SANYO Semiconductors
DATA SHEET
An ON Semiconductor Company

LV5027M — Bi-CMOS IC LED Driver IC

Overview

LV5027M is a High Voltage LED drive controller which drives LED current up to 3A with external MOSFET.
LV5027M is realized very simple LED circuits with a few external parts.

Functions

- High Voltage LED Controller
- Low noise switching system
  - 5 stages skip mode Frequency
  - Soft driving
- Built-in Reference voltage circuit (internal 0.605V)
- Built-in circuit of detection of overvoltage of CS pin.
- Short Protection Circuit

Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum Input voltage	V_{IN} max		-0.3 to 42	V
CS pin			-0.3 to 7	V
OUT pin	V_{OUT}_abs		-0.3 to 42	V
Allowable power dissipation	Pd max	With specified board*	1.0	W
Junction temperature	Tjmax		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)

Recommended Operating Conditions at Ta = 25°C

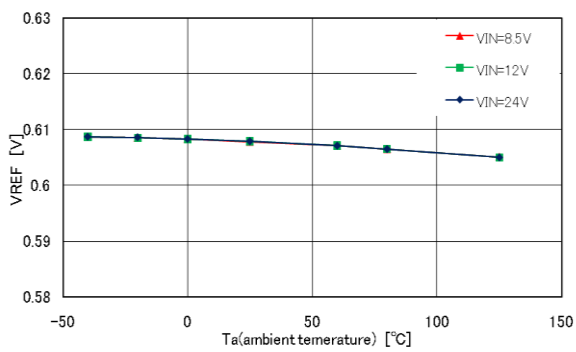
Parameter	Symbol	Conditions	Ratings	Unit
Input voltage	V_{IN}		8.5 to 24	V

Electrical Characteristics at Ta = 25°C, V_{IN} = 12V, unless otherwise specified.

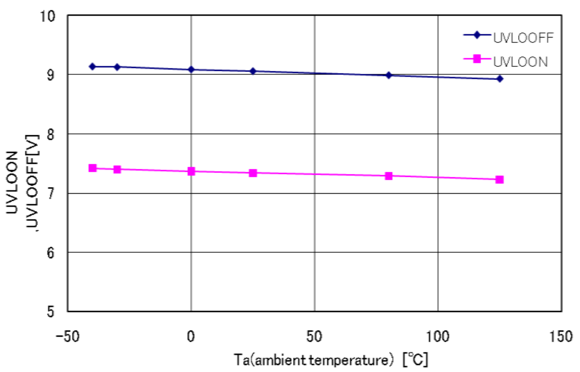
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Reference Voltage block						
Built-in Reference Voltage	VREF		0.585	0.605	0.625	V
VREF V_{IN} line regulation	VREF_LN	V_{IN} = 8.5 to 24V		±0.5		%
Under Voltage Lockout						
Operation Start Input Voltage	UVLOON		8	9	10	V
Operation Stop Input Voltage	UVLOOFF		6.3	7.3	8.3	V
Hysteresis Voltage	UVLOH			1.7		V
Oscillation						
Frequency	FOSC		40	50	60	kHz
Maximum ON duty	MAXDuty			93		%
Comparator						
Input offset Voltage (Between CS and VREF)	V_{IO}_VR			1	10	mV
Input current	IIOCS			160		nA
	IIOREF			80		nA
CS pin max voltage	VOM				1	V
malfunction prevention mask time	TMSK			150		ns
Thermal protection Circuit						
Thermal shutdown temperature	TSD	*Design guarantee		165		°C
Thermal shutdown hysteresis	ΔTSD	*Design guarantee		30		°C
Drive Circuit						
OUT sink current	I_OI		500	1000		mA
OUT source current	I_OO			120		mA
Minimum On time	TMIN			200	300	ns
VIN current						
UVLO mode V_{IN} current	I_{CC}OFF	V_{IN}<UVLOON		80	120	μA
Normal mode V_{IN} current	I_{CC}ON	V_{IN}>UVLOON, OUT = OPEN		0.6		mA
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)

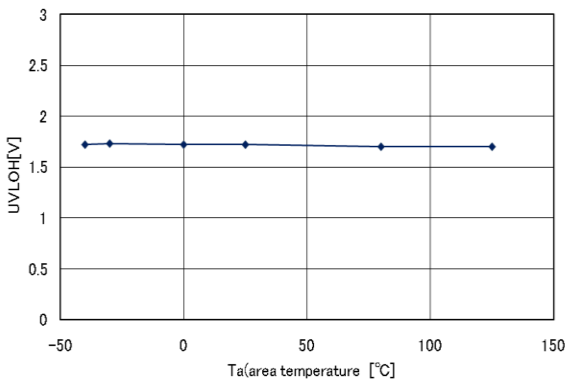
TYPICAL CHARACTARISTICS



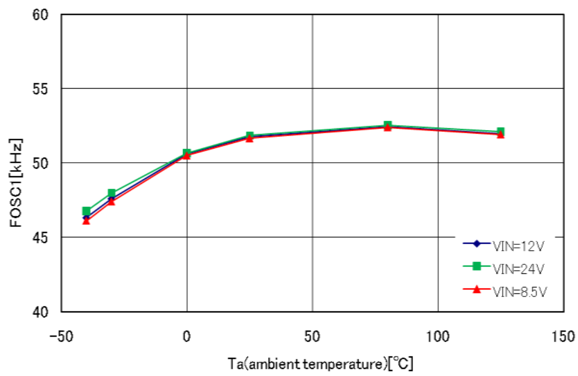
VREF(reference voltage) vs Ta(ambient temperature)



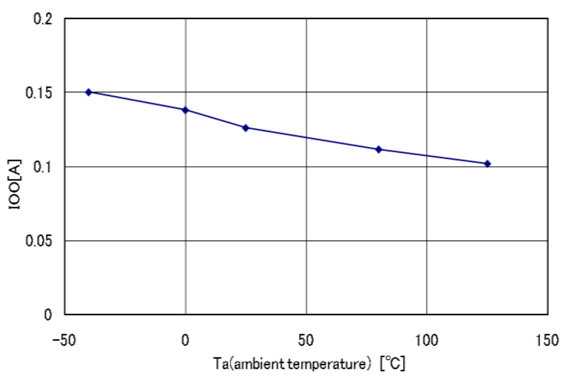
UVLOON, UVLOOFF(UVLOoperating voltage) vs Ta(ambient temperature)



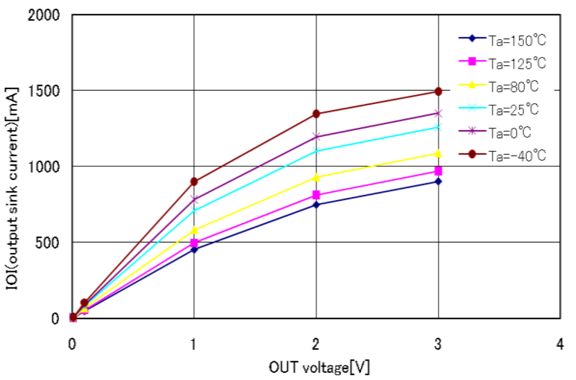
UVLO Hysteresis vs Ta(ambient temperature)



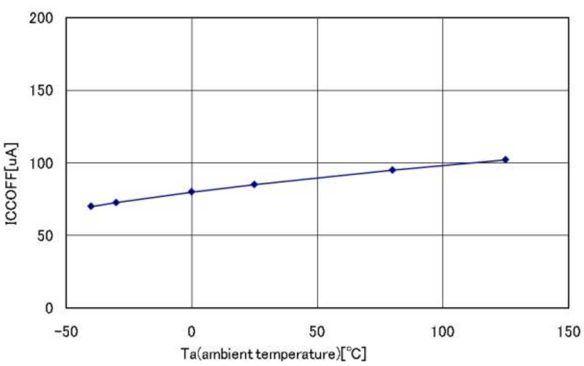
FOSC1(50kHz)(reference scillation freq vs Ta(ambient temperature)



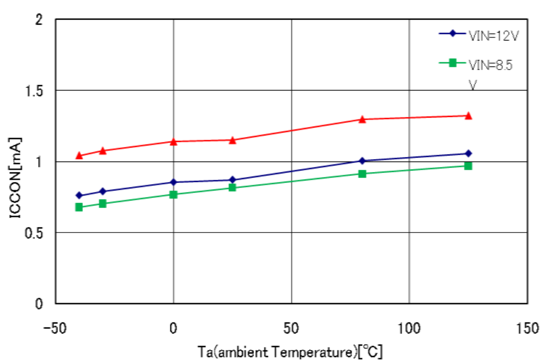
IOO(output source current) vs Ta(ambient temperature)



IOI(output current) vs OUT voltage

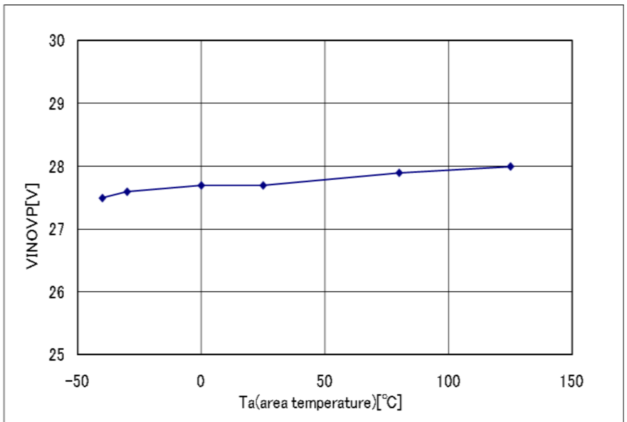


ICCOFF(static current consumption) vs Ta(ambient temperature)

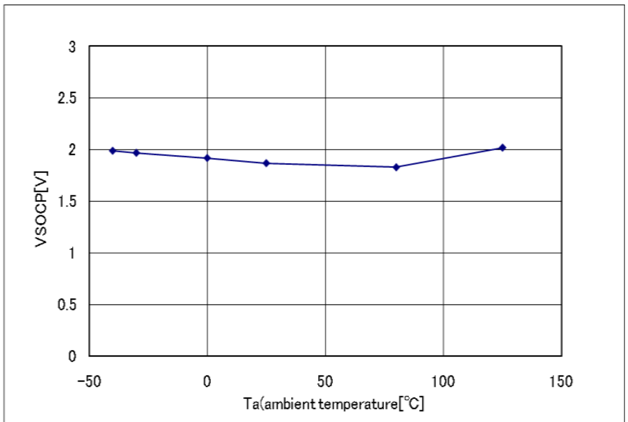


ICCON(curreent consumption) vs Ta(ambient temperature)

TYPICAL CHARACTARISTICS



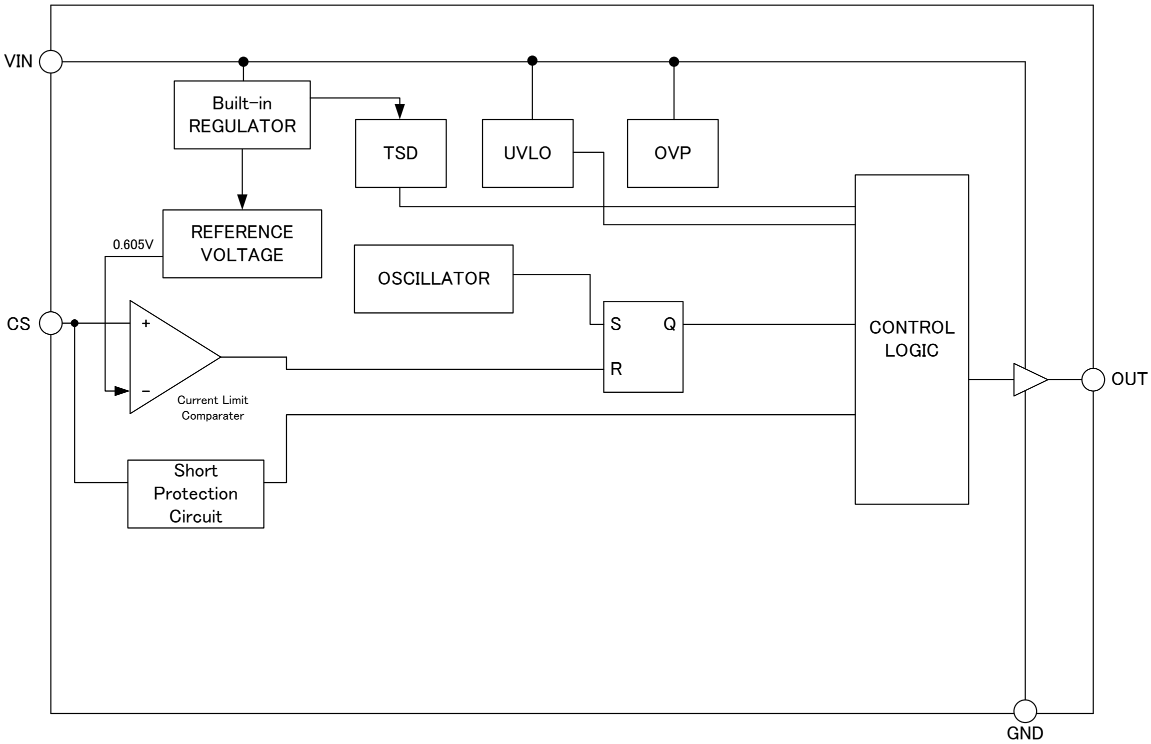
VINOVP vs Ta(ambient temperature)



CSOCP(CS error detection voltage) vs Ta(ambient temperature)

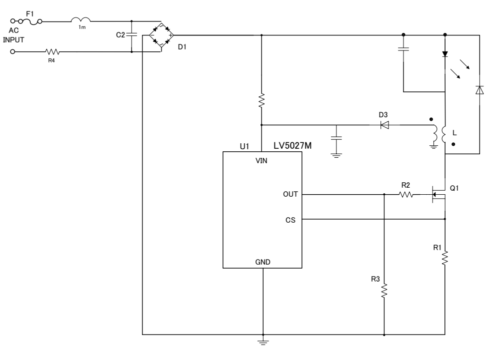
TYPICAL CHARACTARISTICS

Block Diagram

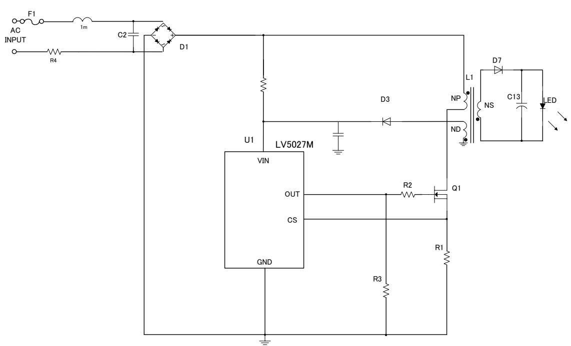


Sample Application Circuit

Non isolation

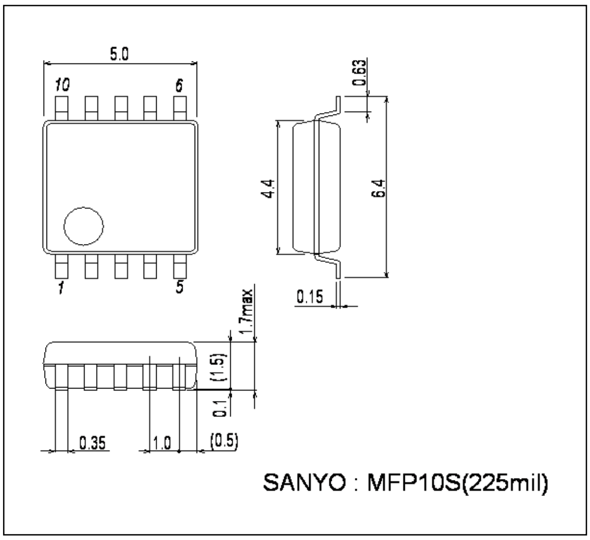


Isolation

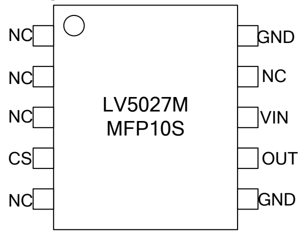


Package Dimensions

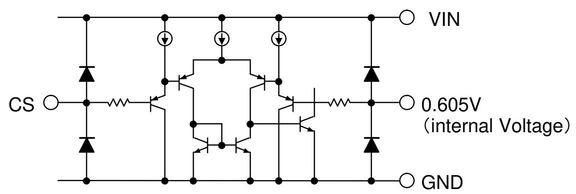
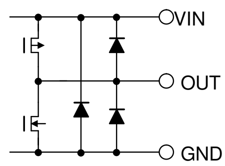
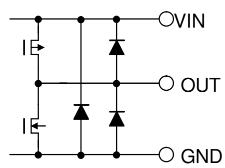
unit: mm (typ)
3086B



Pin Assignment

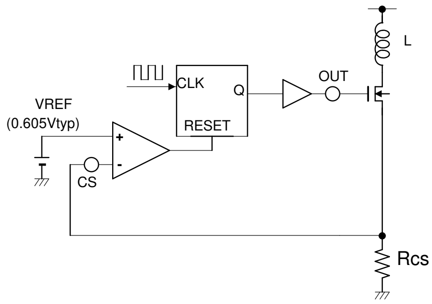


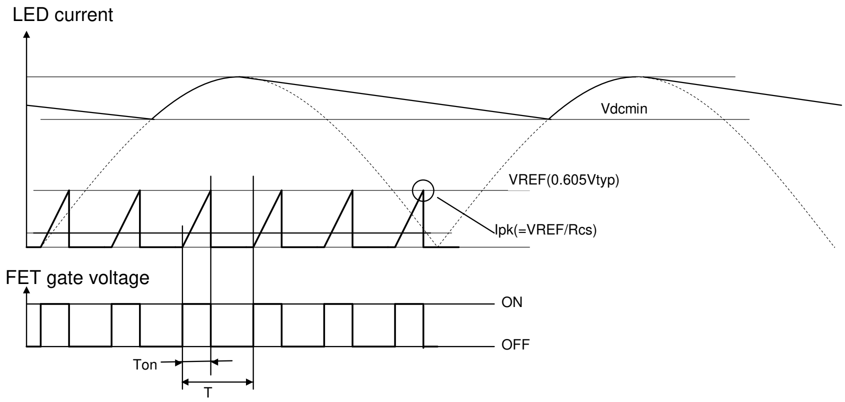
Pin Functions

pin No	Pin Name	Pin Function	Equivalent Circuit
1	NC	No connection	
2	NC	No connection	
3	NC	No connection	
4	CS	LED current sensing in. If this terminal voltage exceeds VREF, external FET is OFF. And if the voltage of the terminal exceeds 1.9V, LV5027M turns to latch-off mode.	
5	NC	No connection	
6	GND	GND pin.	
7	OUT	Driving the external FET Gate Pin.	
8	VIN	Power supply pin. Operation : VIN＞UVLOON Stop: VIN＜UVLOOFF Switching Stop : VIN>VINOVP	
9	NC	No connection	
10	GND	GND pin.	

Relation ship beween VREF and CS pin voltage

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 VREF(internal reference voltage) voltage and Rcs voltage.





$$Ipk = \frac{VREF}{Rcs}$$

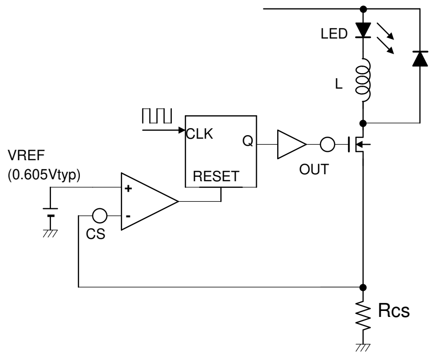
Ipk: peak inductor current
VIN: AC power-supply voltage (minimum value)
VREF: Built-in reference voltage (0.605V)
Rcs: External sense resistor

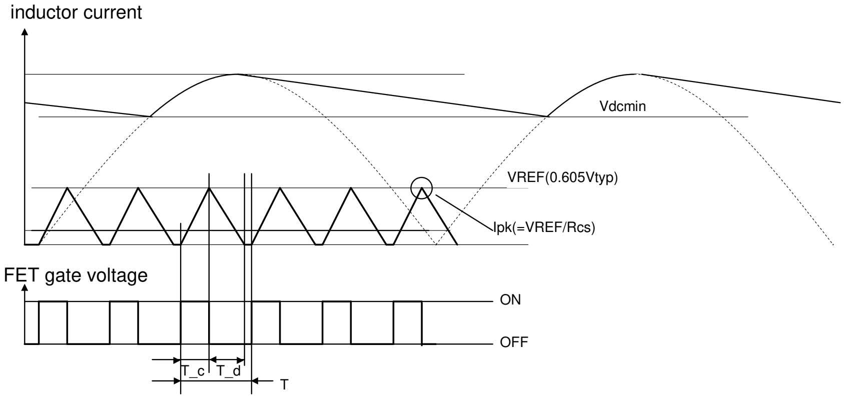
LED current and inductance setting

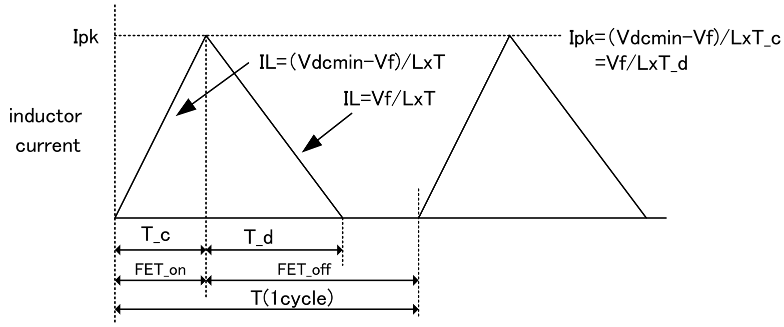
It is available to use both no-isolation and isolation applications.

(For non-isolation application)

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







Given that the period when current flows into coil is

$$\text{DutyI} = \frac{T\_c + T\_d}{T},$$

$$Ipk \times \frac{1}{2} \times (DutyI \times T)/T = ILED$$

$$Ipk = \frac{2 \times ILED}{DutyI} \quad (1) \quad \text{since} \quad Ipk = \frac{VREF}{Rcs}$$

$$Rcs = \frac{VFET}{Ipk} = \frac{DutyI \times VREF}{2ILED} \quad (2)$$

Ipk: peak inductor current
Vf: LED forward voltage drop
Vdcmin: AC power-supply voltage
(Rectified minimum DC voltage)
VREF: Built-in reference voltage (0.605V)
Rcs: External sense resistor

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

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

Since $T\_c + T\_d = DutyI \times T$, $T\_c = DutyI \times T - T\_d$ (4)

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

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

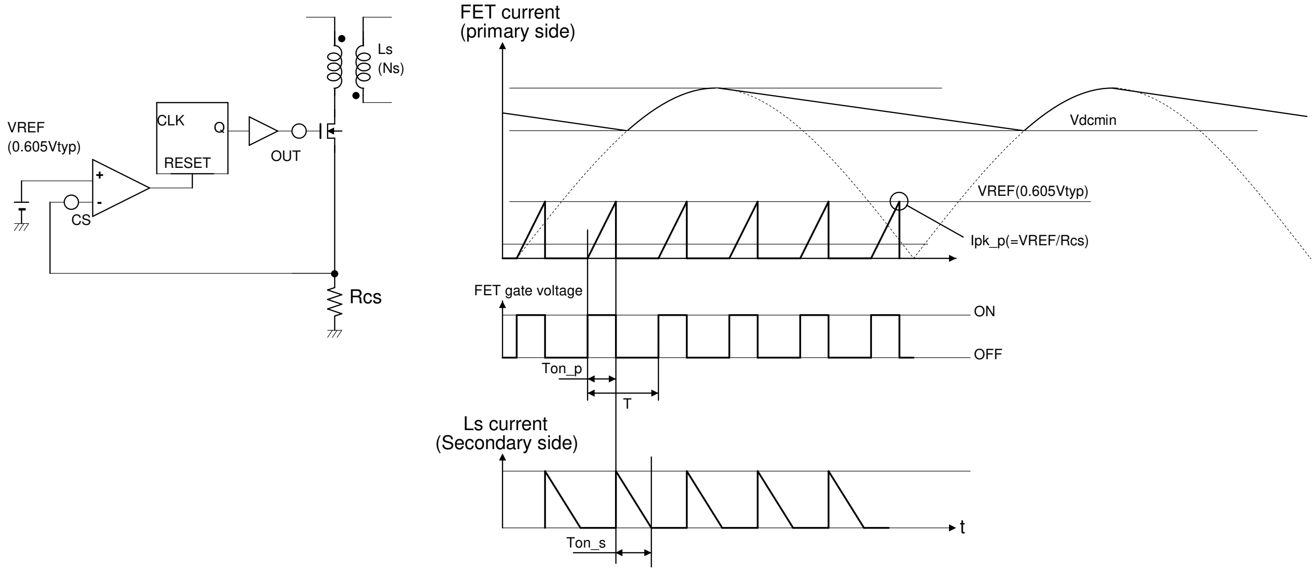
$$L = \frac{Vf \times DutyI}{2 \times ILED} \times DutyI \times T \times \frac{Vdc\min - Vf}{Vdc\min} = \frac{Vf}{2 \times ILED} \times \frac{1}{fosc} \times \frac{Vdc\min - Vf}{Vdc\min} \times (DutyI)^2 \quad (6)$$

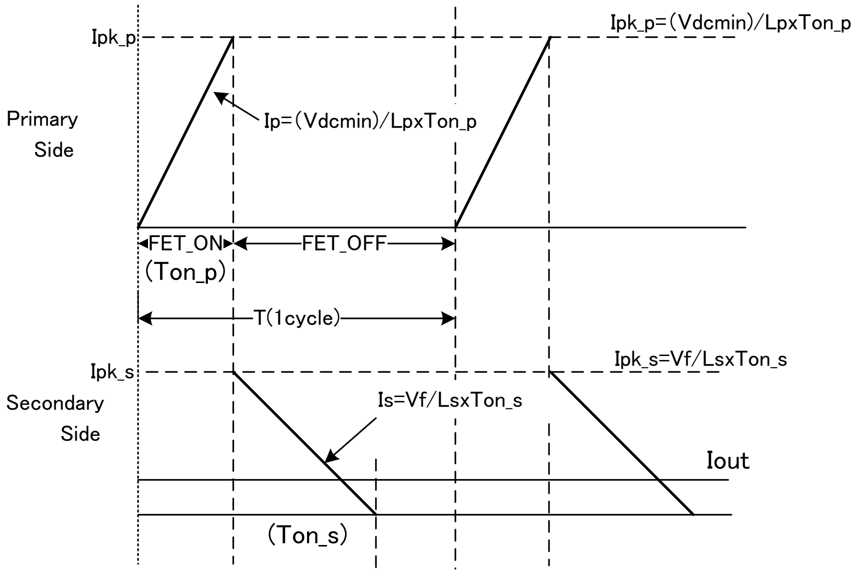
Since LED and inductor are connected in serial in non-isolation mode, LED current flows only when AC voltage exceed VF.

(for Isolation application)

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:

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

$$\because Ipk\_p = \frac{Vdc\min}{Lp} \times Ton\_p \qquad (12)$$

$$\therefore Lp = \frac{Vdc\min^2 \times Ton\_p^2 \times fosc}{2 \times Pin} = \frac{Vdc\min^2 \times Don\_p^2}{2 \times Pin \times fosc} \qquad (13)$$

$$(Don\_p = \frac{Ton\_p}{T} = Ton\_p \times fosc)$$

To substitute the following to the formula below,

$$\because \eta = \frac{Pout}{Pin} \qquad (14)$$

$$\therefore Lp = \frac{Vdc\min^2 \times Ton\_p^2 \times fosc \times \eta}{2 \times Pout} = \frac{Vdc\min^2 \times Don^2 \times \eta}{2 \times Pout \times fosc} \qquad (15)$$

Sense resistor is obtained as follows.

$$Rs = \frac{VREF}{Ipk\_p} = \frac{VREF \times Lp}{Vdc\min \times Ton\_p} = \frac{VREF \times Lp}{Vdc\min \times Don\_p \times T} \qquad (16)$$

[Inductance Ls of secondary side]
Since output current Iout is the average value of current flows to transformer of secondary side

$$Iout = Ipk\_s \times \frac{Ton\_s}{T} \times \frac{1}{2} = \frac{Ipk\_s \times Don\_s}{2} \quad (Don\_s = \frac{Ton\_s}{T} = Ton\_s \times fosc) \qquad (17)$$

$$Ipk\_s = \frac{Vout}{Ls} \times Ton\_s = \frac{Vout}{Ls} \times \frac{Don\_s}{fosc} \qquad (18)$$

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

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

$$\frac{Ns}{Np} = \frac{\sqrt{Ls}}{\sqrt{Lp}} \qquad (20)$$

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

$$\therefore \frac{Np}{Ns} = \frac{Vdc\min}{Vout} \times \sqrt{\eta} \times \frac{Don\_p}{Don\_s} \qquad (21)$$

Calculation of transformer coil on primary side and secondary side

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

⊿B : variation range of core flux density [Gauss]
Ae : core section area [cm^2]

To use Al (L value at 100T),

$$N = \sqrt{\frac{L}{Al}} \times 10^2 \qquad (23)$$

L : inductance [uH]
Al: L value at 100T [uH/N^2]

lg (Air gap) is obtained as follows:

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

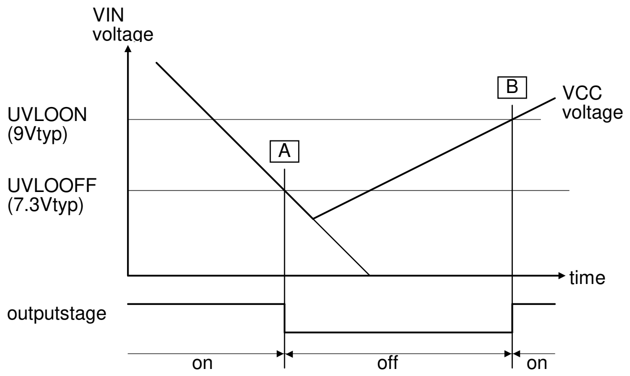
μ_r: relative magnetic permeability, $\mu_r = 1$
μ_0: vacuum magnetic permeability $\mu_0 = 4\pi * 10^{-7}$
N: turn count [T]
Ae: core section area [m^2]
L: inductance [H]

Description of operating protection function

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

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.

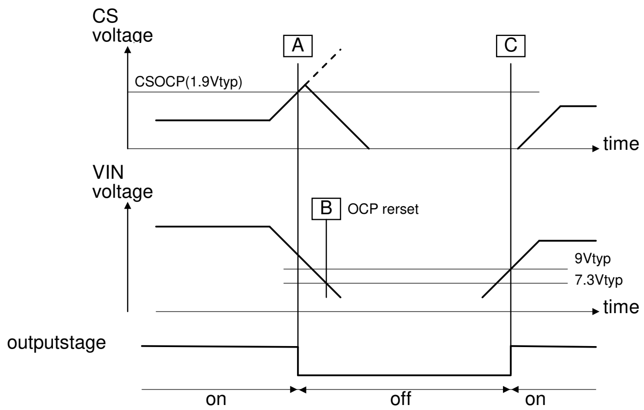


2.OCP(Over Current Protection)

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)(A), the iternal comparator will detect the event and turn off the MOSFET. The peak switch current is calculated

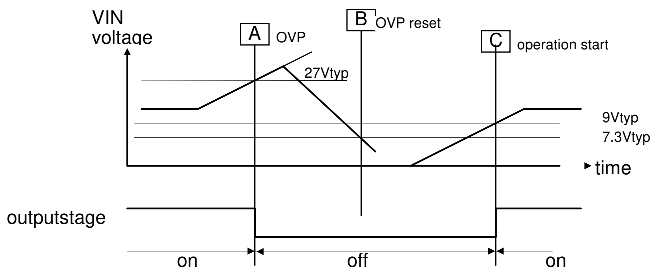
Io(peak) [A] = VSOCP[V]/Rsense[ohm]

The VIN 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 VIN falls below the VIN reset voltage,UVLOOFF(7.3Vtyp)(B). Then VIN rise UVLOON(9Vtyp)(C),restart the switching.



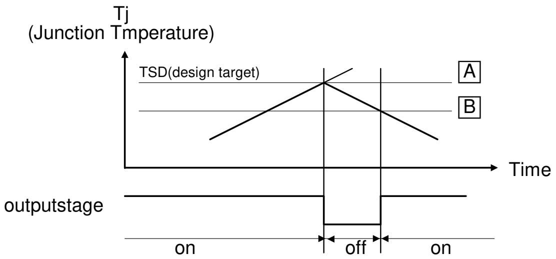
3.OVP(Over Voltage Protection)

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.



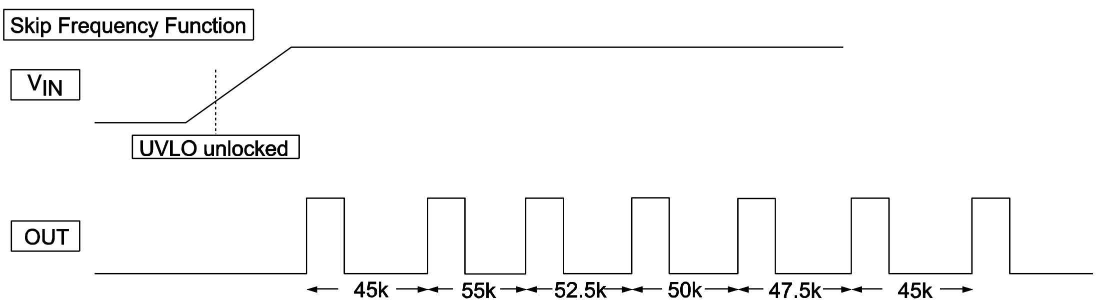
4.TSD(thermal Shut Down protection

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



Skip frequency function

LV5027M 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.
… ×0.9 → ×1.1 → ×1.05 → ×1 → ×0.95 → ×0.9 → ×1.1 …
It's repeated by this loop.

This catalog provides information as of March, 2011. Specifications and information herein are subject to change without notice.