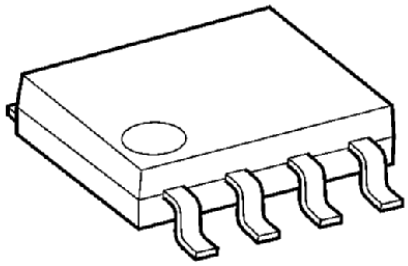
TOSHIBA CD-MOS Integrated Circuit Silicon Monolithic

TC62D902FG

Offline Isolated AC/DC Flyback LED Controller built-in PFC

TC62D902FG



P-SOP8-0504-1.27-001

Weight : 0.07g (typical)

1. Overview

This product is an isolation type flyback mode LED controller.
This device is controlling an average LED current from the primary side current value and the bias side impulse-wave of the transformer and the detection circuit of the secondary side is unnecessary.
Then, this product has the active PFC function of the single stage mode and the active bleeder pin to do triac dimmer and realizes LED lighting with few components.

2. Application

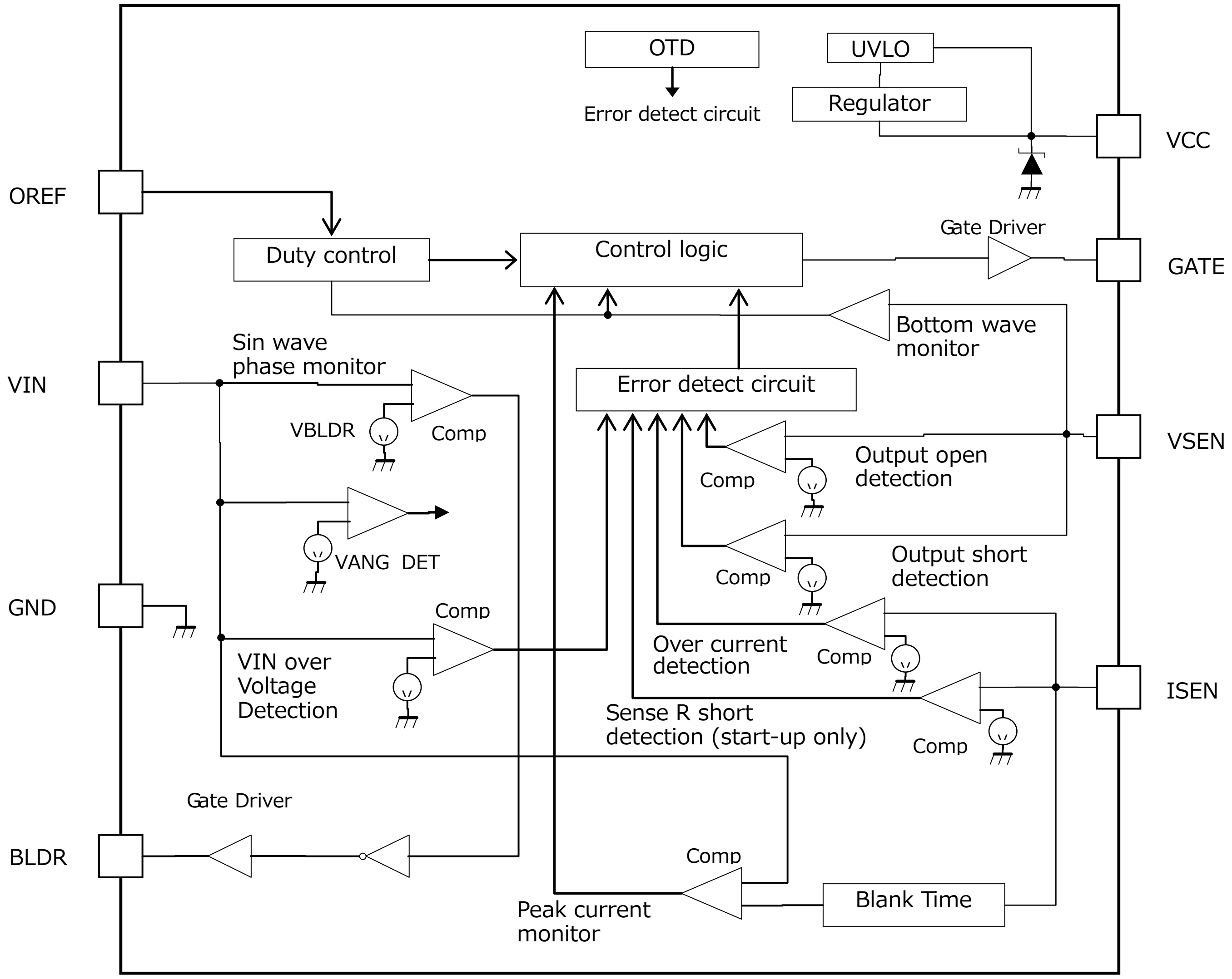
Isolated AC/DC LED lighting

3. Features

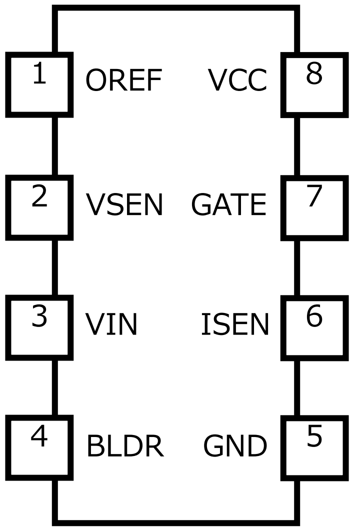
- The isolation type LED control with few components
- The triac dimmable
- Single stage mode PFC
- The secondary side photo-coupler is unnecessary.
- The bottom switch function for the efficiency and the noise modification
- Detection functions
  - The VCC reduced voltage detection (UVLO, Under voltage Lockout)
  - The VIN over-voltage detection (VIN-OVD)
  - The sense resistor short detection at Start-Up (SRSD)
  - The sense wiring open detection (SWOD)
  - The over temperature detection (OTD)
  - The output LED open detection (OOD)
  - The output LED short detection (OSD)
  - The over-current detection at the primary side (OCD)

- Package : P-SOP8-0504-1.27-001

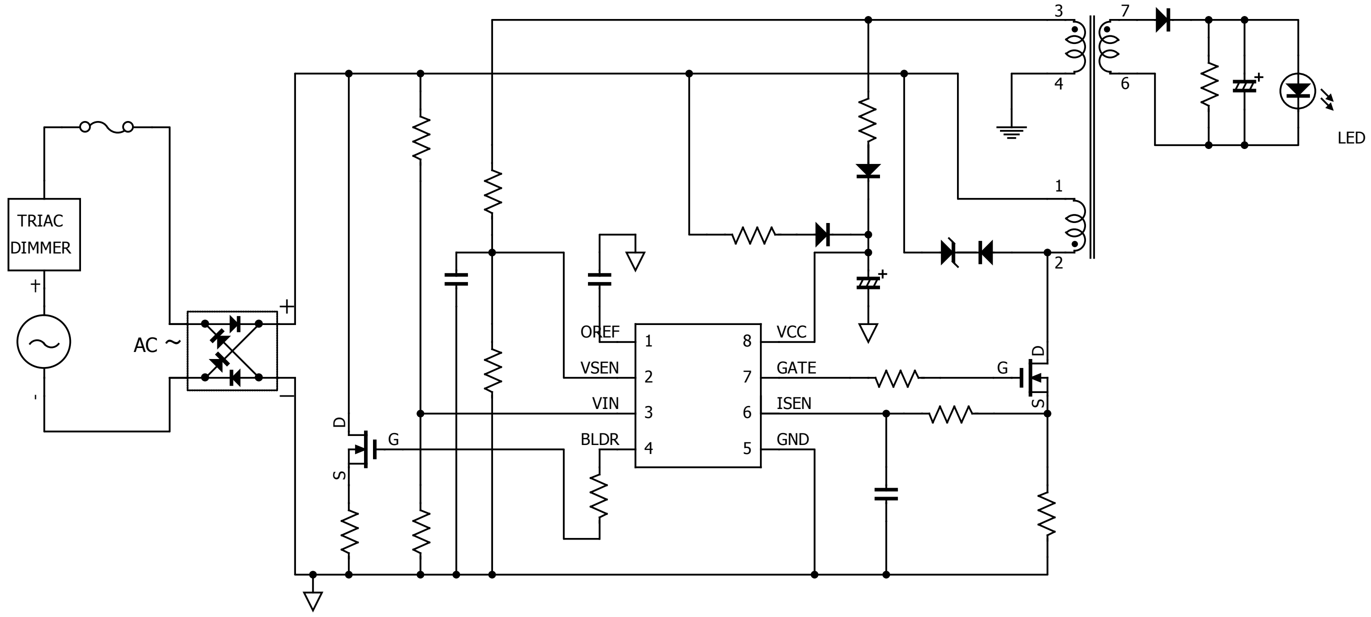
4. Block Diagram



5. Pin Layout



6. Application circuit (Only the basic part)

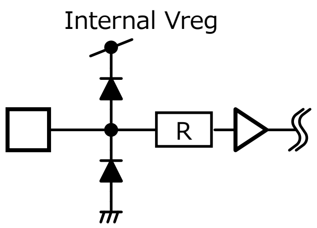


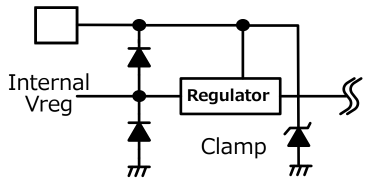
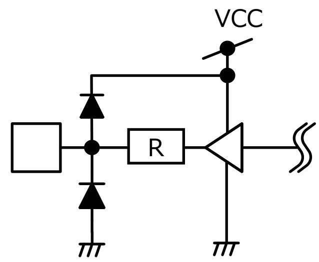
7. Pin Function

Pin No.	Pin name	I/O	Function
1	OREF	I	This is a capacitor connection pin for the internal-oscillator.
2	VSEN	I	This is a monitor pin with secondary side current pulse width.
3	VIN	I	This is the input pin of the sine wave for PFC.
4	BLDR	O	This is the on signal output pin of the outer MOSFET which passes a bleeder current.
5	GND	P	This is a ground pin.
6	ISEN	I	This is the voltage sense pin of the primary side current.
7	GATE	O	This is an outer power MOSFET on signal output pin.
8	VCC	P	This is a connection pin in the IC function supply.

I: Input Pin, O: Output Pin, P: Pin of Supply and Ground.

8. Similar circuit of input and output Pin

Pin No.	Pin name	Equivalent circuit
1	OREF	
2	VSEN	
3	VIN	
6	ISEN	

Pin No.	Pin name	Equivalent circuit
8	VCC	
5	GND	
4	BLDR	 BLDR : R=270 ohm typ. GATE : R=0
7	GATE	

9. Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating Note1	Unit	Remark
Supply voltage	VCC	–0.3~ 26	V	
OREF terminal voltage	VOREF	–0.3~ 6.0	V	
VSEN terminal voltage	VVSEN	–0.7~ 6.0	V	
VIN terminal voltage	VVIN	–0.3~ 6.0	V	
BLDR terminal voltage	VBLDR	–0.3~ VCC	V	
ISEN terminal voltage	VISEN	–0.3~ 6.0	V	
GATE terminal voltage	VGATE	–0.3~VCC	V	
Operating temperature	Topr	–40~85	°C	
Storage temperature	Tstg	–55~150	°C	
Thermal resistance	Rth(j-a)	105	°C/W	Note2
Power dissipation	PD	1.19	W	Note3

Note1: The voltage value is a ground standard.
Note2: Junction-to-ambient thermal resistance is highly application and board-layout dependent.
Note3: When ambient temperature is 25°C or more. Every time ambient temperature exceeded 1°C, please decrease 1/Rth(j-a).

Topr : the ambient air temperature of IC under operation.
Tj : It is the junction temperature of IC under operation.
Tj maximum is restricted by the TSD (thermal shutdown) circuit.
Tj maximum recommends carrying out a thermal design within the limit of a 120 °C

Cautions on absolute maximum ratings

The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.

Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

The value of even one parameter of the absolute maximum ratings should not be exceeded under any circumstances. This device does not have over-voltage protection. Therefore, the device is damaged if a voltage exceeding its rated maximum is applied.

All voltage ratings including supply voltages must always be followed. The section on the protection features on the latter page should also be referred to.

10. Electrical Characteristics (Unless otherwise noted, Ta = -40~85 °C, VCC=15V)

Characteristics	Symbol	Test Circuit	Test Conditions	Min	Typ.	Max	Unit
<VCC part>							
Maximum operating voltage	VCC(MAX)			-	-	25	V
Start-up current	IINST		VIN=10V, C_{VCC}=10µF	-	10	15	µA
Operating supply current	ICC		BLDR=OFF, GATE=OFF	-	1.7	2.5	mA
Zener diode clamp voltage	VZ		Ta = 25°C, Iz = 5 mA	29	-	-	V
UVLO release threshold voltage	VUVLO(REL)		VCC rising	11	12	13	V
UVLO operation threshold voltage	VUVLO(OPE)		VCC falling	6.5	7.5	8.5	V
<VIN part>							
Input voltage range	VIN			0	-	1.8	V
VIN-OVD threshold voltage	VVIN-OVD			1.85	2.10	2.35	V
Conduction angle detection voltage	VANG_DET			0.10	0.14	0.18	V
<BLDR part>							
BLDR terminal off voltage	VBLDR			0.22	0.28	0.34	V
BLDR terminal source resistance	RBLDRH		IBLDR=-5mA	-	300	-	Ω
BLDR terminal sink resistance	RBLDRL		IBLDR=+5mA	-	300	-	Ω
BLDR terminal output voltage	VBLDR			-	Vcc	-	V
<VSEN part>							
Input leakage current	IIN(Vsen)		VSENSE = 2 V	-	-	1	µA
Valley detection voltage	VVMS			0.10	0.14	0.18	V
OOD threshold voltage	VOOD			1.85	2.10	2.35	V
OSD threshold voltage	VOSD			0.10	0.14	0.18	V
<GATE part>							
GATE terminal sauce resistance	RGATEH		IGATE=-10mA	-	30	-	Ω
GATE terminal sink resistance	RGATEL		IGATE=+10mA	-	20	-	Ω
GATE terminal rise time	trGATE		CL=330pF,10% to 90%, Ta=25°C	-	50	-	ns
GATE terminal fall time	tfGATE		CL=330pF,90% to 10%, Ta=25°C	-	30	-	ns
Maximum operating frequency	fSW(MAX)			200	-	-	kHz
GATE terminal output voltage	VGATE			-	Vcc	-	V
<ISEN part>							
OCD threshold voltage	VOCD			1.85	2.10	2.35	V
IOD threshold voltage	VIOD			1.85	2.10	2.35	V
SWOD threshold voltage	VSWOD			0.10	0.14	0.18	V
Blanking time	tBLANK		Ta=25°C	0.2	0.3	0.4	µs
<OTD part>							
OTD operation temperature	TOTD		Temperature rising	-	140	-	°C
OTD hysteresis temperature	TOTD(HYS)		Temperature falling	-	20	-	°C

11. Description of Operation

The basic circuit of this product is a flyback power supply.
An average LED current value is controlled by the peak current value (IS) of the secondary, and the pulse width (tS) and the duty cycle control..

Start-Up Resistor)

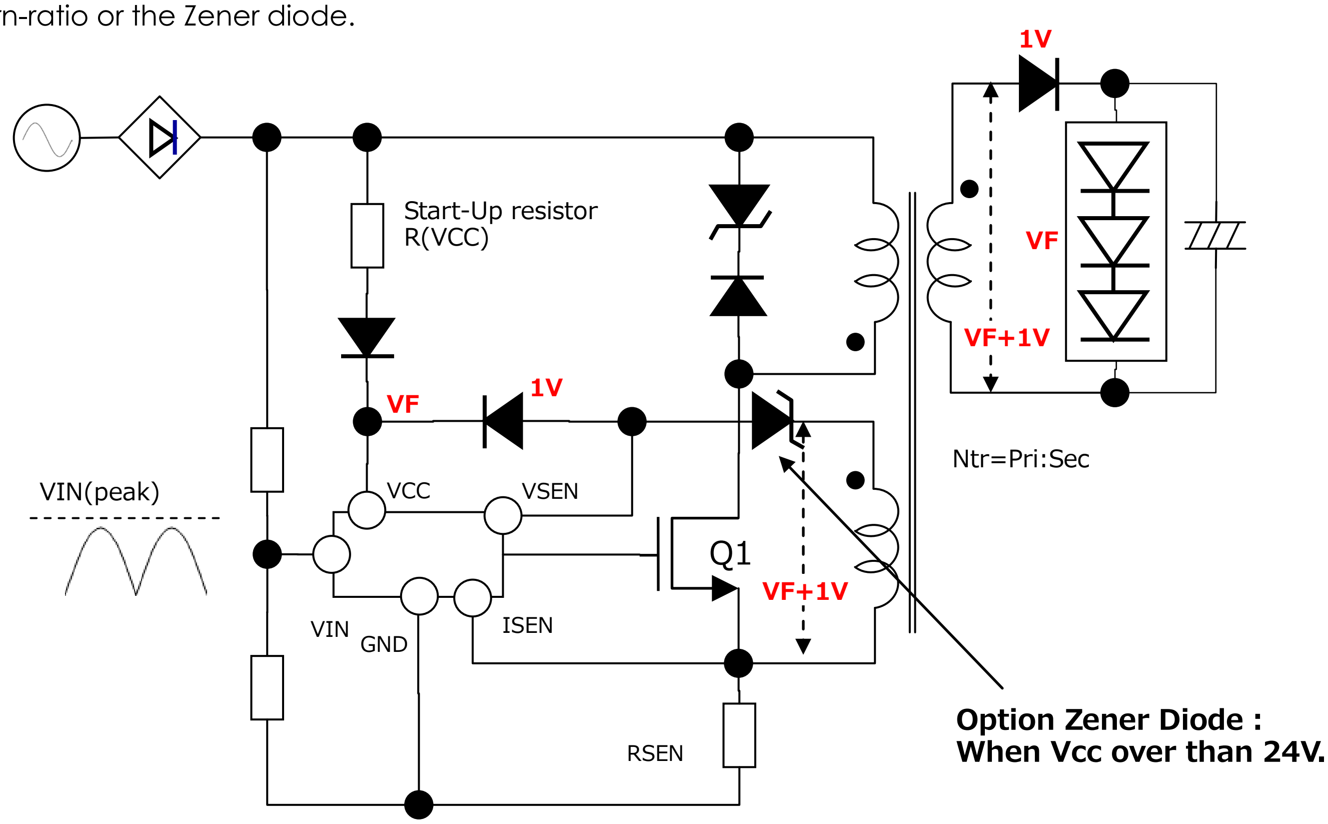
This device is supplied operating current from the VCC terminal. The UVLO release voltage threshold of the VCC pin in this case is a maximum of 13 V, the static operating current is a maximum of 15 μA and the operating supply current is a maximum of 2.5 mA.
Therefore, start-up resistor R (VCC) can be calculated below.

R(VCC) ≦ (IC activation voltage/15μA) - (UVLO release voltage13V/2.5mA)

In the normal operation, this device gets an operating current from the bias side of the transformer. It selects so as not for the VCC pin to exceed 24 V in the turn-ratio of the secondary and the bias. When the turn-ratio is 1, the secondary voltage and the bias voltage are the same almost.

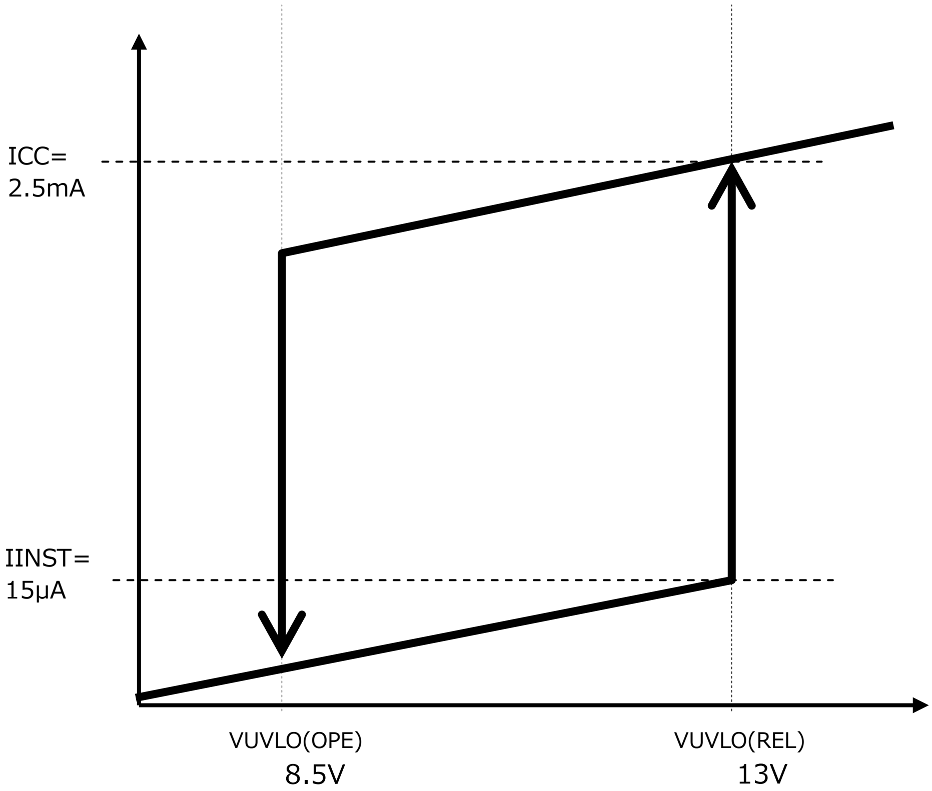
Bias Voltage = LED VF / Turns ratio of Secondary and bias.

For example, if the VF of the LED is equal to or less than 24 V, the turn-ratio of the secondary and the bias is 1:1. When the VF of the LED is bigger than the high value of VCC, it adjusts with the turn-ratio or the Zener diode.



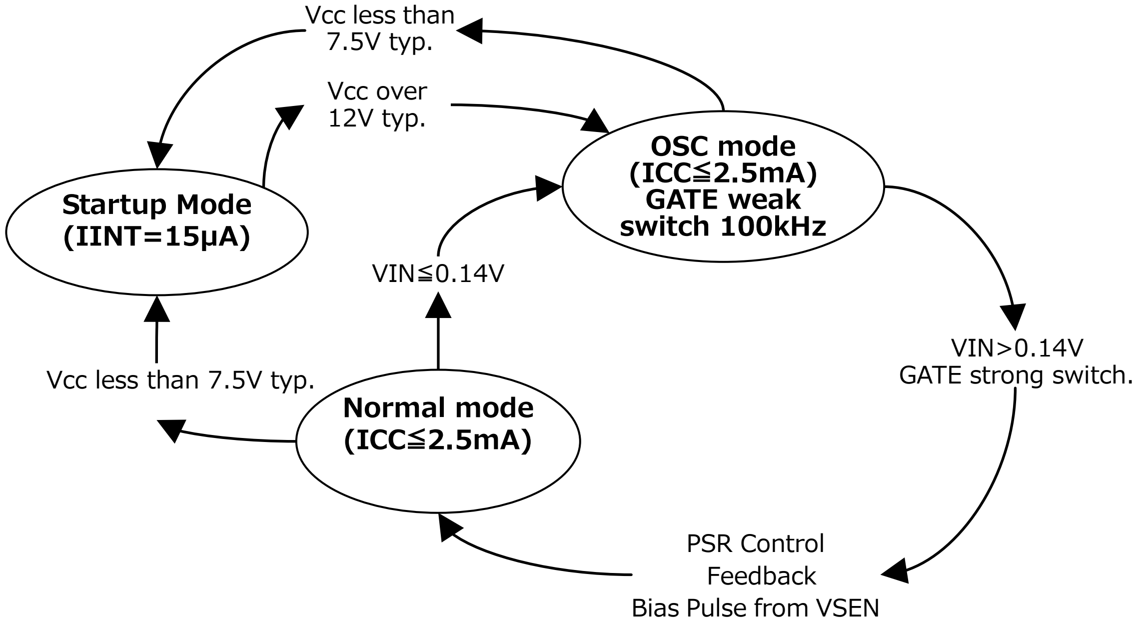
Under Voltage Lock out ; UVLO)

A relation between UVLO and the operating current which watches over the VCC pin is shown in the following figure. Because the this device supplies an operating voltage from the bias side of the triac after starting up in VCC ≥ 13V, it stops a function when the voltage falls below VCC ≤ 8.5V.



Operation sequence)

State-transition-diagram is shown in the following figure.
In start-up time, this device changes a start-up mode and OSC mode with the VCC voltage. After that, in OSC mode, the VSEN pin shifts to PSR control after it recognizes the impulse-wave of the bias side. It continues until the VCC voltage falls below 7.5V typ.

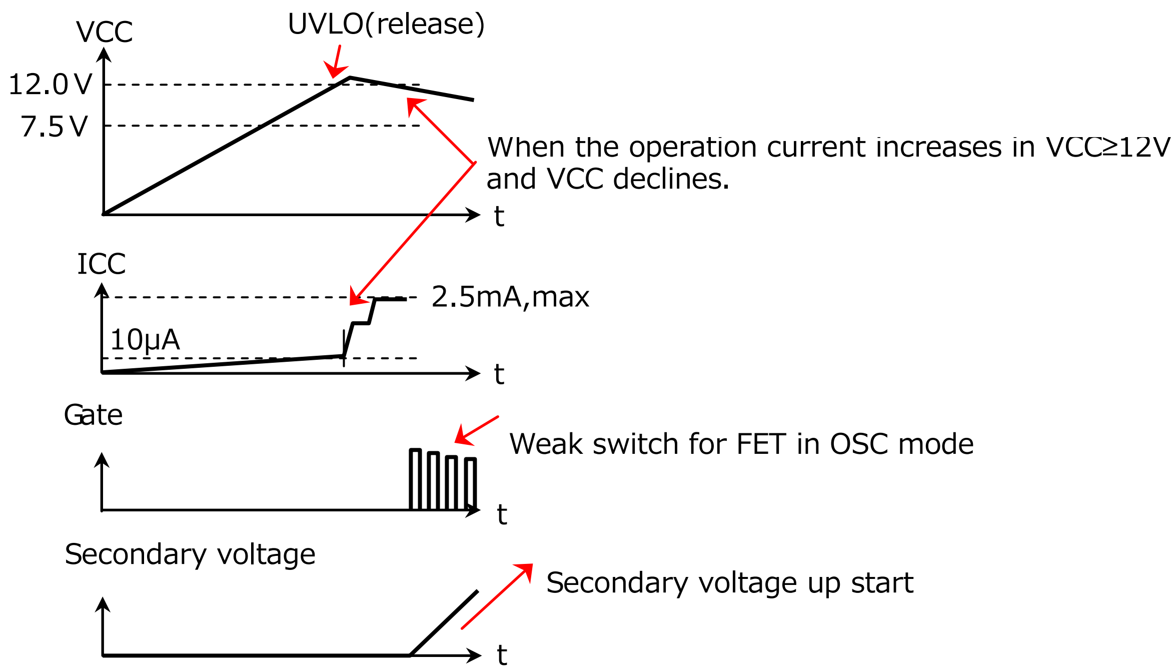


START-UP Mode)

The stand-by and the start-up change from the VCC voltage look out by UVLO.

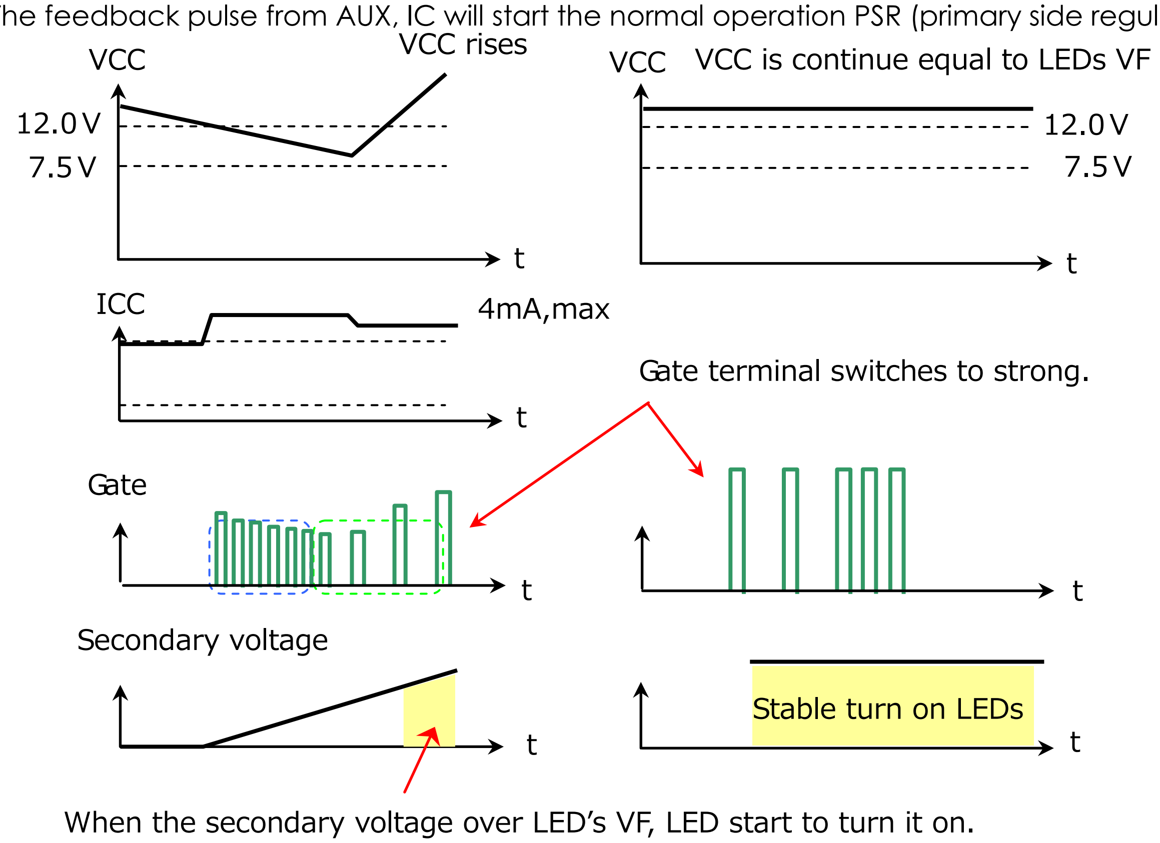
OSC Mode)

When VCC exceeds UVLO(REL) and the VIN voltage is equal to or less than 0.14 V, the GATE pin does weak switch (about 100 kHz).



NORMAL Mode)

In VIN> 0.14V, GATE terminal switches to strong.
The feedback pulse from AUX, IC will start the normal operation PSR (primary side regulation).



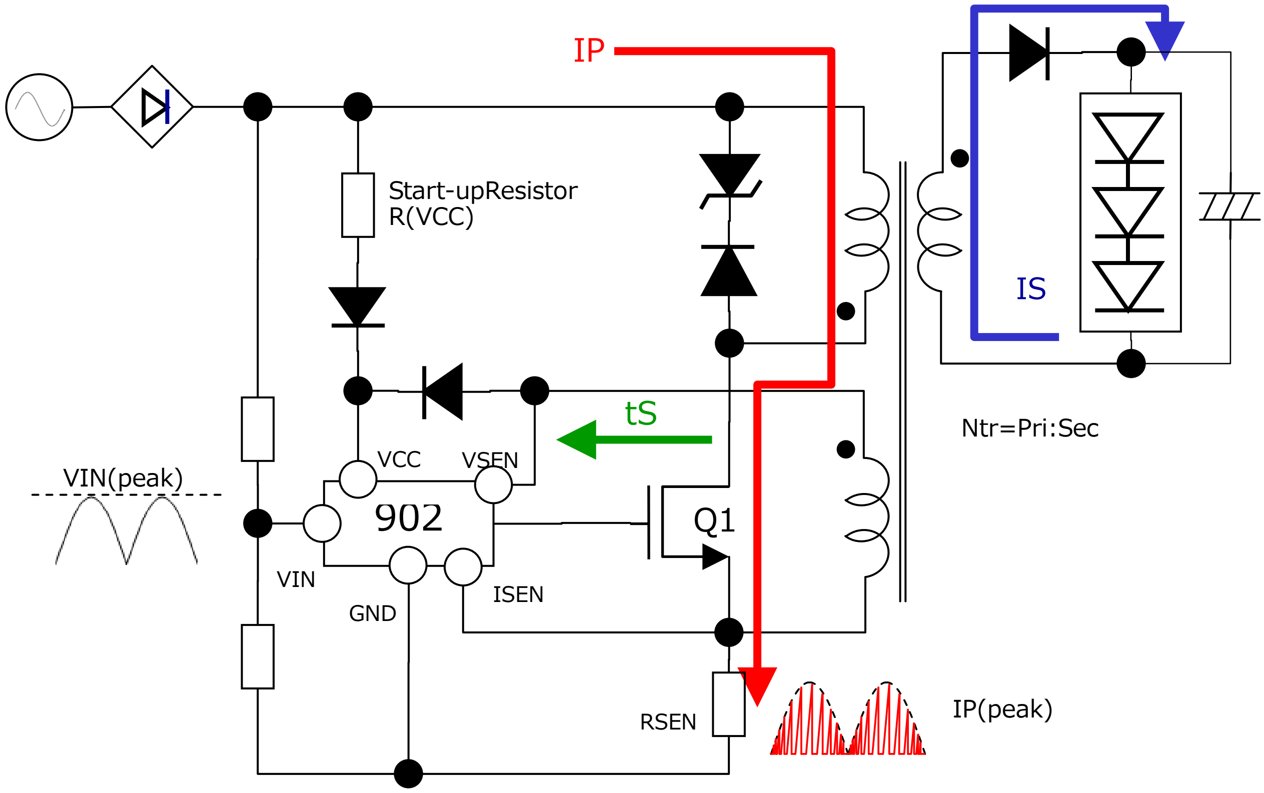
Basic operation and average LED Current : ILED)

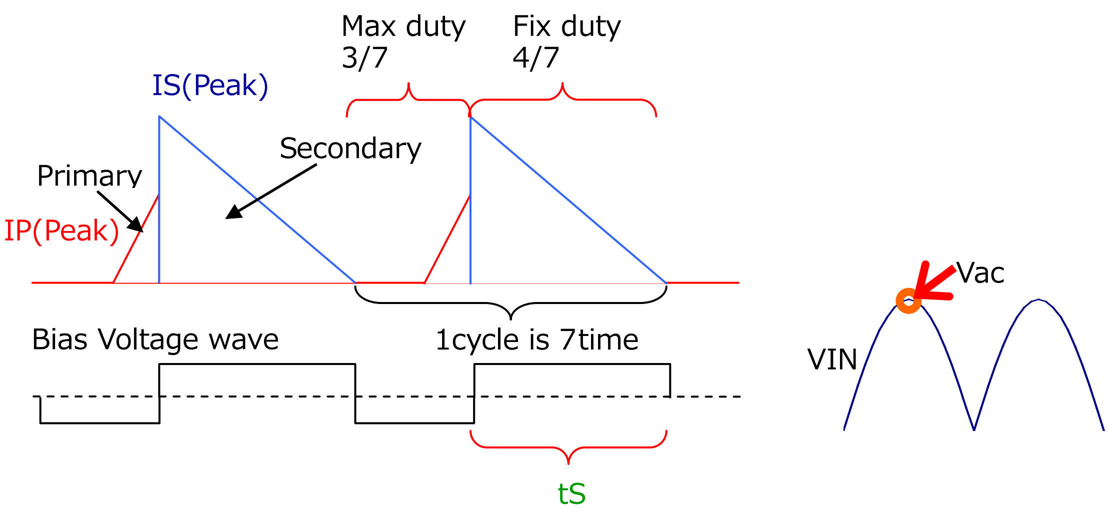
The basics of this device are a flyback power supply. But, it doesn't use the feedback circuit of the secondary side. First, MOSFET Q1 does on and drives a primary current IP.
It detects voltage in the ISEN pin and the IP does Q1 off when it reaches a peak value IP (Peak) from 0. Then, as for the magnetic-energy, it transmits and current IS occurs to the secondary of the transformer.

IS Current is the current waveform which descends from peak value IS (Peak) to 0.
An average LED current is gotten because pulse width TS of current IS is detected at the VSEN pin voltage and makes TS 4/7 duty with PFM (pulse frequency modulation).
In PFC, the VIN terminal-voltage is ISEN pin voltage threshold just as it is.
Therefore, the average LED current can do the following computation.

ILED(ave.) = Secondary Peak current IS(Peak)*1/2×4/7×2/π
= IP(Peak)* turn ratio of Ntr*1/2*4/7*2/π = VIN(peak)/RSEN*Ntr*1/2*4/7*2/π

Note: π is pi. This waveform is an enlarged view of a portion of the waveform AC.





Secondary Peak current
IS(peak) = Primary Peak current * Ntr

Switching Frequency of MOSFET)

The recommendation range of switch frequency fOSC is 30 - 200 kHz.
As explained by the function of the average LED current, it controls the pulse width tS of current IS at the frequency in the standard. Roughly the following estimating is possible from the inductance value LS, peak current IS(Peak) and the LED forward-voltage VF of the secondary.

Switch frequency fOSC = 1/(Secondary on time tS*(7/4))
= 1÷(Inductance of primary LS*Peak secondary current IS(peak)/VF of LEDs)*(7/4)

There is a following relation about the primary inductance LP and secondary inductance LS.

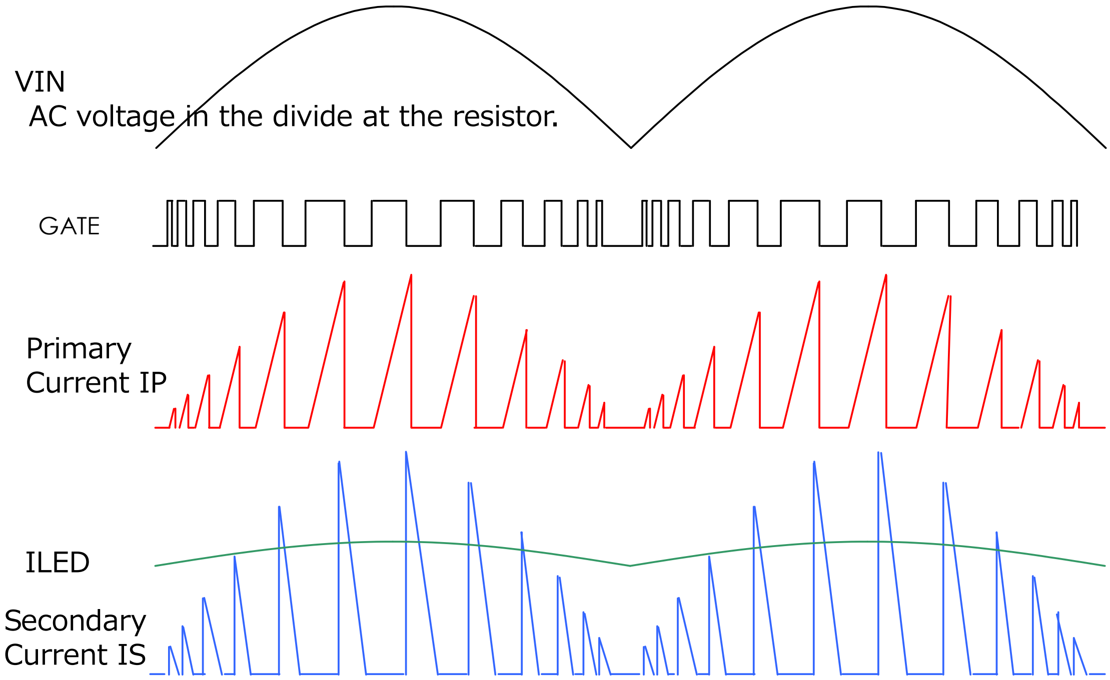
Primary inductance LP=Secondary inductance LS * Turn ratio Ntr^2

At this time, the primary inductance LP is big and recommends above 50μH.

Single state PFC)

This device does power-factor-improvement in making VIN terminal-voltage ISEN pin voltage threshold and controlling an IP(Peak). Because the primary current is a discontinuity (DCM), it is difficult for the power factor of the light-load to be high.
The power factor depends on the operating condition and it is possible for approximately and PF=0.75~0.9 to be realized.

It inputs to the VIN pin voltage after doing AC voltage in the divide at the resistor.
This waveform becomes the voltage threshold of the ISEN pin voltage as gain 1. The VIN pin voltage input-voltage-range is from 0V up to 1.8 V.

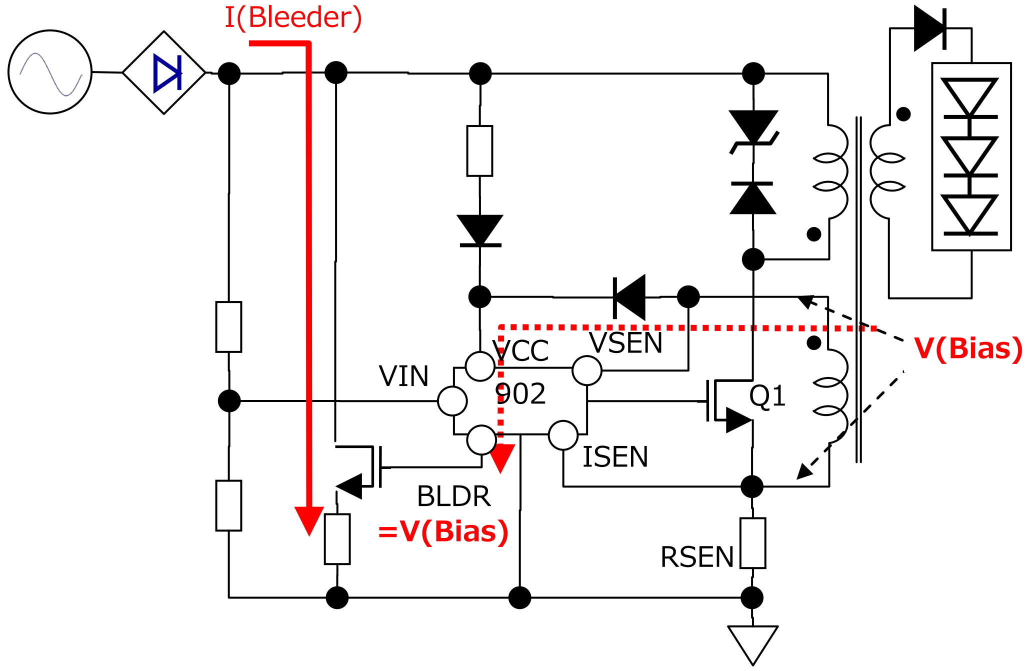


Because the main system is single stage PFC, the LED current waveform of the secondary side includes a ripple. To make LED current waveform smoother, it makes a secondary output capacitor big. The GATE pin is modulating a frequency.

Remark)

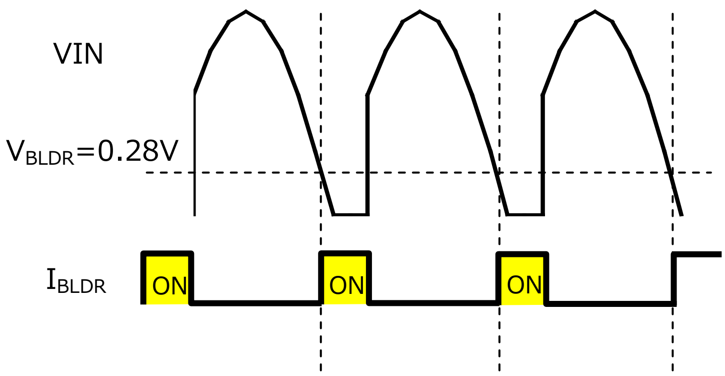
This waveform is a function image and the actual waveform and the figure above are sometimes different.

Active bleeder function for the triac dimmer)



The phase cognition of the triac)
There is divide and the AC voltage that triac dimmer was done is inputted to the VIN pin.
Active bleeder pin BLDR controls the holding-current of the triac.
The VIN pin has a 0 - 0.18 V range and on does the MOSFET which connected with the BLDR pin.

VIN pin voltage	Bleeder Current
＞1.85Vmin	IC stop switch
≦ 0.28V	BLDR pin = VCC
＞0.28V	BLDR pin = Lo



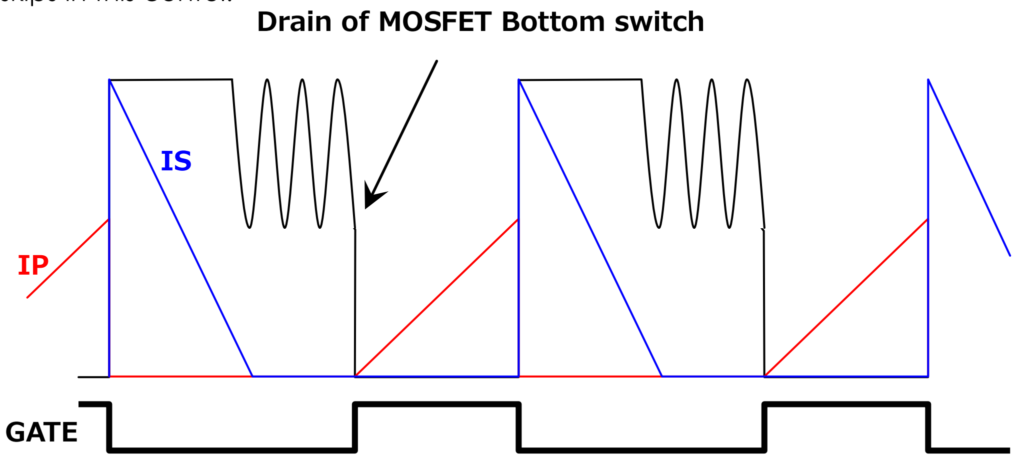
The current of active-bleeder)
The bleeder current can be computed below. Because VCC is the bias voltage of the transformer, it chooses the current value which depended on LEDs VF and the triac performance.

$$I_{BLDR} = (VCC\text{-}MOSFETs\ Vth) \div \text{setting resistor}$$

Because the individual difference of the holding-current of the triac is big, the dimming depends on the triac. The range which passes a bleeder current can be controlled at the VIN pin waveform and the voltage proportion of VBLDR.

The bottom switch function)

The MOSFET is the timing which does on and when the resonance waveform of the drain voltage becomes a bottom, it does a MOSFET on. This is soft switch of the MOSFET and the reductional effect of switch loss is expected. It detects drain waveform from the VSEN pin. When the resonance period is short, it sometimes skips in this contol.

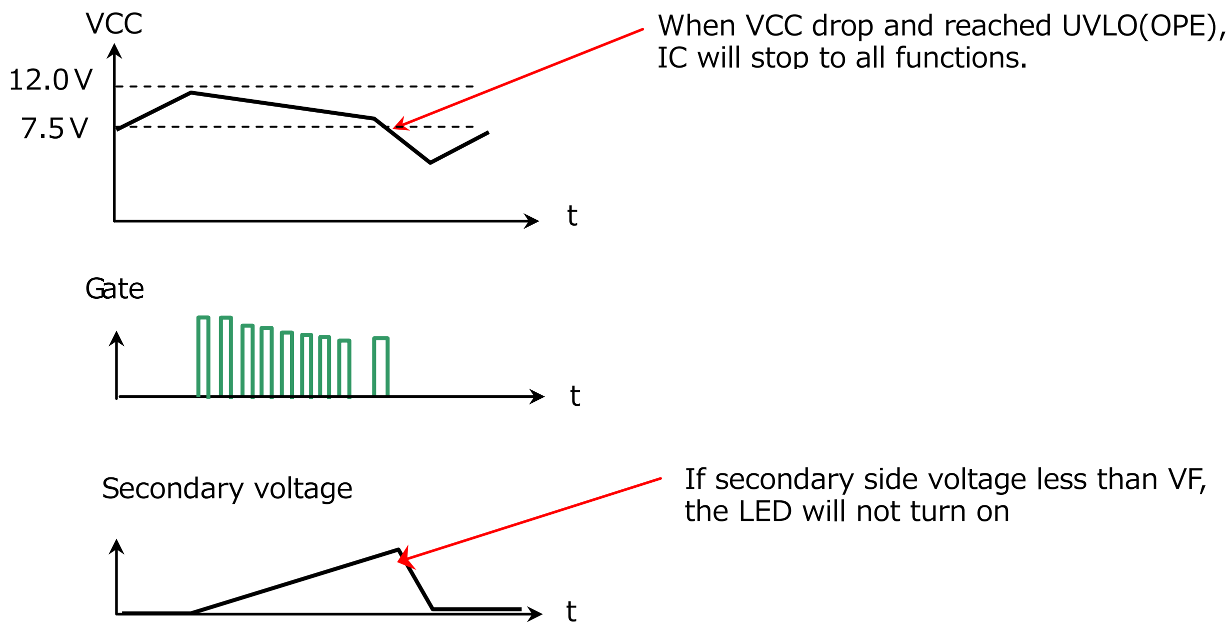


This resonance-amplitude is related to the VF of the LED and primary secondary turn-ratio Ntr.

Drain resonance amplitude(V) = VF * Ntr

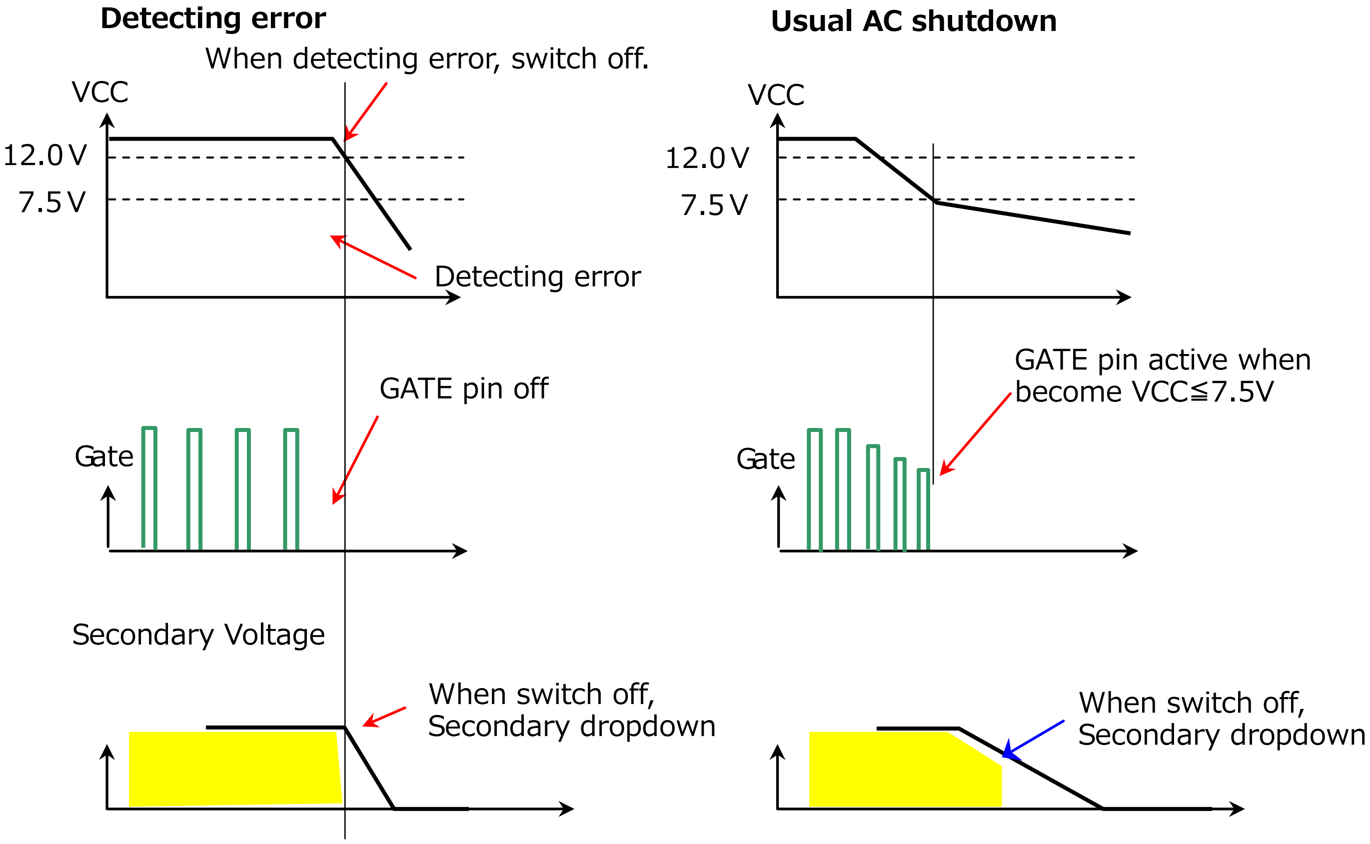
Stop of IC at start-up time)

The VCC capability declines when switch of the MOSFET stops this device in some reason. In case of start-up, too, when VCC doesn't rise to the stability, it isn't possible to light up.



IC stop ; The error detection and the AC voltage shutdown)

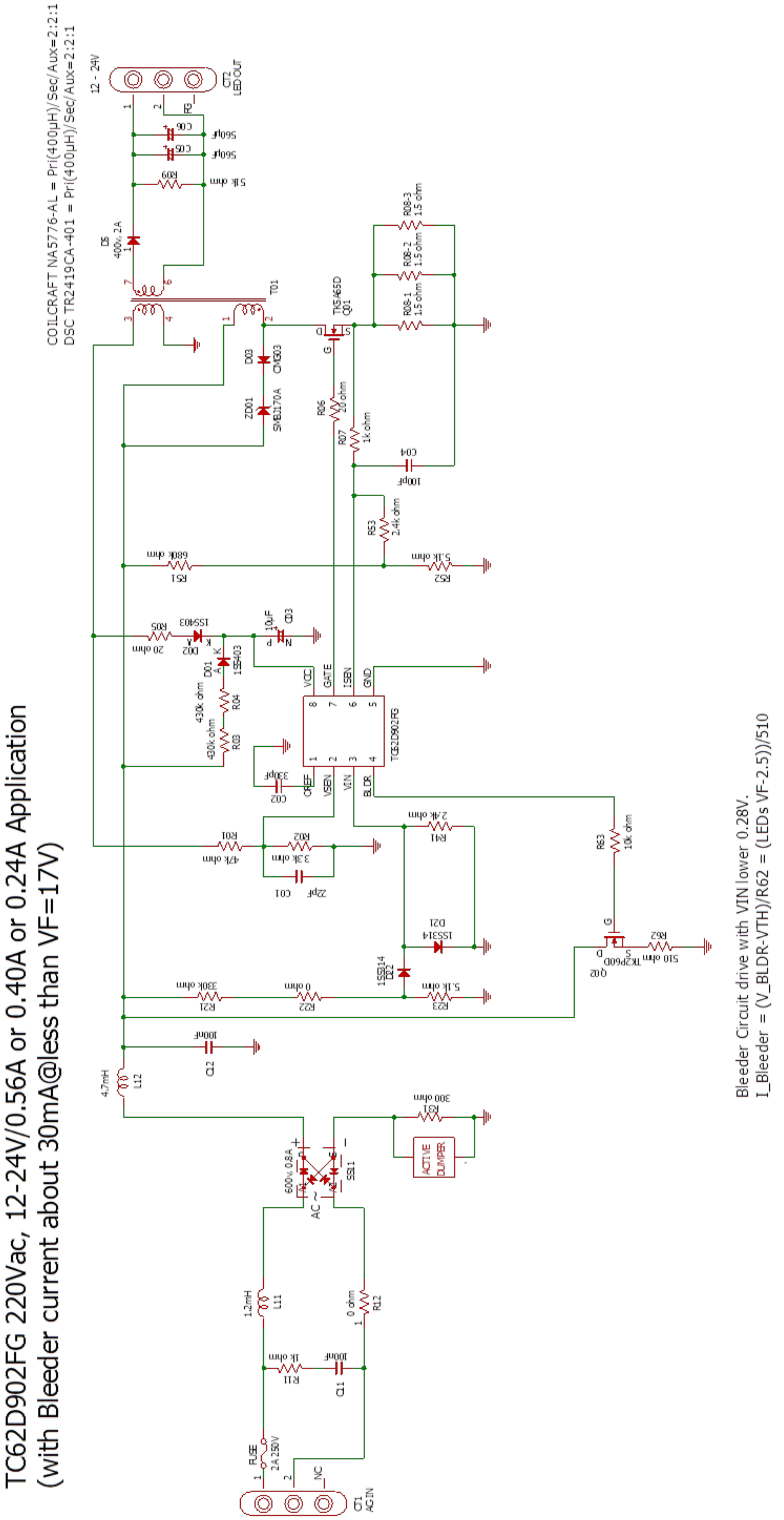
The GATE pin stops switch if detecting an error and the turn off to LED.
Also, until VCC declines about usual AC shutdown, because GATE continues a function, the LED sometimes turns off slowly.



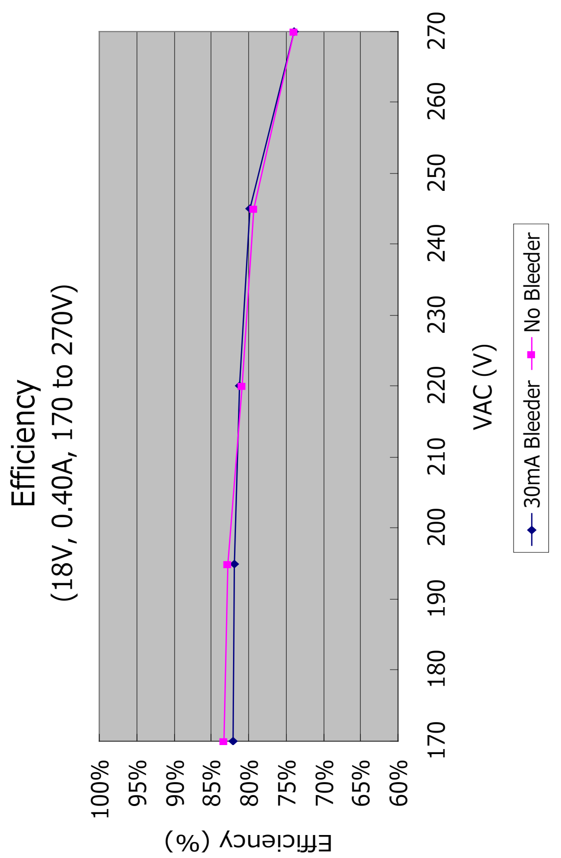
The kind and the condition of the error detection)

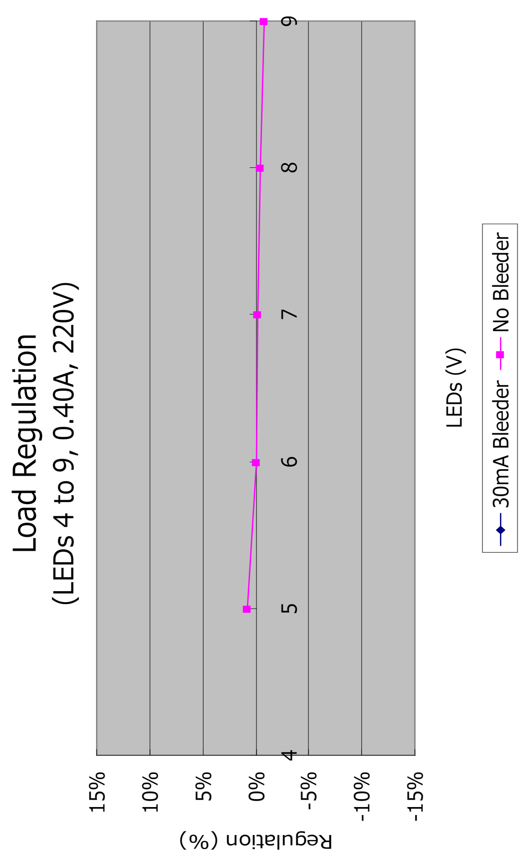
Detection function	Effect	Detection point	Condition	Operation time	Release condition
Over temperature detection (OTD)	Over heating prevention	Internal temperature of IC	140°C(typ)	GATE terminal output voltage is set to 0V, and switching control of Power MOS is stopped in the state of OFF.	Equal to or more than 20 °C fall from the detection temperature.
Under voltage lockout (UVLO)	Malfunction prevention by IC Supply voltage abnormality	VCC terminal voltage	7.5V(typ)		Equal to or more than 4.5 V rise from the detecting voltage.
VIN over voltage detection (VIN-OVD)	Malfunction prevention by IC Supply voltage abnormality	VIN terminal voltage	2.10V(typ) for 15 continuous half AC cycles		Descends from the detecting voltage.
Output LED open circuit detection (OOD)	Over-voltage prevention by LED open-circuit of LED	VSEN terminal voltage	2.10V(typ) for 2 continuous switching cycles	Repeat of the start-up and the Stop	The function of UVLO
Output LED short circuit detection (OSD)	Malfunction prevention by IC by Short-circuit of LED	VSEN terminal voltage	0.14V(typ)		
Over current Detection (OCD)	Over current prevention by circuit short-circuit	ISEN terminal voltage	2.1V(typ)	GATE terminal output voltage is set to 0V, and switching control of Power MOS is stopped in the state of OFF.	
Sense wiring open detection (SWOD)	The insufficient prevention of the IC function by the open of the ISEN pin wiring	ISEN terminal voltage	2.1V(typ)		
Sense resistor short detection (SRSD)	Over current prevention by resistor short-circuit.	ISEN terminal voltage	Over 0.28V for 2cycle when start-up.		

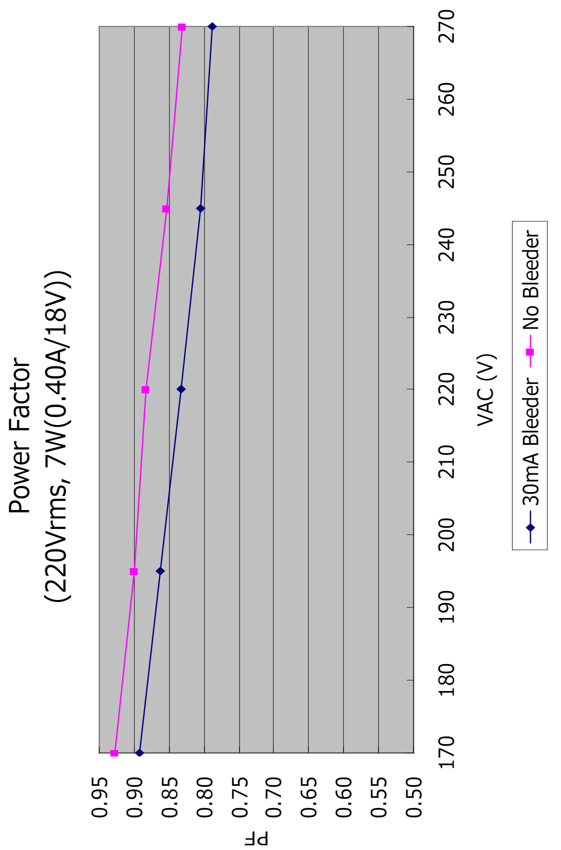
12. Application reference

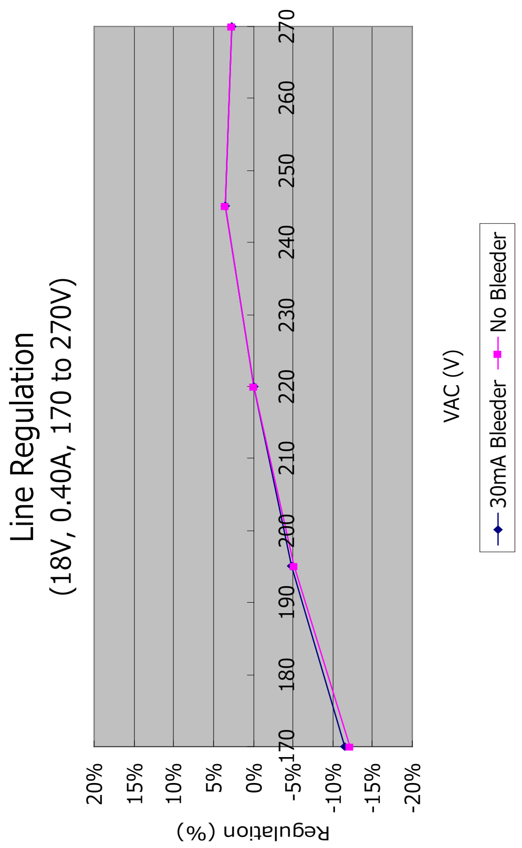


Application result : 220V 7W 400mA LED lighting（reference）
Line regulation = +3%~-12%@170~270V, -5%~+3%@195~245V
Power factor =0.87@Vac=220V, Efficiency=82%@Vac=220V





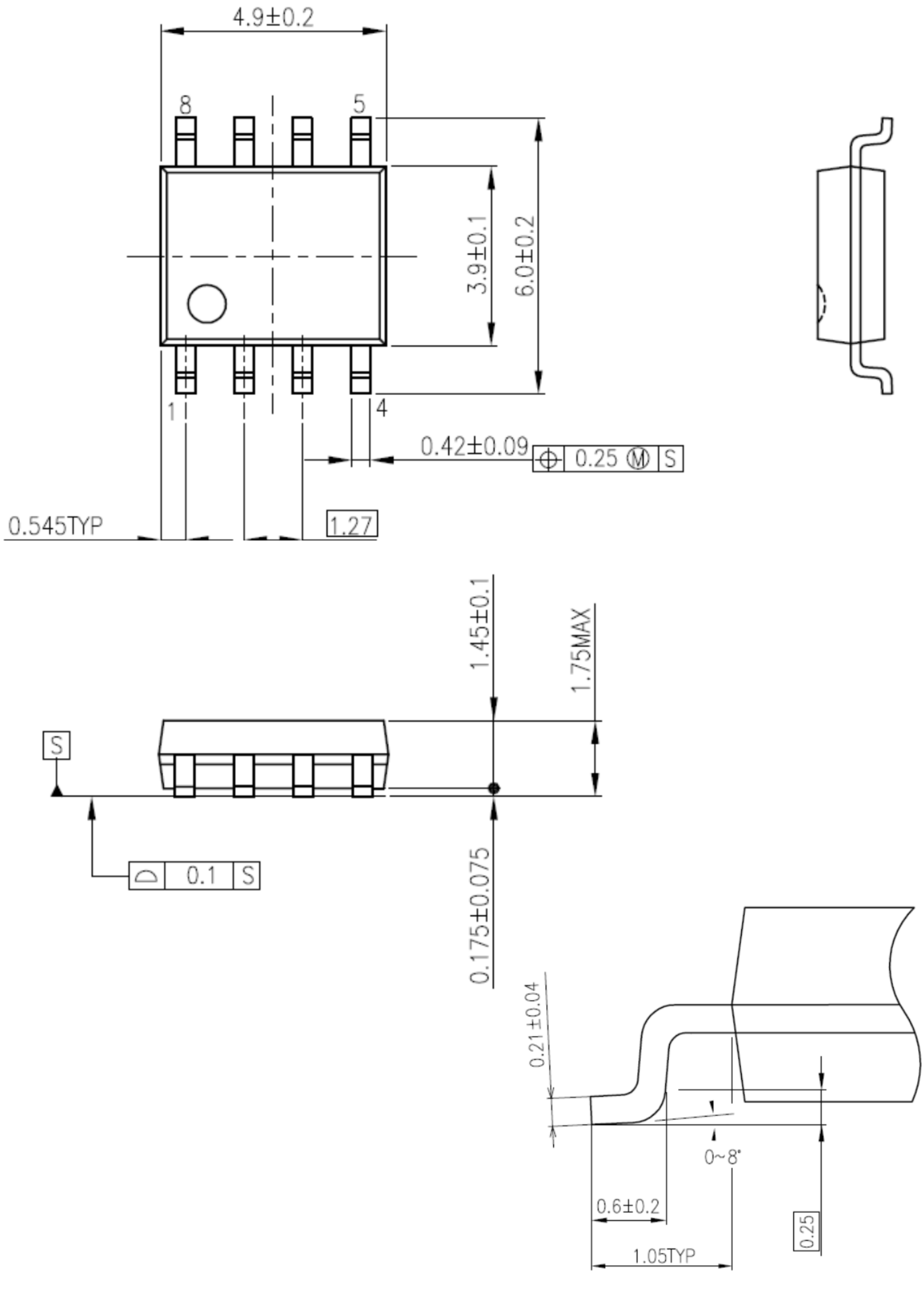




13. Package

P-SOP8-0504-1.27-001

UNIT: mm



Note) This drawing is a picture for the description.
As for the size not to write by this drawing, please inquire of our product person in charge.

Notes on Contents

1. Block Diagrams

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts

Timing charts may be simplified for explanatory purposes.

4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.
Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.

5. Test Circuits

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations

Notes on handling of ICs

[1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

[2] Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

[3] If your design includes an inductive load such as a motor coil, incorporate a detection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.
Use a stable power supply with ICs with built-in detection functions. If the power supply is unstable, the detection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

[4] Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

[5] Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator.
If there is a large amount of leakage current such as input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, over current or IC failure can cause smoke or ignition. (The over current can cause smoke or ignition from the IC itself.) In particular, please pay attention when using a Bridge Tied Load (BTL) connection type IC that inputs output DC voltage to a speaker directly.

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