

## Primary PWM Controller

- **Current-mode PWM Controller**
- **High-current output drive suitable for Power MOSFET**
- **Automatic burst mode in zero-load condition**
- **Primary overcurrent protection (hiccup mode)**
- **Internal leading edge blanking on current sense**
- **External slope compensation capability**
- **Programmable soft start**
- **Frequency modulation for low emi**
- **Accurate oscillator frequency**
- **77% duty cycle limitation**
- **5V reference**
- **Under voltage protection**
- **Thermal shutdown at 130°C**
- **2kV ESD protection**

### DESCRIPTION

The TSM006 integrated circuits incorporate all circuitry to implement off line or DC-DC power supply applications using a fixed frequency current mode control.

Based on a standard current mode PWM controller, these devices include additional features for higher integration.

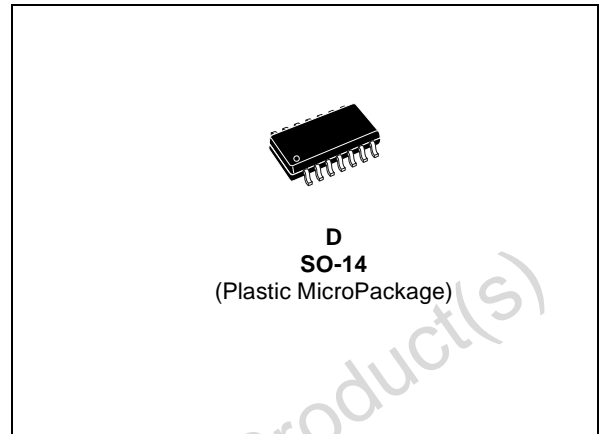
### APPLICATIONS

- **AC/DC adapter**

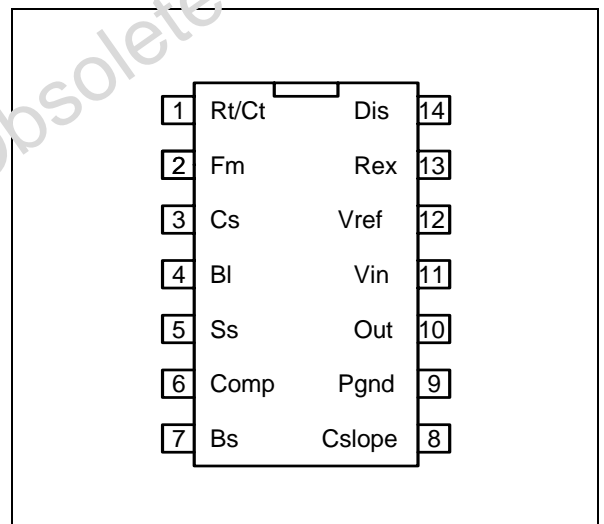
D = Small Outline Package (SO) - also available in Tape & Reel (DT)

### ORDER CODES

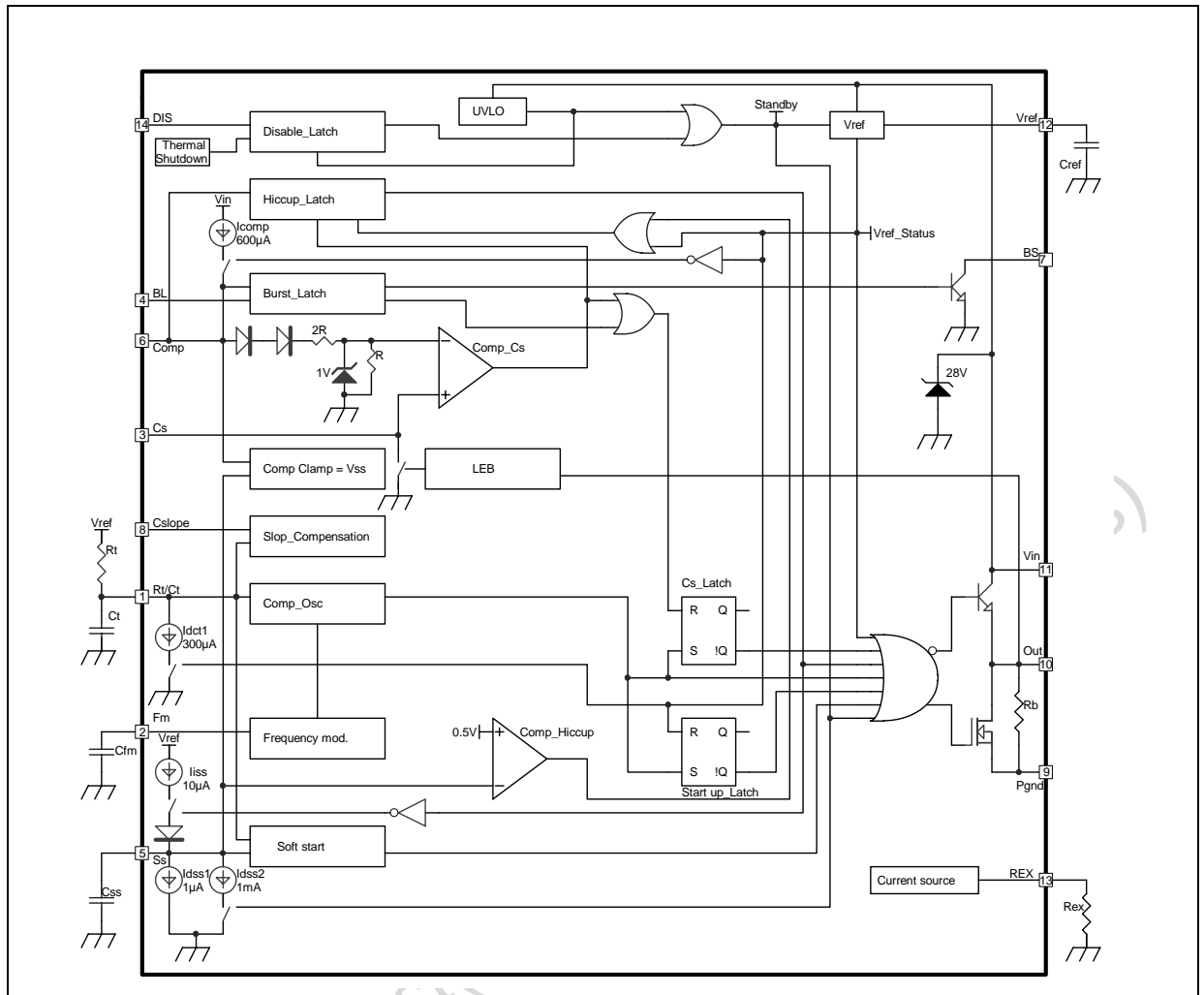
Part Number	Temperature Range	Package	Packaging	Marking
TSM006ID	0, +105°C	SO	Tube	TSM006
TSM006IDT			Tape & Reel	TSM006



### PIN CONNECTIONS (top view)



## 1 Block Diagram



## PIN DESCRIPTION

Name	SO14	Type	Function
RT/CT	1	Timing capacitor	Sets the oscillator frequency and maximum duty cycle
FM	2	Analog input	Frequency modulation
CS	3	Analog input	Current sense.
BL	4	Analog output	Burst level
SS	5	Timing capacitor	Soft start and hiccup timing, latched disable input.
COMP	6	Analog input	Current comparator for current mode control.
BS	7	Output input	Burst mode status
CSLOPE	8	Analog output	Slope compensation
PGND	9	Power supply	Power ground
OUT	10	Analog output	Totem pole output to direct drive a power MOSFET.
VIN	11	Power supply	Supply input voltage.
VREF	12	Analog output	+5V Voltage reference
REX	13	Analog input	External resistor for internal constant current
DIS	14	Analog input	Latched disable

## 2 Absolute Maximum Ratings

Symbol	DC Supply Voltage	Value	Unit
Vin	DC Supply Voltage (Iin<50mA) <sup>1</sup>	-0.3 to self limit	V
Io	DC output current	0.1	A
Iopeak	Peak output current	1	A
Vcomp	COMP terminal voltage	-0.3 to 6.5	V
Isinkcomp	COMP terminal sink current	6	mA
Vss	SS terminal voltage	-0.3 to 8	V
Vout	OUT terminal voltage	-0.3 to Vin	V
Vter	Other terminal voltage (CT, VREF, BS, BL, CSLOPE REX, CS, FM, DIS)	-0.3 to Vref	V
Pt	Power dissipation at 25°C	500	mW
Tstg	Storage temperature	-40 to 150	°C
Tj	Junction temperature	150	°C
ESD	Electrostatic Discharge	2	kV

1) All voltage values, except differential voltage are with respect to network ground terminal (GND).

### OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
Vcc	DC Supply Conditions	8 to 20	V
Toper	Operating Free Air Temperature Range	0 to 105	°C

### 3 Electrical Characteristics

Tamb = 25°C, Vin=15V, Rt=39k, Ct=470pF, Rex=27k, Cfm=1nF unless otherwise specified

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
<b>Main oscillator</b>						
Fosco	Lower oscillating frequency	8≤Vin≤20V, 0≤Ta≤105°C Vfm=GND	63	68	73	kHz
Foscl	Upper oscillating frequency	Vfm=Vref	57.6	62	66.4	kHz
Fjit	Frequency jitter	Fjit=Fosco - Foscl	6	7	8	kHz
Ffm	Frequency modulation			4.5		kHz
Vthct	Upper trip point	Vfm=GND		3.0		V
Vtlct	Lower trip point	Vfm=GND		1.4		V
ΔVct	Amplitude	Vfm=GND		1.6		V
ldct1	Discharge current	Vct=2V		300		μA
ldct2	Current at Ct in UVLO	Vct=1V	1	3		mA
<b>Disable</b>						
Vdis	Voltage threshold		2.5	2.65	2.8	V
<b>Vref reference pin</b>						
Vref	Voltage reference		4.91	5.00	5.09	V
ΔVline	Line regulation	12V ≤ Vin ≤ 20V		5	10	mV
ΔVload	Load regulation	1mA ≤ Iref ≤ 5mA		10	20	mV
ΔVtotal	Total variation	Line, load, temp	4.85	5.00	5.15	V
los	Short circuit current	Vref=0	10			mA
<b>Slope Compensation</b>						
IsinkCP	Sink current	Vct=2.2V, VCslope=1V		90		μA
IsrcCP	Source current	Vct=2.2V, VCslope=0V	2			mA
<b>Comp</b>						
Icomp	Source current	Vcomp=5V	0.5	0.6	0.7	mA
<b>Current sense</b>						
Avcs	Gain	0V ≤ Vcs ≤ 0.8V	2.85	3.00	3.15	
Vz1	Maximum sensing voltage	Vcomp=5V	0.9	1.0	1.1	V
PSRR	Power supply voltage rejection ratio	8V ≤ Vin ≤ 20V		70		dB
<b>Leading edge blanking</b>						
LEB	Delay to output	Vcs = 0 to 2 V Vcomp = 2 V		280		ns
<b>Output</b>						
VOL1	Output low voltage 1	Iosink=20mA			1.0	V
VOL2	Output low voltage 2	Iosink=200mA		0.8	2.2	V
VOH1	Output high voltage 1	Iosource=20mA	Vin-2.0			V
VOH2	Output high voltage 2	Iosource=200mA	Vin-3.0			V
tr	Rise time	CL=1nF, 10% to 90%		70	100	ns
tf	Fall time	CL=1nF, 90% to 10%		40	60	ns
VOL3	UVLO saturation	Vin=5V, Iosink=1mA			0.5	V
Fout	Output frequency	Option 1		Fosc		kHz
DCmax	Maximum Duty Cycle	Option 1		77.5		%

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
<b>Soft start</b>						
liss	Charge current	V <sub>ss</sub> =2V	8	10	12	μA
dliss	Temperature stability	0°C ≤ Ta ≤ 105°C	7	10	13	μA
ldss1	Discharge current (hiccup)	V <sub>ss</sub> =2V, V <sub>cs</sub> =2V		1	1.2	μA
ldss2	Sink current (uvlo)	V <sub>ss</sub> =2V, V <sub>in</sub> =7V	3			mA
liss/ldss1	Charge/discharge ratio			10	11	
VH <sub>ss</sub>	Clamp voltage		4			V
VL <sub>ss</sub>	Low voltage (uvlo)	V <sub>in</sub> =7V, I <sub>dss</sub> =1mA			0.5	V
<b>Under Voltage Lockout (UVLO)</b>						
VH	UVLO top threshold		11.5	12	12.5	V
VL	UVLO bottom threshold		8.0	8.4	8.8	V
<b>Supply current</b>						
I <sub>in</sub>	Operating current	CL=1nF		4.5	5.0	mA
I <sub>idle</sub>	Supply current in idle mode	V <sub>comp</sub> =1V		3.3	3.8	mA
I <sub>stby</sub>	Supply current in standby mode	V <sub>in</sub> <VH		40	60	μA
V <sub>clamp</sub>	Clamp voltage	I <sub>in</sub> =50mA	22	25	30	V
<b>Burst</b>						
V <sub>bsol</sub>	Output low voltage	I <sub>obs</sub> =1mA		0.3		V
I <sub>ohbs</sub>	Leakage current	V <sub>bs</sub> =5V		2		μA
V <sub>b1</sub>	Threshold level on Comp to enter Burst mode	BL pin left unconnected		1.25		V
V <sub>b1hyst</sub>	V <sub>b1</sub> Hysteresis			0.3		V
V <sub>b2</sub>	Threshold level on Comp to exit burst mode			1.75		V
<b>Hiccup</b>						
V <sub>z2</sub>	Threshold level on Cs to enter Hiccup mode		1.15	1.25	1.35	V
V <sub>hicc</sub>	Threshold level on Ss to exit Hiccup mode			0.5		V

## 4 Functional Description

TSM006: PWM Controller IC.

### UVLO function

The Under Voltage Lock Out function disables the whole device when supply voltage is lower than the threshold.

### Vref block

The Vref block provides a 5V reference voltage. An internal Vref status signal is active when Vref is lower than 4.7V and is used to drive the output driver low when Vref is not valid.

### Current sense input

A voltage proportional to the output inductor current is applied to the CS pin. The control IC uses this information to perform current mode control. The PWM function will be stopped if the CS pin voltage is greater than 1.0V.

### Current leading edge blanking

An internal delay is built into the IC to mask the first 100ns of the current sense signal. This delay is made of a capacitor charged with a current source. The capacitor is discharged when CT reaches its maximum level.

### COMP input

This pin is connected to the current comparator for current mode control. The pin should be connected to the collector (primary side) of an optocoupler which anode (secondary side) is driven by the output of error amplifier.

The COMP input is used to set the reference level for the current sense comparator. The current sense threshold is set to  $(V_{comp} - 2 * V_{be}) / 3$ .

During the soft start period, COMP voltage is clamped to the SS pin plus two  $V_{be}$  voltage.

### Startup latch

The startup latch is set when the IC exits from standby mode or UVLO state. It is reset when the CT capacitor is discharged for the first time.

### Output driver

The OUT totem pole output is capable to sink and source more than 1.0A (peak) in order to direct drive a power MOSFET.

### Oscillator

A capacitor from the RT/CT pin to GND and a resistor to the VREF set the oscillating frequency. The maximum duty cycle at the OUT pin is limited at 77%.

### Frequency modulation

A FM generator adds a small amount of jitter on the oscillator frequency in a way that reduces the conducted and radiated EMI. The FM frequency is set by an external capacitor connected to the FM pin.

### Slope compensation

A buffered Rt/Ct voltage is brought to the Cslope pin. This signal is used to provide the necessary slope compensation.

### Soft start

A capacitor from the SS pin to GND provides the soft start function. The capacitor starts to charge when VIN reaches the UVLO threshold and Vref is good.

The soft start block enables the IC to start with a progressive PWM duty cycle. The soft start comparator drives the output driver low when the SS pin voltage is greater than the CT pin voltage minus one  $V_{be}$  voltage.

During soft start, the COMP pin voltage is clamped to the SS pin voltage plus two  $V_{be}$  voltage, limiting the maximum peak current.

### External reference pin

An external resistor at REX pin sets the internal current reference.

### Automatic burst mode

Burst mode is used during light load condition to reduce the number of MOS switching, and thus reducing overall power dissipation. Light load condition is detected when **COMP** voltage is low. When **COMP** voltage is lower than a threshold  $V_{BL1}$  set by the external **BL** pin, the device output is forced to off state, providing minimum duty cycle and pulse skipping.

The burst status is available on the **BS** pin to put other devices in standby mode when in light load condition.

When **COMP** voltage ( $V_{comp}$ ) is higher than  $V_{BL2}$ , the device operates in normal mode. Current is limited to  $(V_{comp} - 2 \cdot V_{be}) / 3 / R_{shunt}$  ( $R_{shunt}$  is the shunt resistor used to measure the primary current,  $V_{be}$  is the forward voltage of a diode, and 3 is the R/2R network attenuation). Maximum current is  $1V / R_{shunt}$ . When  $V_{comp}$  becomes lower than  $V_{BL}$ , device enters burst mode, PWM is stopped while  $V_{comp}$  is lower than  $V_{BL}$ . As PWM is stopped, no more energy is transferred to the secondary side, output voltage is decreasing, and  $V_{comp}$  (which is an image of the error comparator) tends to increase. As soon as  $V_{comp}$  becomes just higher than  $V_{BL}$ , PWM operation can resume for some cycles, so current in burst mode is limited to  $(V_{BL} - 2 \cdot V_{be}) / 3 / R_{shunt}$ .

### OverCurrent detection and Hiccup mode

Overcurrent is detected when voltage at the CS pin is greater than  $V_{z2} = 1.2V$ . To avoid false triggering, the overcurrent detection is delayed in the same way than the normal pulse by pulse current limitation.

When overcurrent is detected, the device enters the hiccup mode. Output is switched off immediately and the soft start capacitor is discharged slowly. When the SS pin voltage goes below 0.5V, normal soft start is started. If the overcurrent is no more present, device operation is resumed normally, otherwise, overcurrent is detected again and the cycle is repeated until the overcurrent situation disappears.

Duty cycle of the hiccup mode is set by the ratio of SS pin discharge and charge currents: 10% typ. With a typical capacitor  $C_{ss} = 100nF$ , soft start delay is about 40ms and hiccup off-time is 400ms.

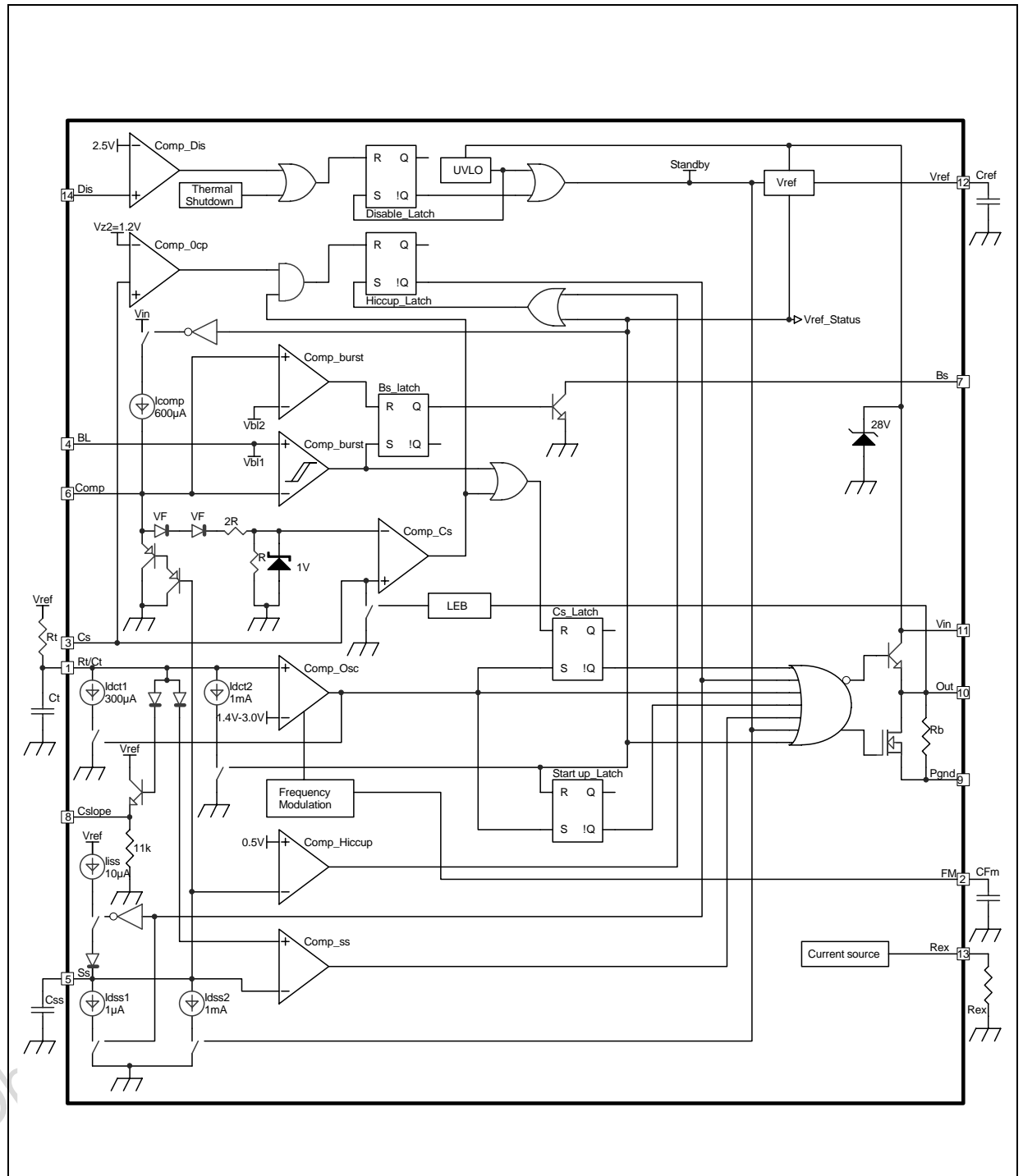
### Latched disable function

Disable mode is entered when the DIS pin voltage is driven above 2.5V. Disable state is latched and can only be exit by driving the  $V_{in}$  power supply voltage under the UVLO level.

### Thermal shutdown

The device operation is shut down when the internal temperature exceed  $130^{\circ}C$ . Hysteresis provides stable working and shutdown states.

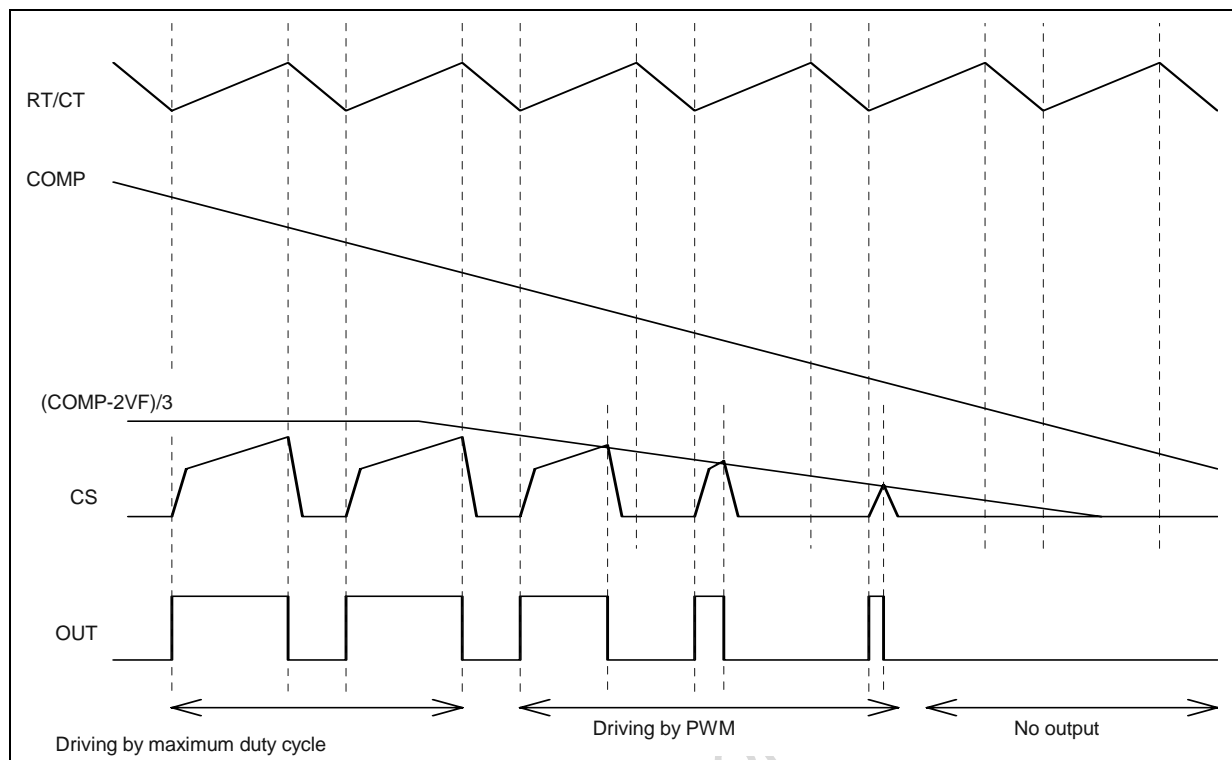
Fig. 1: Detailed Internal Schematic



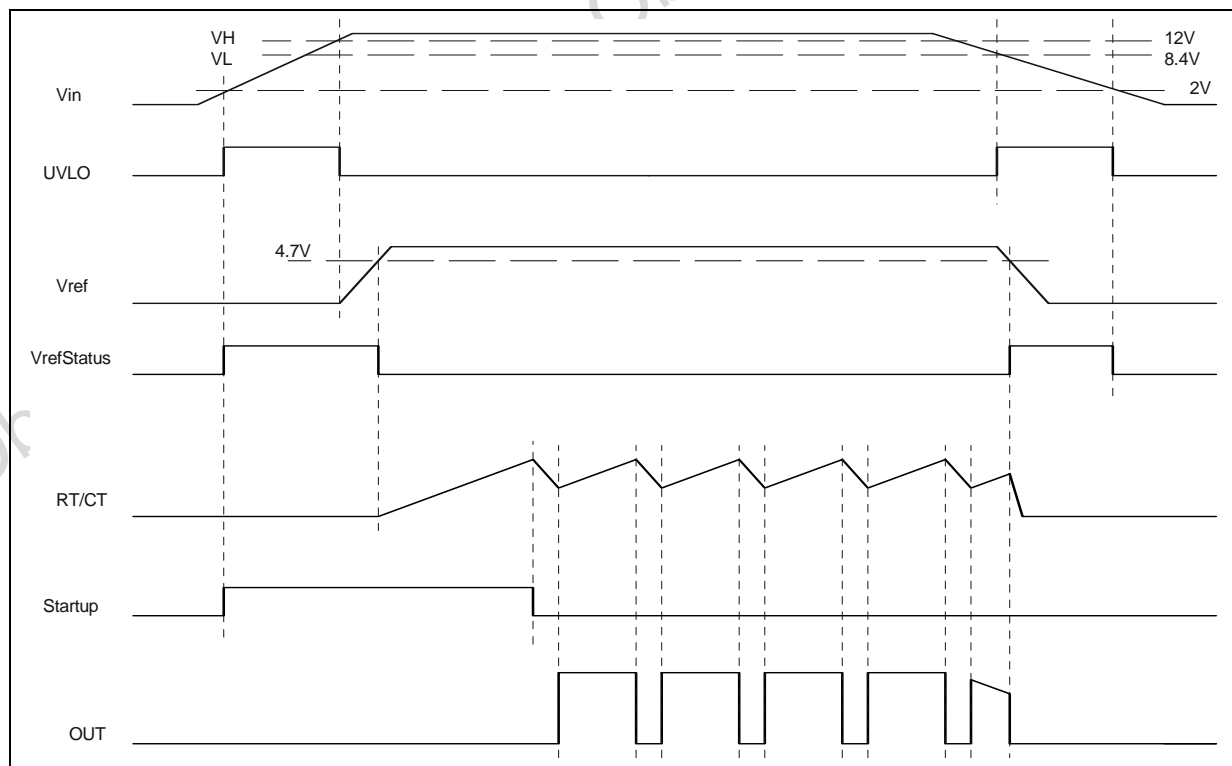


## 5 Timing Diagram

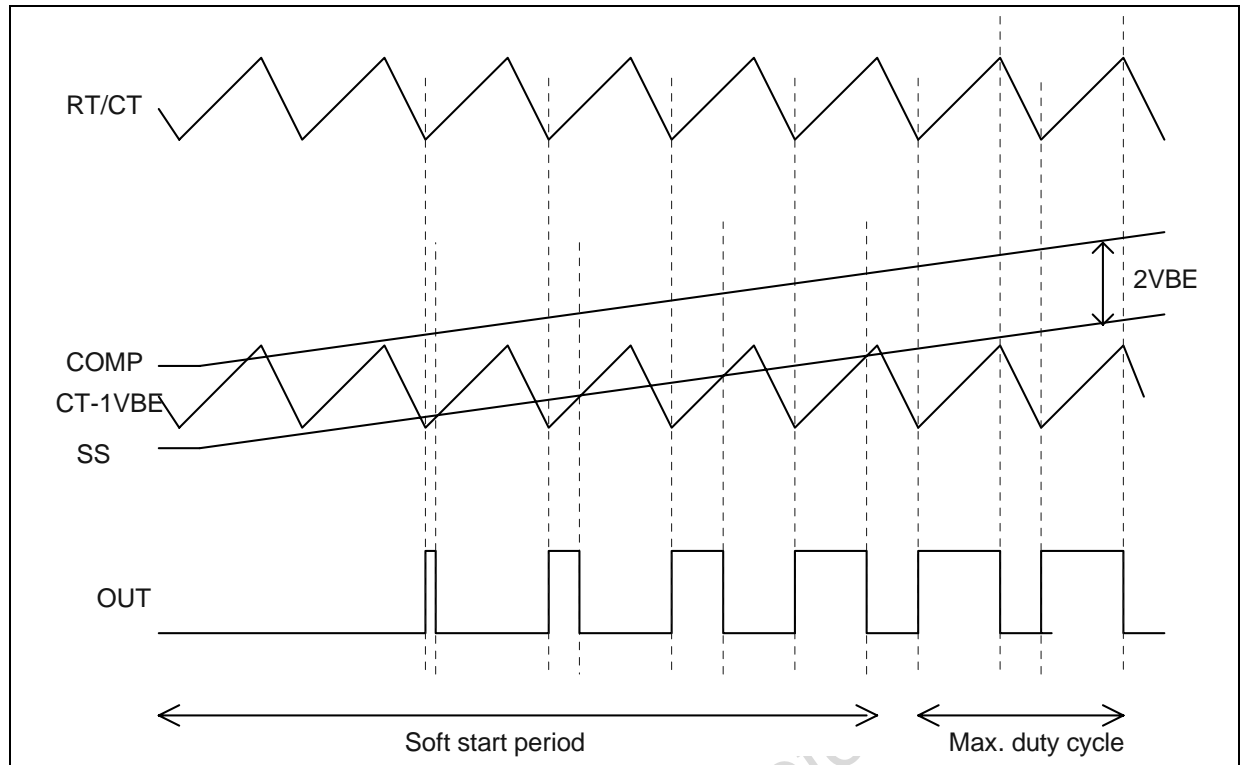
### Timing for PWM function



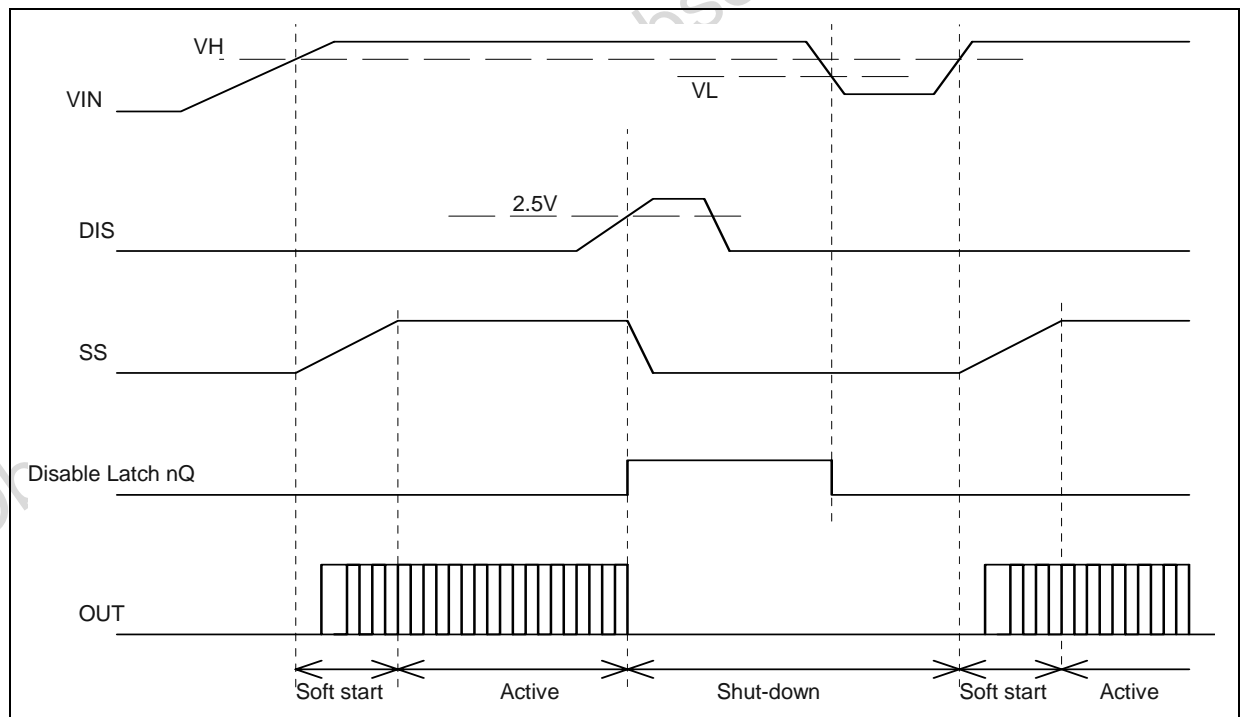
### Timing at Vref rise up and shut down



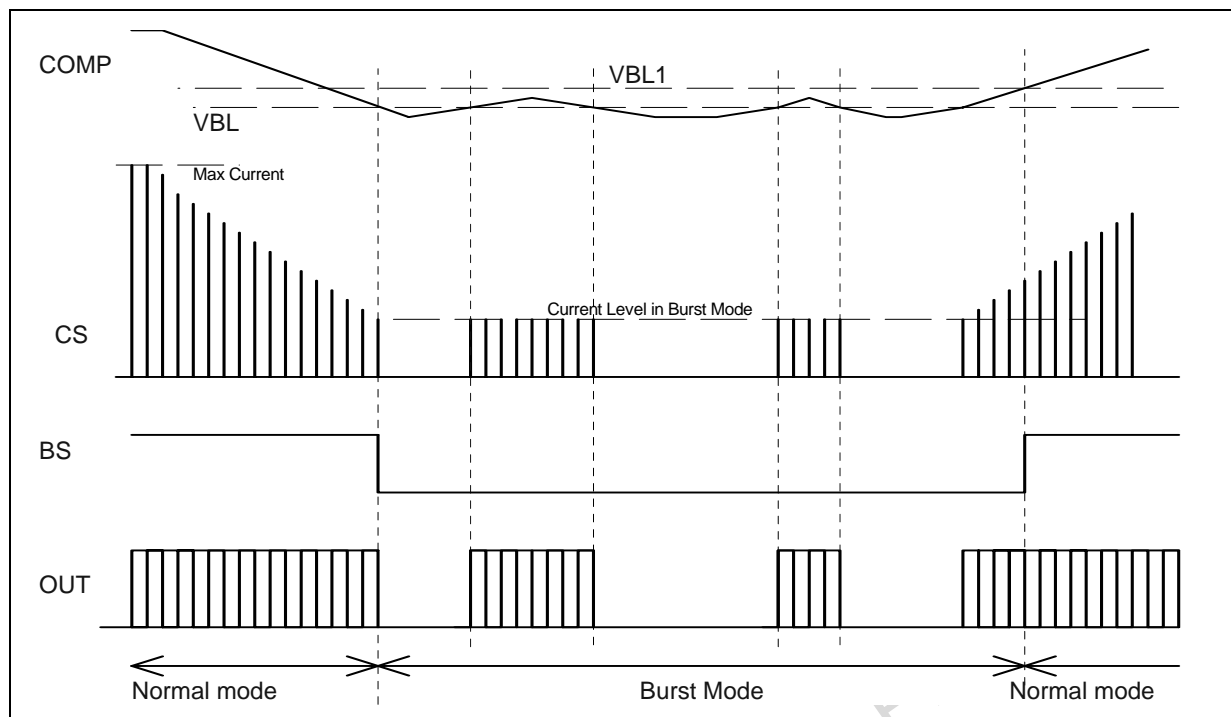
Timing for soft start function



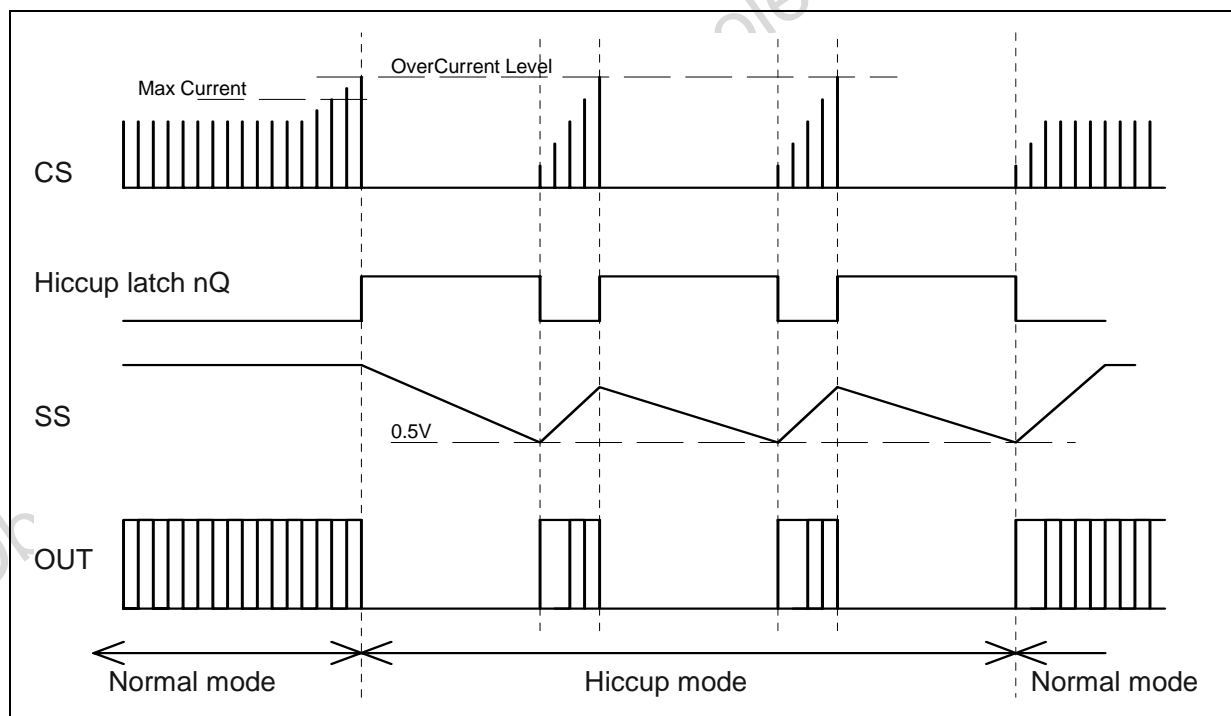
Timing for latched disable function



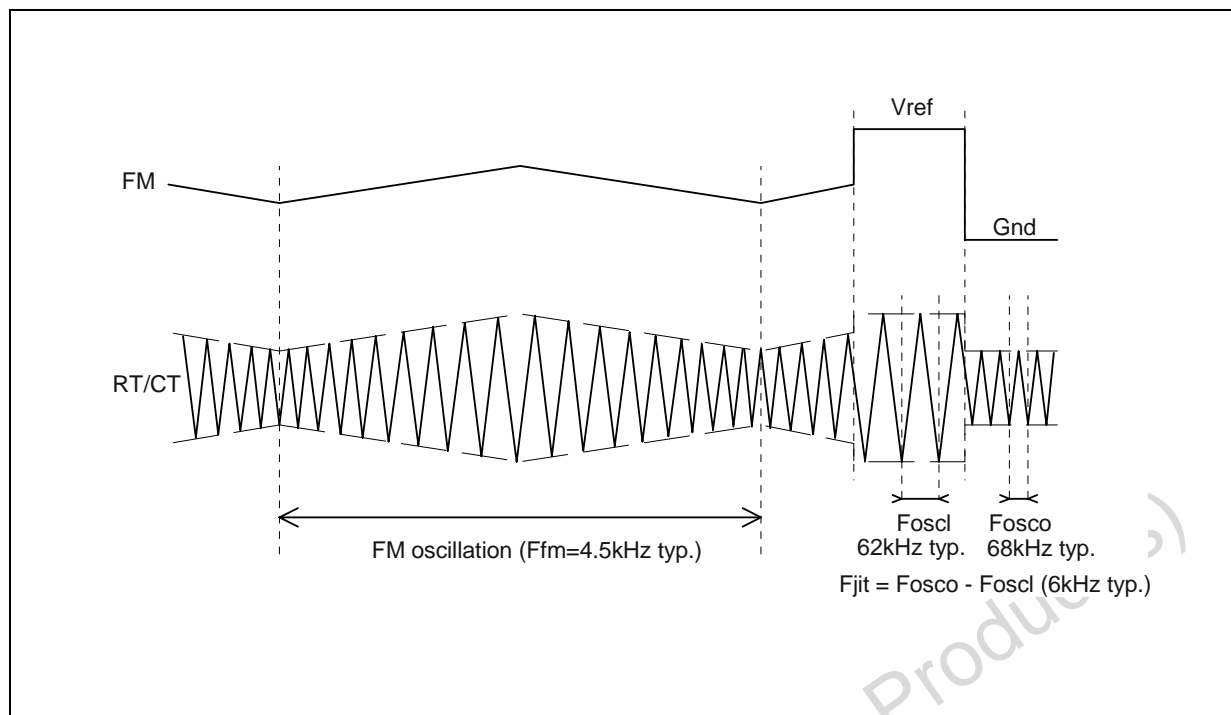
Timing for burst mode function



Timing for hiccup function

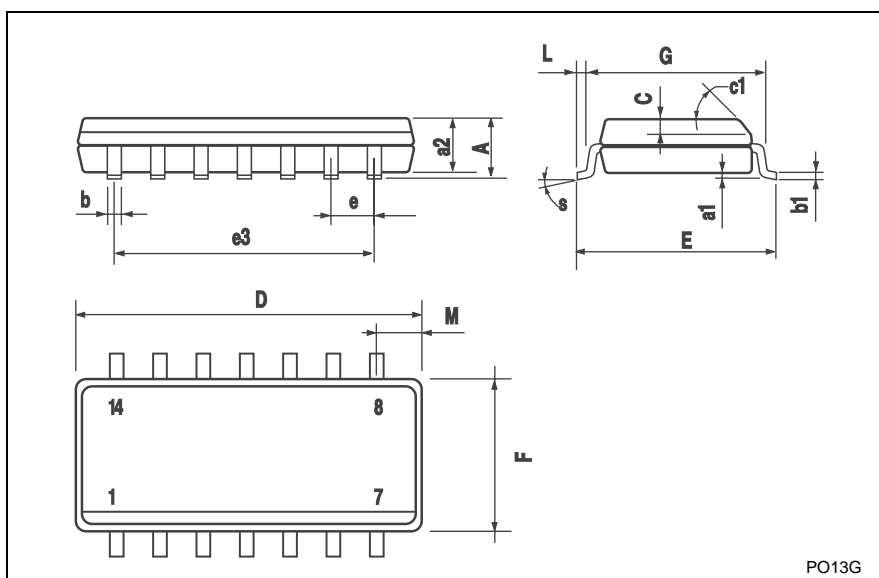


## Timing for oscillator function



## PACKAGE MECHANICAL DATA

SO-14 MECHANICAL DATA						
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.019		0.050
M			0.68			0.026
S	8° (max.)					



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