Ordering number : ENA****

SANYO

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)



SANYO Semiconductor Co., Ltd.
http://semicon.sanyo.com/en/network

**Recommended Operating Conditions** at Ta = 25°C

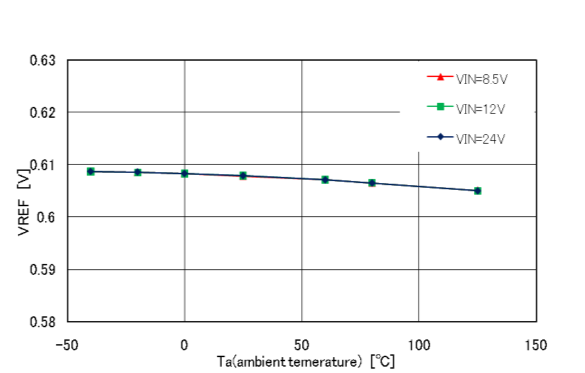
| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Input voltage | $V_{IN}$ | | 8.5 to 24 | V |

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

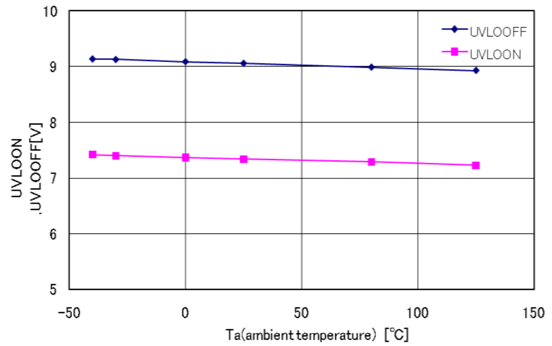
| Parameter | Symbol | Conditions | Ratings | | | Unit |
|---|---|---|---|---|---|---|
| | | | min | typ | max | |
| **Reference Voltage block** | | | | | | |
| Built-in Reference Voltage | VREF | | 0.585 | 0.605 | 0.625 | V |
| VREF $V_{IN}$ line regulation | VREF_LN | $V_{IN}$ = 8.5 to 24V | | ±0.5 | | % |
| **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 | $I_{O}$I | | 500 | 1000 | | mA |
| OUT source current | $I_{O}$O | | | 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)

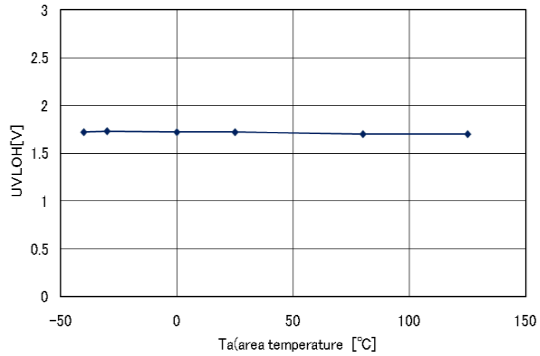
## TYPICAL CHARACTARISTICS



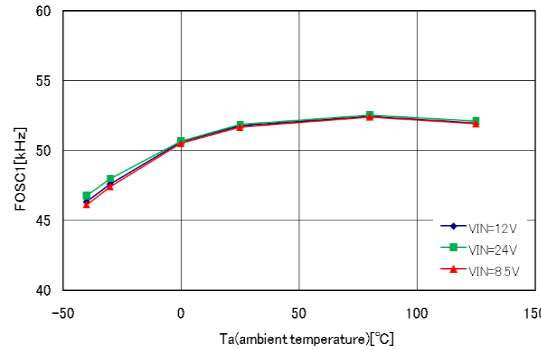

VREF(reference voltage) vs Ta(ambient temperature)



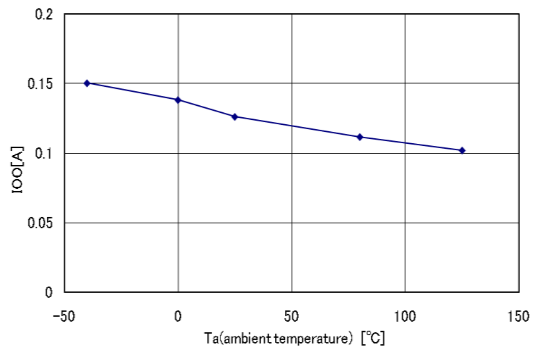

UVLOON, UVLOOFF(UVLOoperating voltage) vs Ta(ambient temperature)



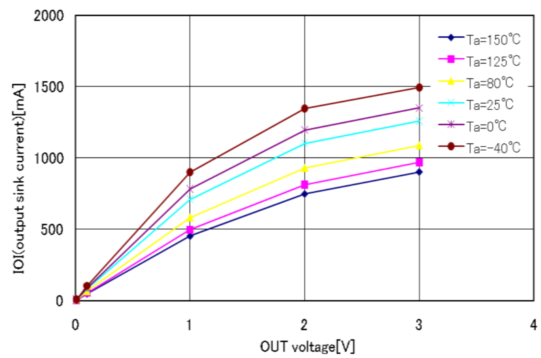

UVLO Hysteresis vs Ta(ambient temperature)



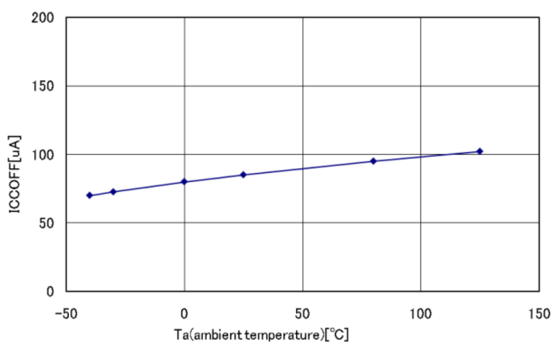

FOSC1(50kHz)(reference scillation freq vs Ta(ambient temperature)



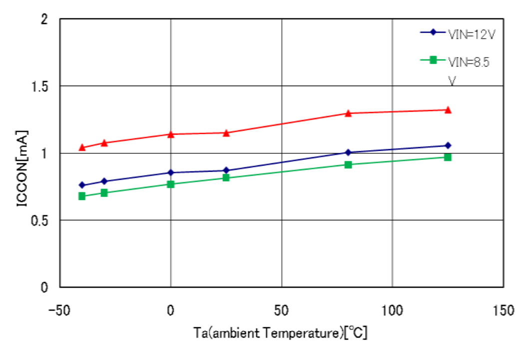

IOO(output source current) vs Ta(ambient temperature)




IOI(output current) vs OUT voltage

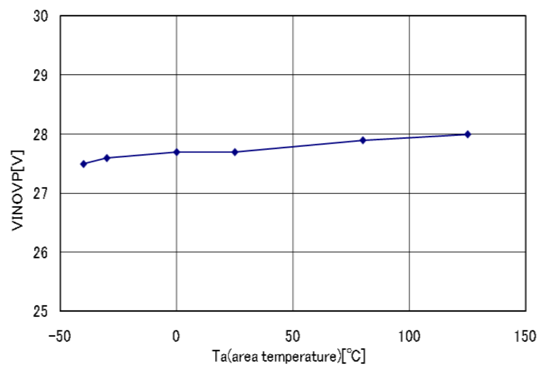



ICCOFF(static current consumption) vs Ta(ambient temperature)

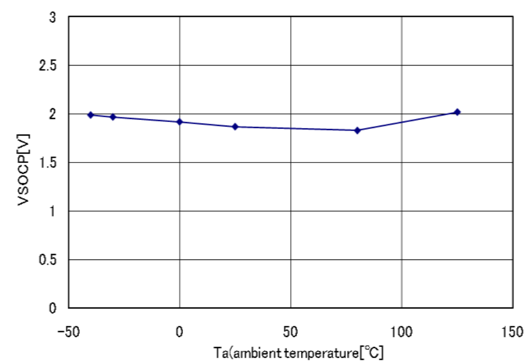



ICCON(curreent consumption) vs Ta(ambient temperature)

## TYPICAL CHARACTARISTICS



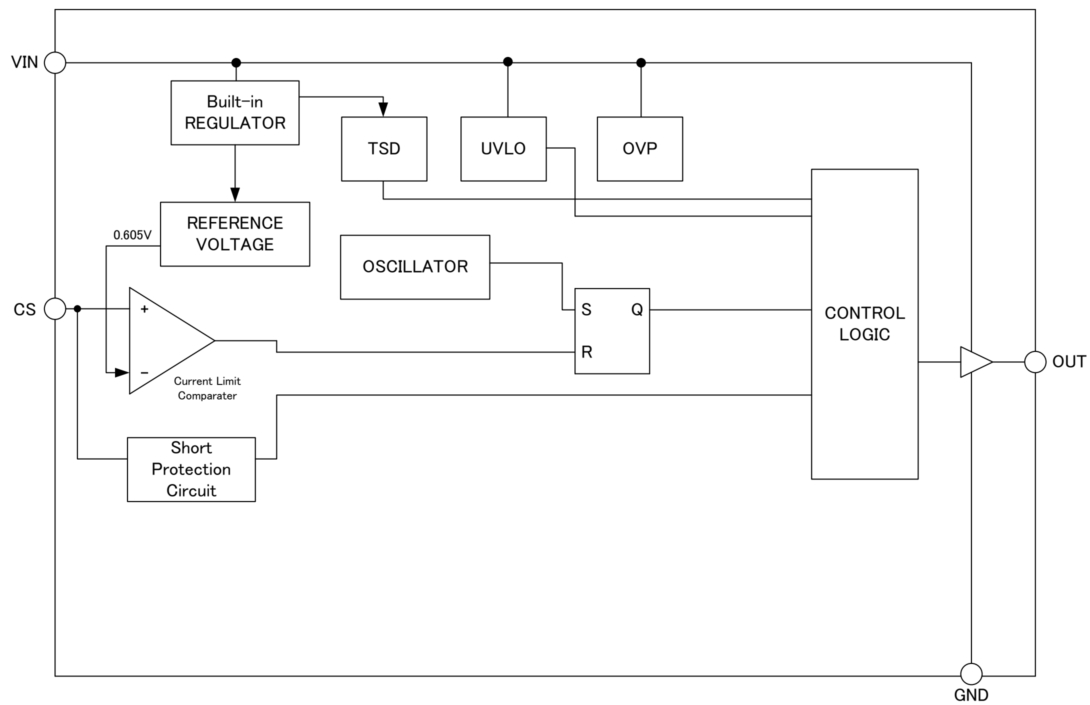

VINOVP vs Ta(ambient temperature)




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

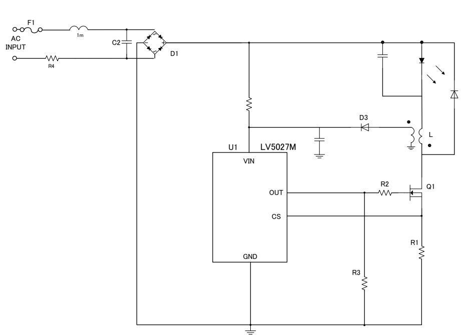
## TYPICAL CHARACTARISTICS

### Block Diagram

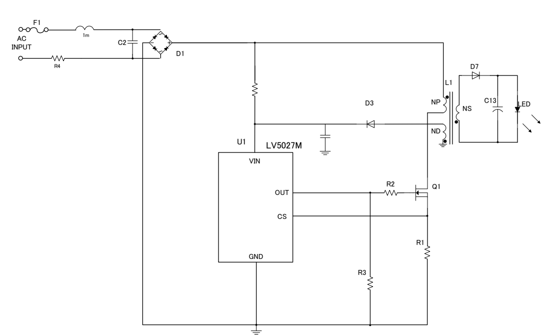



### Sample Application Circuit

#### Non isolation

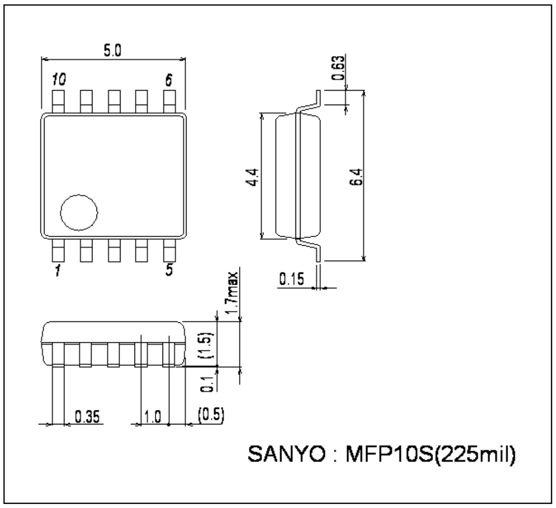



#### Isolation

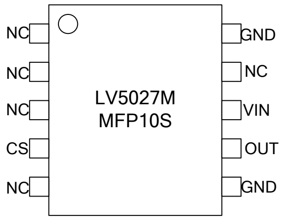


## Package Dimensions

unit: mm (typ)
3086B

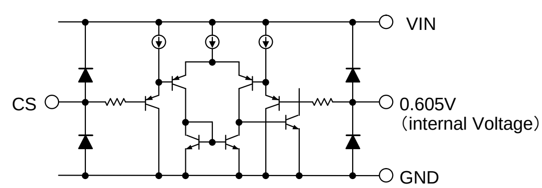
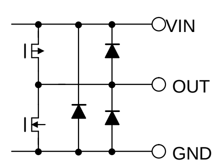
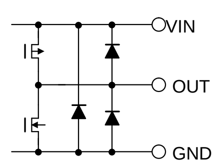



## Pin Assignment



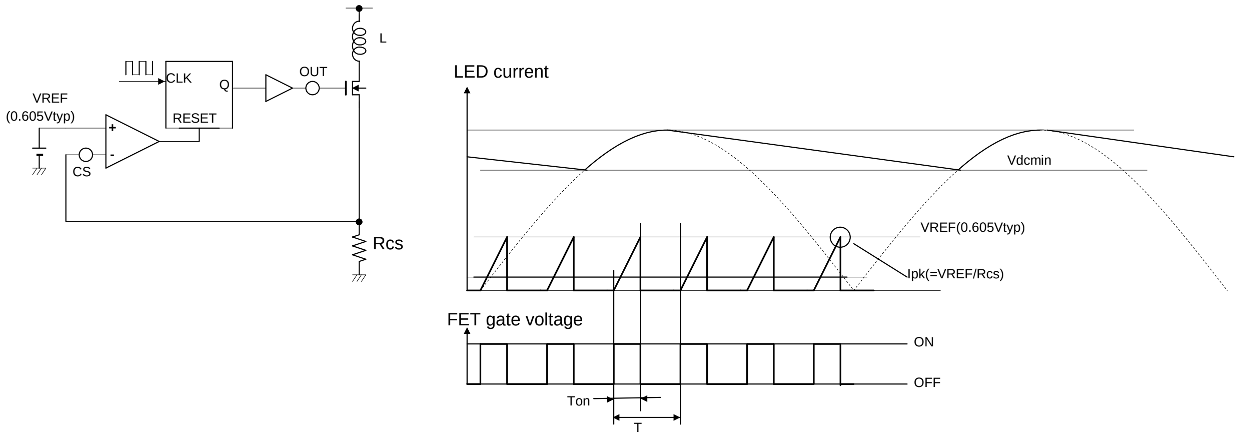

(TOP VIEW)

## 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.<br>Operation : VIN＞UVLOON<br>Stop: VIN＜UVLOOFF<br>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.




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

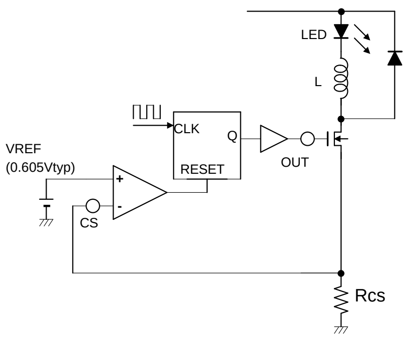
Ipk: peak inductor current
VIN: AC power-supply voltage (minimum value)
VREF: Built-in reference voltage (0.605V)
Rcs: External sense resistor

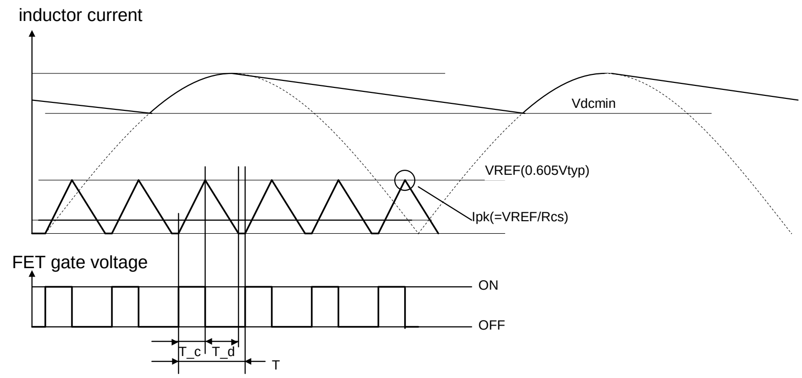
### LED current and inductance setting

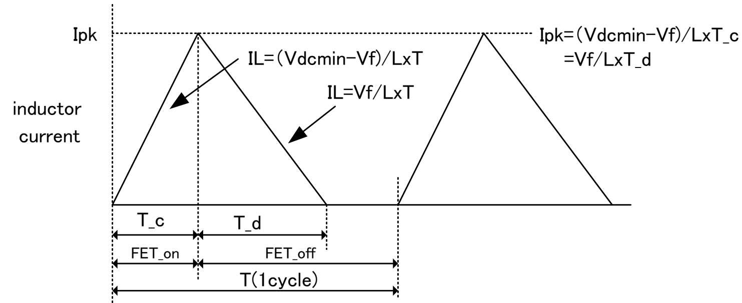
It is available to use both no-isolation and isolation applications.

**(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

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

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

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

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

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),

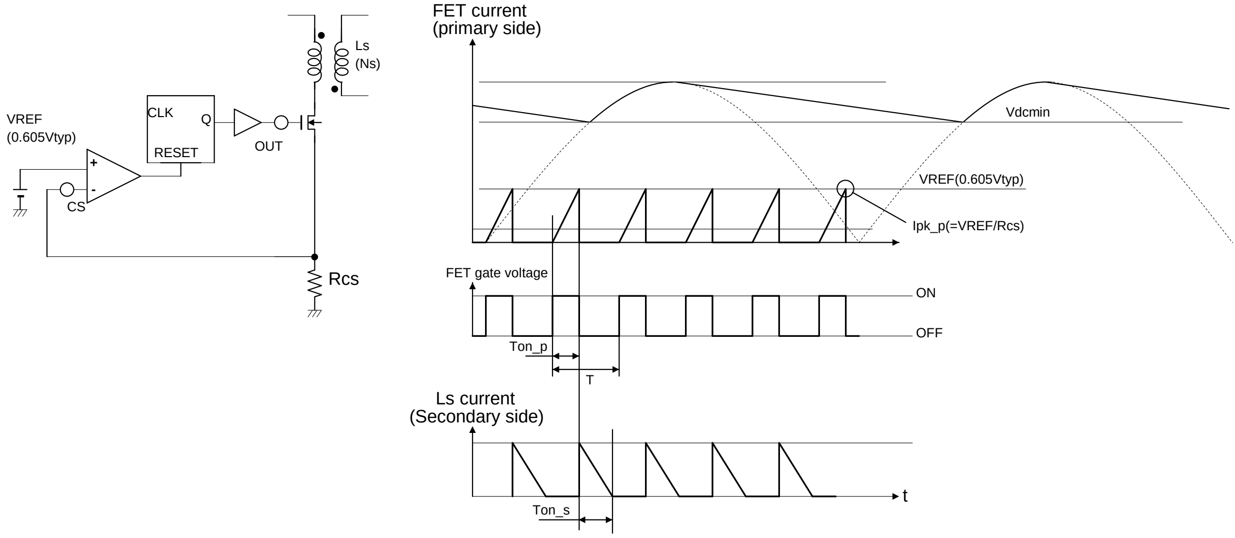
$$L = \frac{Vf \times DutyI}{2 \times ILED} \times DutyI \times T \times \frac{Vdc\min - Vf}{Vdc\min} = \frac{Vf}{2 \times ILED} \times \frac{1}{fosc} \times \frac{Vdc\min - Vf}{Vdc\min} \times (DutyI)^2 \quad (6)$$

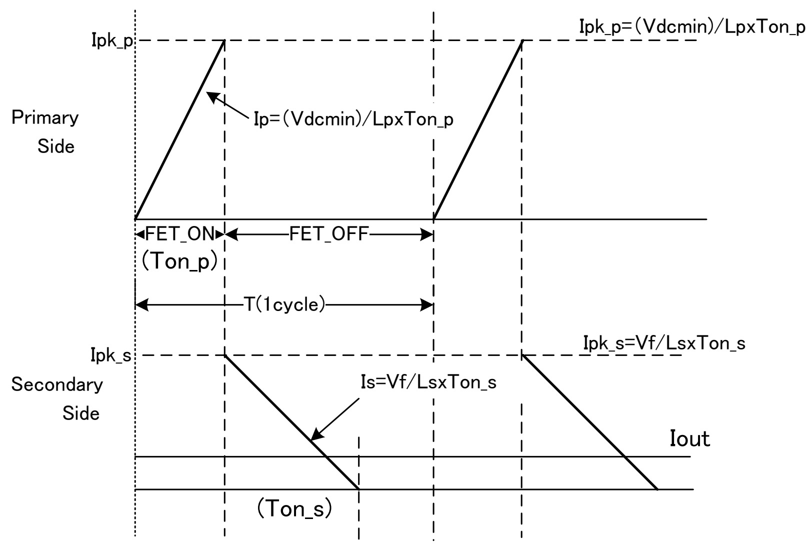
Since LED and inductor are connected in serial in non-isolation mode, LED current flows only when AC voltage exceed VF.

**(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

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

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

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

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:

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

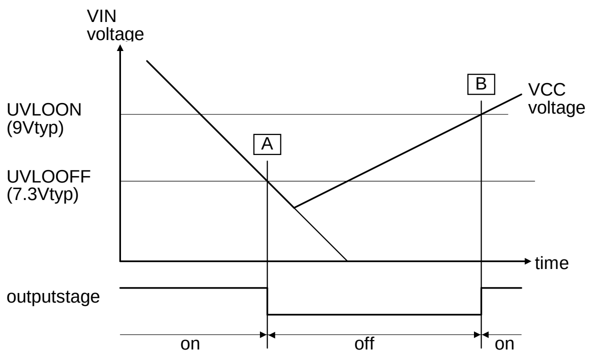
$\mu_r$: relative magnetic permeability, $\mu_r = 1$
$\mu_0$: vacuum magnetic permeability $\mu_0 = 4\pi * 10^{-7}$
N: turn count [T]
Ae: core section area [$m^2$]
L: inductance [H]

**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.

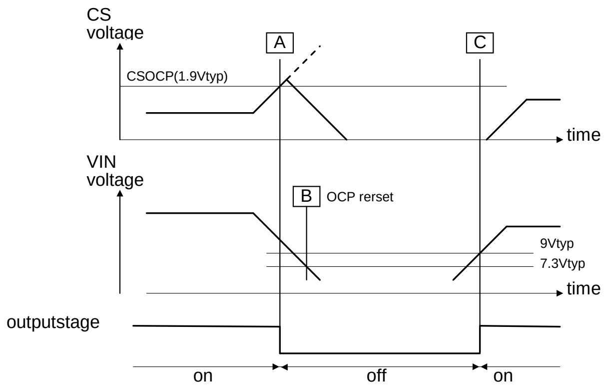



**2.OCP(Over Current Protection)**

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

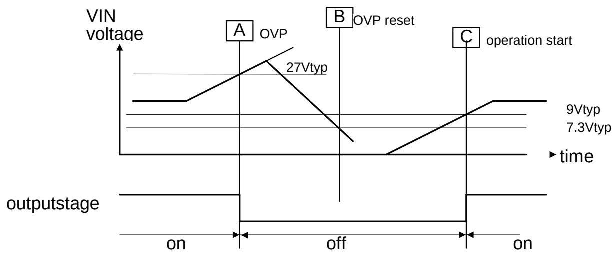
Io(peak) [A] = VSOCP[V]/Rsense[ohm]

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.



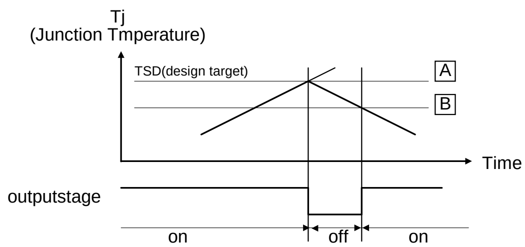
### 3.OVP(Over Voltage Protection)

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.



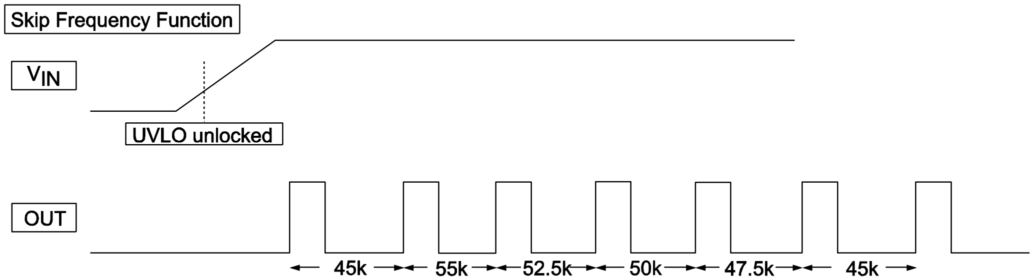

### 4.TSD(thermal Shut Down protection

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.