APPLICATION MANUAL

PWM switching regulator controller IC
TK11840L

CONTENTS

MEETING YOUR NEEDS
TOKO, INC.

PWM switching regulator controller IC
TK11840L

1. DESCRIPTION

The TK11840L is a step-up DC-DC converter that drives an external NPN power transistor using a constant frequency PWM architecture.
The IC works with a wide operating supply range (1.8V to 10V) and has an adjustable output.
The IC timing oscillator operating frequency is programmable and can be set up to 1MHz.
The TK11840L incorporates a soft-start circuit, which ensures that the output pulse width starts from 0 % duty cycle and builds up to its proper level gradually when the IC is first powered up.
The TK11840L also incorporates a short-circuit detection function of a timer-latch type.

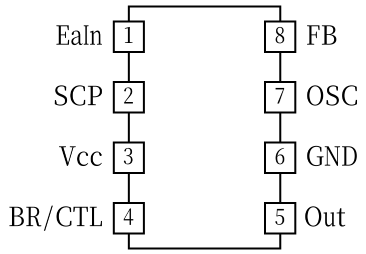
2. FEATURES

- Operation from 1.8V to 10V supply.
- Adjustable output voltage.
- High speed adjustable OSC. (Up to 1MHz)
- Incorporates a soft start circuit.
- Incorporates a short circuit detection of a timer-latch.
- Totem-pole type output in which current is adjustable using an external resistor.(Pin 4)
- 1µA or less shutdown current.
- Low component count.
- Small 8 Pin SOT23L-8 package.

3. APPLICATIONS

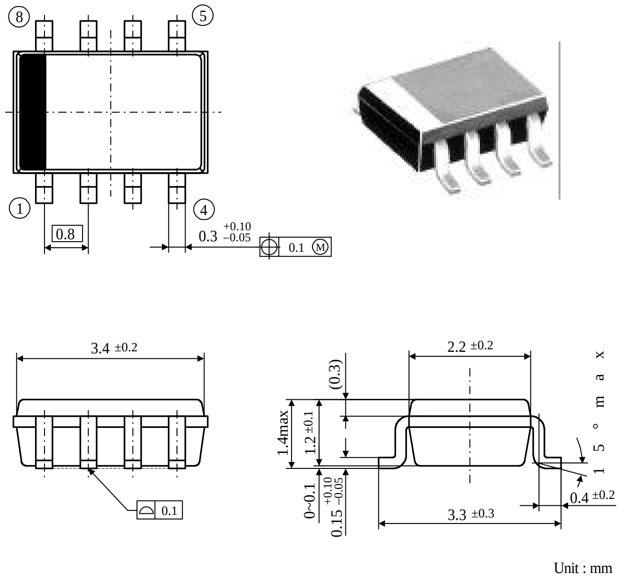
- White LED Backlighing and Frontlighting.
- Step-up DC-DC Converters
- Mobile Communication Systems: Cellular Phone,PHS,DSC,PDA
- Computer Peripherals Equipment
- Battery Powered System
- Portable Equipment

4. PIN CONFIGURATION



5. PACKAGE OUTLINE

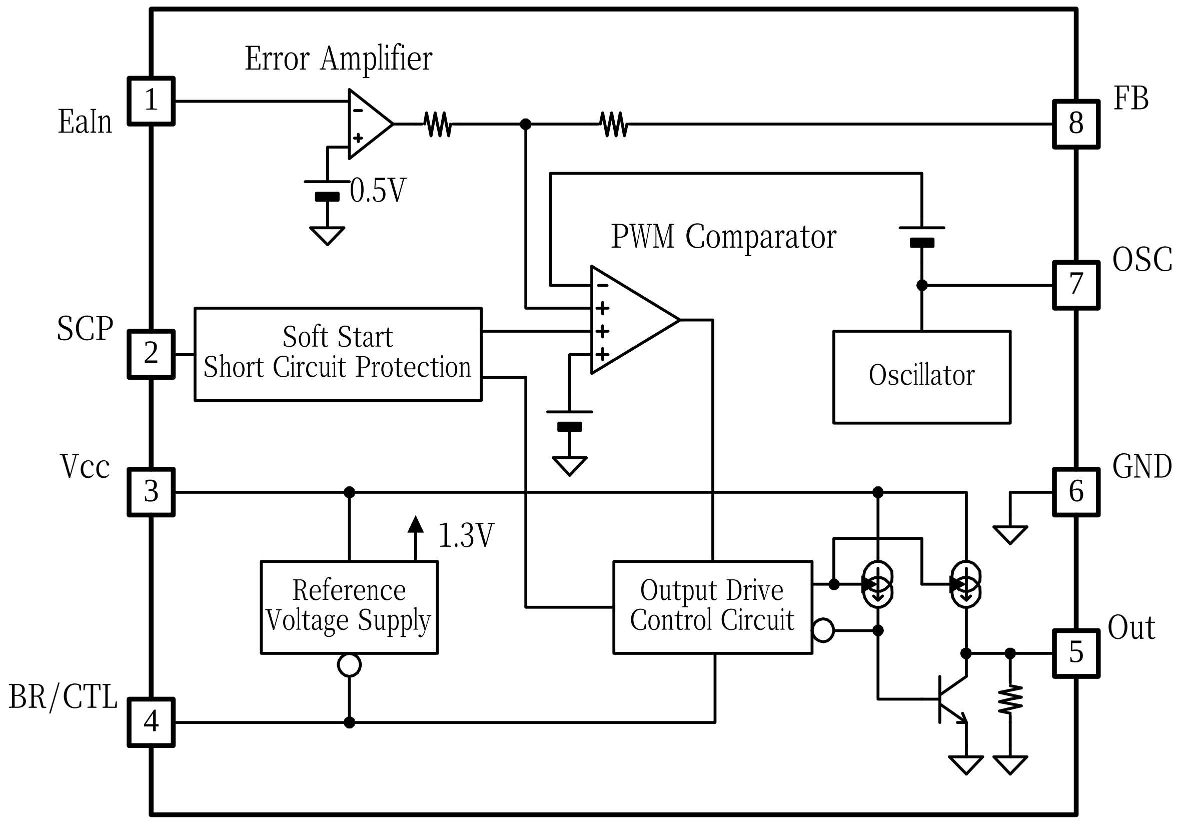
- SOT23L-8



Unit : mm

6. BLOCK DIAGRAM

Pin No.	Symbol	Description
1	EaIn	Error amplifier inverting input Feed back input. Threshold voltage is 0.5V . Connect resistive divider tap to this pin.
2	SCP	Soft start and Short circuit detection Connect external capacitor Cscp to this pin.
3	V_{CC}	Power Supply Voltage Input
4	BR/CTL	Output current setting and shutdown
5	Out	Totem-Pole type Output Connect to base of external NPN switching transistor.
6	GND	Ground
7	OSC	Oscillation frequency setting pin Connect external capacitor Ct and resistor Rt to this pin.
8	FB	Error amplifier output Compensation pin for error amplifier. Connect capacitor Cfb from FB pin (pin 8) to GND.



7. ABSOLUTE MAXIMUM RATINGS

T_a=25°C

Parameter	Symbol	Rating	Units	Conditions
Supply Voltage	V_{CC}	10	V	
Power Dissipation	P_D	400	mW	*
Storage Temperature Range	T_{stg}	-55 ~ +150	°C	
Operating Temperature Range	T_{OP}	-40 ~ +85	°C	
Maximum Operating Frequency	f_{MAX}	~ 1000	kHz	
Operating Voltage Range	V_{OP}	1.8 ~ 10	V	

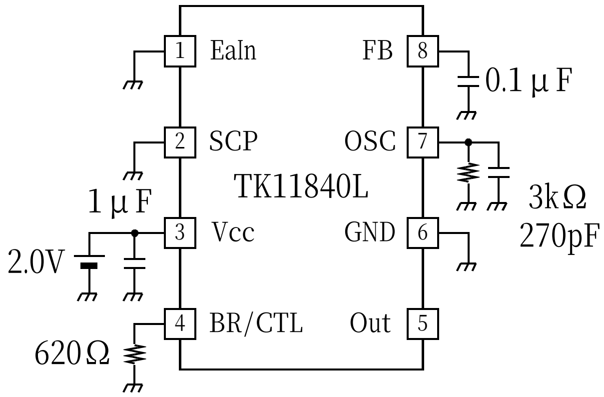
* P_D must be decreased at rate of 3.2mW/°C for operation above 25°C.

8. ELECTRICAL CHARACTERISTICS

V_{CC}=2V, T_a=25°C

Parameter		Symbol	Value			Units	Conditions
			MIN	TYP	MAX		
Circuit to prevent malfunction at low input voltage							
Reset voltage		$V_{CC, Reset}$	-	-	0.9	V	
Threshold voltage		$V_{CC, On}$	1.1	1.3	1.5	V	
Soft start							
Charging current		I_{SS}	-1.8	-1.2	-0.84	µA	V_{SCP}=0V
Threshold voltage		$V_{SS, TH}$	0.65	0.75	0.85	V	
Short circuit protection (S.C.P)							
Charging current		I_{SCP}	-1.8	-1.2	-0.84	µA	V_{SCP}=0V
Threshold voltage		$V_{SCP, TH}$	0.65	0.75	0.85	V	
Oscillator							
Frequency		f_{OSC}	440	550	660	kHz	Rt=3kΩ, Ct=270pF
Frequency input stability		$f_{ÄV}$	-	2	10	%	V_{CC}=2.0V~10V
Frequency variation with temperature		$f_{ÄT}$	-	5	-	%	T_a=-20°C~85°C
Error Amplifier							
Threshold voltage		V_{Ea}	480	500	520	mV	V_{FB}=0.45V
Line regulation		$V_{EaÄV}$	-	1	4	%	V_{CC}=2.0V~10V
Variation with temperature		$V_{EaÄT}$	-	1	-	%	T_a=-20°C~85°C
Input bias current		I_{EaIn}	-1.0	-0.2	1.0	µA	V_{EaIn}=0V
Voltage gain		A_V	35.5	38.5	41.5	dB	
Gain Band Width		GBW	-	6	-	MHz	A_V=0dB
Output high voltage		$V_{EaOut, High}$	0.78	0.87	-	V	V_{EaIn}=0V
Output low voltage		$V_{EaOut, Low}$	-	0.05	0.2	V	V_{EaIn}=1.0V
Output source current		$I_{EaOut, Source}$	-	-40	-24	µA	V_{FB}=0.45V
Output sink current		$I_{EaOut, Sink}$	24	40	-	µA	V_{FB}=0.45V
Dead time control							
Maximum duty cycle		D_{MAX}	65	75	85	%	
Output driver							
Output high voltage		$V_{Out, High}$	1.0	1.2	-	V	I_{Out}=-15mA
Output low voltage		$V_{Out, Low}$	-	0.1	0.2	V	I_{Out}=15mA
Output source current		$I_{Out, Source}$	-	-30	-20	mA	V_{Out}=0.9V
Output sink current		$I_{Out, Sink}$	30	60	-	mA	V_{Out}=0.3V
Pull-down resistor		R_{Out}	20	30	40	kΩ	
Output drive control							
Pin voltage		V_{BR}	0.25	0.35	0.45	V	R_{BR}=620Ω
Input off condition		$I_{BR, Off}$	-15	-	0	µA	
Input on condition		$I_{BR, On}$	-	-	-45	µA	
Pin current range		I_{BR}	-0.9	-	-0.1	mA	
Entire device							
Supply Current	On mode	$I_{CC, On}$	-	5.0	9.0	mA	R_{BR}=620Ω
	Off mode	$I_{CC, Off}$	-	0.1	1.0	µA	BR/CTL Pin=V_{CC}
	Latch mode	$I_{CC, LT}$	-	5.3	9.5	mA	S.C.P. is operating

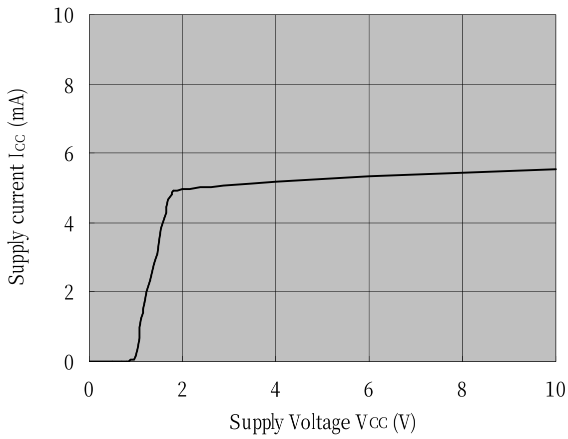
9. TEST CIRCUIT



10. TYPICAL CHARACTERISTICS

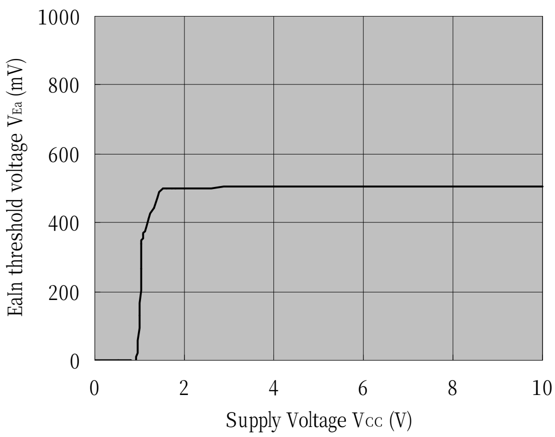
■ Supply current vs. Supply voltage (On mode)

T_a=25°C, R_{BR}=620Ω



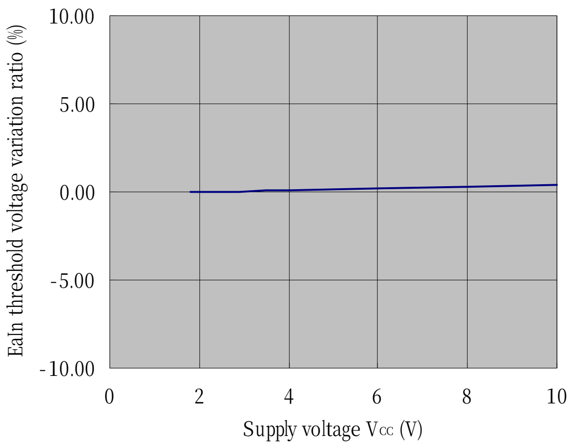
■ EaIn threshold voltage vs. Supply voltage

T_a=25°C



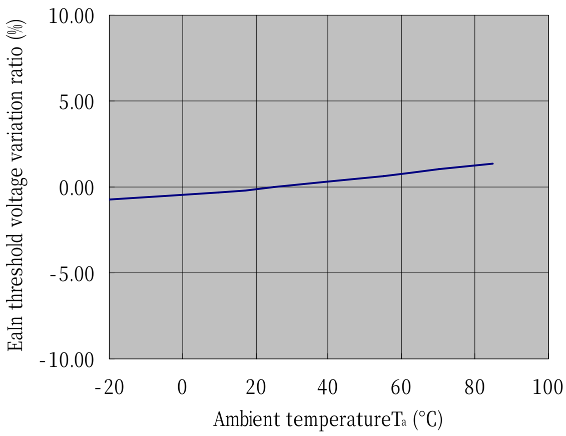
■ EaIn threshold voltage variation ratio vs. Supply voltage

T_a=25°C

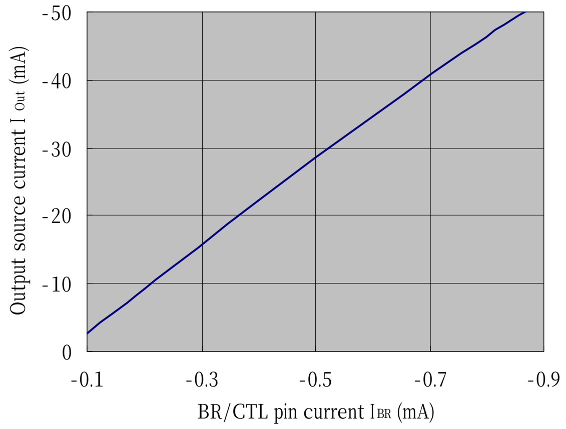


■ EaIn threshold voltage variation ratio vs. Ambient temperature

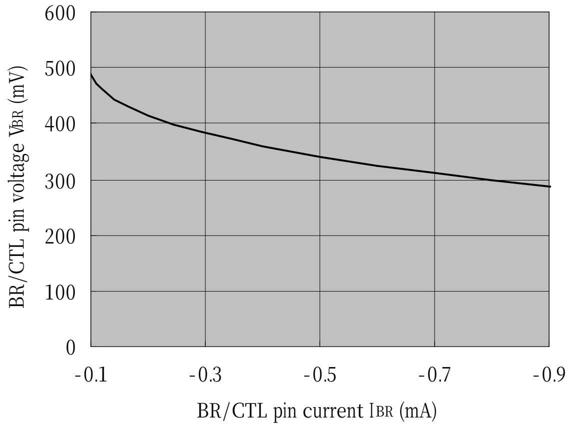
V_{CC}=2.0V



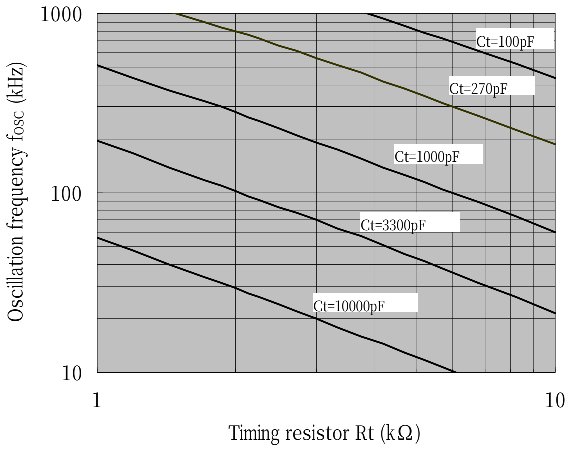
■ Output source current vs. BR/CTL pin current
V_{CC}=2.0V, T_a=25°C



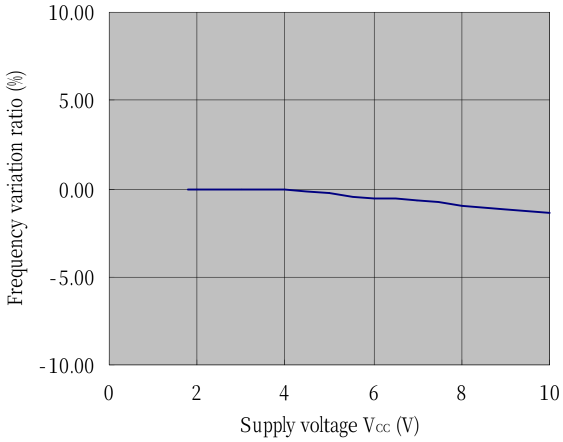
■ BR/CTL pin voltage vs. BR/CTL pin current
V_{CC}=2.0V, T_a=25°C



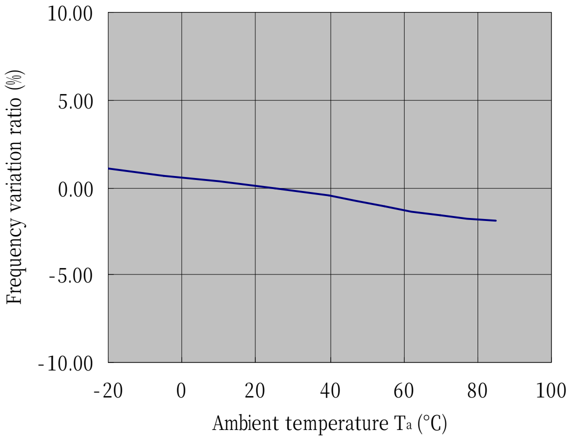
■ Oscillation frequency vs. Timing resistor
V_{CC}=2.0V, T_a=25°C



■ Frequency variation ratio vs. Supply voltage
Ct=270pF, Rt=3kΩ, T_a=25°C



■ Frequency variation ratio vs. Ambient temperature
V_{CC}=2.0V, Ct=270pF, Rt=3kΩ



11. CIRCUIT DESCRIPTION

12-1. Setting the output voltage

To obtain a regulated output voltage for most common step-up regulator applications, connect a voltage-divider from the output (Vout) to EaIn. (See Fig1)

The output voltage is determined by the 0.5V reference level and by the selection of two external resistors according to the equation.

$$Vout = V_{Ref} \times \left(1 + \frac{R2}{R1}\right)$$

where V_{Ref}=0.5V

The input bias current of EaIn has -0.2µA.typical .

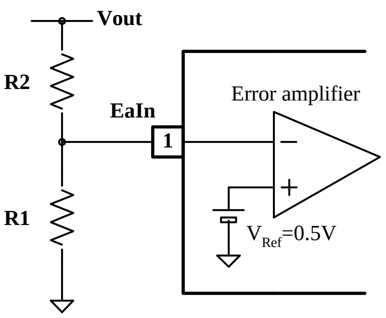


Fig1: Setting the output voltage

12-2. Shutdown

To disable the device (shutdown mode), set BR/CTL Pin (Pin 4) open or connect to V_{CC} as shown in Fig 2.
During shutdown, the supply current of the IC drops to 1µA or less.

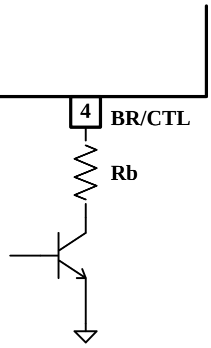


Fig2: Shutdown

12-3. Sawtooth wave Oscillator

The oscillator operates by rapidly charging an external capacitor Ct and resistor Rt with a current from a lower threshold voltage $V_{OSC,L}$ to an upper threshold voltage $V_{OSC,H}$.
Once the Ct voltage reaches the upper threshold voltage, the capacitor is slowly discharged back through resistor Rt to the lower threshold voltage.
The oscillator frequency can be expressed as

$$f_{OSC} \approx \frac{1}{Ct \cdot Rt \cdot \ln \dfrac{V_{OSC,H}}{V_{OSC,L}} + t_{Rise}}$$

where $V_{OSC,H}$=800mV
$V_{OSC,L}$=100mV
t_{Rise}=0.1µSec

This equation is rough estimate, because it takes no account of overshoot around the upper threshold level when Ct is charged rapidly.
A plot of OSC frequency vs. Rt and Ct is shown in Fig 3.

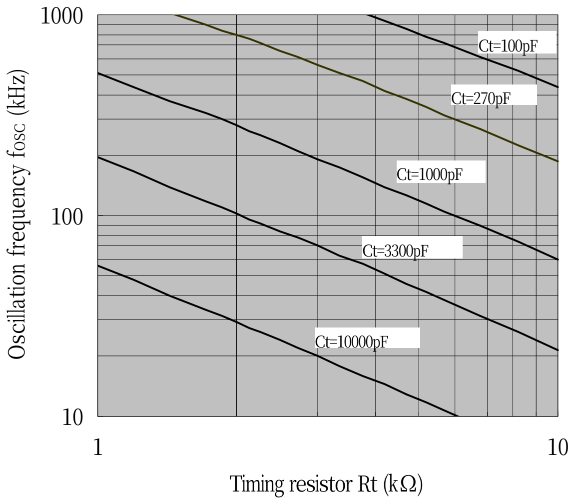


Fig.3: Oscillator frequency vs. Timing resistor

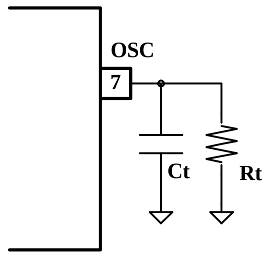
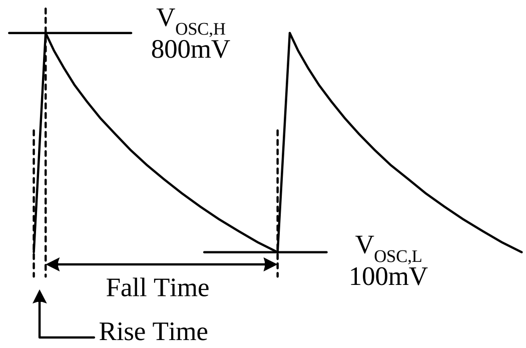


Fig 4. Oscillator pin connection



* t_{Rise}=0.1µSec

Fig 5. Oscillator waveform

12-4. Setting the output source current

The TK11840L is designed to drive an external bipolar NPN switching transistor, enabling high efficiency conversion with low input voltages.
The output current which is a base current of the NPN switching transistor is set by a resistor Rb at pin4.
This function ensures optimum efficiency over a wider range of load currents. The optimum Rb value should be determined by experiment in an actual circuit.

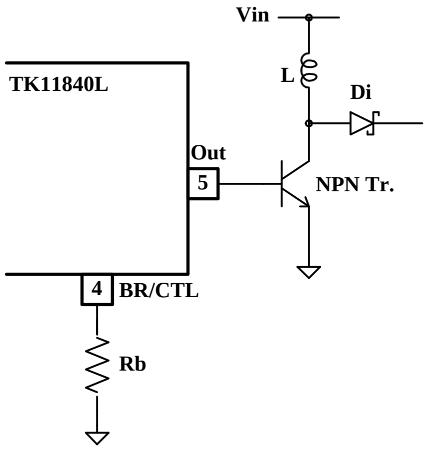


Fig6: Programming output current

The output current can be expressed as

$$I_{Out,source} = \alpha \cdot I_{BR}$$

$$I_{BR} = \frac{V_{BR}}{Rb}$$

where, V_{BR} is a voltage across the resistor Rb at pin4. I_{BR} is the current through Rb to GND.
α:A proportional coefficient which is approximately 50.

Fig.7 shows BR/CTL pin voltage (V_{BR}) vs. BR/CTL pin current (I_{BR}).

Fig.8 show output source current ($I_{Out,\ Source}$) vs. BR/CTL pin current (I_{BR}).

For example follows

$I_{Out,source}$=-10mA
I_{BR}=-0.2mA (from Fig.8)
V_{BR}=0.4V (from Fig.7)

$$\therefore Rb = \frac{V_{BR}}{I_{BR}} = 2k\Omega$$

The value of output source current ($I_{Out,Source}$) is 50mA maximum.

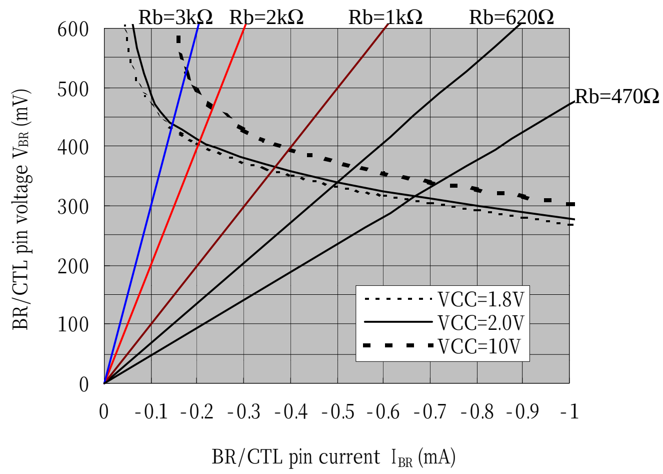


Fig 7. BR/CTL pin voltage vs. BR/CTL pin current

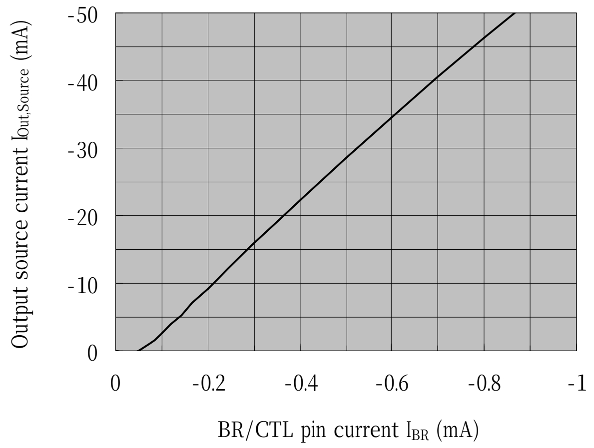


Fig 8. Output source current vs. BR/CTL pin current

12-5. Maximum output source current

Power dissipation within the IC package is a maximum 150mW at T_a= 85°C (ambient temperature)
The power dissipation of IC increases directly with input voltage and output current, which can be expressed as the following relation.

$$P_D \approx V_{CC} \cdot I_{Out,Source} \cdot Duty$$

Fig.9 shows an allowable output current setting area (safety area) under this condition. (150mW at T_a=85°C)
Output current must be set within the safe area. (which is lower than 50mA and "Duty line" in application circuit.)

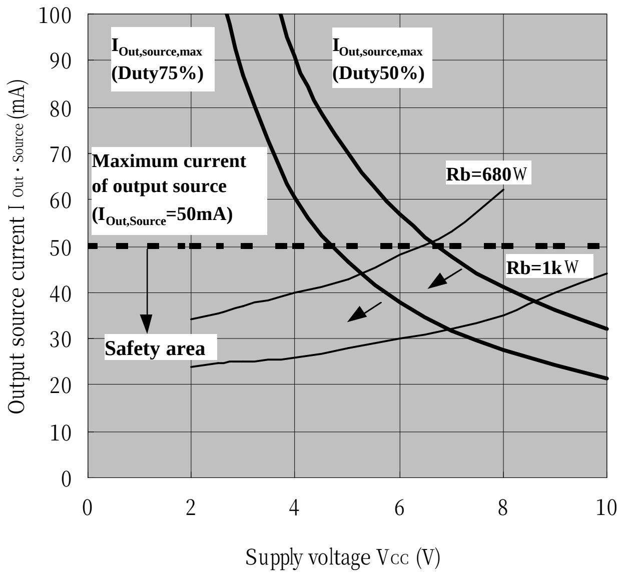


Fig 9. Output source current vs. supply voltage

12-6. Soft start and Short circuit detection

The TK11840L incorporates a soft start function and short circuit detection.
A capacitor Cscp connected to the SCP pin (pin2) is a dual purpose capacitor, one is for soft start function and the other is for short circuit detection. When the IC is first activated, the capacitor Cscp on the SCP pin is charged with about 1.2µA by internal current source.
The PWM comparator compares the soft start setting voltage as a proportion of the voltage at the SCP pin with the sawtooth waveform. The ON duty of the output pin is gradually increased by the PWM comparator output signal.

Soft start time (the time until the output ON duty reaches approximately 50%) is determined by

$$t_{SS}[S] \approx \frac{Cscp[\mu F]}{I_{SS}[\mu A]} \cdot 0.4[V] \approx 0.33 \cdot Cscp[\mu F]$$

where I_{SS} is internal current source of 1.2µA (Typ.).

After soft start operation is over, the voltage of SCP pin returns low and enters the short circuit detection wait state. When an output short circuit occurs as output suddenly drops due to load effect, the error amplifier output is fixed at $V_{EaOut,High}$ and capacitor Cscp starts charging with about 1.2µA. When the voltage of Cscp reaches about 0.75V, the output pin (pin5) is set low and the SCP pin (pin2) stays low.
Short circuit detection time is

$$t_{SCP}[S] \approx \frac{Cscp[\mu F]}{I_{SCP}[\mu A]} \cdot 0.75[V] = 0.625 \cdot Cscp[\mu F]$$

where I_{SCP} is internal current source of 1.2µA (Typ.).

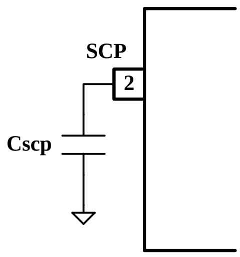


Fig 10. SCP pin connection

Once the protection circuit operates, the timer latch circuit can be restored by resetting the power supply.

Fig.11 shows the timing Diagram of soft start and short circuit detection.

Note :
In application of the simple step-up circuit, the short circuit detection circuitry is not in series with the power path from input to load.
This short circuit detection makes the external switch transistor turn off only.

Timing Diagram of soft start and short circuit detection.

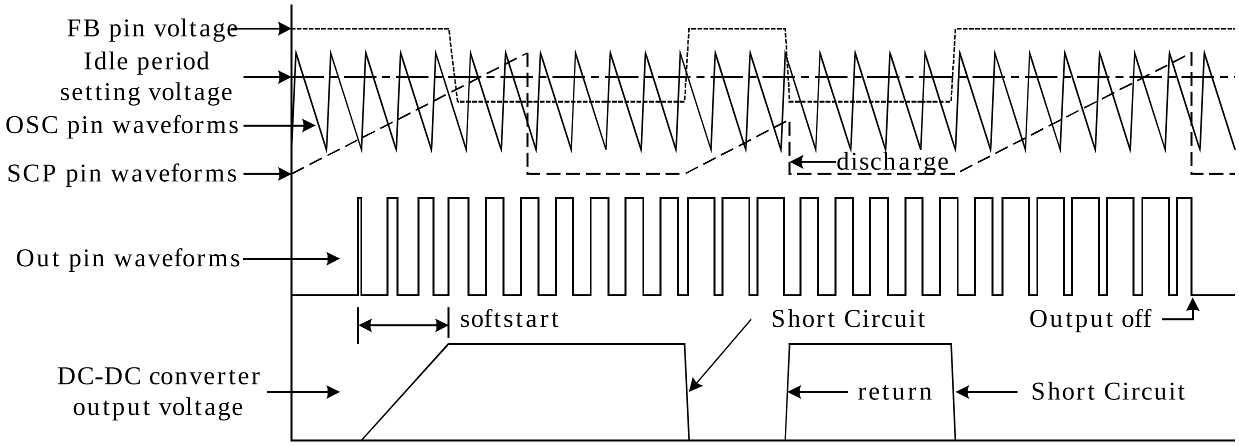


Fig.11: Timing Diagram of soft start and short circuit detection.

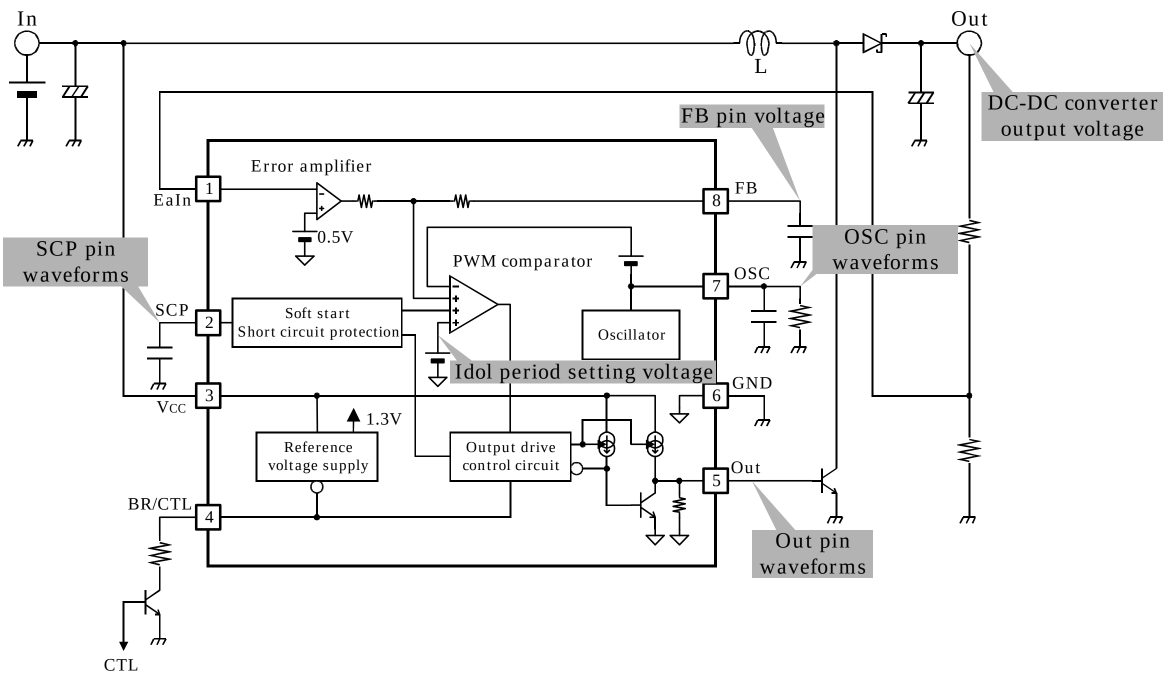


Fig.12: Minimum step-up application

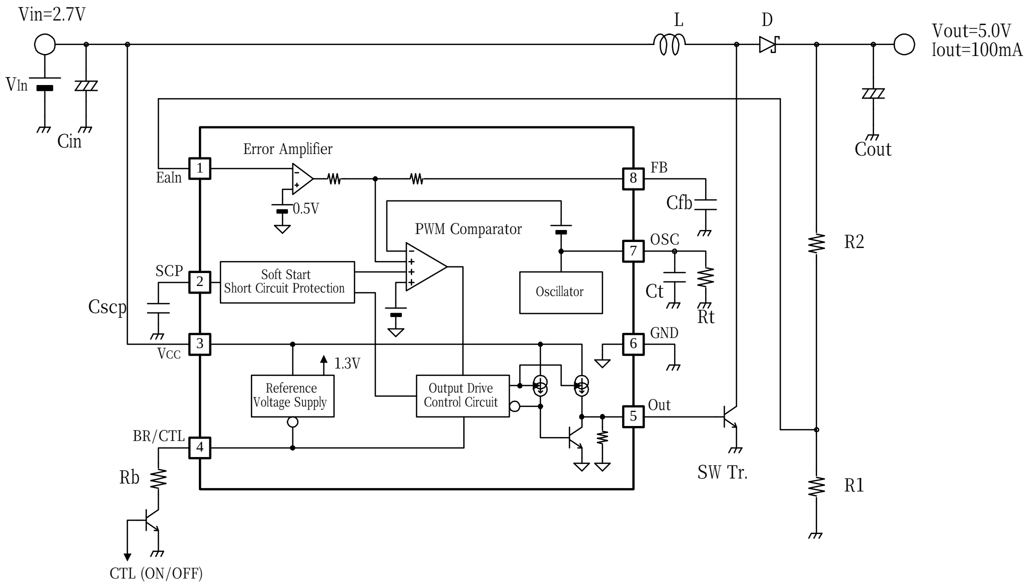
12. APPLICATIONS INFORMATION

■ Step-up DC-DC converter application

Typical application for 2.7V to 5V 100mA DC-DC Converter.

· Vin=2.7V
· Vout=5.0V
· Iout=100mA

Figure13: 2.7V to 5V 100mA DC-DC Converter



· Value of component

L= 15µH (TOKO D52LC TYPE *Parts No.A914BYW-150M)
Cin=10µF/6.3V, Cout=10µF/6.3V
Cfb=0.1µF, Cscp=0.1µF
Ct= 270pF , Rt= 2.2kΩ (Oscillator Frequency 730kHz)
Rb=2.0kΩ
R1=10kΩ, R2=91kΩ (Vout=5.0V)

· Output voltage setting

Set the output voltage by selecting values for R1 and R2.
The regulated output voltage is determined by

$$V_{Out} = V_{Ref}\left(1+\frac{R2}{R1}\right)$$

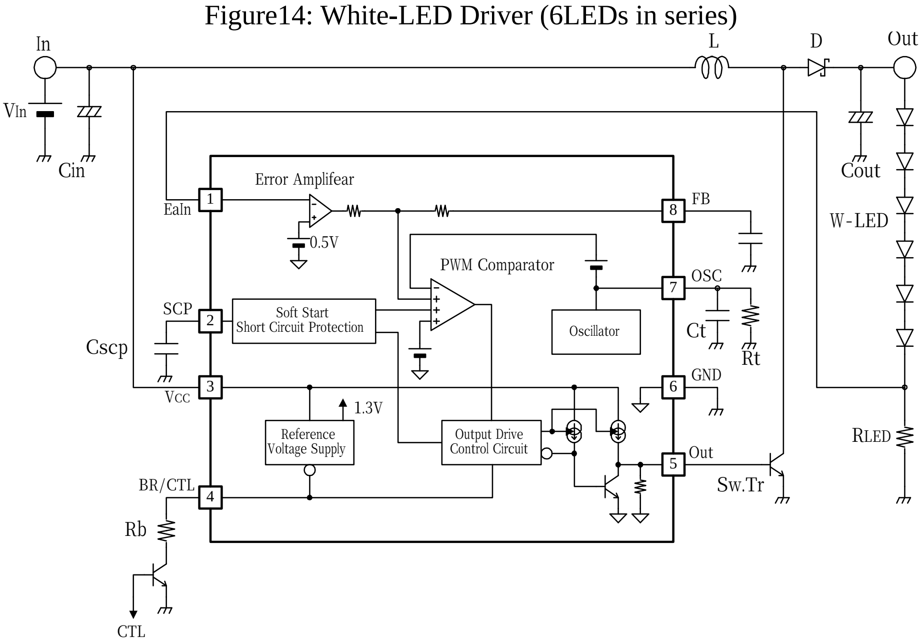
$$V_{Ref} = 0.5V$$

■ White-LED Drive application

Typical application for 6LEDs/20mA in series.

· Vin=2.5V
· I_{LED}=20mA

Figure14: White-LED Driver (6LEDs in series)



· Value of component

L=10μH (TOKO D52LC TYPE *Parts No.A914BYW-100M)
Cin=4.7μF, Cout=2.2μF
Ct=270pF, Rt=6.8kΩ (Oscillator Frequency:260kHz)
Cfb=0.1μF, Cscp=0.1μF
Rb=2.0kΩ

R_{LED}=24Ω ($I_{LED} = \frac{V_{Ref}}{R_{LED}} = \frac{0.5}{24} = 20.8\text{mA}$)

· LED current setting

The LEDs current (I_{LED}) is set by an external resistor (R_{LED}) connected between the EaIn pin and GND.
The current of each LED is same as

$$I_{LED} = \frac{V_{Ref}}{R_{LED}}$$

where V_{Ref} : the feedback reference voltage 0.5V

Output voltage Vout is given by

$$Vout = n \cdot Vf + V_{Ref}$$

where Vf : LED forward voltage drop
n : Number of LEDs in series connection

13. NOTES

■ Please be sure that you carefully discuss your planned purchase with our office if you intend to use the products in this application manual under conditions where particularly extreme standards of reliability are required, or if you intend to use products for applications other than those listed in this application manual.

- Power drive products for automobile, ship or aircraft transport systems; steering and navigation systems, emergency signal communications systems, and any system other than those mentioned above which include electronic sensors, measuring, or display devices, and which could cause major damage to life, limb or property if misused or failure to function.
- Medical devices for measuring blood pressure, pulse, etc., treatment units such as coronary pacemakers and heat treatment units, and devices such as artificial organs and artificial limb systems which augment physiological functions.
- Electrical instruments, equipment or systems used in disaster or crime prevention.

■ Semiconductors, by nature, may fail or malfunction in spite of our devotion to improve product quality and reliability. We urge you to take every possible precaution against physical injuries, fire or other damages which may cause failure of our semiconductor products by taking appropriate measures, including a reasonable safety margin, malfunction preventive practices and fire-proofing when designing your products.

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■ TOKO is not responsible for any problems nor for any infringement of third party patents or any other intellectual property rights that may arise from the use or method of use of the products listed in this application manual. Moreover, this application manual does not signify that TOKO agrees implicitly or explicitly to license any patent rights or other intellectual property rights which it holds.

■ None of ozone depleting substances(ODS) under the Montreal Protocol is used in manufacturing process of us.

14. OFFICES

If you need more information on this product and other TOKO products, please contact us.

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