AT1380

Preliminary

Switching Regulator Power Controller

Features

- Wide supply voltage operating range: 1.8 to15 V
- Low current consumption: Typically 5.5 mA in operation, 1 μA or less in stand-by
- High speed operation is possible: Maximum 1 MHz
- The error amplifier gain is set inside the IC, so peripheral components are minimized.
- Incorporates a soft start circuit.
- Incorporates a timer-latch type short circuit detection circuit (SCP).
- Totem-pole type output with adjustable on/off current (for NPN transistors)
- Incorporates a stand-by function.

Applications

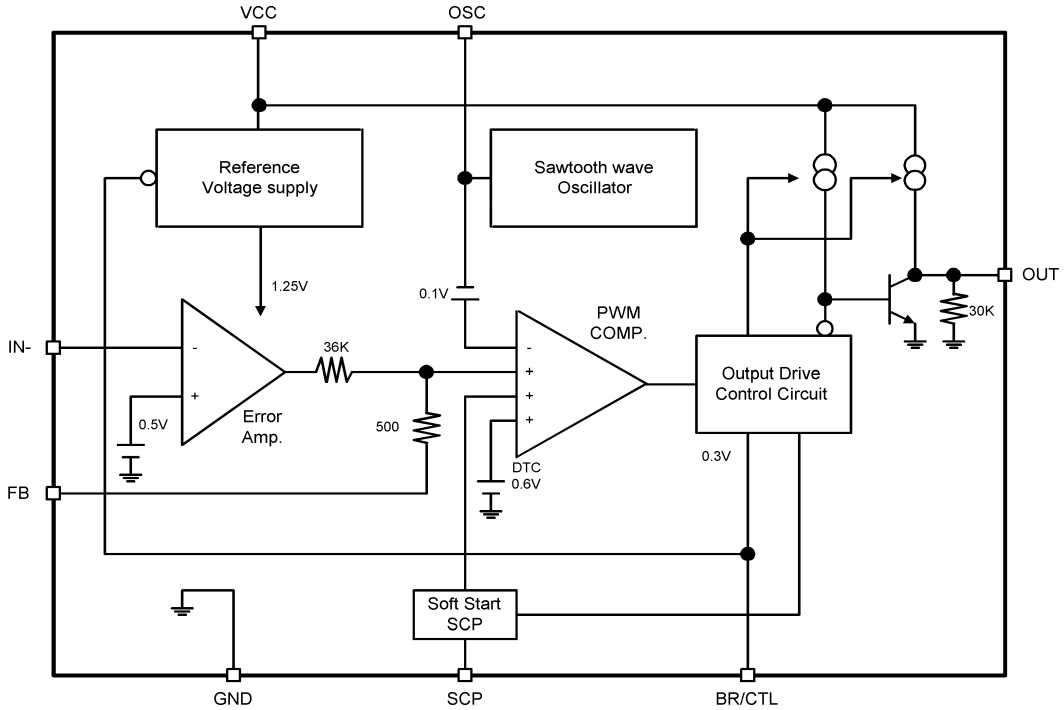
- Power source for battery-powered equipment
- Power source for cameras, camcorders, VCRs, PDAs, electronic data banks, and hand-held Communication equipment

General Description

The AT1380 is a single-channel switching regulator control IC for low voltage applications incorporating a soft start function and short circuit detection function. The device has a low minimum operating voltage of 1.8 V and is ideal for the power supply of battery-operated electronic equipment.

The AT1380 can be operated on two types: non-insulated input/output choppers (step-up, step-down and inverter regulators), and insulated input/output converters (fly-back). The former type is used for DC/DC converters and the latter type is used for DC/DC converts and line-operation-type power supplies.

Block Diagram



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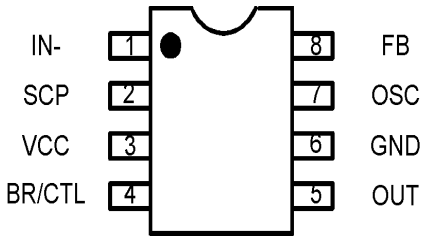
***Sample delivery by Q4/2000**

Pin Configuration

AT1380 (8-Pin SOIC)



Pin Description

Pin No.	Symbol	I/O	Description
1	IN-	I	Error amplifier inverting input pin
2	SCP	—	Soft start and SCP setting capacitor connection pin
3	VCC	—	Power supply pin
4	BR/CTL	I	Output current setting and control pin
5	OUT	O	Totem-pole type output pin
6	GND	—	Ground pin
7	OSC	—	Capacitor and resistor connection pin for setting the oscillation frequency
8	FB	O	Error amplifier output pin

Absolute Maximum Ratings

(T_a=+25^{0}C)

Parameter	Symbol	Condition	Rated Value		Unit
			Min.	Max.	
Power supply voltage	V_{CC}	—	—	16	V
Output source current	I_O^+	—	—	-50	mA
Output sink current	I_O^-	—	—	50	mA
Allowable dissipation	P_D	SOP-8, Ta ≦+25°C	—	430	mW
Operating temperature	T_{OP}	—	0	+75	^{0}C
Storage temperature	T_{stg}	—	-55	+125	^{0}C

* : When mounted on a 10 cm square double-sided epoxy board

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

Recommended Operating Conditions

(Ta=+25^{0}C)

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Power supply voltage	V_{CC}	1.8	--	15	V
Error amplifier input voltage	V_I	-0.2	--	1.0	V
BR/CTL pin input voltage	V_{BR}	-0.2	--	V_{CC}	V
Output source current	I_O^+	-40	--	--	mA
Output sink current	I_O^-	--	--	40	mA
SCP pin capacitance	C_{PE}	--	0.1	--	μF
Phase compensation capacitance	C_P	--	0.1	--	μF
Output current setting resistance	R_B	150	390	5000	Ω
Timing resistance	R_T	1.0	3.0	10.0	kΩ
Timing capacitance	C_T	100	270	10000	pF
Oscillation frequency	f_{OSC}	10	500	1000	kHz
Operating temperature	T_{OP}	-30	+25	+85	°C

WARNING: Recommended operating conditions are normal operating ranges for the semiconductor device. All the device's electrical characteristics are warranted when operated within these ranges. Always use semiconductor devices within the recommended operating conditions. Operation outside these ranges may adversely affect reliability and could result in device failure.

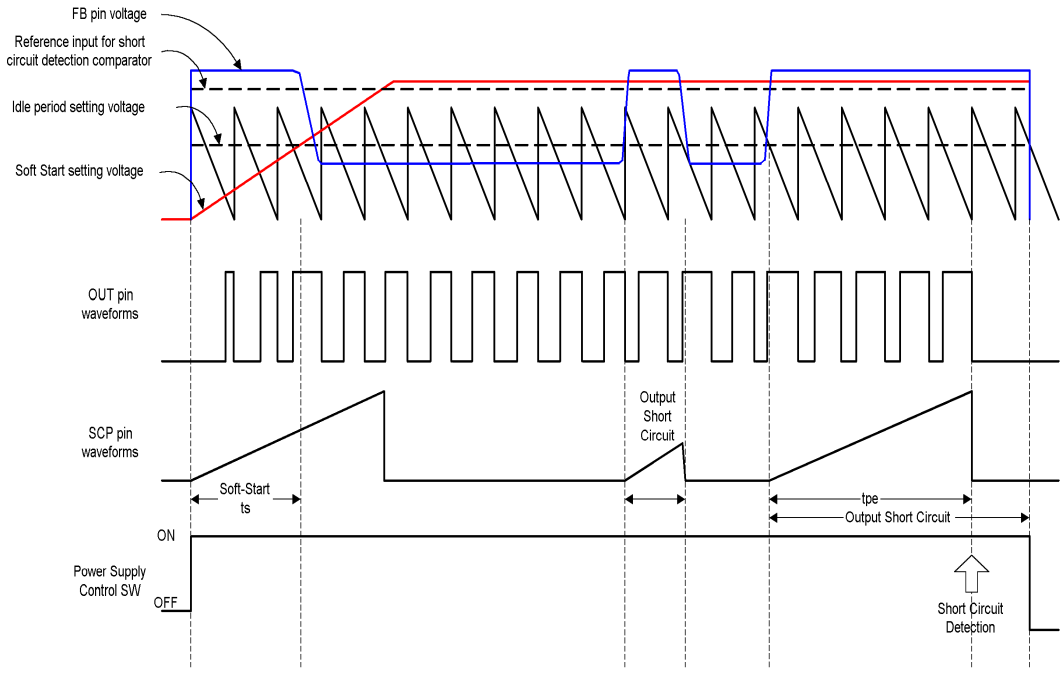
Electrical Characteristics

(V_{CC}=+2V, Ta=+25^{0}C)

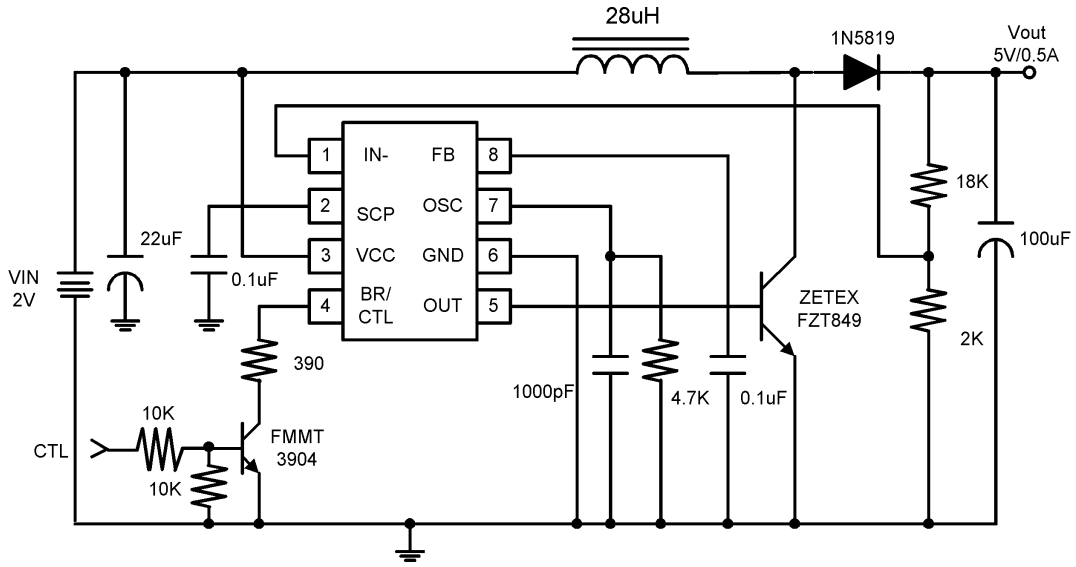
Parameter		Symbol	Condition	Values			Unit
				Min.	Typ.	Max.	
Circuit to prevent malfunction at low input voltage (U.V.L.O.)	Reset voltage	V_R	--	--	--	0.9	V
	Threshold voltage	V_{TH}		1.1	1.3	1.5	V
Soft start	Charging current	I_{CS}	V_{SCP}=0V	-1.5	-1.0	-0.7	μA
	Voltage at soft start completion	V_{ts}	--	0.7	0.8	0.9	V
Short circuit detection (S.C.P.)	Charging current	I_{CPC}	V_{SCP}=0V	-1.5	-1.0	-0.7	μA
	Threshold voltage	V_{tPC}	--	0.7	0.8	0.9	V
Sawtooth wave oscillator (OSC)	Oscillation frequency	f_{OSC}	R_T=3.0kΩ, C_T=270pF	400	500	600	kHz
	Frequency input Stability	f_{dV}	V_{CC}=2V to 15V	--	2	10	%
	Frequency variation with temperature	f_{dT}	Ta =0^{0}C to 85^{0}C	--	5	--	%
Error amplifier	Input threshold Voltage	V_T	V_{FB} = 450mV	480	500	520	mV
	V_T input stability	V_{TdV}	V_{CC}=2V to 15V	--	5	20	mV
	V_T variation with Temperature	V_{TdT}	Ta = -30^{0}C to 85^{0}C	--	1	--	%
	Input bias current	I_B	V_{IN} = 0V	-1.0	-0.2	1.0	μA
	Voltage gain	A_V	--	70	100	145	V/V
	Frequency bandwidth	BW	A_V = 0 dB	--	6	--	MHz
	Maximum output voltage range	V_{OM}^+	--	0.78	0.87	--	V
		V_{OM}^-		--	0.05	0.2	V
	Output source current	I_{OM}^+	V_{FB} = 450mV	--	-40	-24	μA
	Output sink current	I_{OM}^-		24	40	--	μA
Idle period adjustment section	Maximum duty cycle	T_{DUTY}	R_T=3.0kΩ, C_T=270pF V_{FB} = 0.8V	65	75	85	%
Output section	Output voltage	V_{OH1}	R_B= 390Ω, I_O= -15 mA	1.0	1.2	--	V
		V_{OH2}	R_B= 750Ω, V_{CC} = 1.8V I_O= -10 mA	0.8	1.0	--	V
		V_{OL1}	R_B= 390Ω, I_O= -15 mA	--	0.1	0.2	V
		V_{OL2}	R_B= 750Ω, V_{CC} = 1.8V I_O= -10 mA	--	0.1	0.2	V
	Output source current	I_O^+	R_B= 390Ω, V_O = 0.9V	--	-40	-20	mA
	Output sink current	I_O^-	R_B= 390Ω, V_O = 0.3V	30	60	--	mA
	Pull down resistance	R_O	--	20	30	40	kΩ

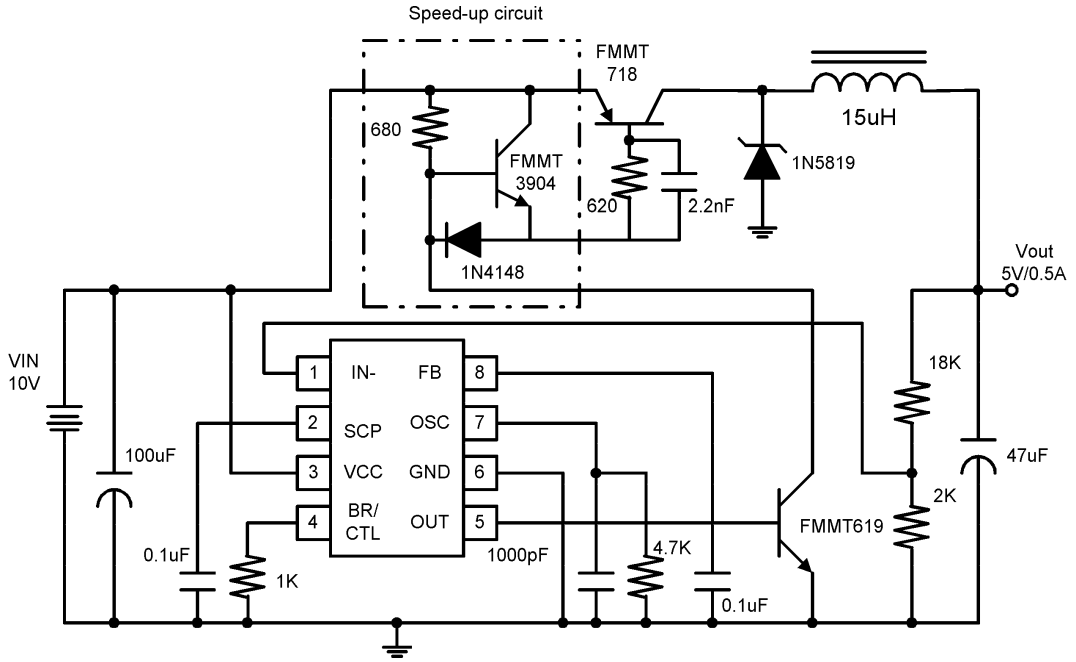
Output current Setting section/ Control section	Pin voltage	V_{BR}	R_B= 390Ω	0.2	0.3	0.4	V
	Input off condition	I_{OFF}	--	-20	--	0	μA
	Input on condition	I_{ON}		--	--	-45	μA
	Pin current range	I_{BR}		-1.8	--	-0.1	mA
Entire device	Stand-by current	I_{CCS}	BR/CTL pin open or V_{CC}	--	--	1	μA
	Average supply current	I_{CC}	R_B= 390Ω	--	5.5	9.3	mA

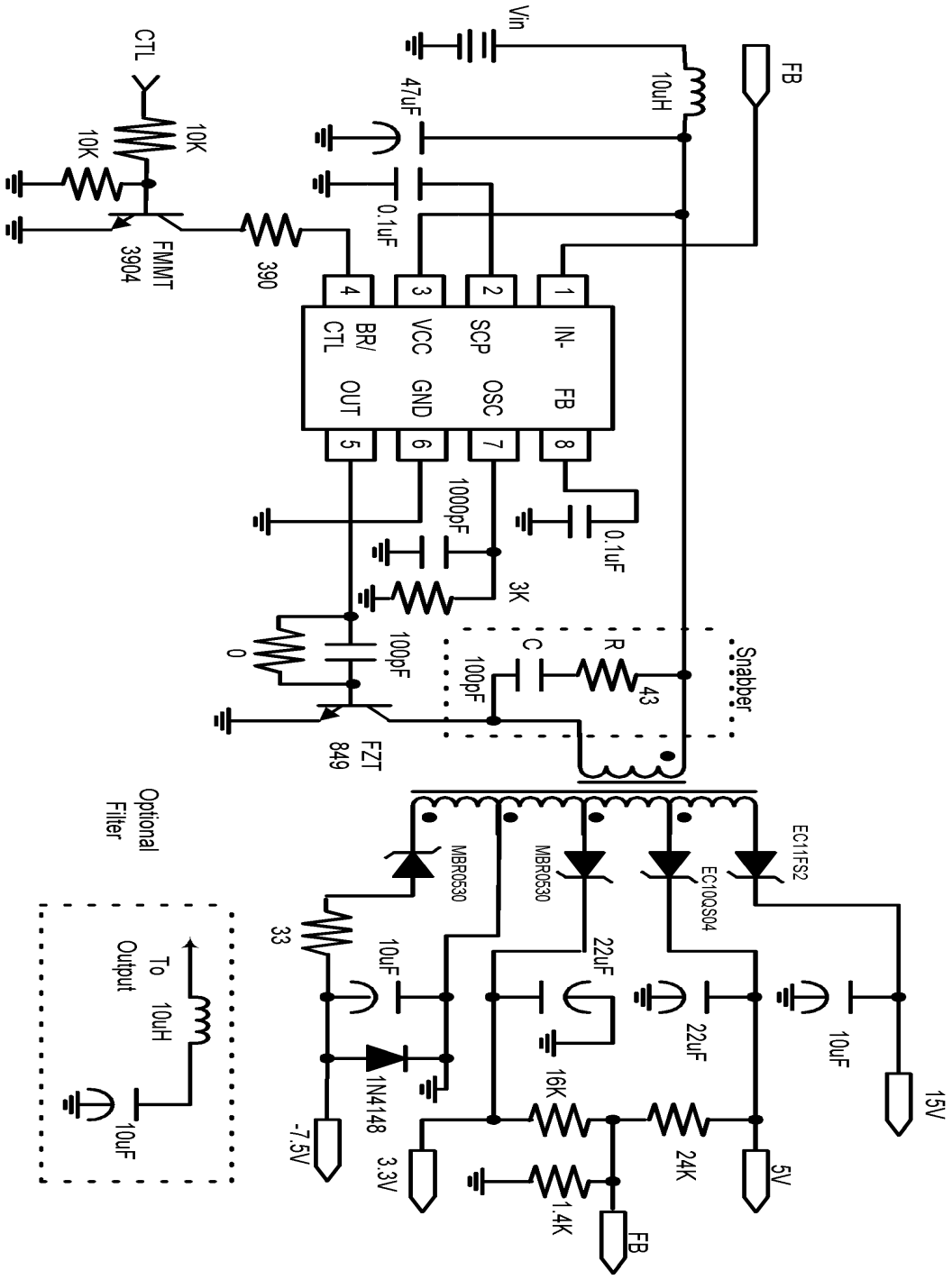
Timing Chart



Typical Application Schematic






Vin
CTL
10K
10K
FMMT
3904
390
47uF
0.1uF
10uH
FB
4
3
2
1
BR/
CTL
VCC
GND
SCP
OSC
IN-
FB
OUT
5
6
7
8
1000pF
0.1uF
3K
0
100pF
C
R
100pF
43
Snabber
FZT
849
Optional
Filter
To
Output
10uH
10uF
MBR0530
MBR0530
EC10QS04
EC11FS2
33
10uF
22uF
22uF
10uF
16K
1N4148
-7.5V
3.3V
24K
5V
15V
1.4K
FB

Functional Description

Soft Start SCP

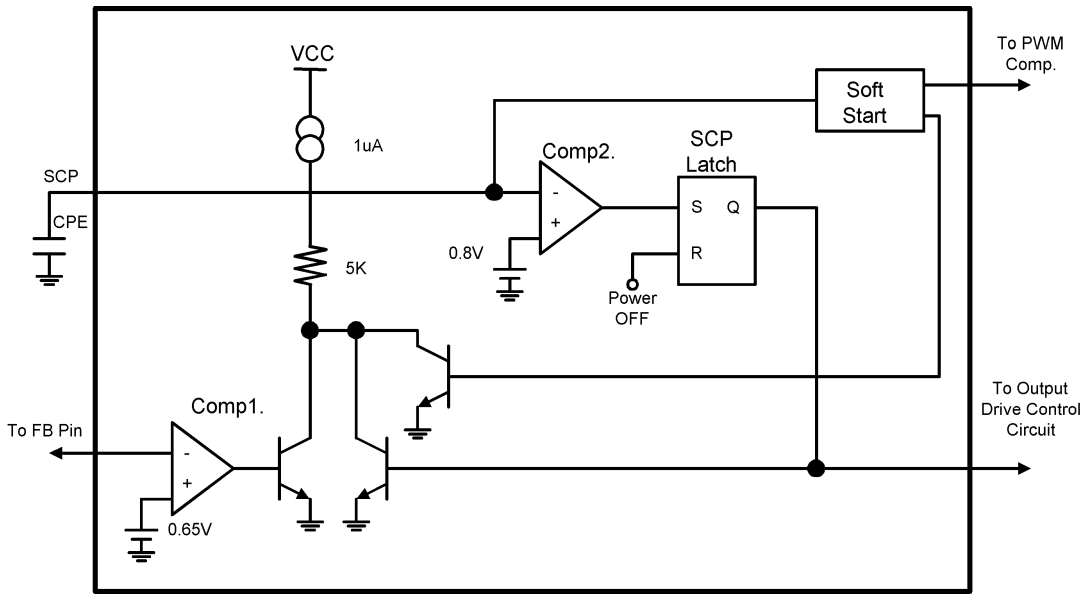


Figure 1 Soft-Start SCP Equivalent circuit

At power-on, the AT1380 operates in the soft-start mode. Since no current is supplied, comp1, comp2, and SCP latch are inactive. Immediately after power-on, the CPE capacitor is charged at a constant current of 1μA to increase from 0V. In the soft-start mode, the VSCP (capacitor CPE voltage) is input to the PWM comparator, so that the soft-start circuit is controlled at the on-duty ratio of 0% with the increase of the VSCP.

When the VSCP reaches 0.8V, the soft-start supplies current to comp1, comp2, and SCP latch and at the same time discharges the CPE capacitor (VSCP=0V). This changes the soft-start mode to the normal mode (output short circuit detection wait state) and the SCP becomes active (stays low). In the normal mode, the input from the soft-start circuit to the PWM comparator is kept at 0.8V.

If the switching regulator output suddenly drops due to load effect, the error amplifier output (FB pin) is fixed at VOM^{+} and capacitor CPE starts charging. When the voltage at the SCP pin reaches approximately 0.8V, the output pin is set low and the SCP pin stays low.

Set time by the following expressions (see **Timing Chart**):

Soft-Start time (The time until the output ON duty reaches approximately 50%)

$$t_S = 0.35 \times CPE(\mu F)$$

Short-circuit detection time:

$$t_{PE} = 0.8 \times CPE(\mu F)$$

Setting Oscillating Frequency

The oscillation frequency of a sawtooth waveform is determined by the timing capacitor (CT) and the timing resistor (RT) which are connected to the OSC pin. When the voltage of the OSC pin falls to 0.1V, the CT is rapidly charged to increase the voltage of the OSC pin instantaneously. When the voltage of the OSC pin reaches 0.6V, Charging stops, so that CT and RT are discharged to decrease the voltage of the OSC pin. The waveform of the OSC pin is shown as Figure 2.

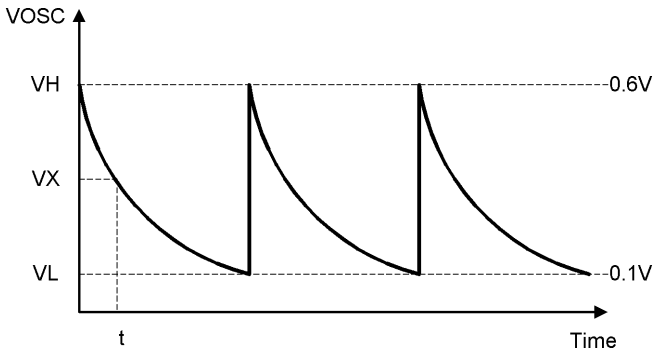


Figure 2 Oscillator Waveform

The cycle (T) can be determined as follows:

$$VX = VHe^{-\frac{t}{CT \times RT}} \qquad t = -CT \times RT \times \log_e(\frac{VX}{VH})$$

$$T = -CT \times RT \times \log_e(0.1/0.6) = 1.8 \times CT \times RT[s]$$

Calculating under the conditions of RT=3.3KΩ and CT=330pF , the oscillating frequency is 512kHz, which is slightly different from the value (500kHz) in the **Electrical Characteristics.** This difference is caused by characteristics, such as changes in the maximum voltage amplitude of the sawtooth waveform with the CT value and the circuit delay causing the maximum amplitude to become large in the case of a high oscillating frequency even for the same capacitor. It is difficult to incorporate these non-linear characteristics into the equation. In practical use, therefore, the user should read the RT and

CT values from the characteristic curve or should determine an approximate target value by using the equation.

Switching Regulator Function

(1) Reference voltage circuit

The reference voltage circuit generates a temperature-compensated reference voltage (~1.25V) from voltage supplied from the power supply pin (pin 3). In addition to providing the reference voltage for the switching regulator, the circuit also sets the idle period.

(2) Error amplifier

The error amplifier detects the output voltage of the switching regulator and outputs the PWM control signal. The voltage gain is fixed, and connecting a phase compensation capacitor to the FB pin (pin 8) provides stable phase compensation for the system.

(3) PWM comparator

The voltage comparator has one inverting and three non-inverting inputs. The comparator is a voltage/pulse width converter that controls the ON time of the output pulse depending on the input voltage. The output level is high (H) when the sawtooth wave is lower than the error amplifier output voltage, soft start setting voltage, and idle period setting voltage.

(4) Output circuit

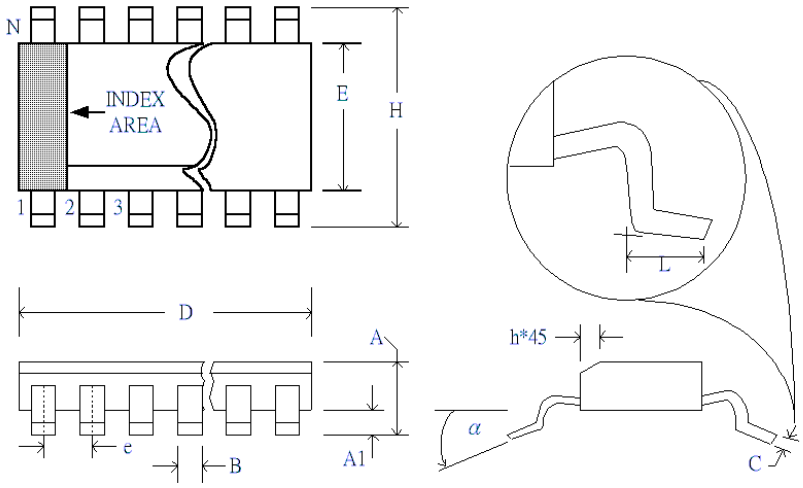
The output circuit has a totem pole type configuration and can drive an external NPN transistor directly. The value of the ON/OFF current can be set by a resistor connected to the BR/CTL pin (pin 4). Stand-by mode (supply current 1μA or less) can be set by connecting the BR/CTL pin (pin4) to VCC or by making the pin open circuit.

(5) Under-Voltage Lockout (UVLO)

Transients when powering on or instantaneous glitches in the supply voltage can lead to malfunction of the control IC and cause system damage or failure. The circuit to prevent malfunction at low input voltage detects a low input voltage by comparing the supply voltage to the internal reference voltage. On detection, the circuit fixes the output pin to low.

The system recovers when the supply voltage rises back above the threshold voltage of the malfunction prevention circuit.

Small Outline Plastic Packages (SOIC)



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.053	0.069	1.35	1.75	-
A1	0.004	0.010	0.10	0.25	-
B	0.014	0.019	0.35	0.49	-
C	0.007	0.010	0.19	0.25	-
D	0.189	0.197	4.80	5.00	-
E	0.150	0.157	3.80	4.00	-
e	0.050BSC		1.27BSC		-
H	0.228	0.244	5.80	6.20	-
h	0.010	0.020	0.25	0.50	-
L	0.016	0.050	0.40	1.27	-
N	8		8		-
α	0^0	8^0	0^0	8^0	-