							
Input current	IIOCS			160		nA	
	IIOREF			80		nA	
CS pin max voltage	VOM				1	V	
malfunction prevention	TMSK			150		ns	
mask time							
PWM_D Circuit		T				V	
OFF voltage	VOFF		2		5		
ON voltage	VON		0		0.6	V	
Thermal protection Circuit	TOD	1 *D	1	46-	1		
Thermal shutdown	TSD	*Design guarantee		165		°C	
temperature Thermal shutdown	ΔTSD	*Design guarantee		30		°C	
hysteresis	1.05	200911 9441411100				J	
Drive Circuit	•						
OUT sink current	IOI		500	1000		mA	
OUT source current	100			120		mA	
Minimum On time	TMIN			200	300	ns	
TRIAC Stabilization Circuit							
Threshold of OUT2	VACS	OUT2=High [less than right record]	2.8	3.0	3.2	V	
OUT2 sink current	I _O 2I	VIN=12V, OUT2=6V		0.6		mA	
OUT2 source current	I _O 2O	VIN=12V, OUT2=6V		0.6		mA	
V _{CC} current	ı <u> </u>		1				
UVLO mode V _{IN} current	I _{CC} OFF	V _{IN} <uvloon< td=""><td></td><td>80</td><td>120</td><td>μА</td></uvloon<>		80	120	μА	
Normal mode V _{IN} current	I _{CC} ON	V _{IN} >UVLOON, OUT = OPEN		0.6		mΑ	
TISHING TIN GOTTON	1.000.1	- IIV		0.0			

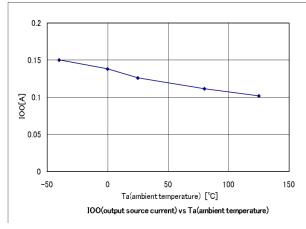
V _{IN} Over Voltage Protection Circuit						
V _{IN} over voltage protection voltage	V _{IN} OVP		24	27	30	V
VIN Current at OVP	IINOVP	V _{IN} =30V	0.7	1.0	1.5	mA
CS terminal abnormal sensing circuit						
Abnormal sensing voltage	CSOCP			1.9		V

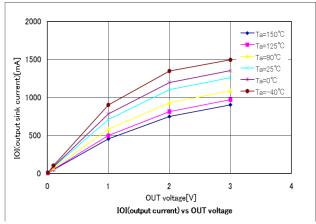
^{*:} Design guarantee (value guaranteed by design and not tested before shipment)

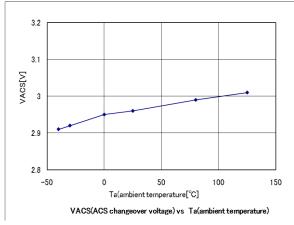
TYPICAL CHARACTARISTICS

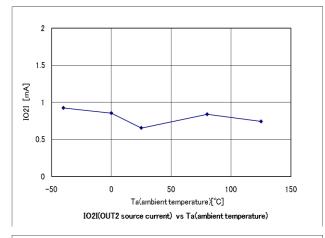


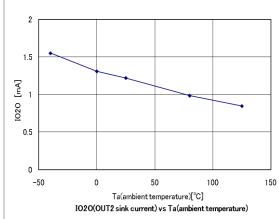
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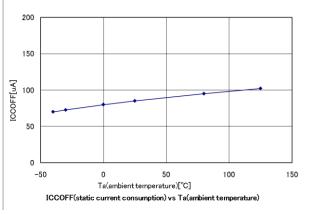


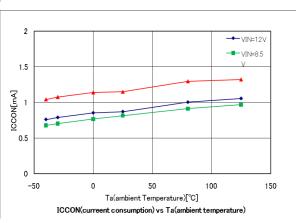




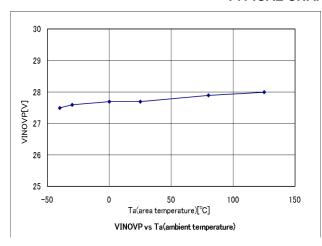


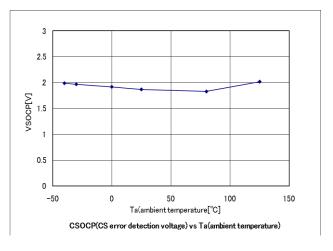




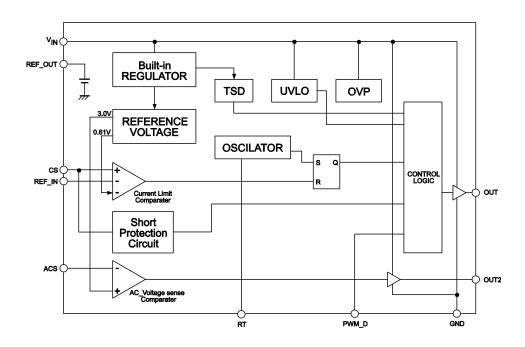


TYPICAL CHARACTARISTICS



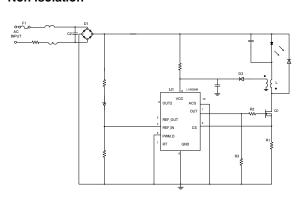


Block Diagram

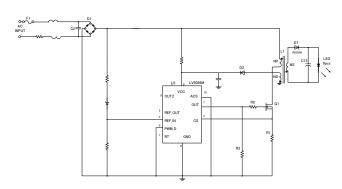


Sample Application Circuit

Non isolation

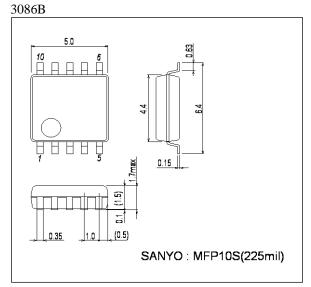


Isolation

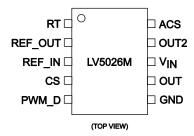


Package Dimensions

unit: mm (typ)



Pin Assignment



Pin Functions

pin No	Pin Name	Pin Function	Equivalent Circuit
	RT	Switching Frequency selection pin.	·
		L or Open: 50kHz Switching,	VREF-OUT O (3Vtyp)
		H: 70 kHz Switching.	1κΩ —
		In case of 70kHz,connect RT pin to REFOUT pin.	RT O-W-IE
		on time	<u> </u>
			GND O
2	REF_OUT	Built-in 3V Regulate out Pin. If this function isn't used, please connect to	 → VIN
		nothing.	-K
			O VREF-OUT
			' Т { (3Vtyp)
			→
			GND
	DEE IN	E	
3	REF_IN	External LED current Limit Setting pin. If less than VREF (0.61V) voltage is input, Peak current	
		value is used at the input voltage. If more than	⊕ ⊕ ⊕
		REF_IN voltage is input, it is done at VREF voltage. If this function isn't used, please connect	★ ├ ☆ ├ ≯ →
		nothing.	CS O REF_IN
			★ >++-< `
			GND
4	CS	LED current sensing in. If this terminal voltage	
		exceeds VREF (Or REF_IN), external FET is	→
		OFF. And if the voltage of the terminal exceeds 1.9V, LV5026M turns to latch-off mode.	
		,	
			CS O + REF_IN
			★ >++< ★
			GND
5	PWM_D	PWM Dimming pin.L or open: normal operation,	0
		H: Stop operation.	VIN O
			PWM_D O
			₹
			GND O
-	OND	CNID min	
6 7	GND OUT	GND pin. Driving the external FET Gate Pin.	OVIN
8	VIN	Power supply pin. Operation	le
		: VIN>UVLOONStop: VIN <uvlooff Switching Stop: VIN>VINOVP</uvlooff 	OUT
		3,	ı <u>↓</u> ★ ★
			GND
9	OUT2	This pin drive the FET which is stabilized the	
3	0012	TRIAC dimming application.	OVIN
		If ACS is less than 3V, OUT2 turn High voltage. If this function isn't used, please connect	I c
		nothing.	1kΩ ····································
			e <mark>- </mark>
			OGND
10	ACS	ACS pin senses AC Voltage.	
		If this function isn't used, please connect GND.	O VIN
			→
			—IF → ACS
			ੑ ੑੑੑੑੑੑੑੑ
			₹I+1E- T
			— → → → ○ GND
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· LED current and inductande setting

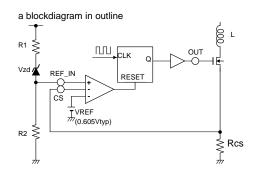
Relation ship beween REF_IN and CS pin voltage(Power Factor Crrection(PFC))

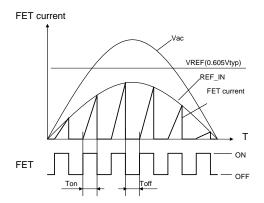
The output current value is the average of the current value that flows during one cycle. The current value that flows into coil is a triangular wave shown in the figure below. Make sure to set Ipk so that (average of current value at one cycle) is equal to (LED current value). Ipk is set by the relationship between REF_IN voltage and Rcs voltage. This relationship make Power Factor Correction (PFC). Therefore, it is available to make LED current a sine curve.

Setting Zener voltage

Vzd depend on LED voltage (VF). Choose Zener diode around Vf (LED voltage). When VAC voltage is lower than Vf, LED operation is not normal. Using Zener diode prevents incorrect operating during VAC voltage lower than Vf.In detail, refer to [LED current and inductance setting]

In case of REF_IN pin open, this error amplifier negative input(-) is under control of internal VREF voltage(0.605Vtyp).





$$Ipk = \frac{\left(Vac - Vzd\right) \times \frac{R2}{R1 + R2}}{Rcs}$$

Ipk: peak inductor current Vf: LED forward voltage drop Vac: effective value,R.M.S value

VREF: Built-in reference voltage (0.605V)

VREF_IN:REF_IN voltage(6 pin)
Rs: External sense resistor

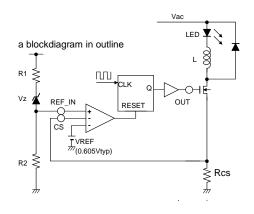
Vzd:Zener diode voltage(REF IN pin)

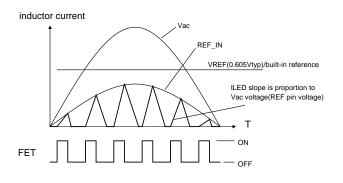
LED current and inductance setting

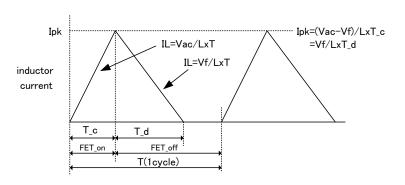
It is available to use both no-isolation and isolation applications.

(For non-isolation application)

The output current value is the average of the current value that flows during one cycle. The current value that flows into coil is a triangular wave shown in the figure below. Make sure to set IL_PK so that (average of current value at one cycle) is equal to (LED current value).







Given that the period when current flows into coil is

Ipk: peak inductor current Vf: LED forward voltage drop Vac: effective value(R.M.S value) VREF: Built-in reference voltage (0.605V) VREF_IN:REF_IN voltage(6 pin)

Rs: External sense resistor Vzd:Zener diode voltage(REF_IN pin)

Since formula for LED current is different between on period and off period as shown above,

$$Ipk = \frac{Vac - Vf}{L} \times T _c = \frac{Vf}{L} \times T _d$$
 (3).

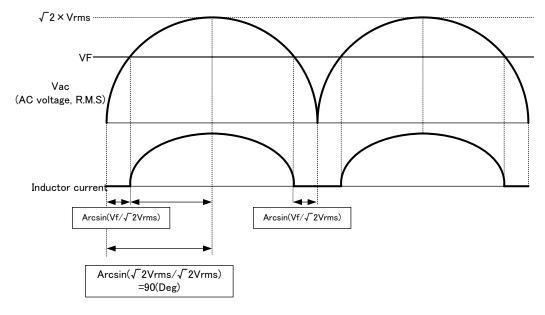
Since
$$T_c + T_d = DutyI \times T$$
, $T_c = DutyI \times T - T_d$ (4)

Based on the result of (3) and (4),
$$T_d = DutyI \times T \times \frac{Vac - Vf}{Vac}$$
 (5)

To obtain L from the equation (1), (3), (5),

$$L = \frac{Vf \times DutyI}{2 \times ILED} \times DutyI \times T \times \frac{Vac - Vf}{Vac} = \frac{Vf}{2 \times ILED} \times \frac{1}{fosc} \times \frac{Vac - Vf}{Vac} \times \left(DutyI\right)^{2}$$
 (6)

Since LED and inductor are connected in serial in non-isolation mode, LED current flows only when AC voltage exceed VF.



Given that the ratio of inductor current to AC input is DutyAC.

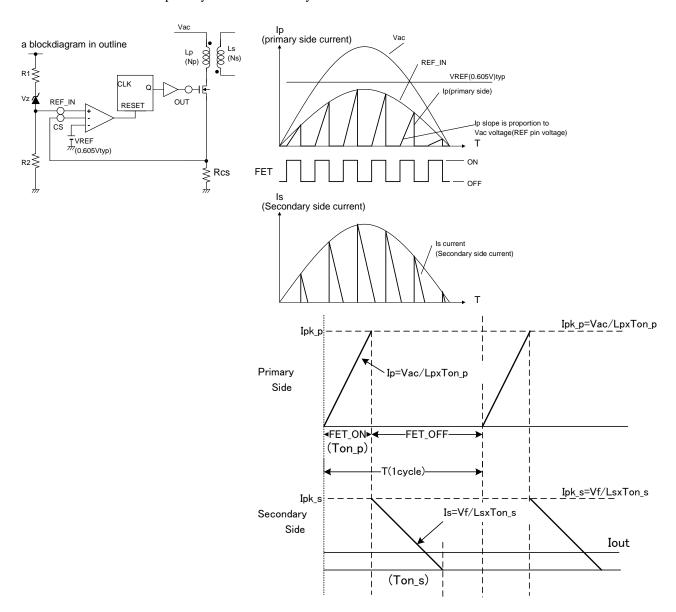
$$DutyAC = \frac{90 - \arcsin(\frac{Vf}{\sqrt{2}Vrms})}{90}$$

Since the period when the inductor current flows are limited by DutyAC, the formula (6) is represented as follows:

$$L = \frac{Vf}{2 \times ILED} \times \frac{1}{fosc} \times \frac{Vac - Vf}{VIN} \times (DutyI)^{2} \times \left(\frac{90 - \arcsin(\frac{Vf}{\sqrt{2}Vrms})}{90}\right)^{2}$$
(7)

(for Isolation circuit)

Using the circuit diagram below, the wave form of the current that flows to Np and Ns is as follows. Current waveform flows to primary side and secondary.



[Inductance Lp of primary side and sense resistor Rs]

If a peak current flow to transformer is represented as Ipk_p, the power (Pin) charged to the transformer on primary side can be represented as:

$$Pin = \frac{1}{2} \times Lp \times (Ipk_{p})^{2} \times fosc \qquad (11).$$

$$\therefore Ipk_{p} = \frac{Vac}{Lp} \times Ton_{p} \qquad (12)$$

$$\therefore Lp = \frac{Vac^{2} \times Ton_{p}^{2} \times fosc}{2 \times Pin} = \frac{Vac^{2} \times Don_{p}^{2}}{2 \times Pin \times fosc} \qquad (13)$$

$$(Don_{p} = \frac{Ton_{p}}{T} = Ton_{p} \times fosc),$$

To substitute the following to the formula below,

$$\therefore \eta = \frac{Pout}{Pin}$$

$$\therefore Lp = \frac{Vac^2 \times Ton_{-} p^2 \times fosc \times \eta}{2 \times Pout} = \frac{Vac^2 \times Don^2 \times \eta}{2 \times Pout \times fosc}$$
(15)

Sense resistor is obtained as follows.

$$Rs = \frac{VREF_IN}{Ipk_p} = \frac{VREF_IN \times Lp}{Vac \times Ton_p} = \frac{VREF_IN \times Lp}{Vac \times Don_p \times T}$$
(16)

[Inductance Ls of secondary side]

Since output current Iout is the average value of current flows to transformer of secondary side

$$Iout = Ipk_s \times \frac{Ton_s}{T} \times \frac{1}{2} = \frac{Ipk_s \times Don_s}{2} \quad (Don_s = \frac{Ton_s}{T} = Ton_s \times fosc)$$

$$Vout \quad Pon_s \quad (17)$$

$$Ipk_s = \frac{Vout}{Ls} \times Ton_s = \frac{Vout}{Ls} \times \frac{Don_s}{fosc}$$
 (18)

$$Ls = \frac{Vout \times T \times Don_s^2}{2 \times Iout} = \frac{Vout \times Don_s^2}{2 \times Iout \times fosc} = \frac{Vout^2 \times Don_s^2}{2 \times Pout \times fosc}$$
(19)

Calculation of the ratio of transformer coil on primary side and secondary side Since ratio and inductance of transformer coil is

$$\frac{Ns}{Np} = \frac{\sqrt{Ls}}{\sqrt{Lp}} \tag{20}$$

substituted equations (15), (19) for (20)

$$\therefore \frac{Np}{Ns} = \frac{Vac}{Vout} \times \sqrt{\eta} \times \frac{Don_p}{Don_s}$$
 (21)

Calculation of transformer coil on primary side and secondary side

$$N = \frac{Vac \times 10^8}{2 \times \Delta B \times Ae \times fosc}$$
 (22)

∠B: variation range of core flux density [Gauss]

Ae : core section area [cm²]

To use Al (L value at 100T),

$$N = \sqrt{\frac{L}{Al}} \times 10^2 \tag{23}$$

L: inductance [uH]

Al: L value at 100T [uH/N²]

lg (Air gap) is obtained as follows:

$$\lg = \frac{\mu_r \mu_0 N^2 A_e 10^2}{L}$$
 (24)

 μ_r : relative magnetic permeability, $\mu_r = 1$

 μ_0 : vacuum magnetic permeability $\mu_0 = 4\pi \times 10^{-7}$

N: turn count [T]

Ae: core section area [m²]

L: inductance [H]

Bleeder current cuircuit for TRIAC dimmer

1. Operating voltage setting

ACS pin voltage set operating voltage at OUT2. ACS pin threshold volage is 3Vtyp. OUT2 operating voltage is set by R1 and R2. R1 and R2 is determined below.

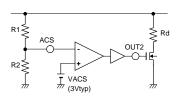
$$ACS = Vac \times \frac{R2}{R1 + R2}$$

2. Bleeder current setting

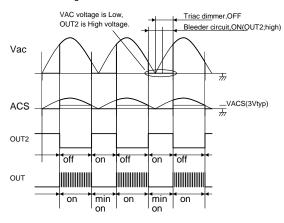
Rd set hold current at Triac dimmer.

Bleeder current is set at Rd depending on Triac dimmer.

a blockdiagram in outline



a blockdiagram in outline



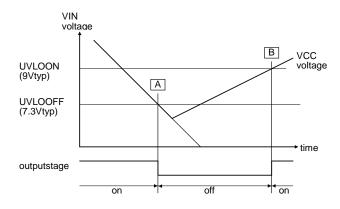
Description of operation

protection function

	tilte	outline	monitor point	note
1	UVLO	Under Voltage Lock Out	VCC voltage	
2	OCP	Over Current Protection	CS voltage	available FET current
3	OVP	Over Voltage Protection	VCC voltage	
4	OTP	Over Temperature Protection	PN Junction temperature	
	(TSD)	(Thermal Shut Down))		

1.UVLO(Under Voltage Lock Out)

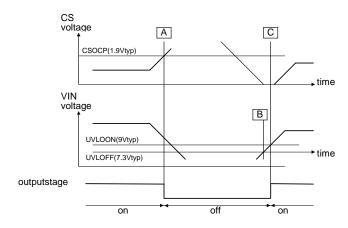
If VIN voltage is 7.3V or lower, then UVLO operates and the IC stops. When UVLO operates, the power supply current of the IC is about 80uA or lower. If VIN voltage is 9V or higher, then the IC starts switching operation.



2.OCP(Over Current Protection)

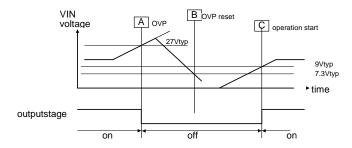
The CS pin sense the current through the MOS FET switch and the primary side of the transformer. This provides an additional level of protection in the event of a fault. If the voltage of the CS pin exceeds VCSOCP(1.9Vtyp)(\boxed{A}), the iternal comparator will detect the event and turn off the MOSFET. The peak switch current is calculated Io(peak) [A] = VSOCP[V]/Rsense[ohm]

The VCC pin is pulled down to fixed level, keeping the controller lached off. The lach reset occurs when the user disconnects LED from VAC and lets the VCC falls below the VCC reset voltage, UVLOOFF(7.3Vtyp)(\boxed{B}). Then VCC rise UVLOON(9Vtyp)(\boxed{C}), restart the switching.



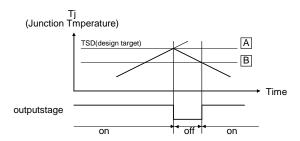
3.OVP(Over Voltage Protection)

If the voltage of VIN pin is higher than the internal reference voltage VINOVP(27Vtyp), switching operation is stopped. The stopping operation is kept until the voltage of VIN is lower than 7.3V. If the voltage of VIN pin is higher than 9V, the switching operation is restated.



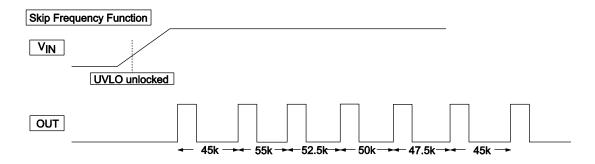
4. TSD(thermal Shut Down protection

The thermal shutdown function works when the junction temperature of IC is 165 deg (typ) (\boxed{A}), and the IC switching stops. The IC starts switching operation again when the junction temperature is 135° Ctyp (\boxed{B}) or lower.



Skip frequency function

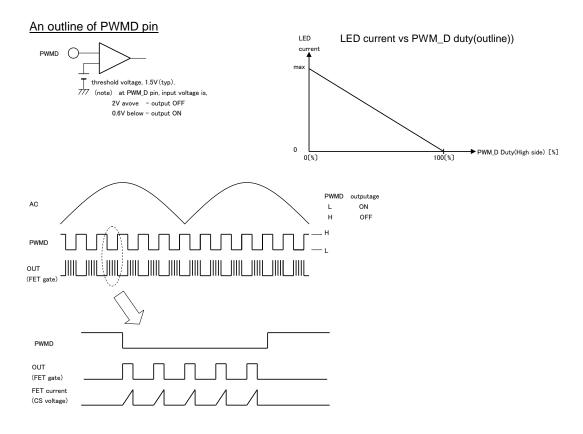
LV5026M contains the skip frequency function for reduction of the peak value of conduction noise. This function changes the frequency as follows.



Switching frequency is changed as follows. ... $\times 0.9 \rightarrow \times 1.1 \rightarrow \times 1.05 \rightarrow \times 1 \rightarrow \times 0.95 \rightarrow \times 0.9 \rightarrow \times 1.1 \dots$ It's repeated by this loop.

PWM dimmer function

LED current can be adjusted according to Duty of PWM pulse input to PWM dimmer pin. PWM pulse is High (2V to 5V) then switching operation stops, and LED current stops flowing. PWM pulse is Low (under 0.6V), then switching operation stop is released, and it returns to normal operation.



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