
HA16666P/FP

600kHz PWM Controlled Switching Regulator

HITACHI

Description

The HA16666P/FP is a voltage mode PWM (pulse width modulation) control IC for switching regulator control. It can drive a power MOS FET efficiently on 600 kHz. Its standby current is 0.3 mA (max), and it is used as the primary control power supply.

Functions

- +5 V reference voltage circuit
- Triangular waveform oscillator
- PWM comparator
- Output circuit (Totem pole output)
- Overcurrent protection circuit (with one-pulse latch mode)
- Undervoltage lockout protection circuit
- Soft start and quick shutdown function
- Remote control function
- Comparator with internal 1.3 V reference voltage

Features

- High-speed switching;
tr = 80 ns (15 V amplitude)
tf = 40 ns (15 V amplitude)
- Low power dissipation;
0.3 mA max in standby state
12 mA max in operation state ($V_{IN} = 15$ V)
- Dual-slope highly accurate dead-band duty setup circuit; Setup accuracy $D_u = \pm 3\%$ (max)
- Wide output pulse width control range; 0 to 75%

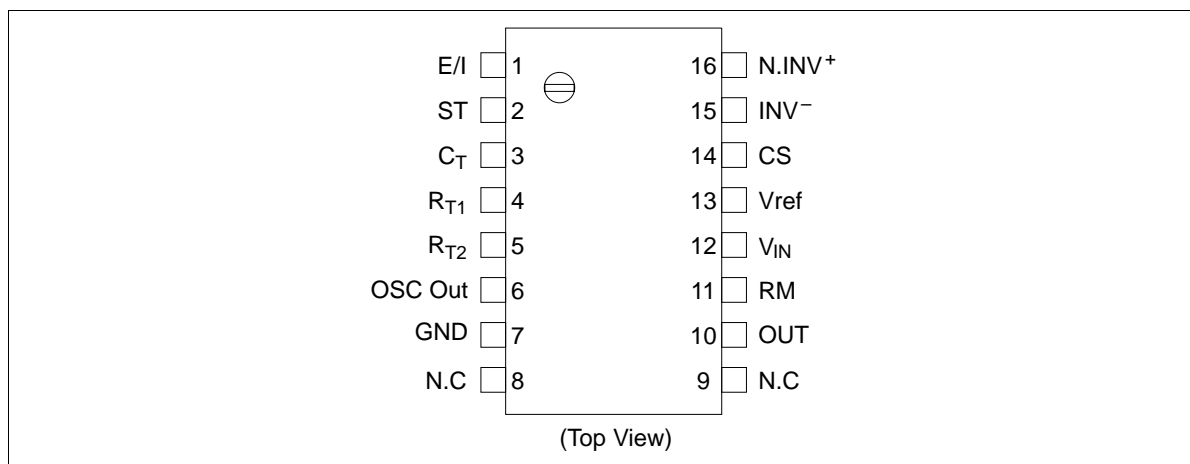
HA16666P/FP

- Undervoltage lockout protection;
 V_{IN} high threshold voltage 10 V typ
 V_{IN} low threshold voltage 8 V typ
- Two input threshold voltage for overcurrent protection comparator;
 fixed voltage (1.3 V)
 variable voltage
- Double pulse output protection by overcurrent protection circuit with one-pulse latch mode
- Wide input supply voltage range; $V_{CC} = 11$ to 40 V

Ordering Information

Type	Package
HA16666P	DP-16
HA16666FP	FP-16DA

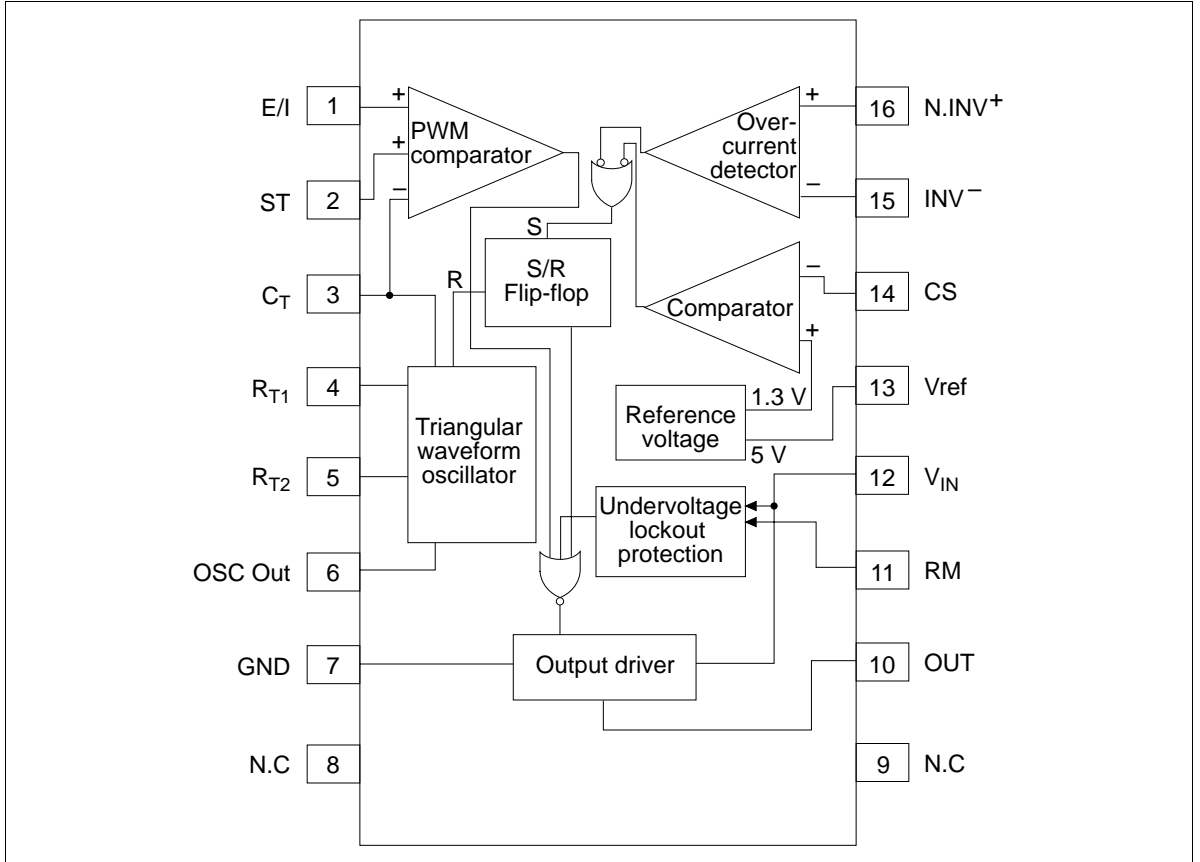
Pin Arrangement



Pin Functions

Pin No.	Symbol	Description
1	E/I	Error input
2	ST	Soft start
3	C _T	Timing capacitance
4	R _{T1}	Timing resistor (rise section)
5	R _{T2}	Timing resistor (fall section)
6	OSC Out	Triangular waveform oscillator
7	GND	Ground
8	N.C	No connect
9	N.C	No connect
10	OUT	Pulse output
11	RM	Remote control
12	V _{IN}	Power supply voltage
13	Vref	Reference voltage (5 V) output
14	CS	Comparator input (-) with reference voltage (1.3 V)
15	INV ⁻	Comparator input (-) for overcurrent protection
16	N.INV ⁺	Comparator input (+) for overcurrent protection

Block Diagram



Absolute Maximum Ratings ($T_a = 25^\circ\text{C}$)

Item	Symbol	Rating		Unit	
		HA16666P	HA16666FP		
Power supply voltage	V_{IN}	+40	+40	V	
Output current (Push-pull)	DC	$I_{O(DC)}$	100	100	mA
	Peak	$I_{O(peak)}$	500*1	500*1	mA
Error input	V_{EI}	Vref	Vref	V	
OSC input voltage	V_{OSC}	$V_{IN} - 3V_{BE}$	$V_{IN} - 3V_{BE}$	V	
CS input voltage	V_{CS}	Vref	Vref	V	
RM input voltage	V_{RM}	V_{IN}	V_{IN}	V	
RT2 input current	I_{R2}	1	1	mA	
RT1 input current	I_{R1}	1	1	mA	
Power dissipation	P_T	680*2	680*3	mW	
Operation temperature	T_{opr}	-20 to +85	-20 to +85	$^\circ\text{C}$	
Storage temperature	T_{stg}	-55 to +125	-55 to +125	$^\circ\text{C}$	

Notes: 1. Value at 300 ns of switching time

2. Value at $T_a \leq 45^\circ\text{C}$. If $T_a > 45^\circ\text{C}$, derated by 8.3 mW/ $^\circ\text{C}$

3. Value under the condition of 40 mm × 40 mm × 0.8 t ceramics board epoxy board

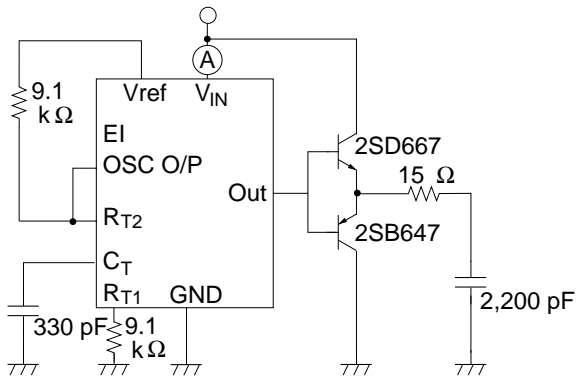
Electrical Characteristics ($V_{IN} = 15\text{ V}$, $T_a = 25^\circ\text{C}$, $f_{osc} = 300\text{ kHz}$)

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Voltage reference	Output voltage	Vref	4.75	5.00	5.25	V no load
	Line regulation	Line	—	50	100	mV $V_{IN} = 11\text{ to }40\text{ V}$
	Load regulation	Load	—	9	20	mV $I_O = 0\text{ to }10\text{ mA}$
	Temperature stability	V_{RTC}	—	+60	—	ppm/ $^\circ\text{C}$ no load
	Short circuit current	I_{OS}	10	35	—	mA $V_{ref} = 0\text{ V}$
Triangular waveform oscillator	Maximum frequency	f_{max}	600	—	—	kHz $C_T = 150\text{ pF}$
	Minimum frequency	f_{min}	—	—	1	kHz $C_T = 0.15\text{ }\mu\text{F}$
	Frequency accuracy	f_{der}	-10	0	+10	%
	Voltage stability	f_T	—	1	—	% $11\text{ V} \leq V_{IN} \leq 40\text{ V}$
	Temperature coefficient of frequency	f_i	—	2	—	% $-20^\circ\text{C} \leq T_a \leq +85^\circ\text{C}$

Electrical Characteristics ($V_{IN} = 15\text{ V}$, $T_a = 25^\circ\text{C}$, $f_{osc} = 300\text{ kHz}$) (cont)

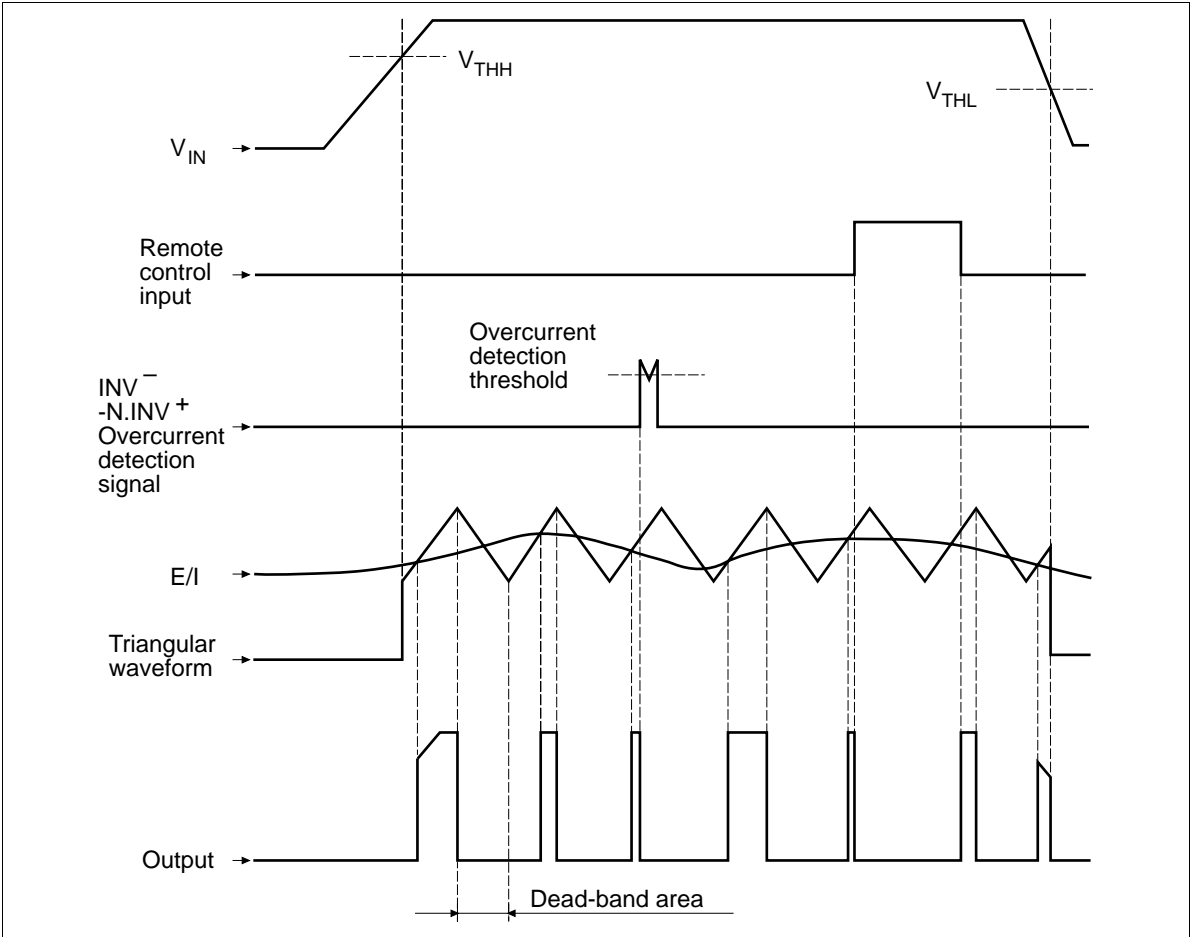
Item		Symbol	Min	Typ	Max	Unit	Test Condition
PWM comparator	Maximum duty cycle	Du	75	—	—	%	
	Input bias current	I_b	-2	—	—	μA	Pin 1
	Low-level threshold voltage	V_{OSCL}	—	1.5	—	V	Pin 1
	High-level threshold voltage	V_{OSCH}	—	2.5	—	V	Pin 1
	Dead-band duty accuracy	ΔDu	—	± 1	± 3	%	
	Dead-band duty input voltage stability	D_T	—	1	—	%	$11\text{ V} \leq V_{IN} \leq 40\text{ V}$
	Temperature coefficient of dead-band duty	D_{UT}	—	1	—	%	$-20^\circ\text{C} \leq T_a \leq +85^\circ\text{C}$
Overcurrent detector	Input bias current	I_{B1}	-2	—	—	μA	Pin 15, 16
	Common-mode input voltage range	V_{CM1}	0 to $V_{IN} - 3$	—	—	V	Pin 15, 16
Comparator	Input bias current	I_{B2}	—	5	13	μA	$V_{CS} = 5\text{ V}$
	Input threshold voltage	V_{th}	1.2	1.3	1.4	V	
	Input voltage range	V_{CS}	0	—	V_{ref}	V	
Remote controller	Input current to remote control pin	I_{RM}	—	—	1.5	mA	$V_{RM} = 5\text{ V}$
	Input high-voltage	V_{INH}	1	—	—	V	
	Input low-voltage	V_{INL}	—	—	0.4	V	
Undervoltage lockout protector	High-level threshold voltage	V_{THH}	9	10	11	V	
	Low-level threshold voltage	V_{THL}	7	8	9	V	
	Hysteresis width	Hys	1.5	2.0	2.8	V	
Output driver	Output low-level	V_L	—	0.7	1.4	V	$I_{O(SINK)} = 10\text{ mA}$
	Output high-level	V_H	$V_{IN} - 2.2$	—	—	V	$I_{O(SOURCE)} = 10\text{ mA}$
	Output rise time	t_r	—	80	150	ns	Note 1
	Output fall time	t_f	—	40	100	ns	Note 1
Total current	Standby current	I_{CS}	—	0.15	0.3	mA	Note 1
	Operation current	I_{CL}	—	8	12	mA	Note 1

Note: 1. Measurement conditions of I_{CS} , I_{CL} , t_r , t_f are defined as following diagram.

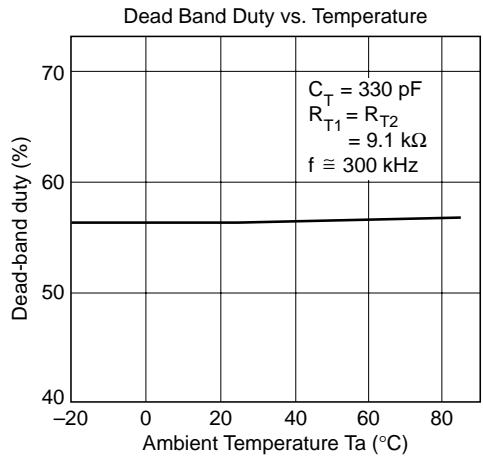
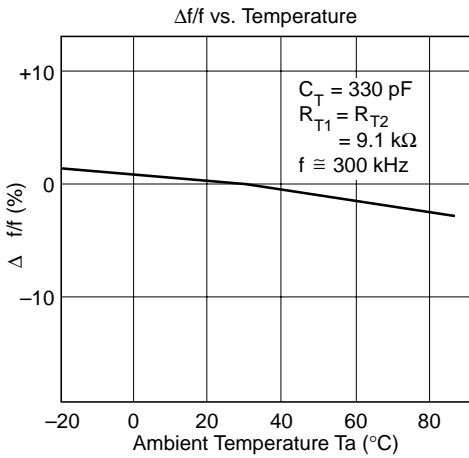
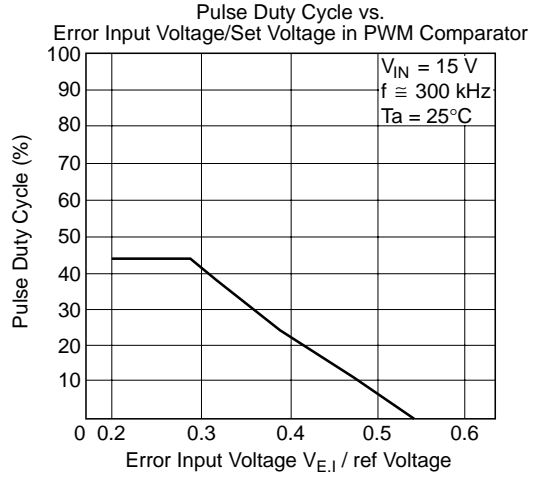
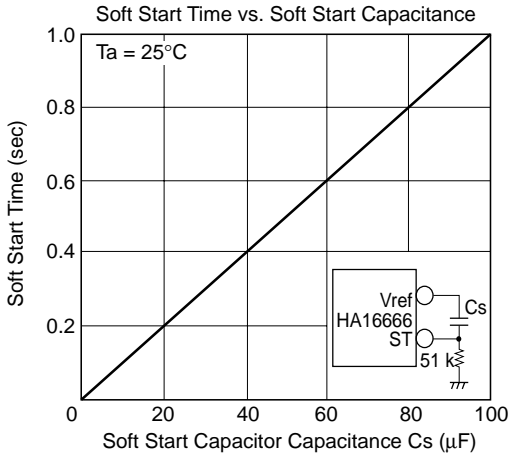
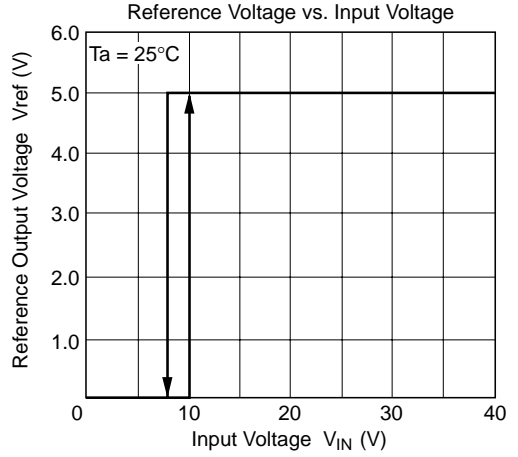
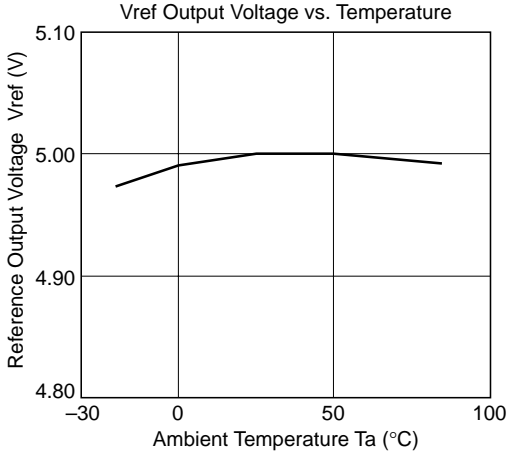


h_{FE} of 2SD667 is defined as 60 min and 200 max.

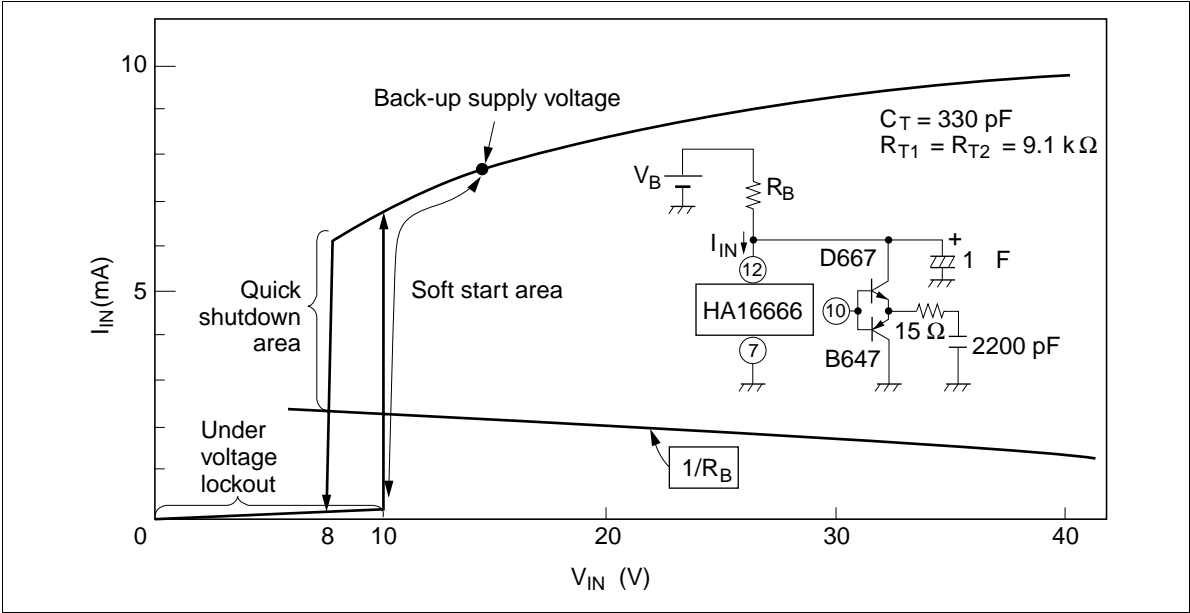
Waveform Timing



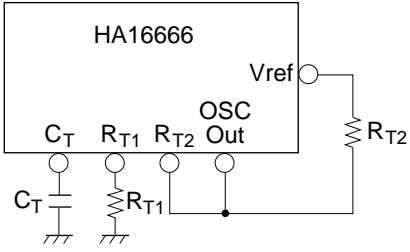
Characteristic Curves



V_{IN} Bias Point



Formula for the oscillation frequency



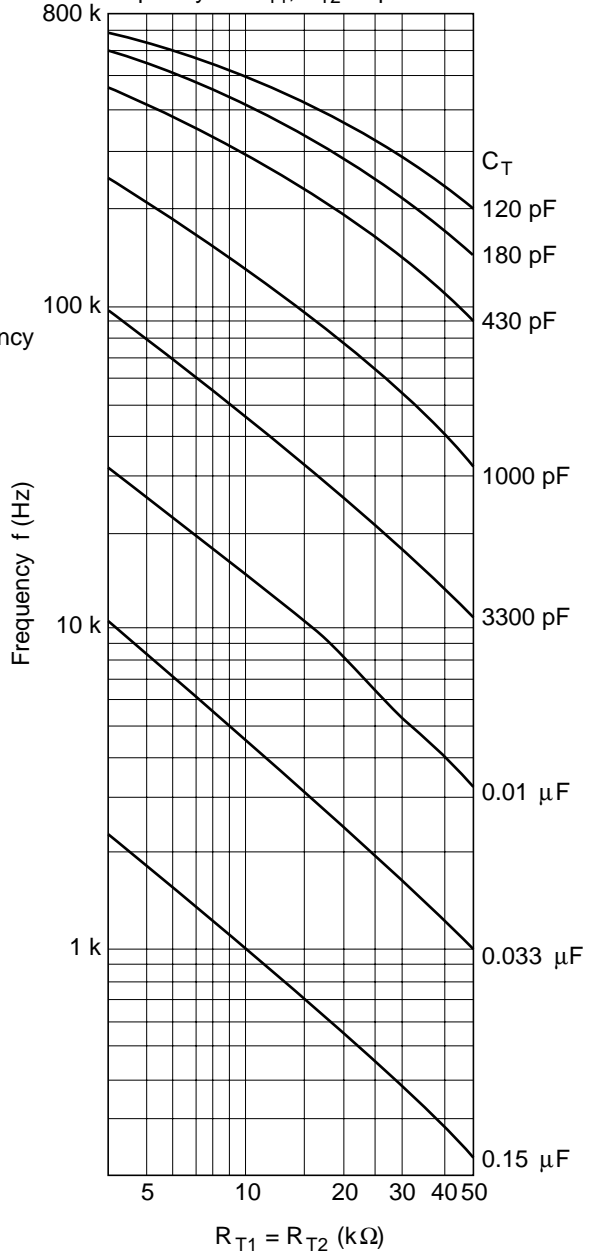
HA16666 summary formula of the oscillation frequency
 $\log(f) \approx a \times \log(R_{T1}) + b$

↑
(= R_{T2})

The following table show empirical values of a and b for different values of C_T .

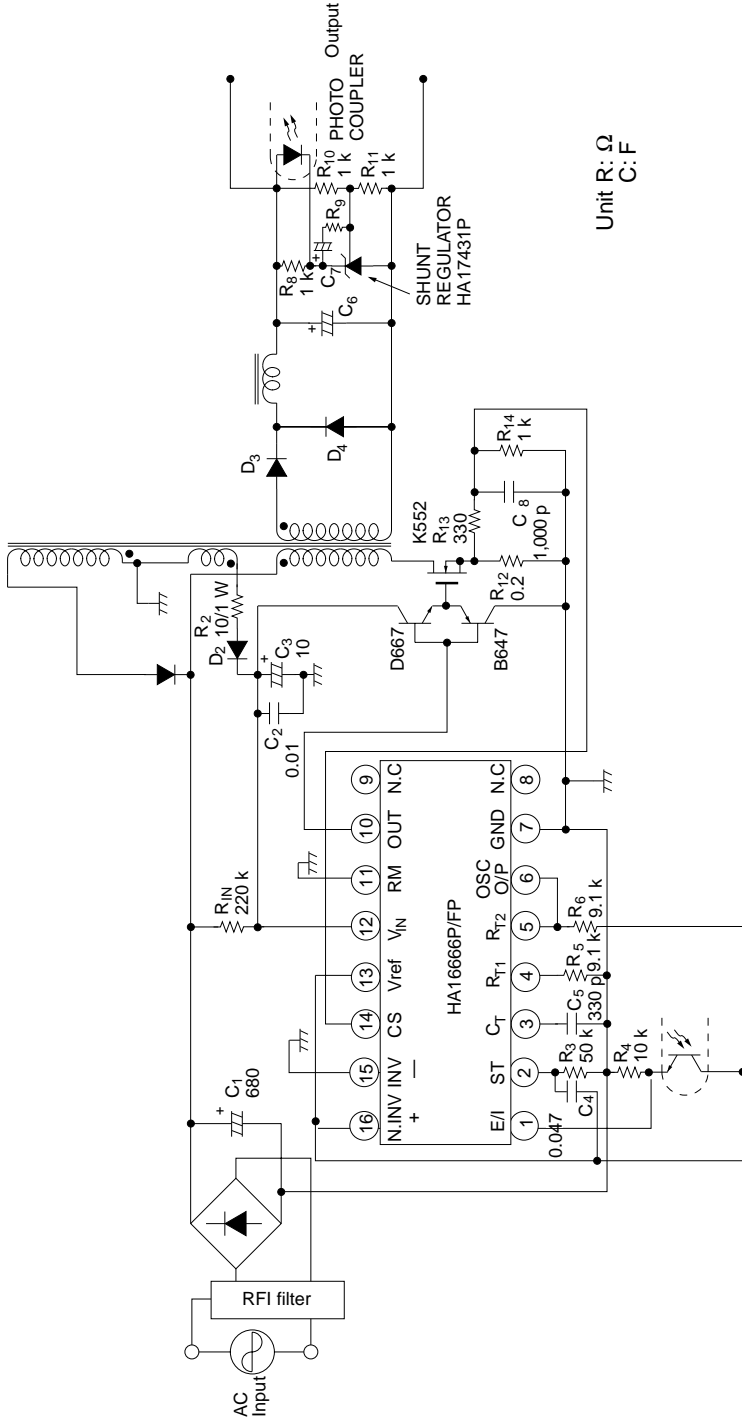
C_T	a	b
180pF	-0.50	7.58
330pF	-0.61	7.86
1000pF	-0.75	8.09
0.01 μ F	-0.86	7.57
0.15 μ F	-0.86	6.45

Frequency vs. R_{T1} , R_{T2} Dependence



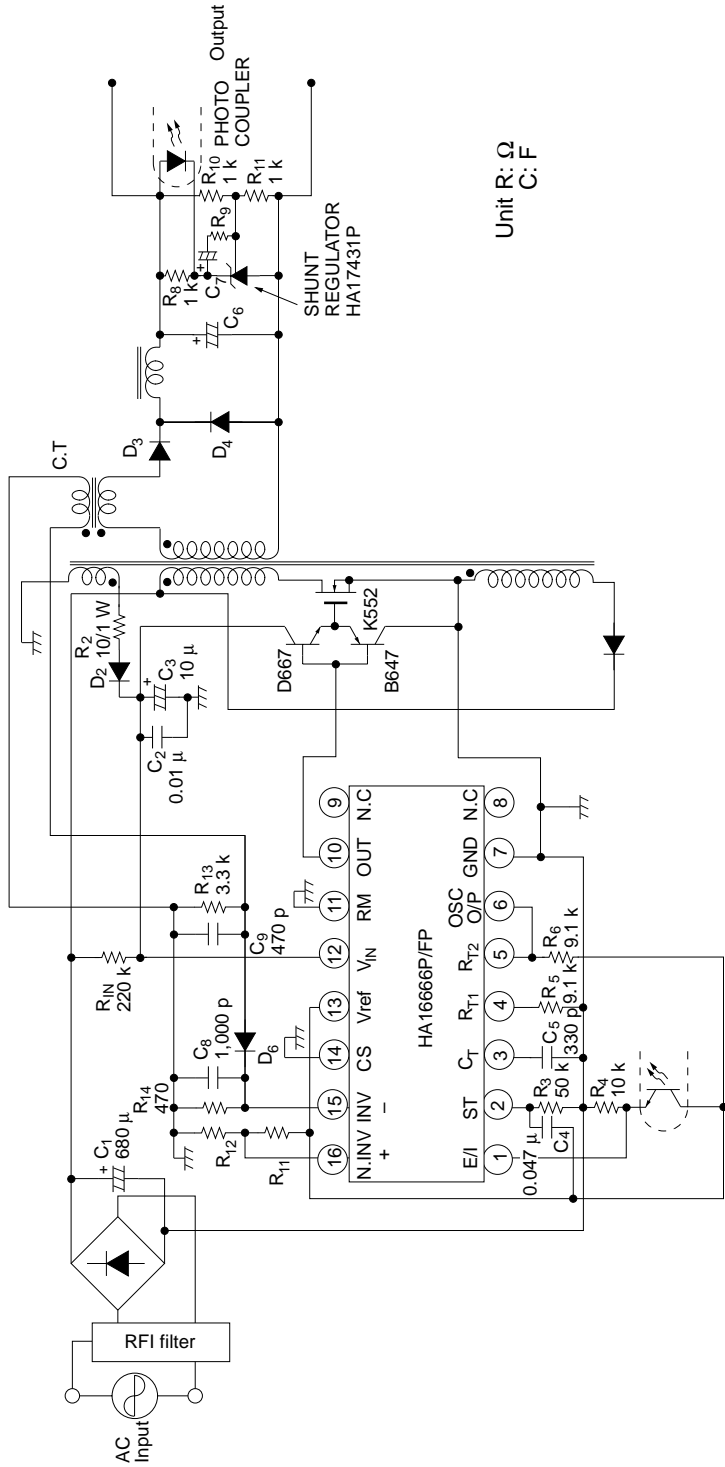
System Connection Example

Over current protection; Resistance sensing method

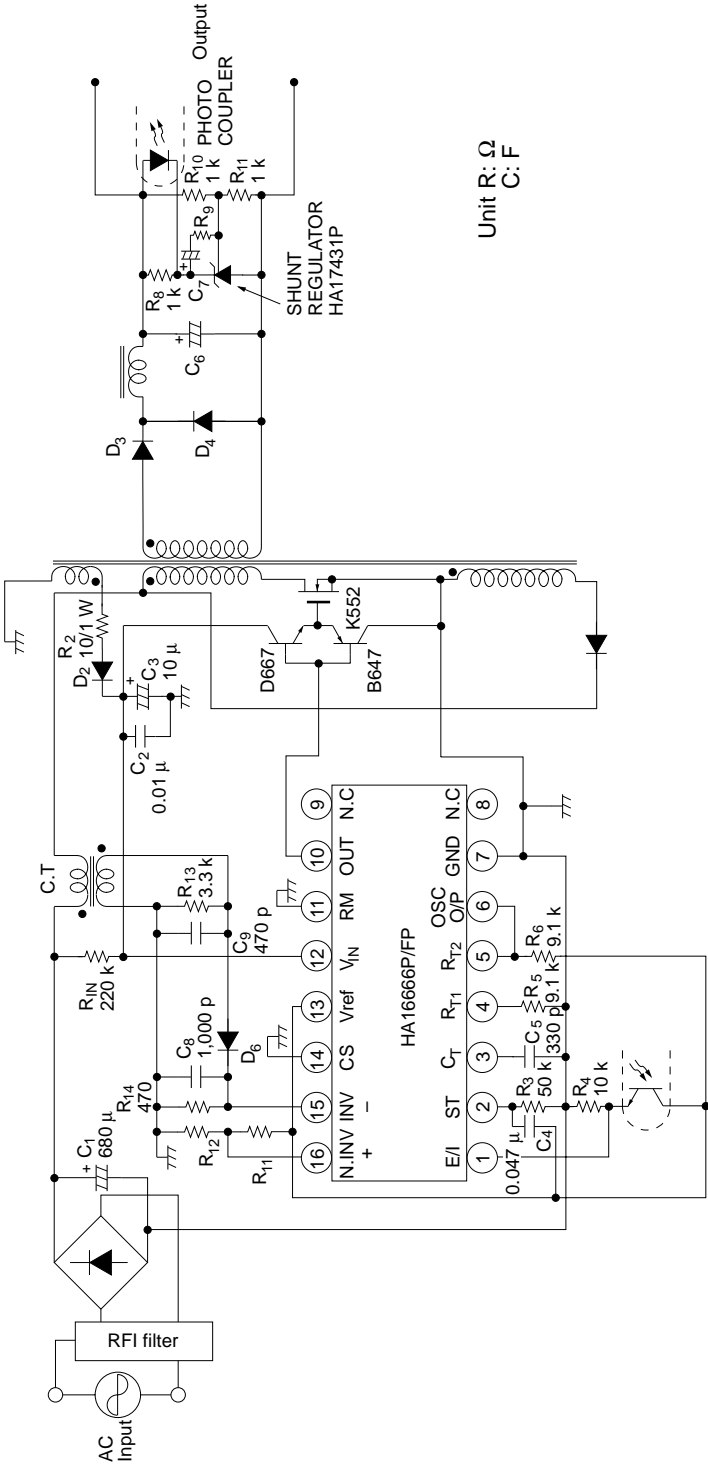


Unit R: Ω
C: F

Over current protection; Current transformer method



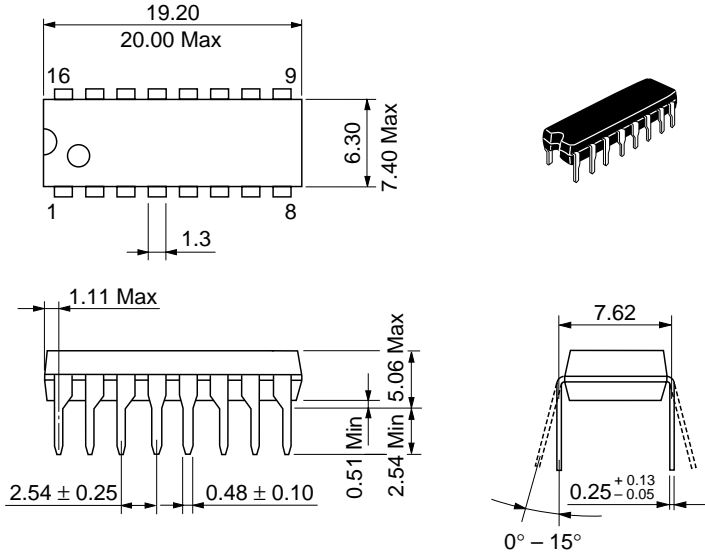
Over current protection; Current transformer method



Unit R: Ω
C: F

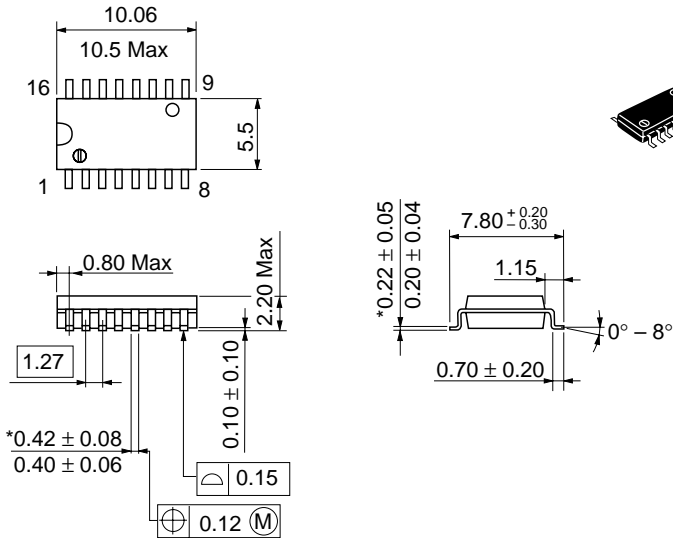
Package Dimensions

Unit: mm



Hitachi Code	DP-16
JEDEC	Conforms
EIAJ	Conforms
Mass (reference value)	1.07 g

Unit: mm



Hitachi Code	FP-16DA
JEDEC	—
EIAJ	Conforms
Mass (reference value)	0.24 g

*Dimension including the plating thickness
Base material dimension

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