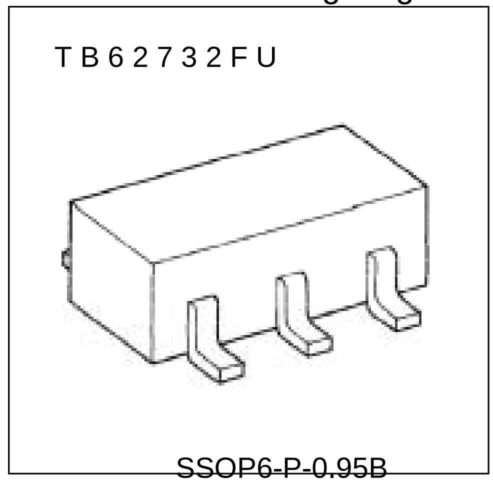
TOSHIBA BiCD DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

T B 6 2 7 3 2 F U

The step up type DC-DC converter only for white LED driver lighting



Weight: 0.016 g (typ)

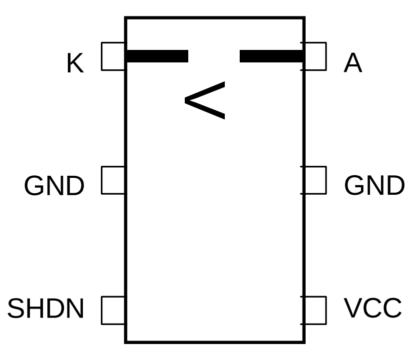
FEATURE

The TB62732FU is a LED driver by the high efficiency step up type DC-DC converter that 2-4 serial white LED can be turned on.
This IC builds in the NchMOS FET transistor to switch the coil, and builds in the function which derate the LED current corresponding to the rise in temperature.
And, the average LED current can be set up easily by the resistance with the outside.
This IC is the most suitable as a driver of the LED liquid crysta back light of the PDA, the cellular phone and the the handy terminal.

CHARACTERISTICS

*Maximum output voltage Vo =< 17V
*The variable setup of the average LED current value by the resistance with the outside.
 18 mA (typ) @ R_sens = 2.7 ohms
 20 mA (typ) @ R_sens = 2.4 ohms
*Supply electric power
 It is turned on to the 320 mW load.
*Compact package
 SSOP6 - P - 0.95B (SOT23-6pin)
*The LED current derating function is built in.
 The derating of LED current vs set temperature, on the automatic operation.
*High efficiency
 80% of the efficiency. @ 2-3LEDs turn on. IF=20mA (typ))
 Ron=2.0 ohms (standard) @ Vin = 3.0 - 5.5V
 The power MOS transistor building in of low Ron.

*Pin assignment (Top View)



Note 1:
Be careful of handling because there is a terminal which is poor at ESD in this product.

BLOCK DIAGRAM

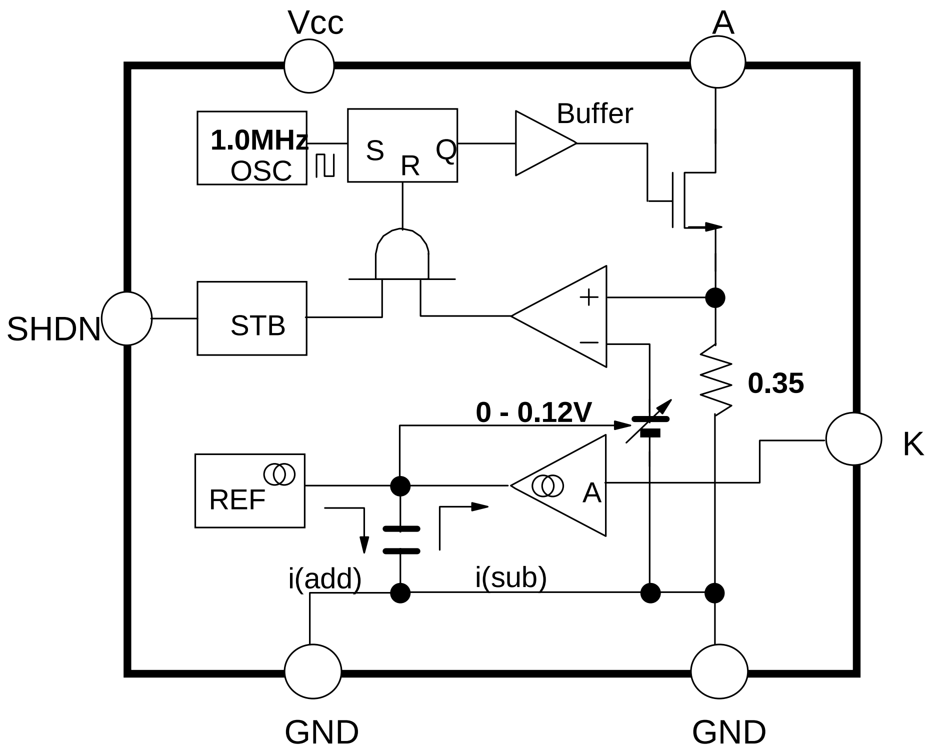


FIg 1 : BLOCK DIAGRAM

TERMINAL EXPLANATION

No	Name	Function explanation
1	K	It is the connection terminal with cathode and IF setup resistance of LED. It is the feedback terminal of the charge voltage wave form for the LED current control.
2, 5	GND	It is the ground terminal of the logic part.
3	SHDN	It is the enable terminal. It becomes the standby mode with "L", and the LED is turned off. The lighting operation is given with "H".
4	Vcc	It is the input terminal of the operation voltage for the IC. The operating voltage is 3.0 to 5.5V.
6	A	It is the switch terminal of the coil for the DC/DC converter. The switch is a Nch MOSFET transistor. This is low Ron.

Note 2 : Connect all the GND terminals to the ground electric potencial.

ABSOLUTE MAXIMUM RATING (unless otherwised notice Topr = 25 degree)

Characteristics	Symbol	Rating	Unit
Supply voltage	Vcc	- 0.3 to + 6.0	V
Input voltage	Vin	- 0.3 to VCC + 0.3	
A(anode) terminal current	Io(A)	+ 380	mA
A(anode) terminal voltage	Vo(A)	- 0.3 to + 17	V
Power dissipation	Pd	0.41 (not on PCB)	W
		0.47 (on PCB) *Note 3	
Saturation heat resistance	Rth(j-a)1	300 (not on PCB)	degree/W
	Rth(j-a)2	260 (onPCB)	
Operation temperature	Topr	- 40 to + 85	degree
Storage temperature	Tstg	- 40 to + 150	
Maximum juction temperature	Tj	125	

Note 3 : When every time the ambient temperature gets over 25 degrees with 1 degree, the allowable loss must reduce 3.8mW/degree more than maximum rated value. (When on PCB.)

RECOMMENDED OPERATION CONDITION (unless otherwise notice Topr = -40 to 85 degree)

Characeristics	Symbol	Test condition	min	typ	max	Unit
Supply voltage	Vcc	-	3.0	-	4.3	V
SHDN terminal H-level input voltage	VIH	-	Vcc -0.5	-	Vcc	V
SHDN terminal L-level input voltage	VIL	-	0	-	0.5	
SHDN terminal "H"level input pulse width	tpw SHDN	-	0.5	-	-	ms
Setup LED current (mean)	Io	Maximum step up condition. Vo (A) is change from 3V to 16V	5	-	20	mA

ELECTRIC CHARACTERISTICS
(unless otherwised notice, Topr = -40 to 85 degree & Vcc = 3.0 to 5.5 V)

Characteristics	Symbol	Test condition	min	typ	max	Unit
Supply voltage	Vcc		3.0	-	5.5	V
Operation supply current	Icc(On)	Vcc = 3.6V	-	0.9		mA
Stand-by supply current	Icc(SHDN)	SHDN = 0 V	-	0.5	1.2	uA
SHDN terminal current	I_SHDN	SHDN = Vcc, built in pull-down resisance	-	4.2	7	uA
MOS-Tr on resistance	Ron	Io(A) <= 380 mA, detection resistance value is contained.	-	2.0	2.5	ohms
MOS-Tr switching frequency	fOSC		0.7	1.0	1.3	MHz
A terminal voltage	Vo(A)		17	-	-	V
A terminal current	Io(A)		320	350	380	mA
A terminal leakage current	Ioz(A)		-	0.5	1	uA
Set up LED current (mean)	Io	Vcc = 3 - 4.3V, R_sens = 2.7 ohms,		19.6		mA
LED current Vcc dependence	dIo	L = 6.8uH, Topr = 25 degree (Note 4)		+/-5	+/-10	%
Derating start ambient temperature	Tdel	R_sens = 2.7 ohms, L = 10uH, Vo = 16V (Note 5)	-	45	-	degr ee

Note 4 : The derating function carries out the measurement in Ta= 25 degree not to work. The specifications don't contain the dispersion of the R_Sens resistor. Io has the possibility to be different from the specifications by the inductance value and the relations of the load.
Note 5 : It is a specifications guarantee by the design.

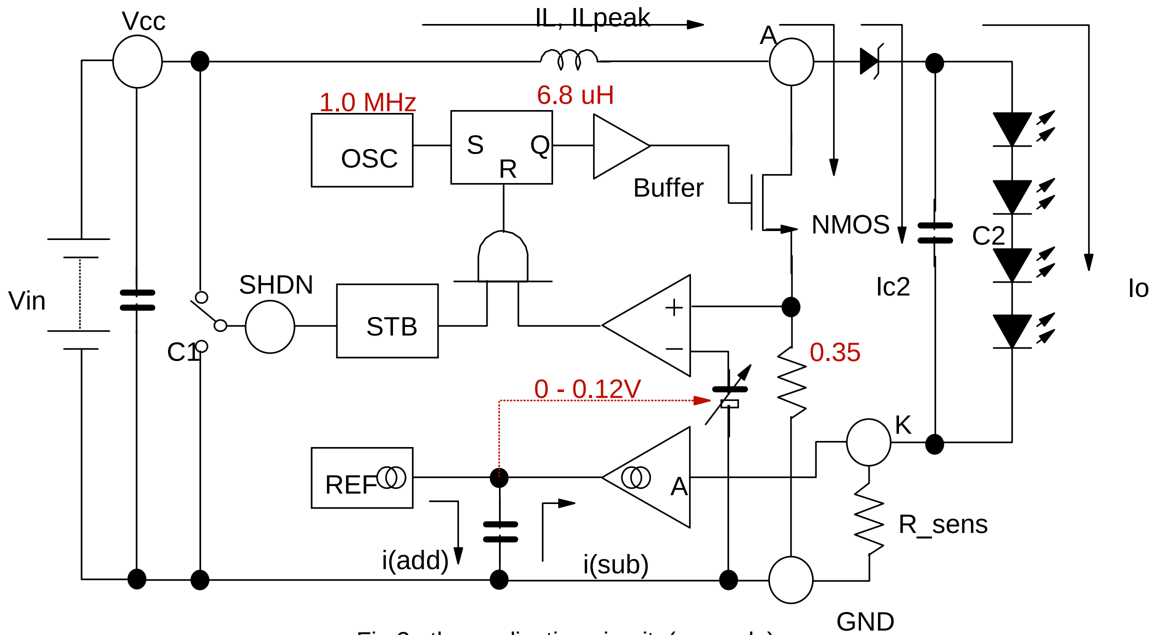


Fig 2 : the application circuit (example)

BASIC OPERATION

The step up type DC/DC converter is applied, and the basic circuit of the TB62732FU adopts peak control of the current pulse.

The internal MOS transistor NMOS is turned on in the fixed frequency fOSC =1MHz, and the charge has the energy in the inductance.
Inductance electric current IL turns off NMOS when it reaches 80% of 1/1MHz when it increased from IL = 0 and it reached IL = ILpeak = 380 (mA, typ).
The shot key diode is turned on, and IL = Ic2 flows, because the coil may keep IL = ILpeak.
After that, Ic2 is decrease, and become IL = 0.
This operation is repeated, and Ic2 is fully done as to the charge, and it becomes Io, and flows to LED.
The details of a basic pulse to use for the current control are shown in Fig 3.

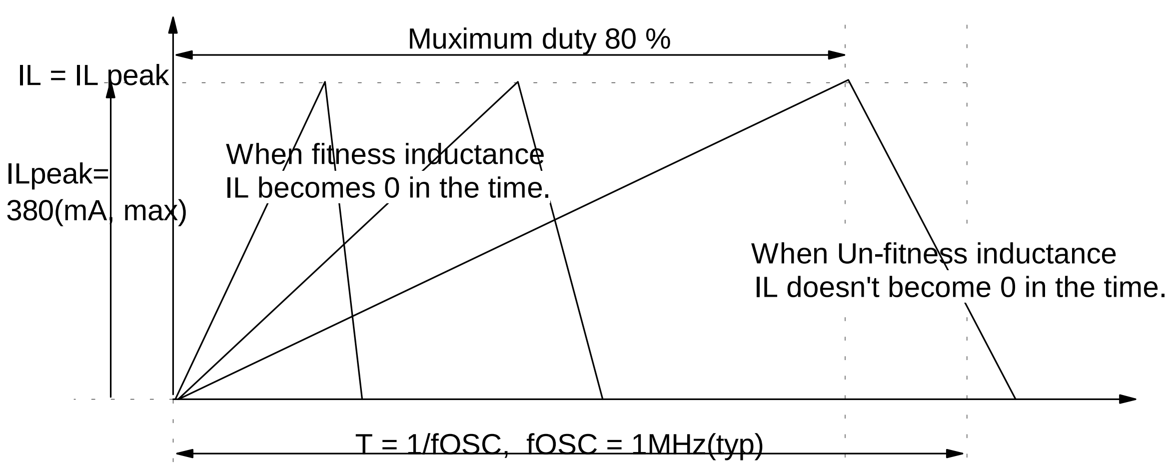


Fig 3 : the switching wave form of the inductance

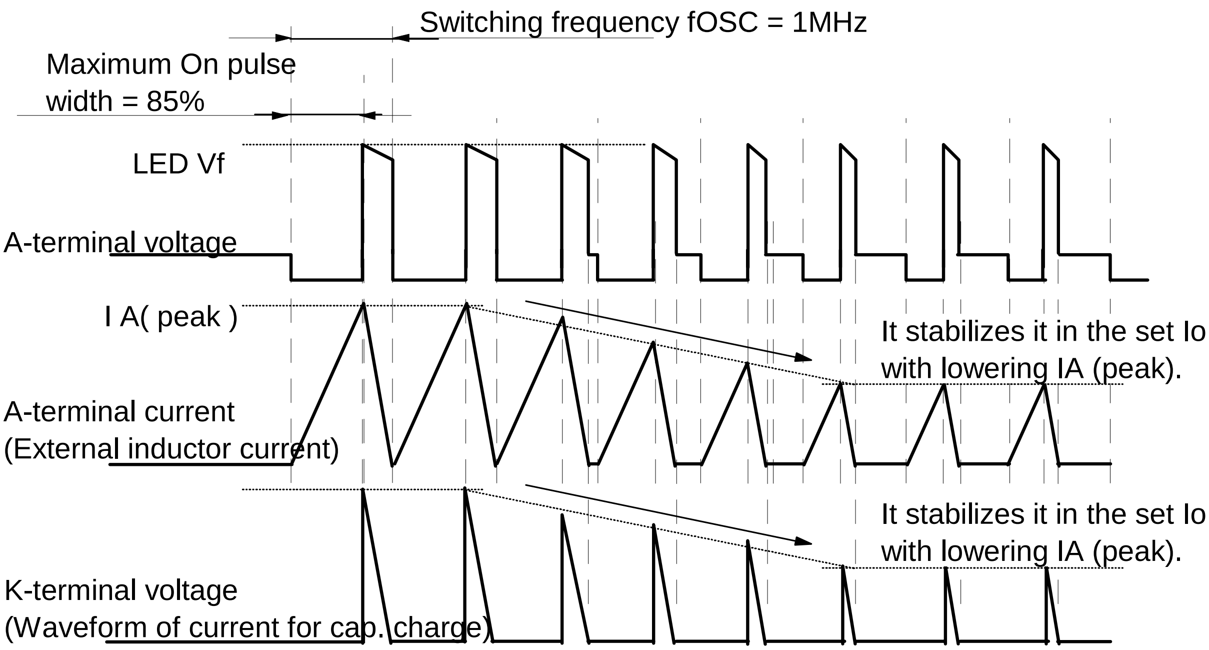


Fig 4 : burst control wave form

THE STAE OF THE PEAK CURRENT CONTROL

The peak current control is repeat in the control the waveform which showed it in the Fig 3.
The current pulse of the Fig 3 is a charging current on the output capacitor C2.
It is supplied to LED as a discharge current on the output side capacitor, and it through the R_sens to GND.
And, as for the charging voltage waveform of the output capacitor C2, it returns in the IC from the K terminal.
The internal circuit which the K terminal should be input from controls the current pulses so that the average voltage value of the voltage wave form which it could get may become 53 mV (typ).
The constant current is controlled as a result as an average electric current value. Therefore, when R_sens = 2.7 ohm is connected, the average current value of (53 mV /2.7 ohms) = 19.6 mA can get it.

This IC is designed for the purpose of supplying the power 320 mW (min).
Generally it is a step up inductance 6.8 uH to the load power 320 mW. And, when the load electric power is small, it can be done small for the inductance.

As a condition about the LED load between the generator terminal and the K terminal,

Please keep the condition in Vin (Vcc) < LED VF total.

There are no relations with the control of the IC, and LED is always turned on.

STANDBY MODE OPERATION

The SHDN terminal set-up the normal operation and the standby operation. The lighting operation is possible in the "L" level in the stop (at the standby mode), the "H" level. Still, consumption supply current in the standby mode is 1.2uA (max).

THE SETUP ON THE OUTPUT SIDE CAPACITOR

The C2 is upper 0.47(uF) above is recommended from the consideration to the IF peak.

Capacitor C2 (uF)	Ripple current (mA)	Note
0.01	15-25	
0.1	5-8	
0.47	2-4	Recommend
1	1-3	

THE SETUP ON THE INDUCTANCE

The minimum inductance with the outside is calculated with the next formula.

L(uH) = ((K*Po)-Vin min.*Io)*(1/fOSC min.)*2*(1/(Ip min.*Ip min.)) - - - Form 2

Each clause is as mentioned in the following.

Po (W) : output power (the electric energy which should be necessary the LED load)

Po (W) = (VF LED*IF LED)+(Vf schottky*IF LED)+(R_sens*IF LED*IF LED)

(Forward current of LED is IF LED (mA) = Setup currnet Io (mA), Forward voltage of LED is VF LED (V), Forward voltage of schottky diode is VF schottky (V), Setup resistance of output currnet is R_sens (ohms))

Vin min (V) : Minimum input voltage(battely voltage)

When there is a resistance element on the input voltage side, that one for the voltage descent is taken into consideration to the minimum input voltage.

The input Iin is estimated roughly in Form 3.

Iin (mA) = Vo / Vin * IF --- Form 3

Example, the voltage drop of 1(V) occurs when it becomes Iin = 0.1(A) and has the line resistance of 1 (ohms).

At this time, Vin=3.1 (V) becomes minimum Vin value because the minimum Vcc specifications of spec is Vcc=3.0 (V).

Io (A) : The average current value established with R_sens. Show the fig-5 on next page.

fOSC(Hz) : The switching frequency of the internal MOS transistor.

The specification of fOSC(MHz) = 0.7 min, 1.0 typ and 1.3 max.

Ip (A) : Peak current value to supply to the inductance.

The specification of Ip (mA) = 320 min, 350 typ, 380 max.

For example, the following condition is substituted for the formula.

It is supposed under condition.

Input voltage Vin : Vin=3.0-4.3(V),

Output side capacitance C2 : C2=0.47(uF) - - - C2 is ignored by the calculation.

VF LED = 16(V), schottly diode VF: Vf schottky = 0.3(V),

Setup resistence R_sens : R_sens = 2.7(ohms), Setup current Io : Io = 19.6(mA).

L (uH) = ((16*0.0196+0.3*0.0196+2.7*0.0196*0.0196)-**Vin***0.0196)*(1/700e3)*2*(1/(0.32*0.32))

= 7.19(uH, Vin = 3.0V) and 6.59 (uH,Vin = 4.3V)

Therefore, 7.19(uH) in Vcc=3.0V whose input voltage is low is chosen.

It is sufficient by the above calculation on the standard condition.

If the worst case is taken into consideration, the coil of about 1.1 times of the calculation is chosen.

L(uH)=7.19(uH)*1.1 >= 7.90 (uH)

CHOICE OF THE R_sens
The resistance R_sens (ohm) in the K terminal - GND is of the outout current Io for the setup.
The average outout current Io(mA) can be set up by a resistance value.

Average setup electric current Io (mA) is estimated roughly in the following.

Io (mA) = 53(mV) / R_sens (ohm)

For example, R_sens = 2.7 (ohm) becomes Io = 19.6 (mA).
The absolute value accuracy of the current is to take the +/-12 percent into consideration.
(The accuracy of R_sens isn't contained.)

When 320 (mW) is output, this IC recommends L=10 (uH).
Example, when the output power gets over 320 (mW), the setup current Io has the possibility that Io doesn't meet the set point.

And, this IC can get the setup current Io even if the output side capacitor C2 isn't connected.
In this case, be careful in the rush current IFP (mA) to LED because the LED current becomes the pulse current of the maximum peak magnitude 380 (mA).
Shortening circuit board wiring by using the part whose reactance element is small as much as possible is recommended with the R_sens resistor.
And, mounting it near here as much as possible is recommended with each part in application circuit as well.

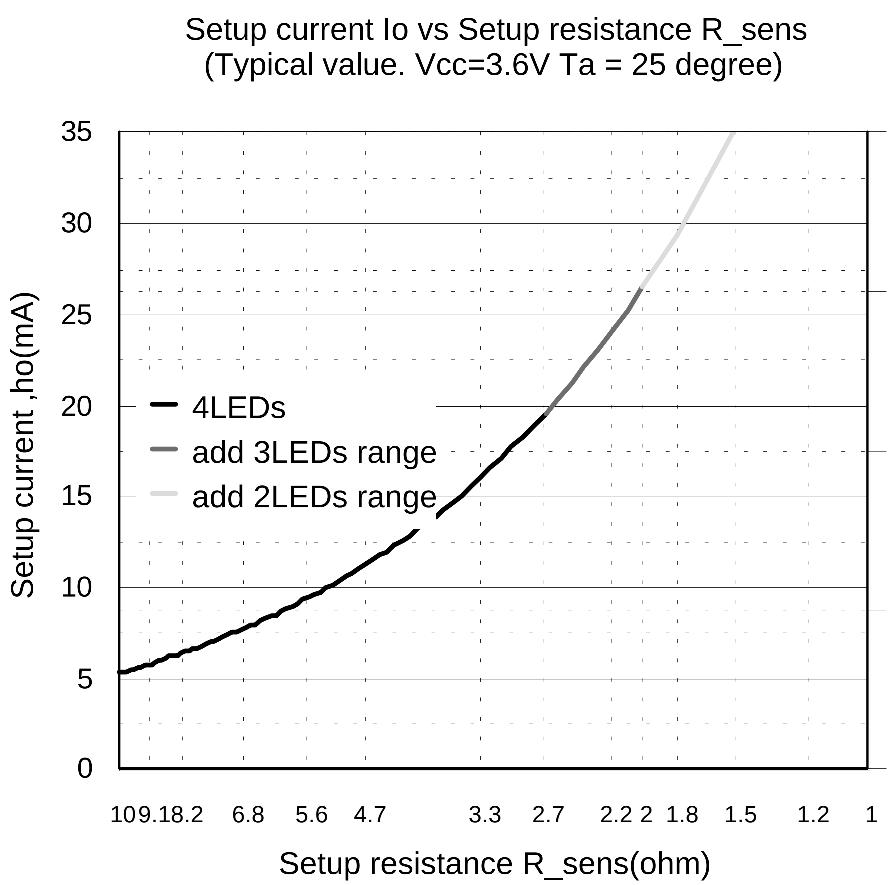


Fig 5 : The graph of the setup current Io and the setup resistance R_sens

ABOUT THE CURRENT DERATING FUNCTION

As for the LED current, generally the current derating recommended against the rise in the ambient temperature. The TB62732FU aims at turning on white LED of the back light illuminant of the color LCD safely and efficiently, and builds in the current derating function which set temperature was presumed.

This IC has the character which makes the current 100(%) in the case of Tjs=45 (degree) and which makes the current 0(%) again in the case of Tjs=100 (degree) corresponding to internal detection temperature Tjs. When it is seen from set temperature Ta (degree), the temperature that self-fever temperature Tup (degree) in the operation was reduced from Tjs = 45 (degree) becomes a starting temperature Ts (degree).

Starting temperature Ts (degree) = 45 (degree) - self-fever temperature Tup (degree) --- Form 4

Therefore, the derating character functions as the figure 6, and shows internal detection temperature Tjs and the rate of change of the outout current.

Self-fever temperature Tup (degree) in the operation is calculated with the Form 5.

Self-fever temperature Tup (degree) ---- ceremony 5

= (P loss (W) - P parts(W))*Rth(j-a) (degree/W)

It is described in the following about each clause.

DC resistance of the inductance : RDC(ohm), Forward current of LED : IF LED(A),
Total forward voltage of LED : VF LED(V), Forward voltage : VF schottky(V),
Setup resistance : R_sens(ohm), Power loss of lighting circuit : P loss(W)=(Po/efficiency)-Po(W),
Power loss of parts : P parts(W)=RDC*Iin+VF schottky*IF LED+R_sens*IF LED*IF LED,
Saturation thermal resistance of package :
Rth(j-a) (degree/W) =< 260 - - - when on board, muximum
Output power : Po(W) = VF LED*Io(A)
Input power : Pi(W) = Vin (V)*Iin(A)
Efficiency : Efficiency(%)=100*(Po/Pi)

Example : When the measurement of the lighting circuit tightened each following value.
RDC=0.5(ohm), Po=320(mW), Iin=0.1(A), Io=20(mA), R_sens=1.8(ohm), VF schottky=0.3(V), Efficiency=70(%)

In this case, self-fever temperature Tup
Tup (degree)= ((0.32-(0.32*0.7))-(0.5*0.1+0.3*0.0196+2.7*0.0196*0.0196))*260 =10.16 (degree)
Start temperatue Ts(degree)=45(degree)-10.16(degree)=33.4(degree)

Io is controlled as the Fig 6 as a result within the recommendation current area of LED.

The saturation thermal resistance Rth(j-a) = 260 (degree /W) is maximum value. They sometimes become the Rth(j-a) = 210 - 260 (degree /W) by mounting.

And, the individual difference is formed in the starting temperature with the character of the IC and the influence of the difference in the environment of the use.

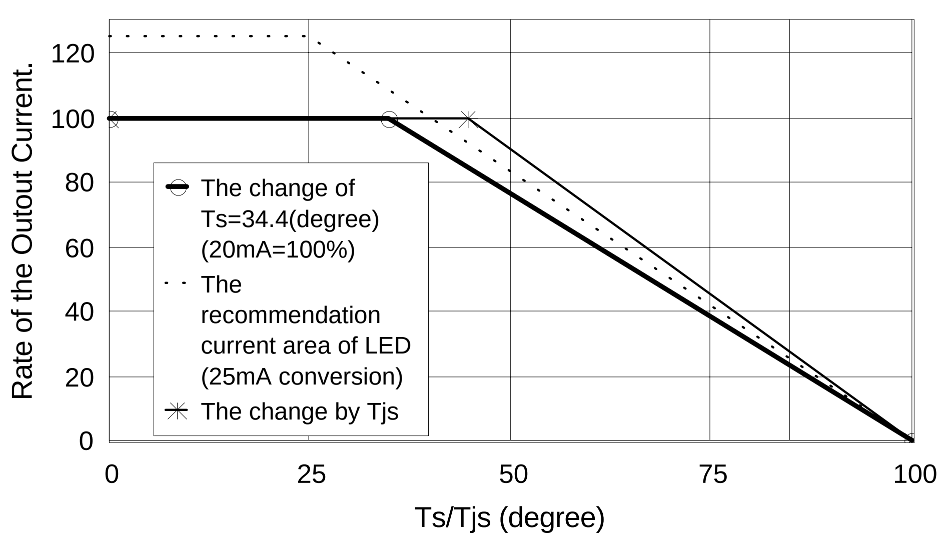
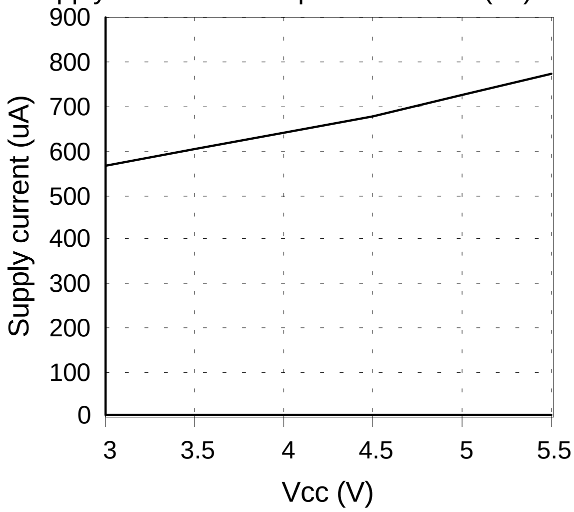
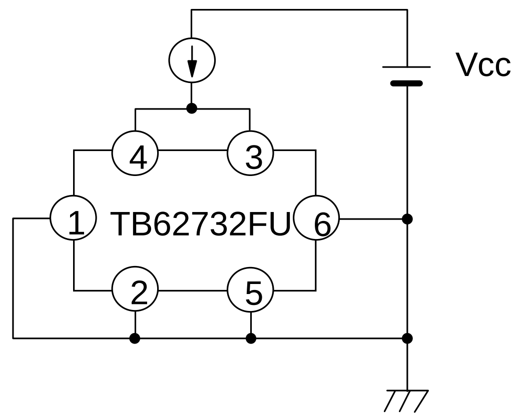


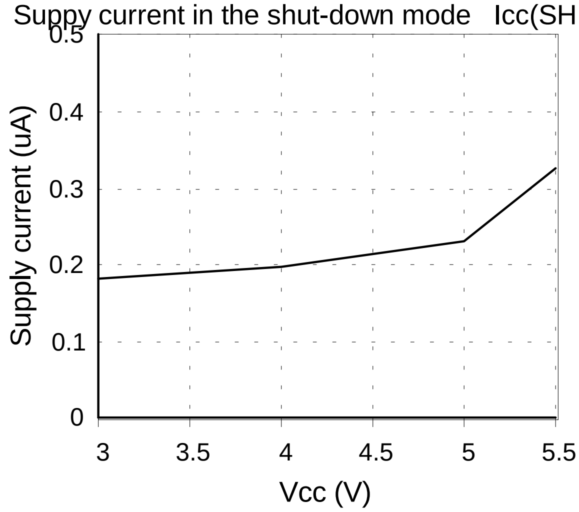
Fig 6 : the derating function of the setup current

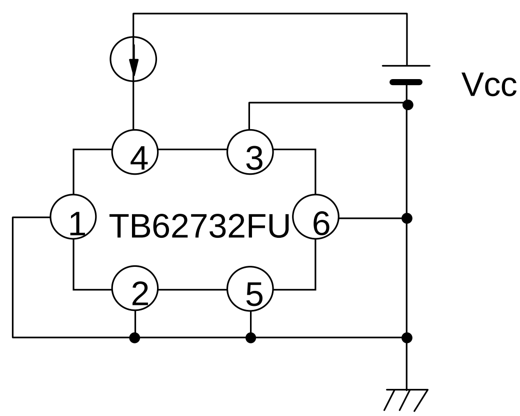
Supply current in the operation ICC (on)



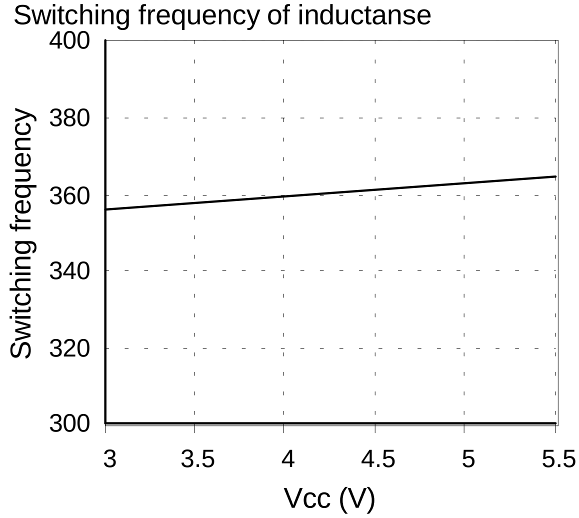


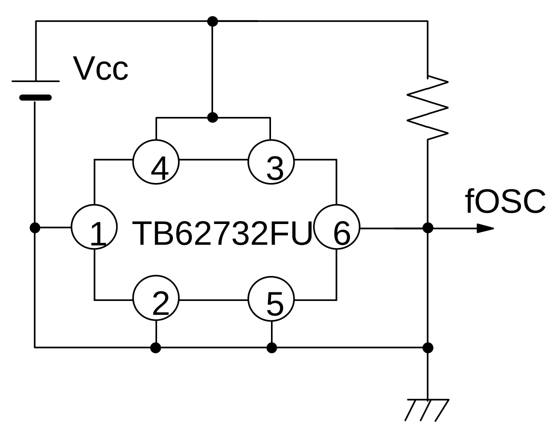
Suppy current in the shut-down mode Icc(SHDN)





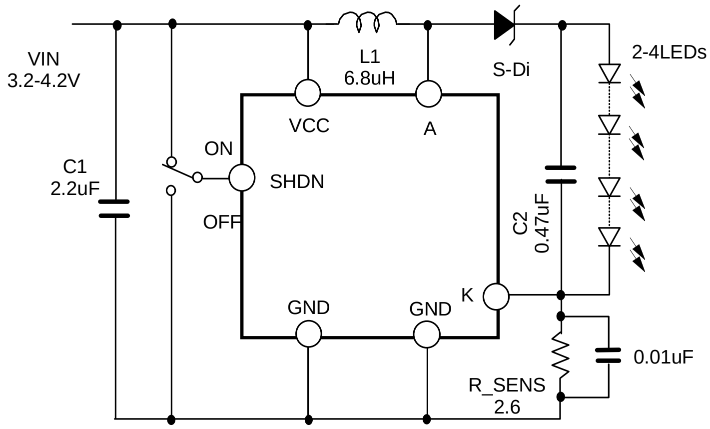
Switching frequency of inductanse



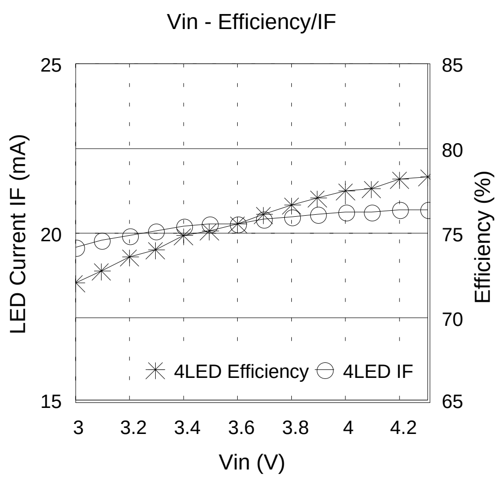


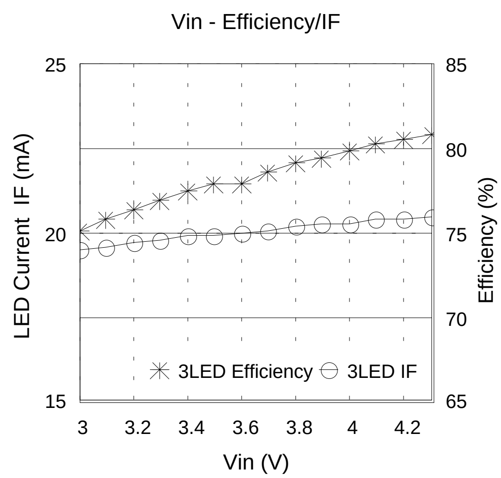
Application evaluation circuit example 1
(The evaluation result example by the small coil. : Coil = LDR304612T-6R8)

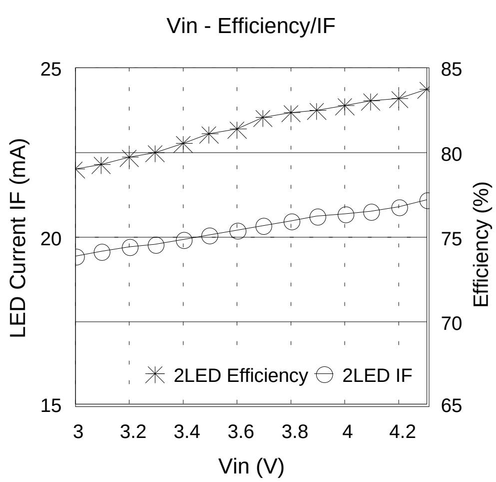
6.8uH is the most suitable when serial 3-4LED are turned on by IF= 20m A.
4.7uH is recommended when serial 2LED is turned on steadily in the range of VIN>4.5V.



L1: TDK LDR304612T-6R8
S-Di: TOSHIBA 1SS404 20V/1A
LED: NICHIA NSCW215T







<Measurement>

The efficiency of the VIN=3.0-4.3V range

	Efficiency(%)	Ave Efficiency(%)
2LED	79.0-83.8	81.6
3LED	75.1-80.9	78.3
4LED	72.0-78.3	75.7

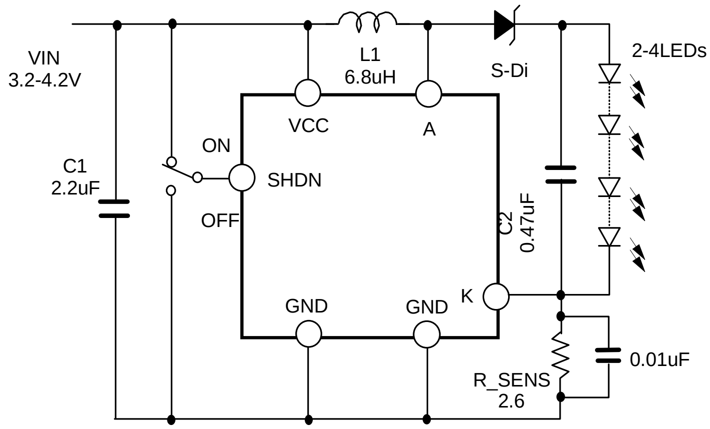
The IF of the VIN=3.0-4.3V range

	IF (mA)	Vcc dependence (%)
2LED	19.5-21.1	7.8
3LED	19.5-20.5	4.9
4LED	19.6-20.7	5.3

Note : The value is our company actual measurement value.
The result has the possibility to be different by the measurement environment.

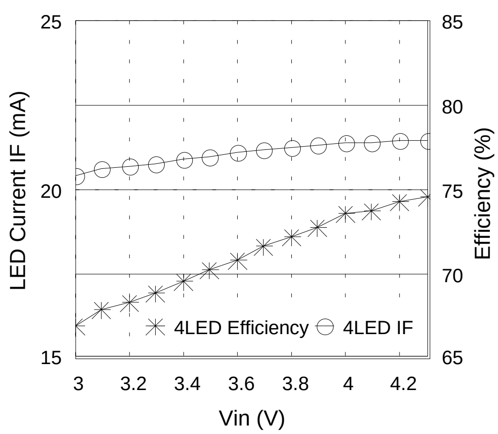
Application evaluation circuit example 2
(The evaluation result example by the small coil. : Coil = CXML321610-7R0)

6.8uH is the most suitable when serial 3-4LED are turned on by IF= 20m A.
4.7uH is recommended when serial 2LED is turned on steadily in the range of VIN>4.5V.

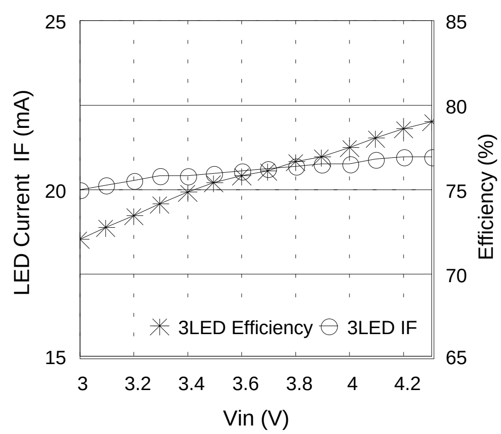


L1: SUMITOMO CXML321610-7R0
S-Di: TOSHIBA 1SS404 20V/1A
LED: NICHIA NSCW215T

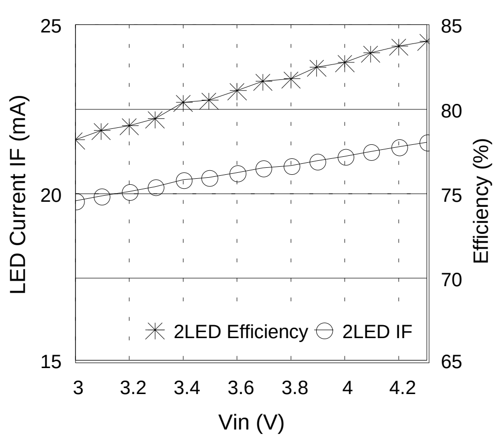
Vin - Efficiency/IF



Vin - Efficiency/IF



Vin - Efficiency/IF



<Measurement>

The efficiency of the VIN=3.0-4.3V range

	Efficiency(%)	Ave Efficiency(%)
2LED	78.2-84.1	81.3
3LED	72.0-79.1	75.8
4LED	66.9-71.1	74.6

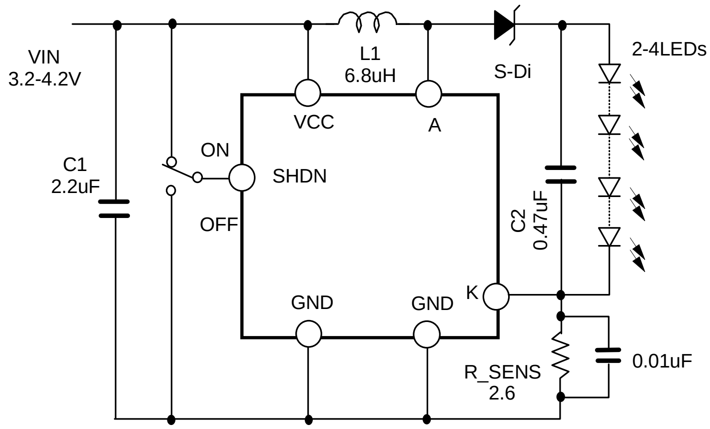
The IF of the VIN=3.0-4.3V range

	IF (mA)	Vcc dependence (%)
2LED	19.8-21.6	8.1
3LED	20.0-21.0	4.8
4LED	20.4-21.5	4.9

Note : The value is our company actual measurement value.
The result has the possibility to be different by the measurement environment.

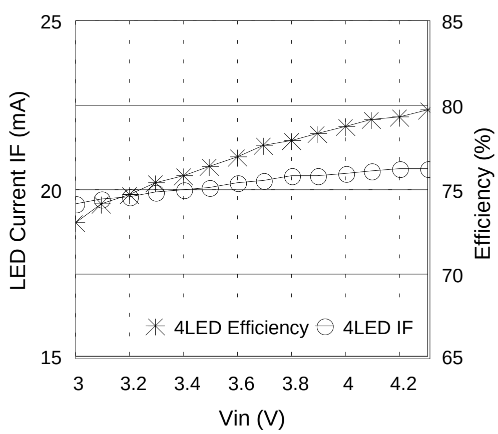
Application evaluation circuit example 3
(The evaluation result example by the small coil. : Coil = 976AS-6R8)

6.8uH is the most suitable when serial 3-4LED are turned on by IF= 20m A.
4.7uH is recommended when serial 2LED is turned on steadily in the range of VIN>4.5V.

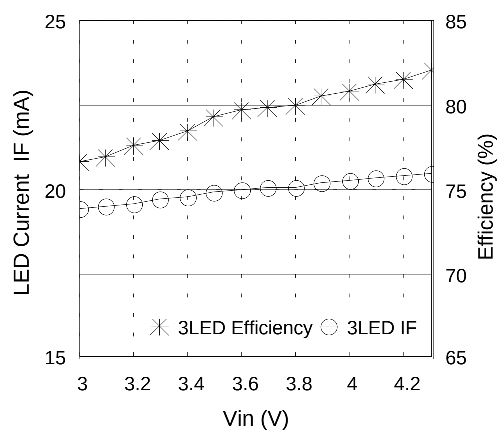


L1: TOKO 976AS-6R8
S-Di: TOSHIBA 1SS404 20V/1A
LED: NICHIA NSCW215T

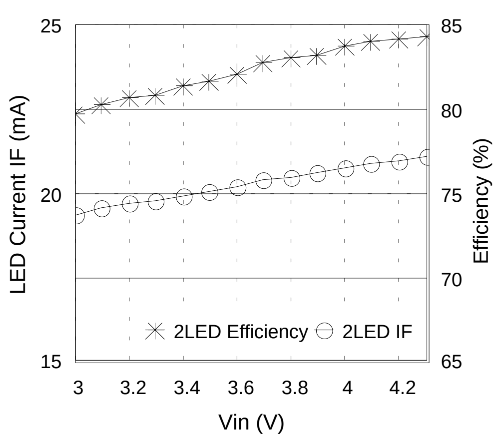
Vin - Efficiency/IF



Vin - Efficiency/IF



Vin - Efficiency/IF



<Measurement>

The efficiency of the VIN=3.0-4.3V range

	Efficiency(%)	Ave Efficiency(%)
2LED	79.7-84.4	82.3
3LED	76.7-82.1	79.5
4LED	73.1-79.7	74.0

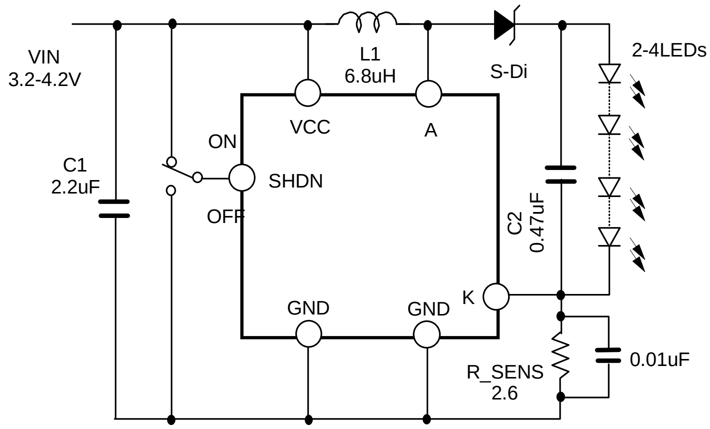
The IF of the VIN=3.0-4.3V range

	IF (mA)	Vcc dependence (%)
2LED	19.4-21.1	8.1
3LED	19.5-20.5	5.1
4LED	19.6-20.7	5.3

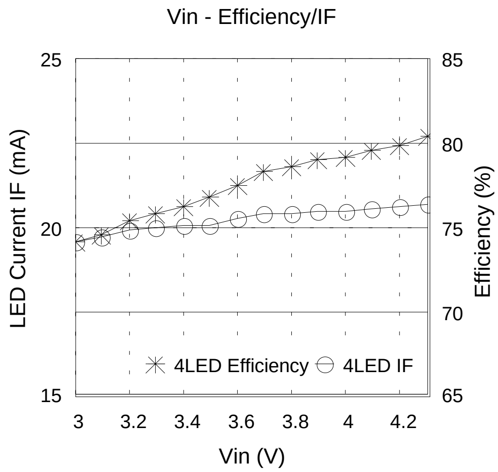
Note : The value is our company actual measurement value.
The result has the possibility to be different by the measurement environment.

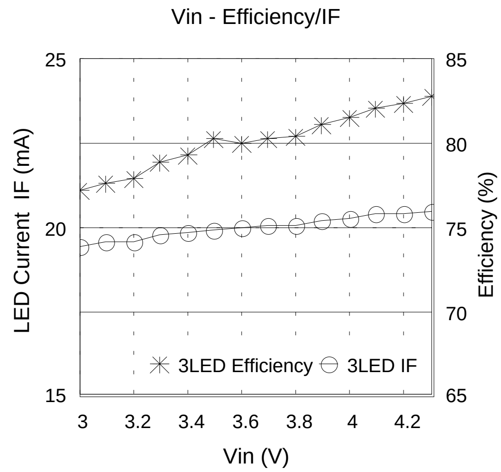
Application evaluation circuit example 4
(The evaluation result example by the small coil. : Coil = CXLD140-6R8)

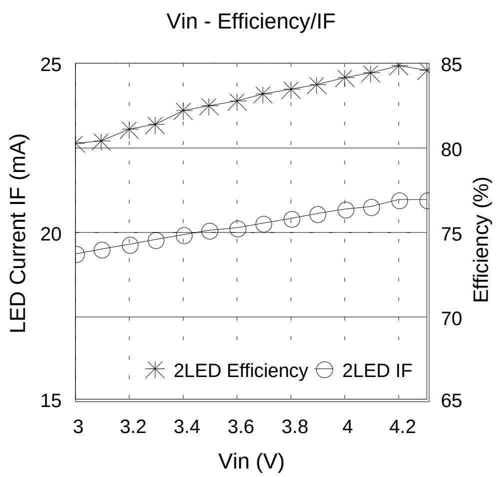
6.8uH is the most suitable when serial 3-4LED are turned on by IF= 20m A.
4.7uH is recommended when serial 2LED is turned on steadily in the range of VIN>4.5V.



L1: SUMITOMO CXLD140-6R8
S-Di: TOSHIBA 1SS404 20V/1A
LED: NICHIA NSCW215T







<Measurement>

The efficiency of the VIN=3.0-4.3V range

	Efficiency(%)	Ave Efficiency(%)
2LED	80.3-84.9	82.9
3LED	77.2-82.8	80.2
4LED	74.1-80.4	77.6

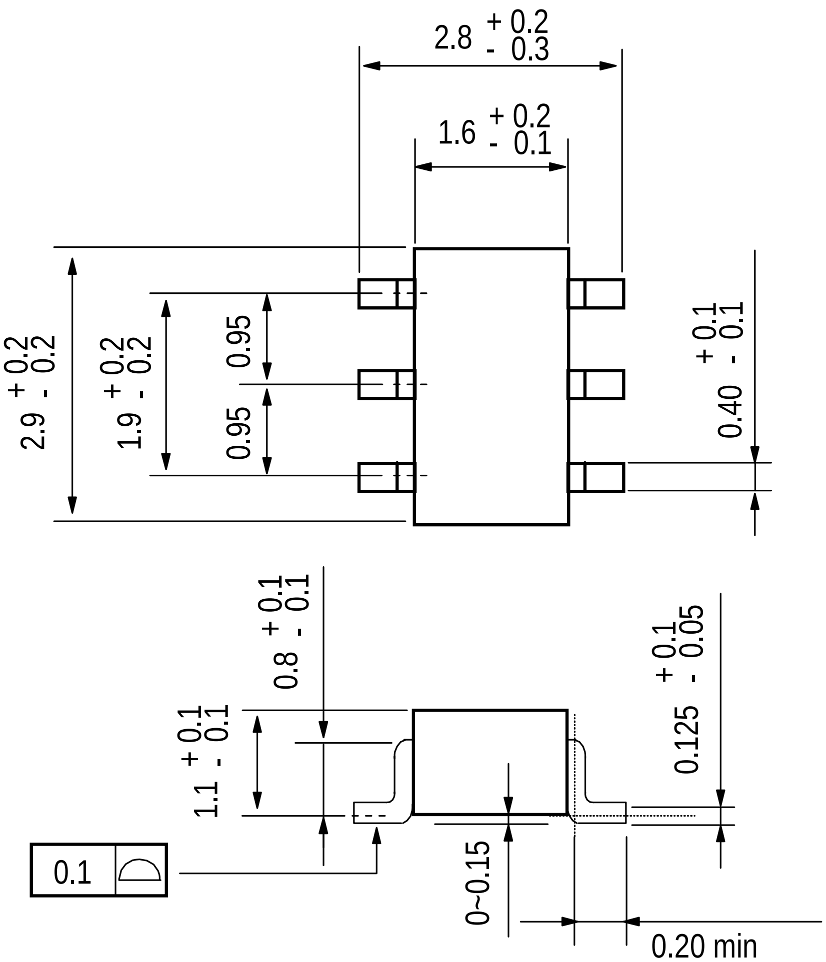
The IF of the VIN=3.0-4.3V range

	IF (mA)	Vcc dependence (%)
2LED	19.4-21.0	7.6
3LED	19.5-20.5	5.1
4LED	19.6-20.7	5.3

Note : The value is our company actual measurement value.
The result has the possibility to be different by the measurement environment.

PACKAGE

SSOP6-P-0.95B



UNIT : mm