HA16107FP/P, HA16108FP/P

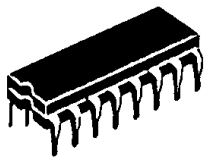
600kHz PWM Switching Regulator Controller

Description

The HA16107 and HA16108 series are primary control switching regulator control IC's appropriate for directly obtaining stable voltage from commercial and public power.

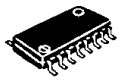
They can directly drive power MOSFET's, and have the following built in functions: over-current protection (OCL), timer latch over-voltage protection (HA16107), and ON/OFF timer over-current protection (HA16108).

HA16107P, HA16108P



(DP-16C)

HA16107FP, HA16108FP



(FP-16DA)

Functions

- 6.45V standard voltage circuit
- Triangle wave generator circuit
- PWM comparator circuit
- Output circuit (totem pole output)
- Pulse by pulse over-current detection and protection function
- Low input operational error protection circuit
- Soft start, quick shutdown function
- Timer latch over-voltage protection function (HA16107)
- ON/OFF timer over-current protection function (HA16108)

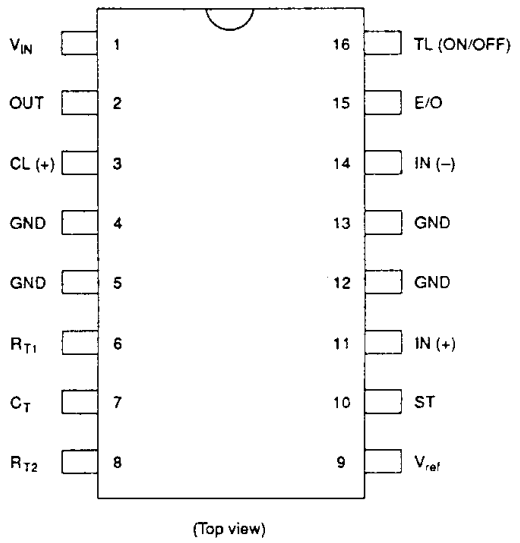
Features

- The operating frequency is a high 600 kHz.
- Built-in pre-driver circuit for driving power MOSFET's
- Parallel synchronous driving of IC pairs
- Over current protection (OCL)
- Built-in timer latch over-voltage protection function (HA16107)
- OCL and intermittent operation may be used for the prevention of secondary output current increases using the ON/OFF timer function. (HA16108)
- A low input voltage lock out function (UVL) is applied to both V_{IN} and V_{ref}.
- The ON/OFF reset is a built-in auto-reset function based on the time constant of an external capacitance and observation of drops in V_{IN}.
- The over-voltage protection (TL terminal) reset can be used appropriately in response to the goals of the OVP and ON/OFF terminals, due to observation of drops in input voltage only.
- Soft start and quick shutdown functions are built in.
- Built-in 34-volt Zener diode between V_{IN} and ground
- Built-in error amp

Ordering Information

Product Name	Function	Package
HA16107P	Timer latch over-voltage protection function	DP-16C
HA16107FP		FP-16DA
HA16108P	ON/OFF timer over-current protection	DP-16C
HA16108FP		FP-16DA

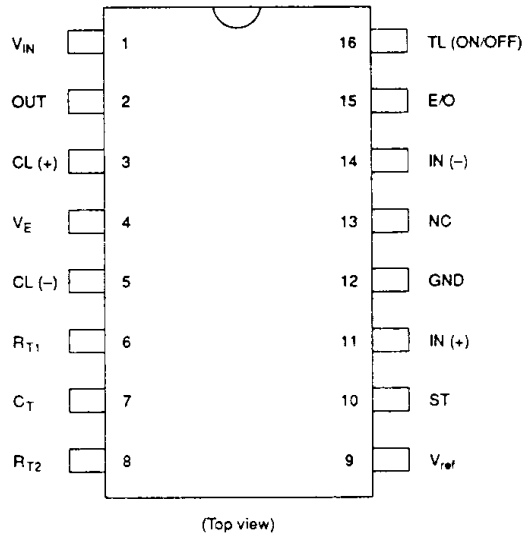
Pin Arrangement (HA16107FP/P, HA16108FP/P)



(Top view)

Notes: 1. The 4 IC grounds are connected inside the package. However, all 4 ground pins (GND) must be grounded.
2. Pin labels in parentheses are for the HA16108FP.

Pin Arrangement (HA16107P, HA16108P)



(Top view)

Notes: 1. If the V_E terminal (pin 4) or the CL(–) terminal (pin 5) are not used, they should be grounded.
2. Pin labels in parentheses are for the HA16108FP.

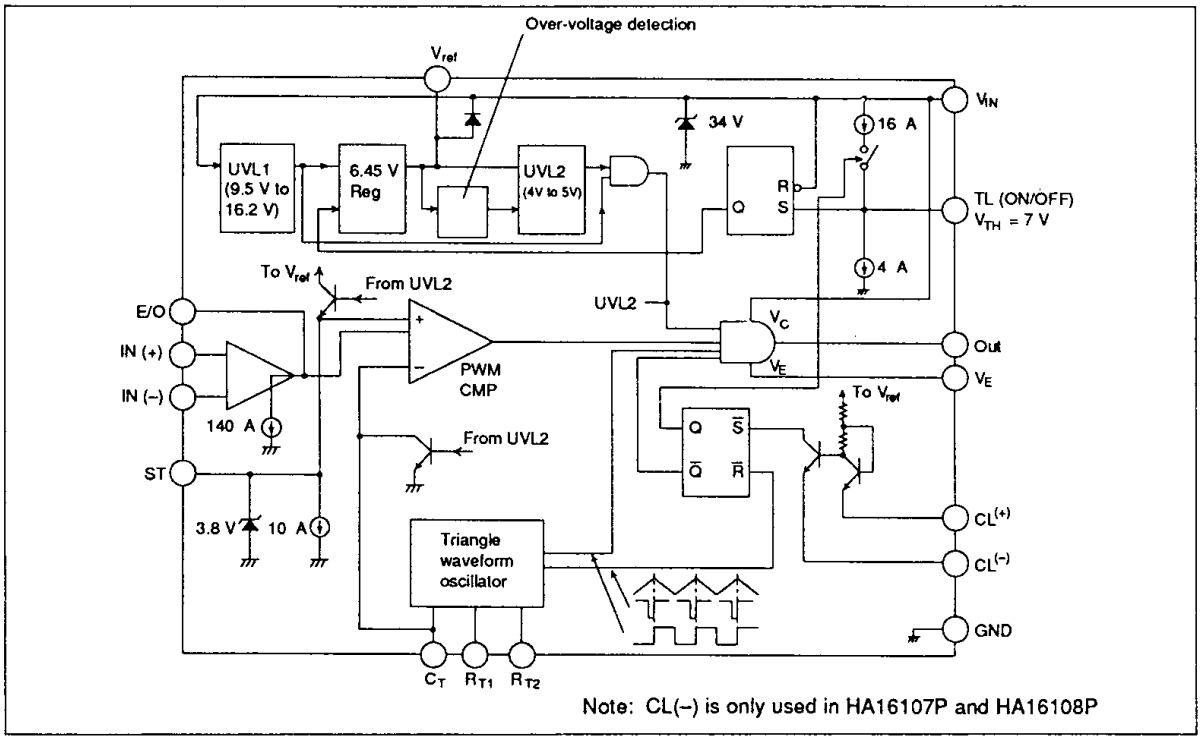
Pin Functions

No.	Symbol	Pin Functions
1	V_{IN}	Input voltage
2	OUT	Pulse output
3	CL (+)	Current limiter
4	V_E	Output ground
5	CL (–)	Current limiter
6	R_{T1}	Timing resistor (rise time)
7	C_T	Timing capacitor
8	R_{T2}	Timing resistor (fall time)

No.	Symbol	Pin Functions
9	V_{ref}	Reference voltage output
10	ST	Soft start
11	IN (+)	Error amp (+) input
12	GND	Ground
13	NC	Not used
14	IN (–)	Error amp (–) input
15	E/O	Error output
16	TL	Timer latch

Note: With the HA16107FP and HA16108FP, although pins 4, 5, 12, and 13 are connected inside the package, they all must be connected to ground.

Block Diagram

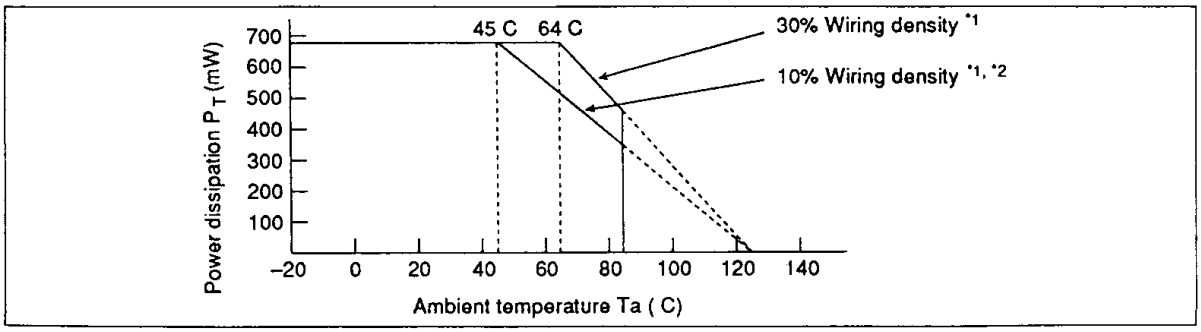


Note: CL(–) is only used in HA16107P and HA16108P

Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating Value	Unit
Power supply voltage	V_{IN}	30	V
Output current (DC)	I_O	±0.2	A
Output current (peak)	I_{Opeak}	±2	A
Current limiter voltage	V_{CL}	±3	V
Error amp input voltage	V_{IEA}	Vref	V
Error amp output voltage	$V_{IE/O}$	Vref	V

Item	Symbol	Rating Value	Unit
R_{T1} pin output current	I_{RT1}	500	μA
R_{T2} pin output current	I_{RT2}	5	mA
Power dissipation*1	P_T	680	mW
Operation temperature range	T_{opr}	–20 to +85	°C
Storage temperature range	T_{stg}	–55 to +125	°C



The absolute maximum ratings are limiting values, to be applied individually, beyond which the device may be permanently damaged. Functional operation under any of these conditions is not guaranteed. Exposing a circuit to its absolute maximum rating for extended periods of time may affect the device's reliability.

Notes: 1. These values are for HA16107FP, HA16108FP mounted on a 40 x 40 x 1.6 mm glass epoxy board. However, when the wiring density is 10%, these must be derated by 8.3 mW/°C for temperatures above 45°C, and when the wiring density is 30%, by 11.1 mW/°C at temperatures above 64°C.
2. For the HA16107P and HA16108P, these values are valid up to 45°C, and must be derated by 8.3 mW/°C above 45°C.

Electrical Characteristics (Ta = 25°C, V_{IN} = 18 V, f_{osc} = 100 kHz)

Section	Item	Symbol	Min	Typ	Max	Unit	Test Conditions
Reference voltage	Output voltage	V_{ref}	6.10	6.45	6.80	V	
	Line regulation	Line	–	30	60	mV	12 V ≤ V_{IN} ≤ 30 V
	Load regulation	Load	–	30	60	mV	0 ≤ I_o ≤ 10 mA
	Output voltage temperature stability	$\Delta V_{ref}/\Delta Ta$	–	400	–	ppm /°C	
	Short circuit current	I_{OS}	30	50	–	mA	V_{ref} = 0 V
	Over voltage protection	V_{rovp}	7.4	8	9	V	
Triangle wave oscillator	Maximum frequency	f_{max}	600	–	–	kHz	
	Minimum frequency	f_{min}	–	–	1	kHz	
	Voltage stability	$\Delta f/fo_1$	–	± 1	± 3	%	12 V ≤ V_{IN} ≤ 30 V ($fo_1 = f_{max} + f_{min}/2$)
	Temperature stability	$\Delta f/fo_2$	–	± 8	–	%	–20°C ≤ Ta ≤ +85°C ($fo_2 = f_{max} + f_{min}/2$)
	Frequency accuracy	f_{osc}	270	300	330	kHz	$R_{T1} = R_{T2}$ = 27 kΩ, C_T = 120 pF
PWM comparator	Minimum deadband pulse width	t_{DB}	–	–	1.0	µs	
	Low level threshold voltage	V_{TL}	1.9	2.2	2.5	V	
	High level threshold voltage	V_{TH}	3.8	4.2	4.6	V	
	Differential threshold voltage	ΔV_{TH}	1.7	2	2.3	V	
	Deadband width initial accuracy	ΔDB1	–	± 1	± 3	%	$R_{T1} = R_{T2}$ = 27 kΩ, C_T = 470 pF
	Deadband width voltage stability	ΔDB2	–	± 0.2	± 2.0	%	12 V ≤ V_{IN} ≤ 30 V ($D_{max} - D_{min}$)/2
	Deadband width temperature stability	ΔDB3	–	± 1	–	%	–20°C ≤ Ta ≤ +85°C ($D_{max} - D_{min}$)/2
Error amp	Input offset voltage	V_{IO}	–	2	10	mV	
	Input bias current	I_{IB}	–	0.8	2.0	µA	
	Input sink current	I_{osink}	80	140	–	µA	V_O = 2 V
	Output source current	$I_{osource}$	80	140	–	µA	V_O = 5 V
	High level output voltage	V_{OH}	V_{ref} –1.5	–	–	V	I_O = 10 µA

Electrical Characteristics (Ta = 25°C, V_{IN} = 18 V, f_{osc} = 100 kHz) (cont)

Section	Item	Symbol	Min	Typ	Max	Unit	Test Conditions
Error amp	Low level output voltage	V_{OL}	–	–	0.5	V	I_O = 10 µA
	Voltage gain	G_V	–	55	–	dB	f = 10 kHz
	Band width	BW	–	15	–	MHz	
	(–) Common mode voltage	V_{CM-}	1.2	–	–	V	
	(+) Common mode voltage	V_{CM+}	–	–	V_{ref} –1.5	V	
Over-current detector	(+) Threshold voltage	V_{TH+}	0.216	0.24	0.264	V	
	(+) Bias current	I_{B+}	–	180	250	µA	V_{CL}+ = 0 V
	(–) Threshold voltage*1	V_{TH-}	–0.264	–0.24	–0.216	V	
	(–) Bias current*1	I_{B-}	–	950	1350	µA	
	Response time	t_{off}	–	100	–	ns	
Soft start	High level voltage	V_{STH}	3.2	3.8	4.4	V	I_{sink} = 1 mA
	Sink current	I_{sink}	7	10	13	µA	V_{ST} = 2.0 V
Under voltage lockout	V_{IN} high level threshold voltage	V_{INTH}	14.7	16.2	17.7	V	
	V_{IN} low level threshold voltage	V_{INTL}	8.5	9.5	10.5	V	
	Threshold differential voltage	ΔV_{TH}	5.2	6.2	7.2	V	(V_{INTH} – V_{INTL})
	V_{ref} high level threshold voltage	V_{rTH}	4.5	5.0	5.5	V	
	V_{ref} low level threshold voltage	V_{rTL}	3.5	4.0	4.5	V	
Timer latch (HA16107), ON/OFF timer (HA16108)	Latch threshold voltage*2	V_{TH}	6.5	7.0	7.5	V	
	Low level threshold Voltage*3	V_{THL}	1.0	1.3	1.6	V	
	V_{IN} reset voltage	V_{INR2}	6.0	6.5	7.0	V	
	Differential threshold	ΔV	2.0	3.0	–	V	(V_{INTL} – V_{INR2})
	Source current (OCL mode)	I_{source}	8	12	16	µA	CML: Normally open
	Sink current (latch mode)	I_{sink}	2.5	4	5.5	µA	ON/OFF terminal = 4 V

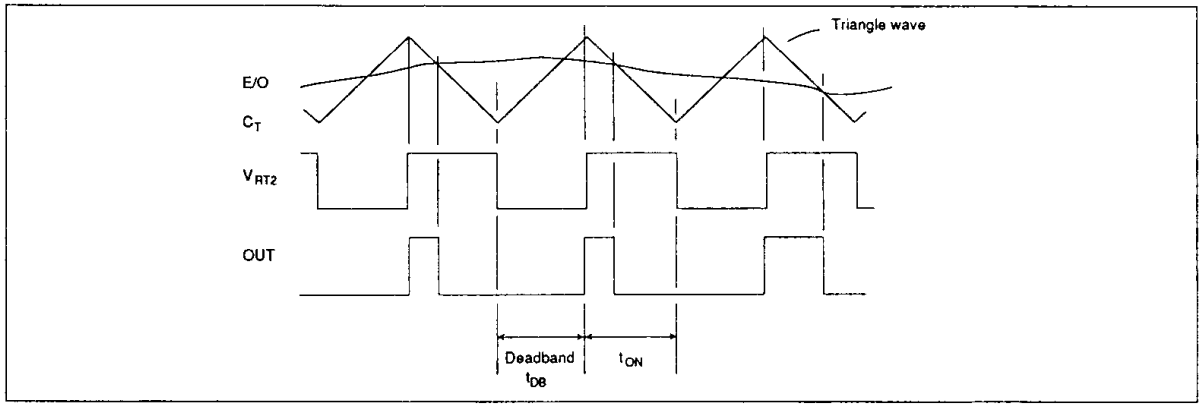
Notes: 1. V_{TH}- and I_B- are only applicable to HA16107P and HA16108P.
2. The HA16108 is not latched by a high level threshold voltage.
3. Only applicable to the HA16108.

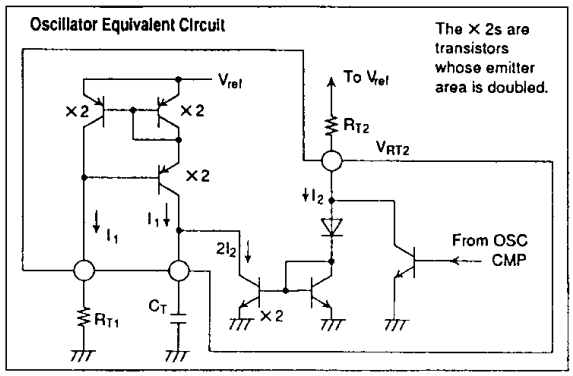
Electrical Characteristics (Ta = 25°C, V_{IN} = 18 V, f_{osc} = 100 kHz) (cont)

Section	Item	Symbol	Min	Typ	Max	Unit	Test Conditions
Output	Low voltage	V_{OL1}	–	1.7	2.2	V	I_{osink} = 0.2 A
	High voltage	V_{OH}	V_{IN} –2.2	–	–	V	$I_{osource}$ = 0.2 A
	Low voltage (standby mode)	V_{OL2}	–	–	0.5	V	I_{osink} = 1 mA
	Rising time	tr	–	40	–	ns	C_L = 1000 pF
	Falling time	tf	–	80	–	ns	C_L = 1000 pF
Total	Standby current	I_{st}	–	160	250	µA	V_{IN} = 14 V
	Operation current	I_{IN1}	–	16	20	mA	V_{IN} = 30 V, C_L = 1000 pF, f = 100 kHz
	Operation current	I_{IN2}	–	12	16	mA	V_{IN} = 30 V, f = 100 kHz, Output open
	ON/OFF latch current	I_{IN3}	–	350	460	µA	V_{IN} = 14 V
	V_{IN} – GND Zener voltage	V_Z	30	34	–	V	

Function and Timing Chart

1. Triangle waveform and PWM output





$$I_1 = \frac{V_{ref} - 2V_{BE}}{R_{T1}}$$

$$I_2 = \frac{V_{ref} - 2V_{BE}}{R_{T2}}$$

$$t_{DB} = \frac{C_T \times R_{T1} \times 2V}{V_{ref} - 2V_{BE}} \approx 0.35 \times C_T \times R_{T1} \text{ (sec)}$$

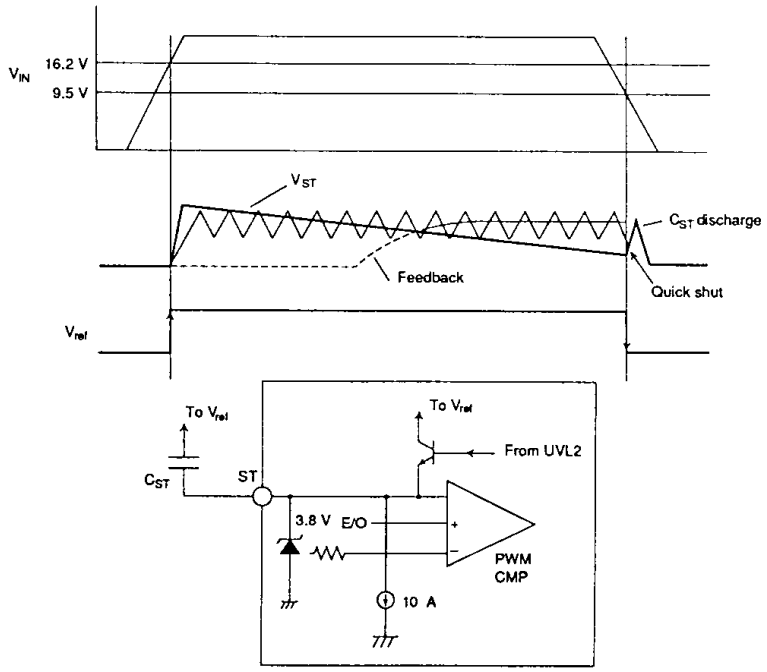
$$t_{ON} \approx t_{DB} \frac{R_{T2}}{2R_{T1} - R_{T2}} \text{ (sec)}$$

$$D_{umax} = \frac{R_{T2}}{2R_{T1}}$$

$$f_{osc} \approx \frac{1 - D_{umax}}{t_{DB}} \text{ (Hz)}$$

Notes: When fosc is small, the actual value will differ from that given by the formula due to the delay time. Determine the correct constants after constructing a test circuit.

2. Soft start and quick shut

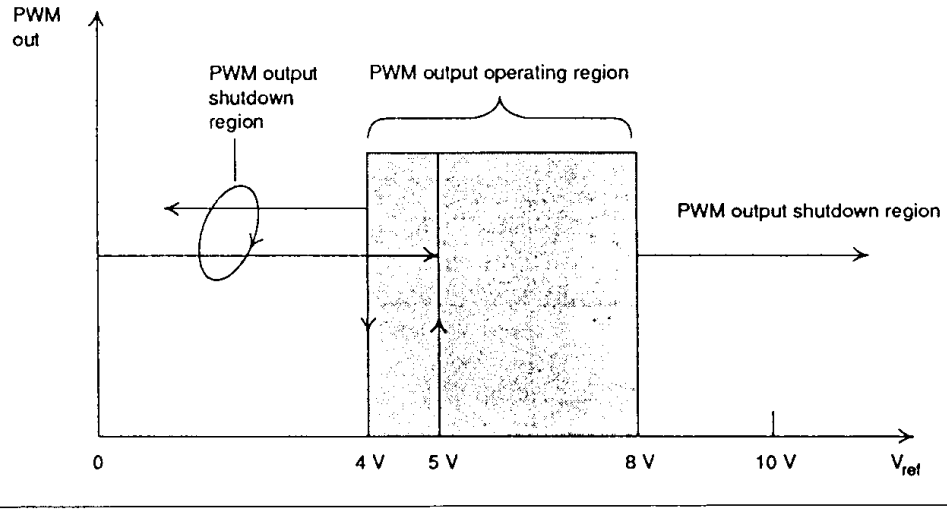


The soft start time constant is determined by the values of C_{ST} and the constant current (10 μA typ).

3. V_{ref} Protection (Over-voltage protection and UVL2 protection)

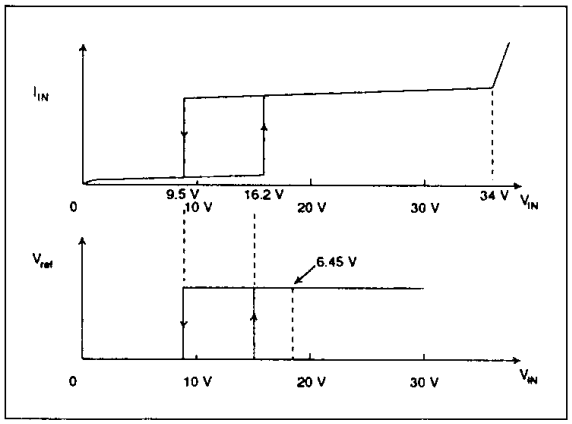
Under- and over-voltage in V_{ref} are detected by the "UVL2 circuit" and the "over-voltage detection circuit". PWM output is shutdown at a V_{ref} of 8 volts or over. Also, UVL2 will detect low voltages with a hysteresis of about 4 to 5 volts, and PWM output will be shutdown at lower voltages.

Therefore, if the V_{ref} pin is shorted up to V_{IN}, or shorted to ground, PWM output will be shutdown. Also, when V_{IN} is connected or disconnected, PWM output will be shutdown.

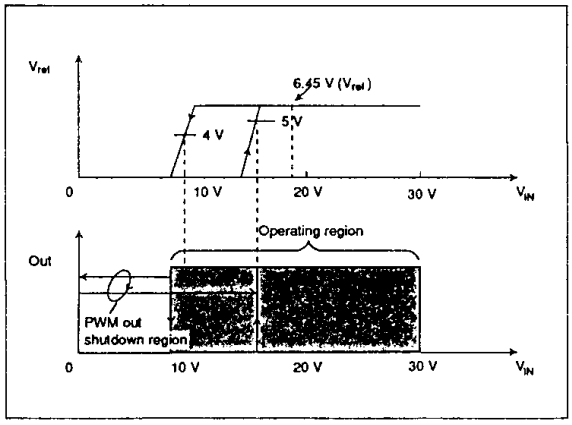


4. Relationship between UVL1, UVL2, and PWM output

• UVL1 (V_{IN} and V_{ref})



• UVL2 (V_{ref} and PWM output)



• UVL1 and UVL2

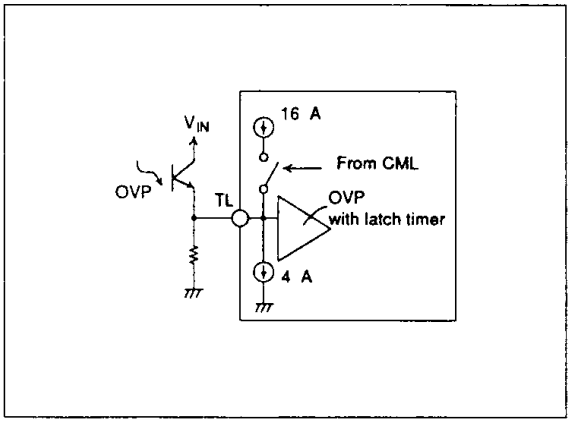
V_{IN} (UVL1)	L	H	H	L
V_{IN} (UVL2)	L	L	H	H
PWM OUT	L	L	OUT	L
Standby mode	O	O	—	O

Note: O: Standby mode
—: Not standby

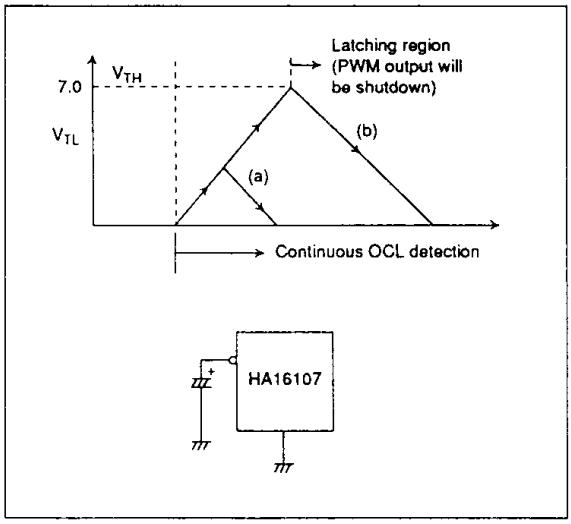
5. T_L (Time Latch)

(1) T_L: Can be "OVP" function
T_L: The timer latch pin can be used as an OVP pin.

(2) Using the T_L pin as an OVP pin

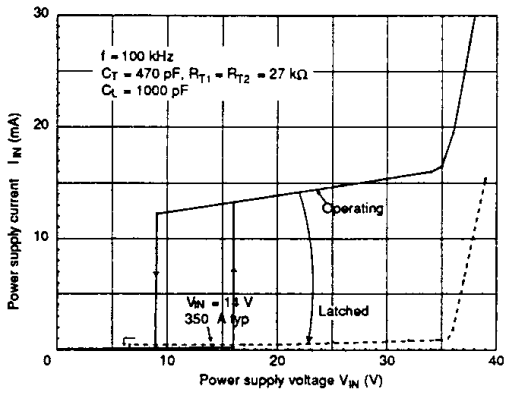


(3) T_L operation

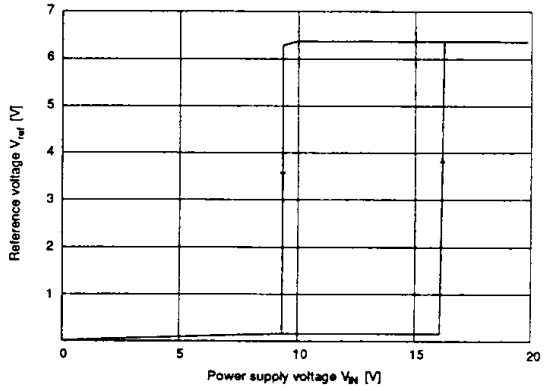


Notes: 1. (a) is the case where OCL detection ceases before V_{TL} reaches V_{TH}.
2. (b) is the case where OCL detection continues until V_{TL} reaches V_{TH}.
3. The latch function will be cleared when V_{IN} drops below about 6.5 volts.

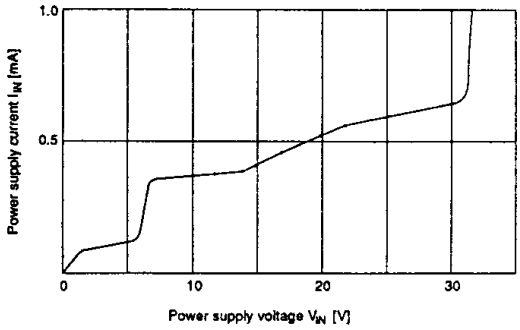
Power Supply Current vs. Voltage Characteristics



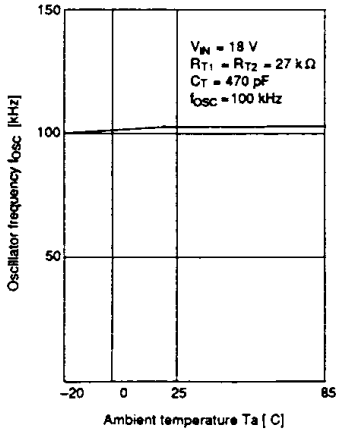
Reference Voltage vs. Power Supply Voltage Characteristics



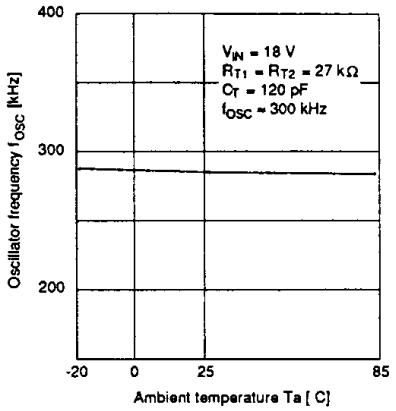
Latched Power Supply Current vs. Voltage Characteristics



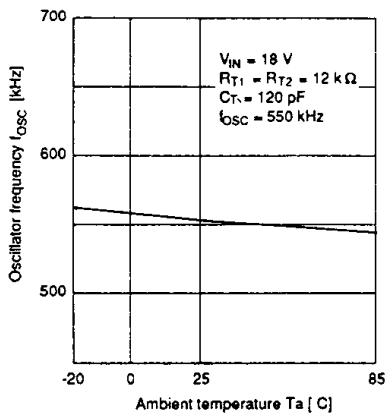
Oscillator Frequency vs. Ambient Temperature Characteristics



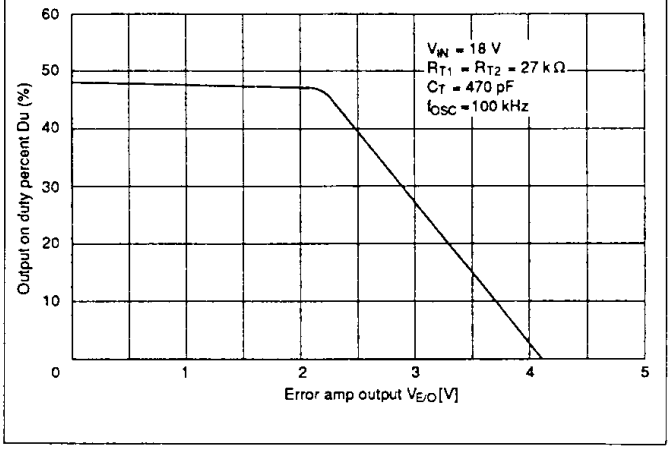
Oscillator Frequency vs. Ambient Temperature Characteristics



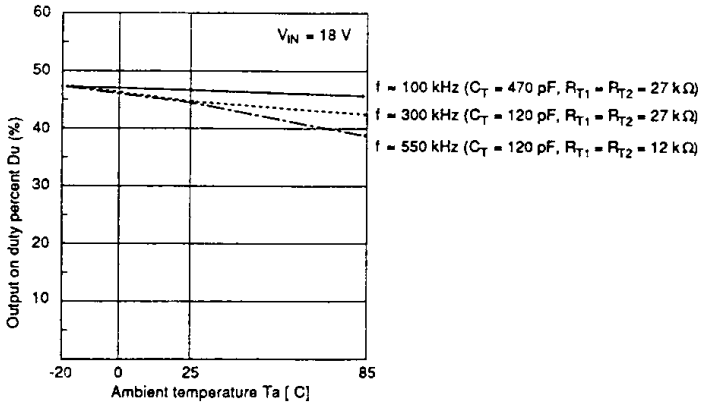
Oscillator Frequency vs. Ambient Temperature Characteristics



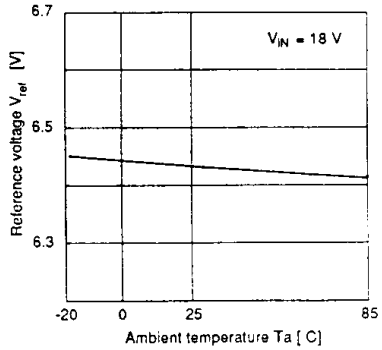
Output on Duty Percent vs. Error Amp Output Characteristics



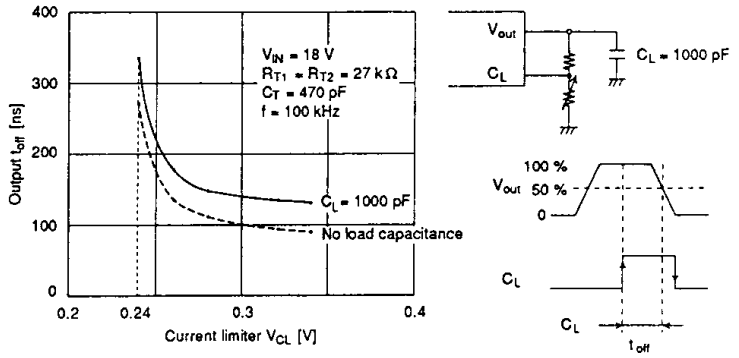
Output on Duty Percent vs. Ambient Temperature



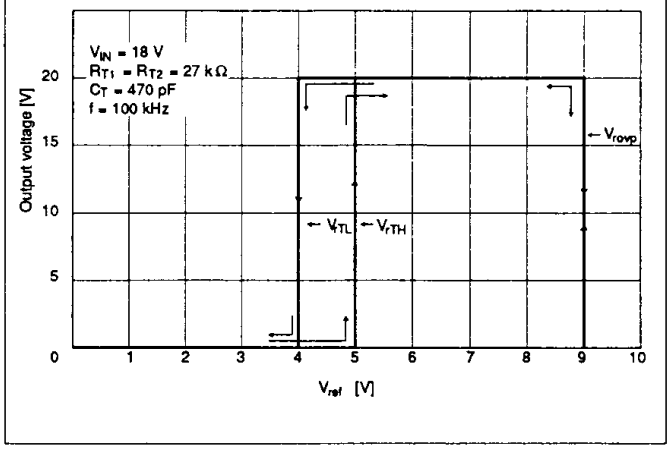
Reference Voltage vs. Ambient Temperature Characteristics



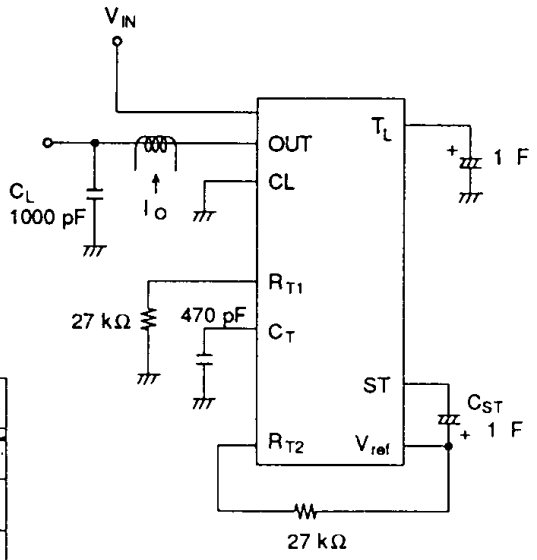
Output t_{off} vs. Current Limiter Characteristics



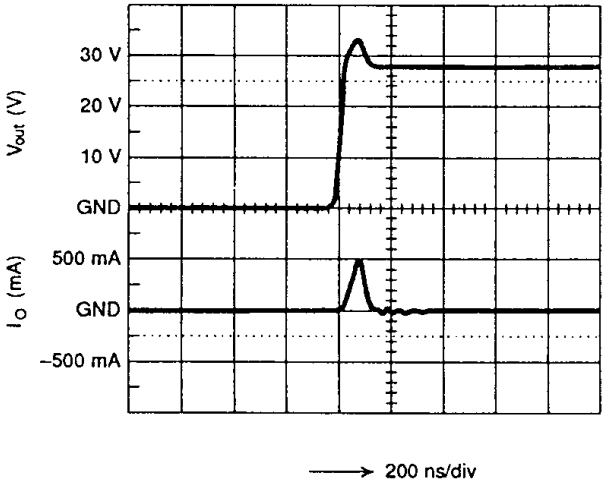
V_{ref} UVL and OVP Characteristics



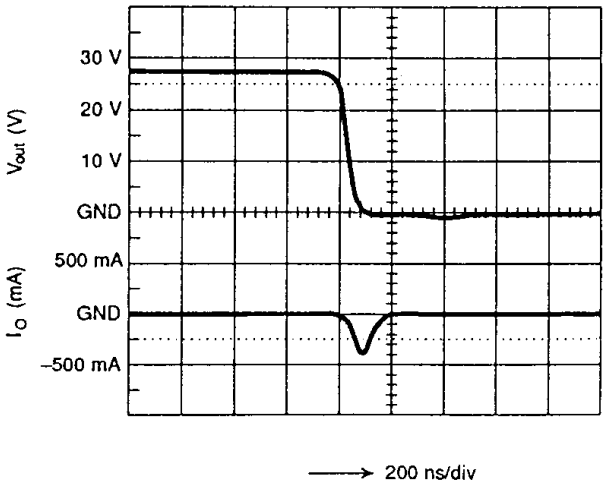
Test circuit



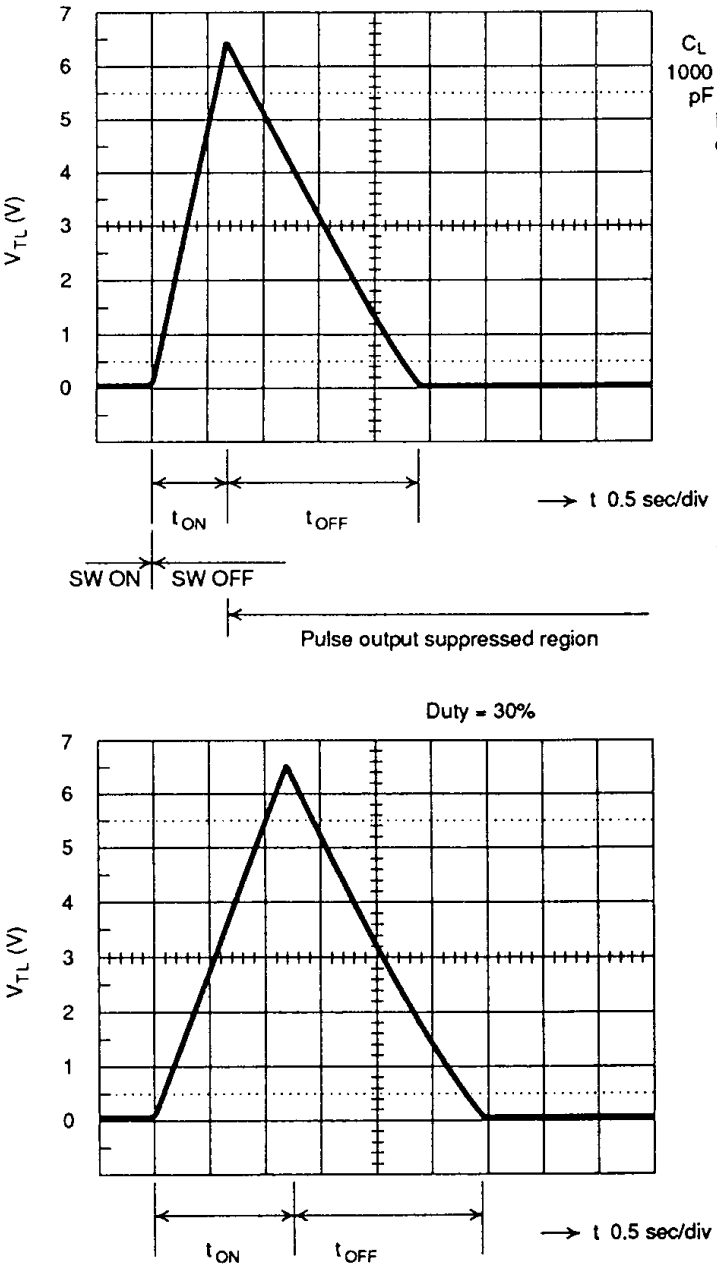
Output (V_{out}) rising waveform



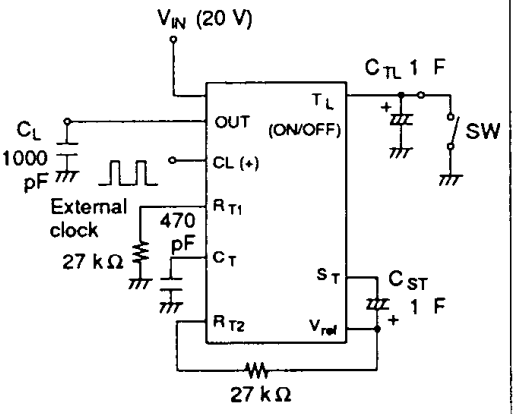
Output (V_{out}) falling waveform



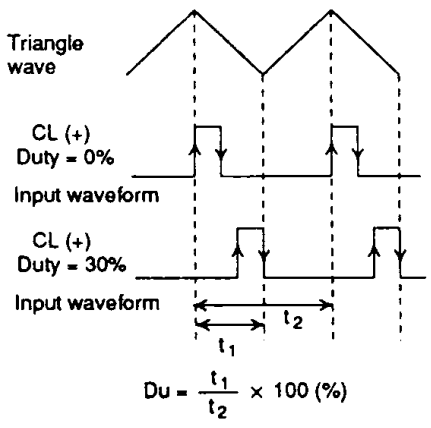
TL Pin Waveform of HA16107



Test circuit

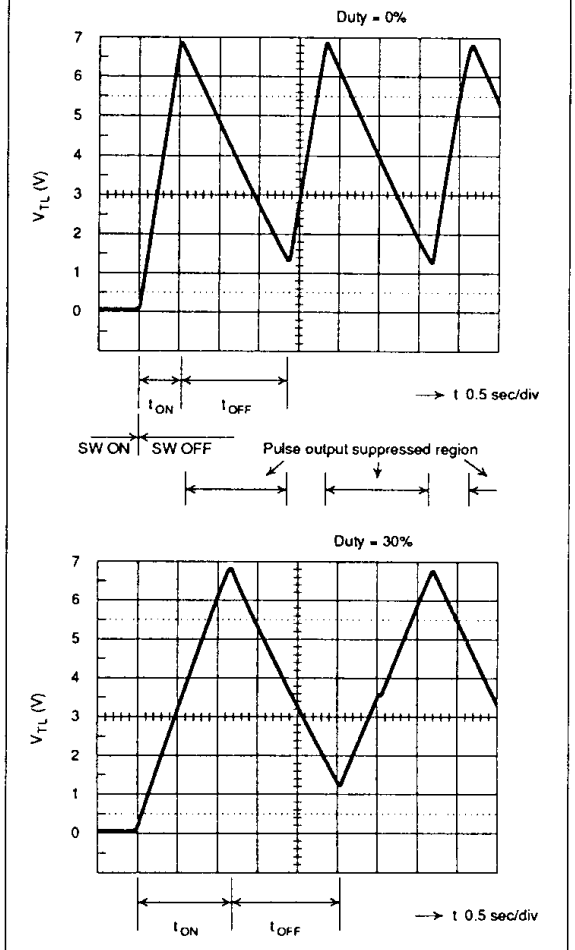


Test conditions

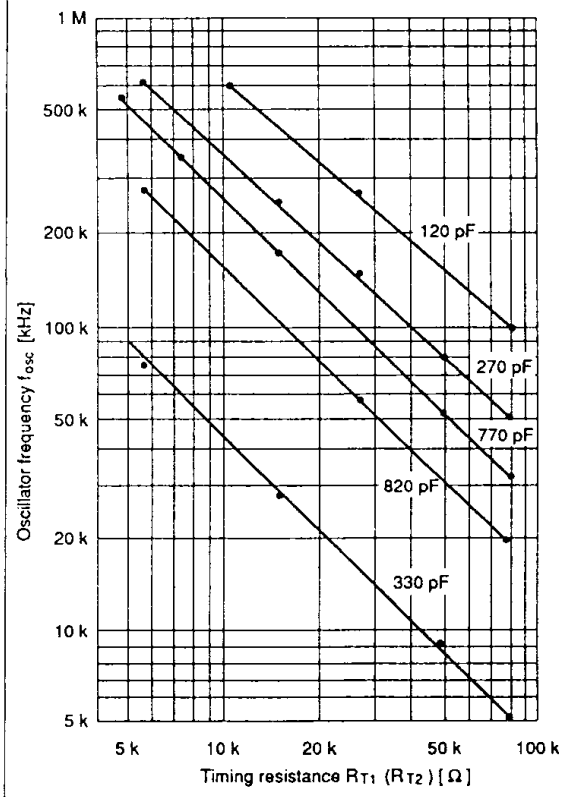


$$Du = \frac{t_1}{t_2} \times 100\ (\%)$$

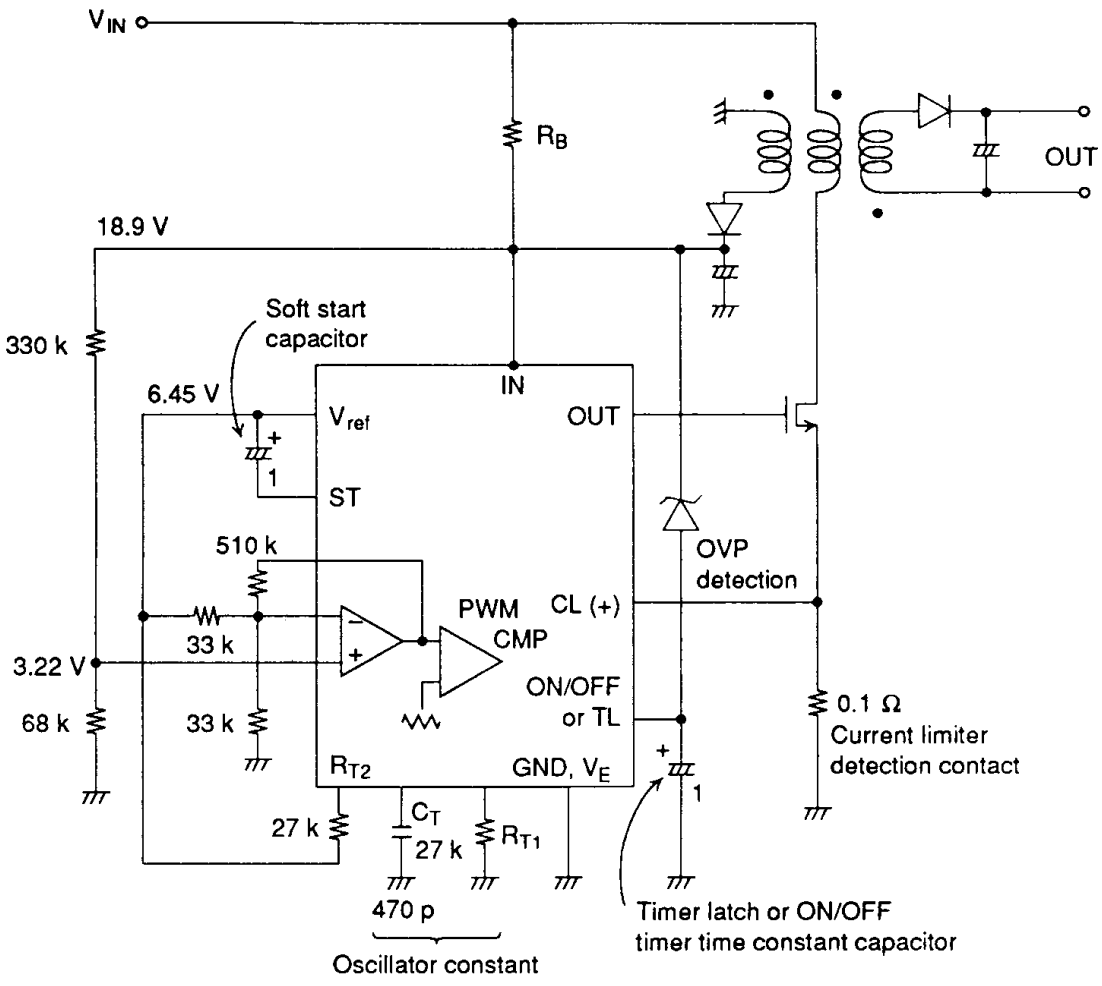
On/Off Pin Waveform of HA16108



Oscillator Frequency f_{osc} VS. Timing Resistance ($R_{T1} = R_{T2}$) Characteristics



Operational Circuit Example



Forward Transformer Application Example