
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;
 $t_r = 80 \text{ ns}$ (15 V amplitude)
 $t_f = 40 \text{ ns}$ (15 V amplitude)
- Low power dissipation;
0.3 mA max in standby state
12 mA max in operation state ($V_{IN} = 15 \text{ V}$)
- 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%

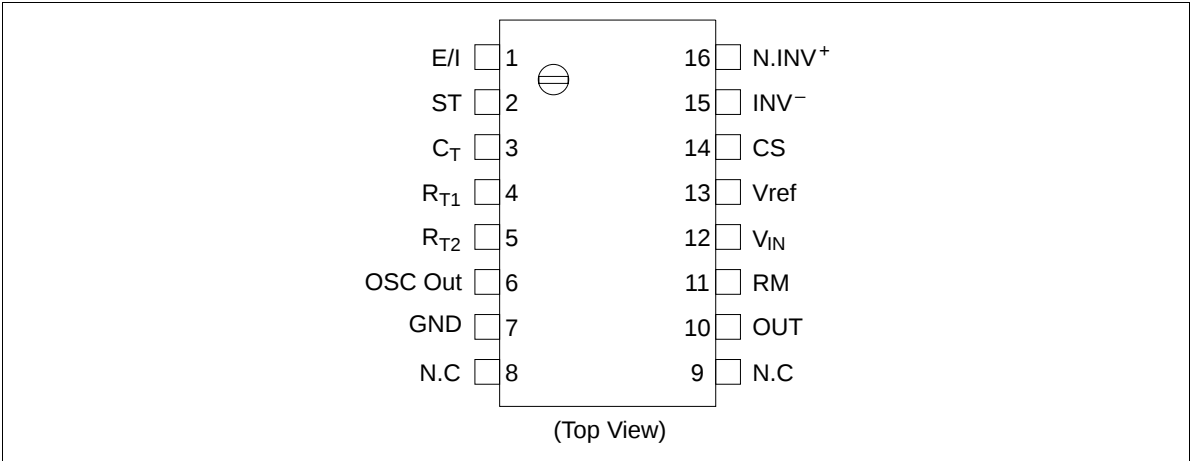
HA16666P/FP

- 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 cmparator;
 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

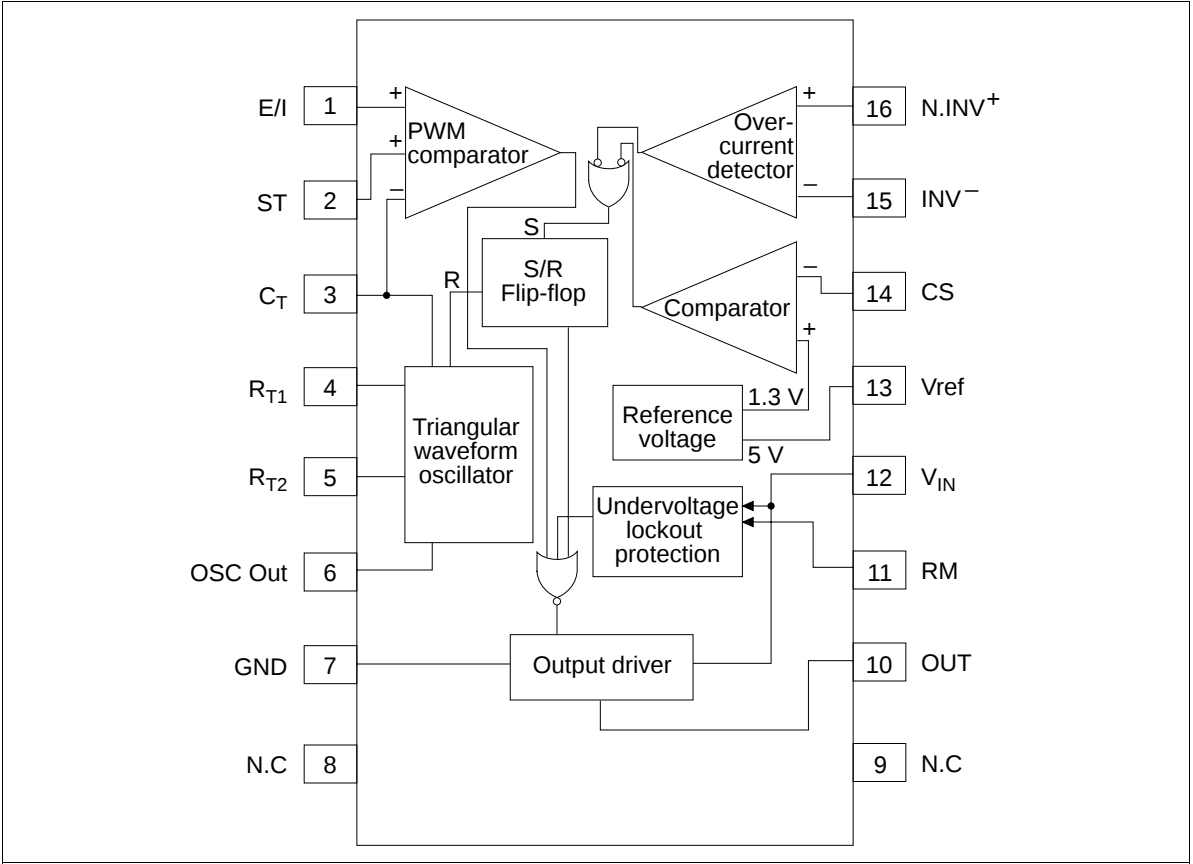
Pin Arrangement



Pin Functions

Pin No.	Symbol	Descreption
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	mA
	Peak	$I_{O(peak)}$	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	Topr	-20 to +85	-20 to +85	°C
Storage temperature	Tstg	-55 to +125	-55 to +125	°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 $8.3 \text{ mW}/^\circ\text{C}$
 3. Value under the condition of $40 \text{ mm} \times 40 \text{ mm} \times 0.8 \text{ t}$ ceramics board epoxy board

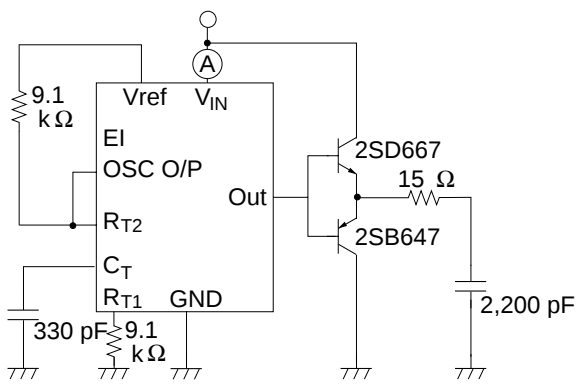
Electrical Characteristics ($V_{IN} = 15 \text{ V}$, $T_a = 25^\circ\text{C}$, $f_{osc} = 300 \text{ kHz}$)

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/°C	no load
	Short circuit current	I_{OS}	10	35	—	mA	Vref = 0 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 V, Ta = 25°C, fosc = 300 kHz) (cont)

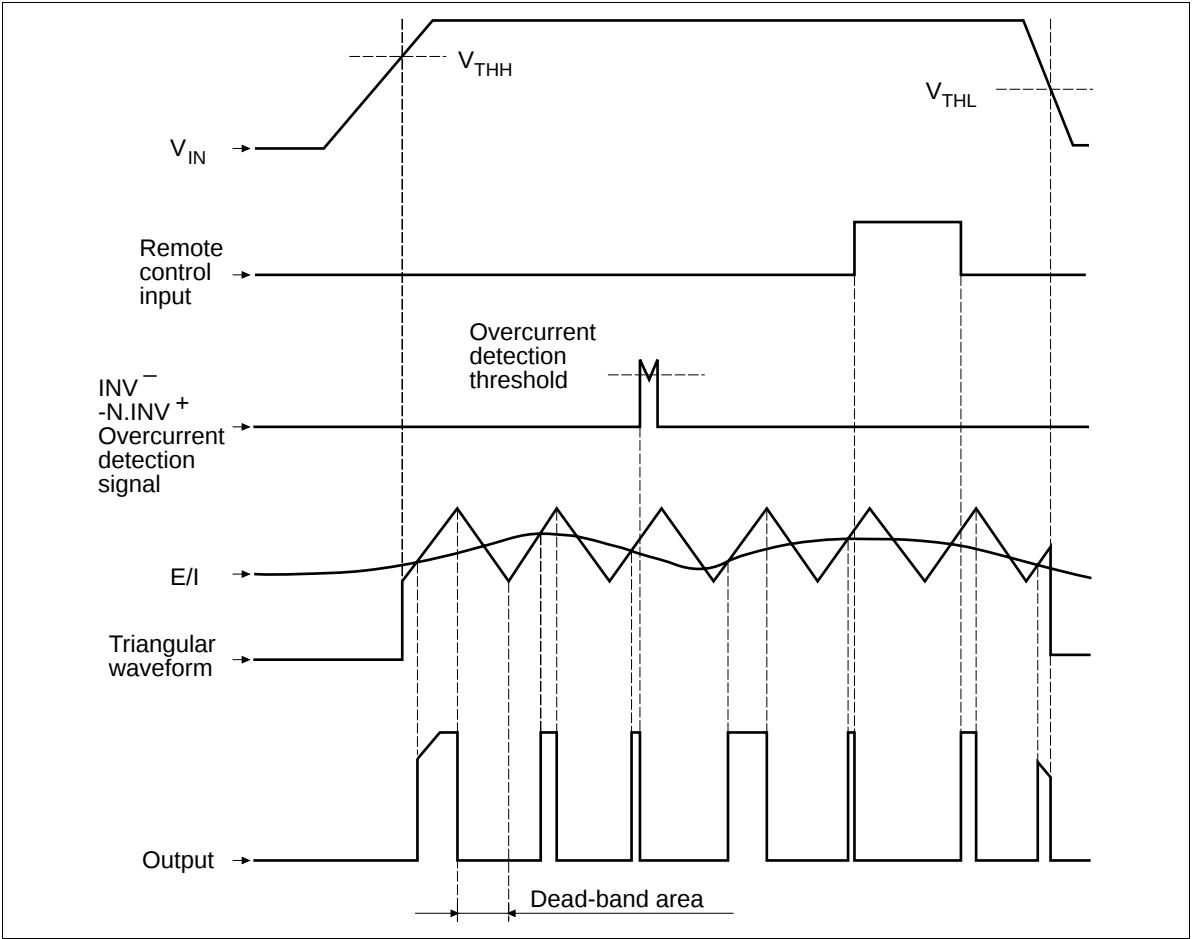
Item		Symbol	Min	Typ	Max	Unit	Test Condition
PWM comparator	Maximum duty cycle	Du	75	—	—	%	
	Input bias current	I _B	−2	—	—	μA	Pin 1
	Low-level threshold voltage	V _{OSCL}	—	1.5	—	V	Pin 1
	High-level threshold voltage	V _{OSCH}	—	2.5	—	V	Pin 1
	Dead-band duty accuracy	Δ Du	—	±1	±3	%	
	Dead-band duty input voltage stability	D _T	—	1	—	%	11 V ≤ V _{IN} ≤ 40 V
	Temperature coefficient of dead-band duty	D _{uT}	—	1	—	%	−20°C ≤ Ta ≤ +85°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 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 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 mA
	Output high-level	V _H	V _{IN} − 2.2	—	—	V	I _{O (SOURCE)} = 10 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.

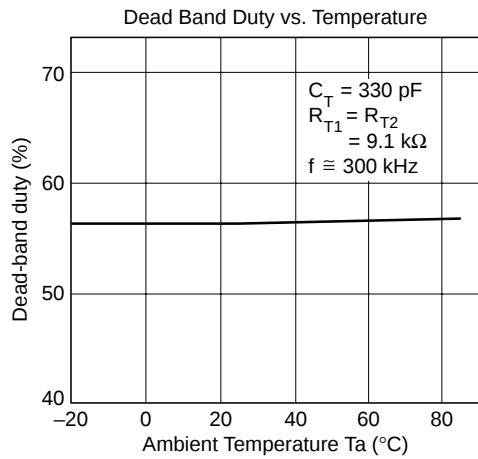
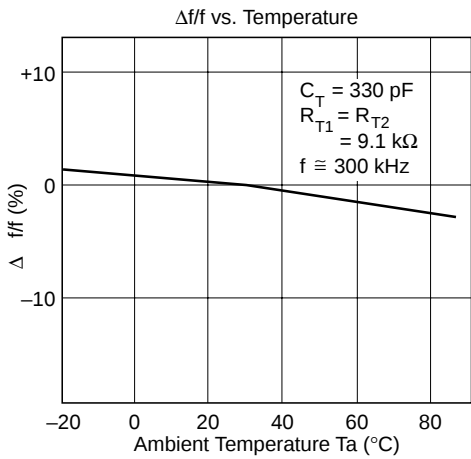
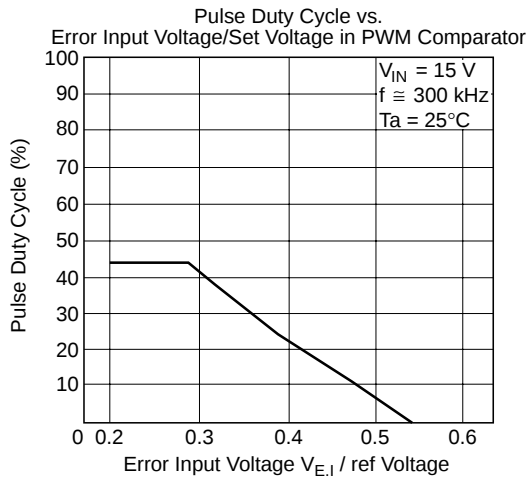
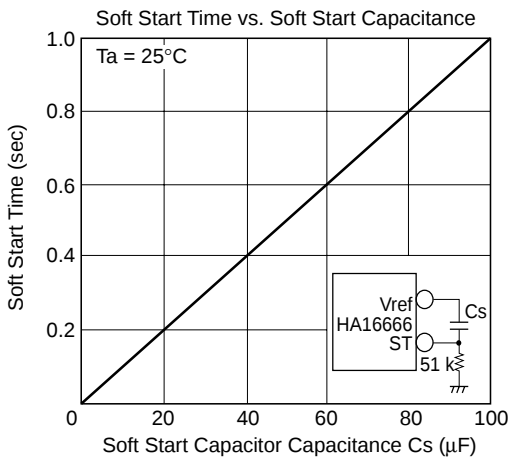
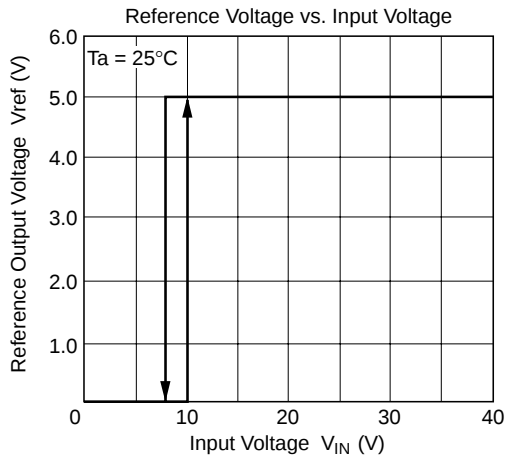
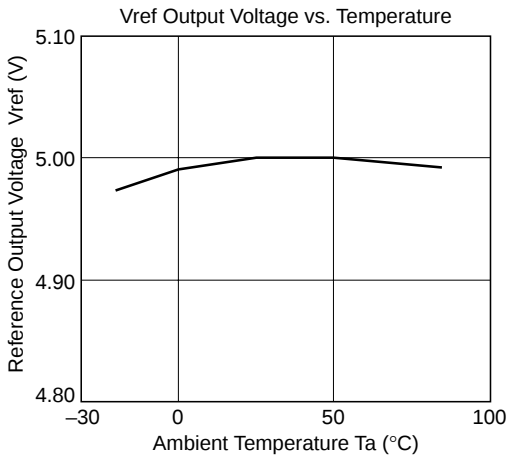


h_{FE} of 2SD667 is defined as 60 min and 200 max.

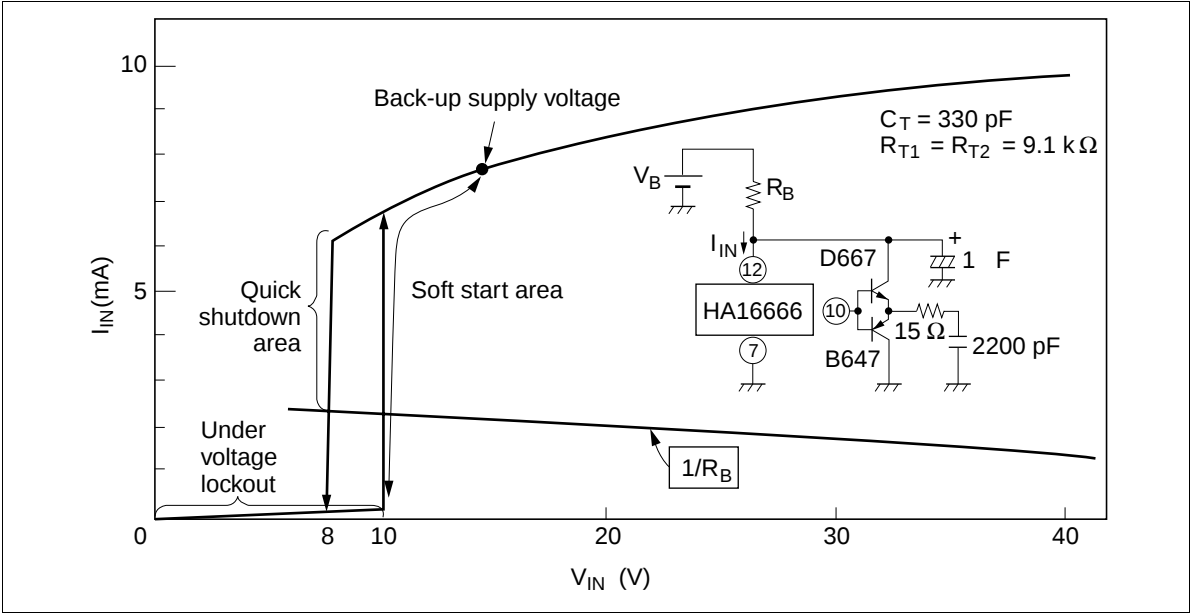
Waveform Timing



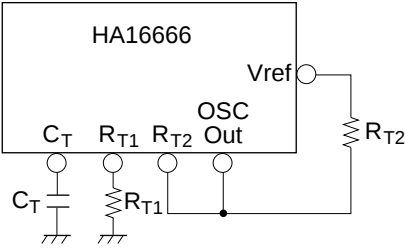
Characteristic Curves



V_{IN} Bias Point



Formula for the oscillation frequency



HA16666 summary formula of the oscillation frequency

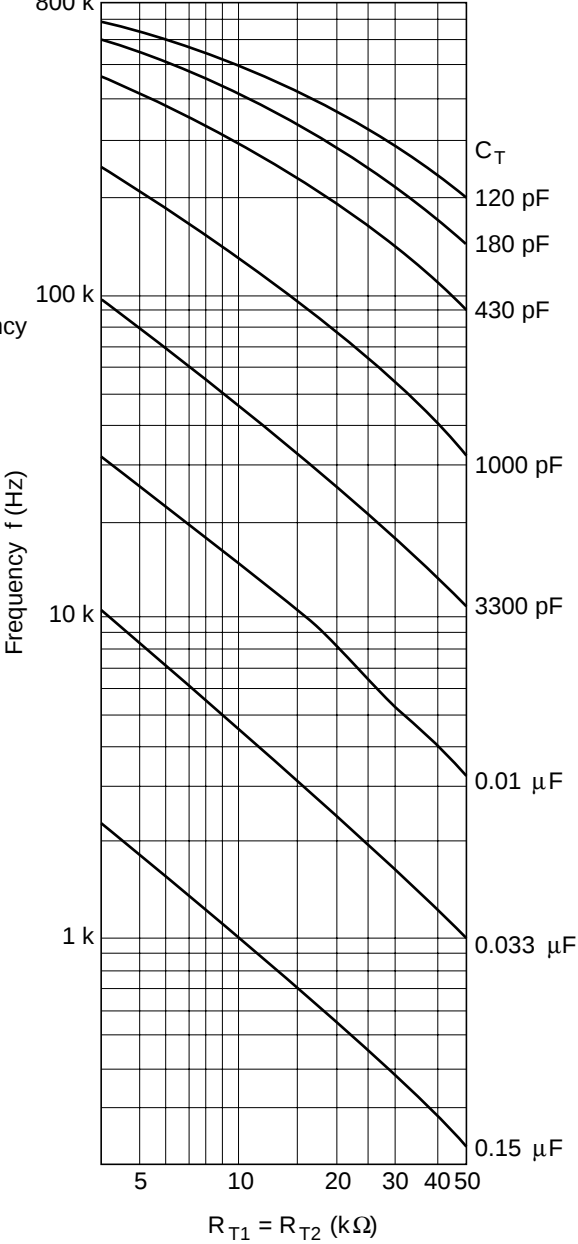
$$\log(f) \approx a \times \log\left(\frac{R_{T1}}{R_{T2}}\right) + b$$

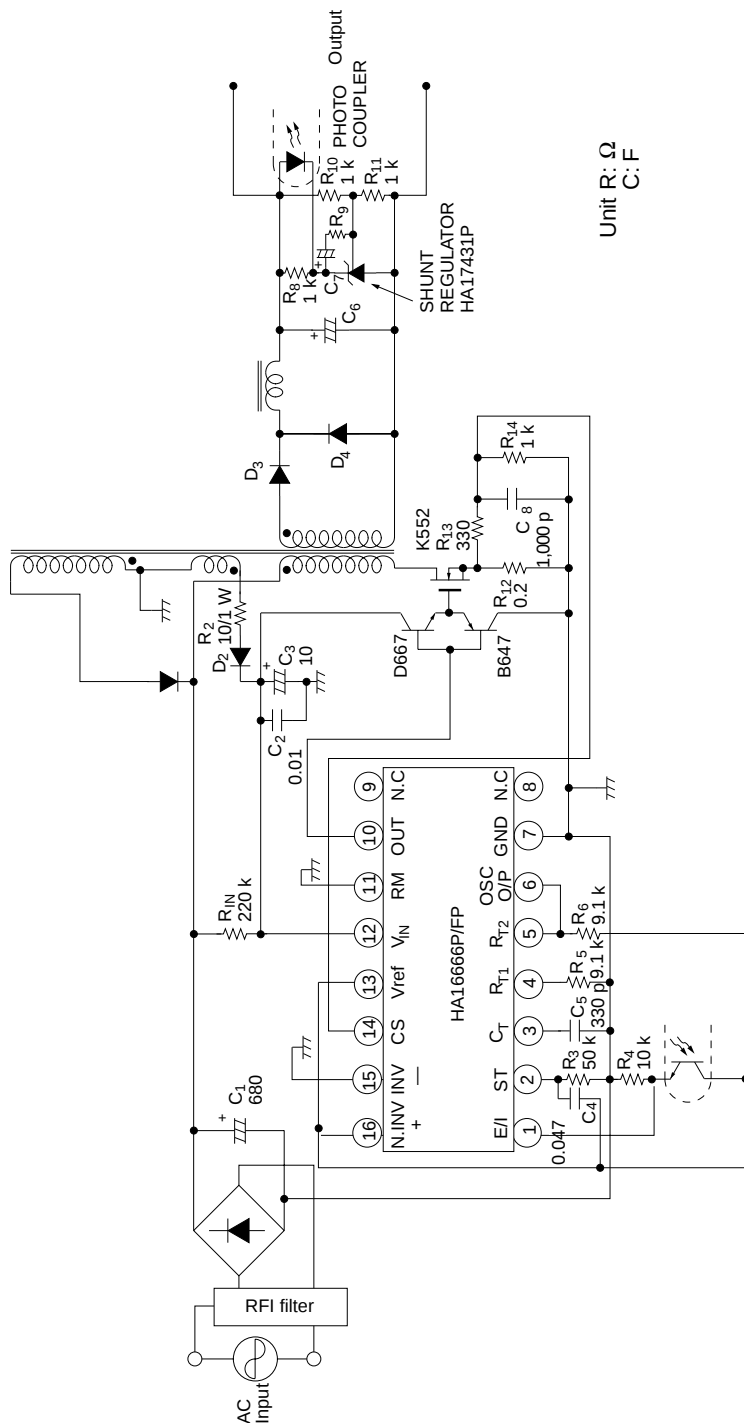
$\uparrow$
(= R_{T2})

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

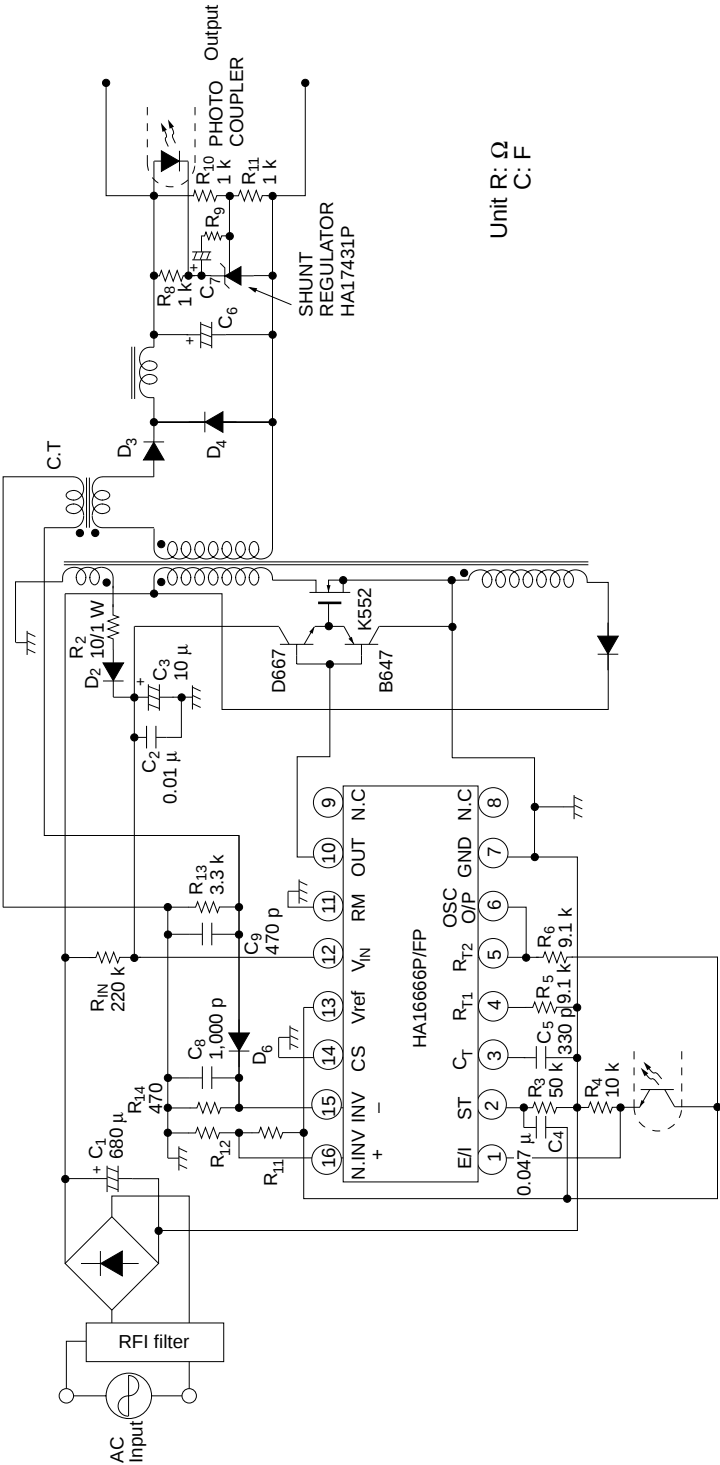
C_T	a	b
180pF	-0.50	7.58
330pF	-0.61	7.86
1000pF	-0.75	8.09
0.01μF	-0.86	7.57
0.15μF	-0.86	6.45

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

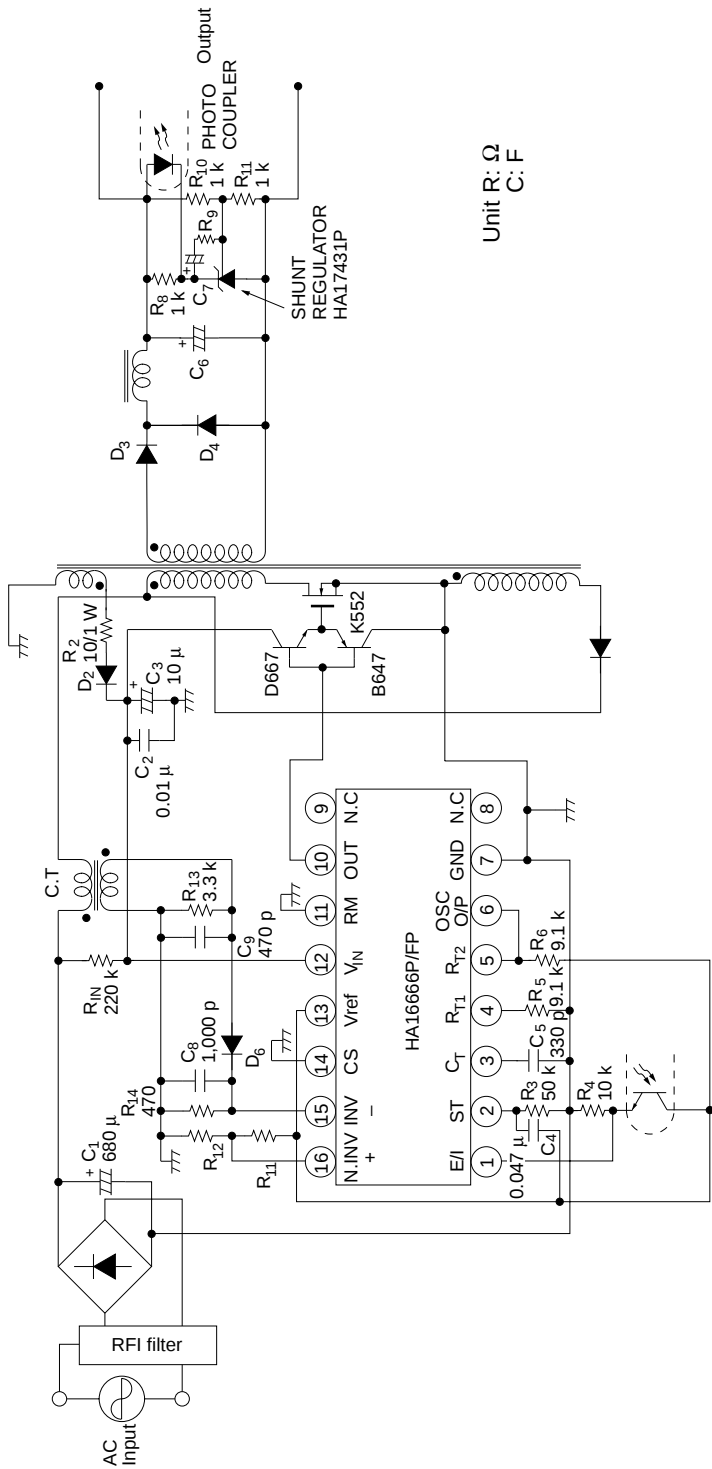


Unit R: Ω
C: F

Over current protection; Current transformer method

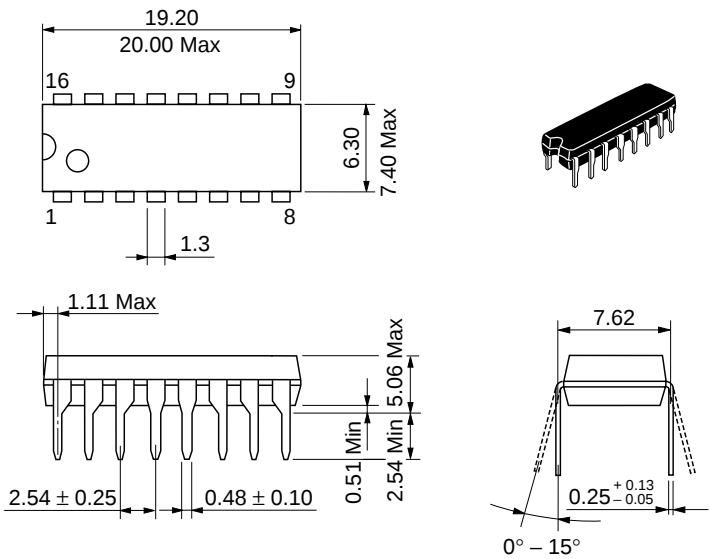


Over current protection; Current transformer method



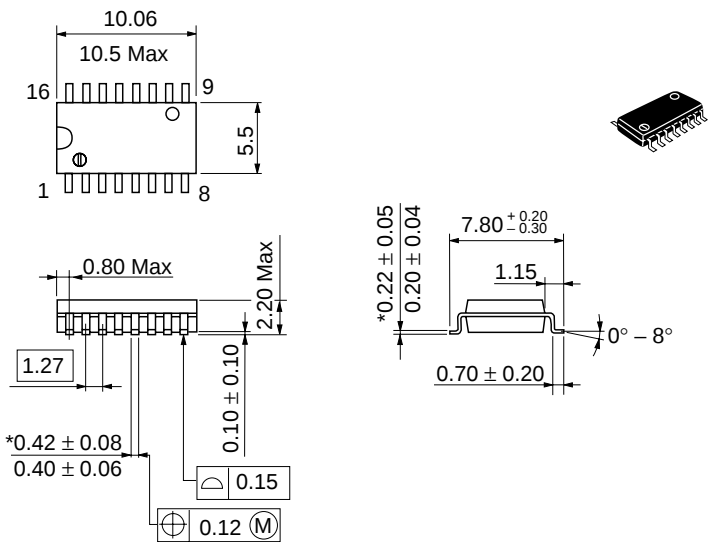
Package Dimensions

Unit: mm



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

Unit: mm



*Dimension including the plating thickness
Base material dimension

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

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