HA16654A, HA16664A Series

PWM Controlled Switching Regulator

HITACHI

The HA16654A and HA16664A are PWM control switching regulator ICs which drive a power MOSFET at high speed and high frequency. The standby current is limited to as small as 1.5 mA (typ). These devices incorporate totem pole circuits suited for high-speed push-pull operation at the output stage, accomplishing high-speed switching with rising time t_r = 80 ns (typ) and falling time t_f = 40 ns (typ) at 20 V swing.

Functions

- Reference voltage circuit
- Triangular waveform oscillation circuit
- PWM comparator circuit
- Low-input malfunction protection circuit
- Output drive circuit
- Soft start and quick shut down

Features

- High speed switching: t_r = 80 ns, t_f = 40 ns (typ) when use exernal driver circuit
- High frequency operation:
  HA16654A (f = 100 kHz to 500 kHz)
  HA16664A (f = 100 kHz to 200 kHz)
  Low power dissipation : 2 mA max in standby state
- 5 V reference voltage
- Low-input malfunction protection (High threshold voltage: 10 V Typ, Low threshold voltage: 8 V Typ)
- Adjustable dead band width
- Enlarged output pulse width control range (0 to 80%)
- Soft start and quick shut down functions
- Single output: totem pole

Hitachi semiconductor

Ordering Information

Type No.	Operating Frequency	Package
HA16654APS	100 kHz to 500 kHz	DP-8
HA16654AFP		FP-14DA
HA16664APS	100 kHz to 200 kHz	DP-8
HA16664AFP		FP-14DA

Pin Arrangement

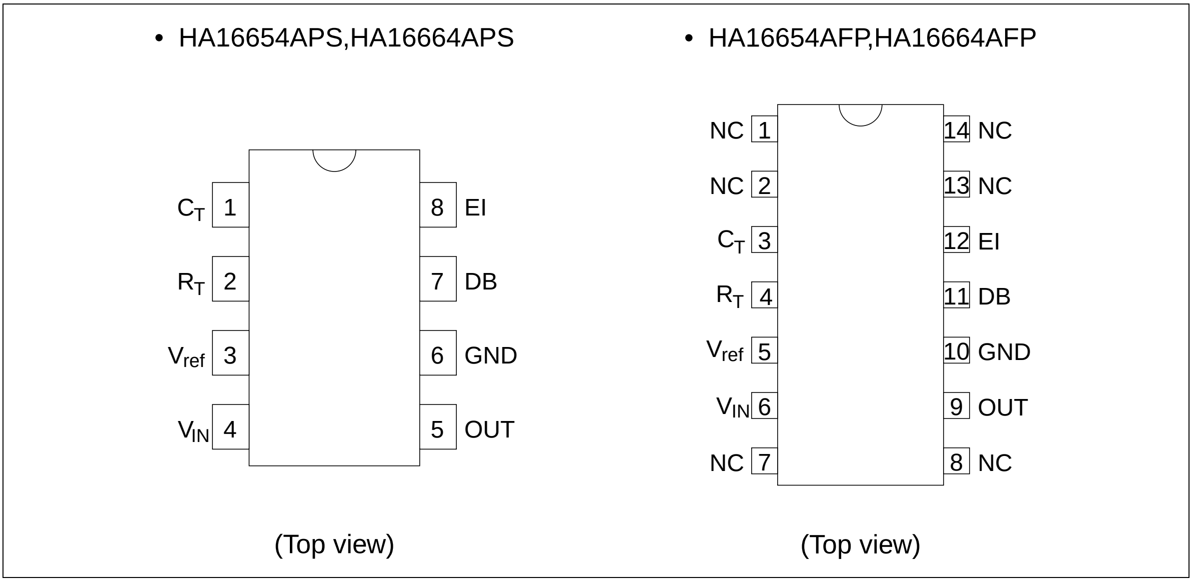
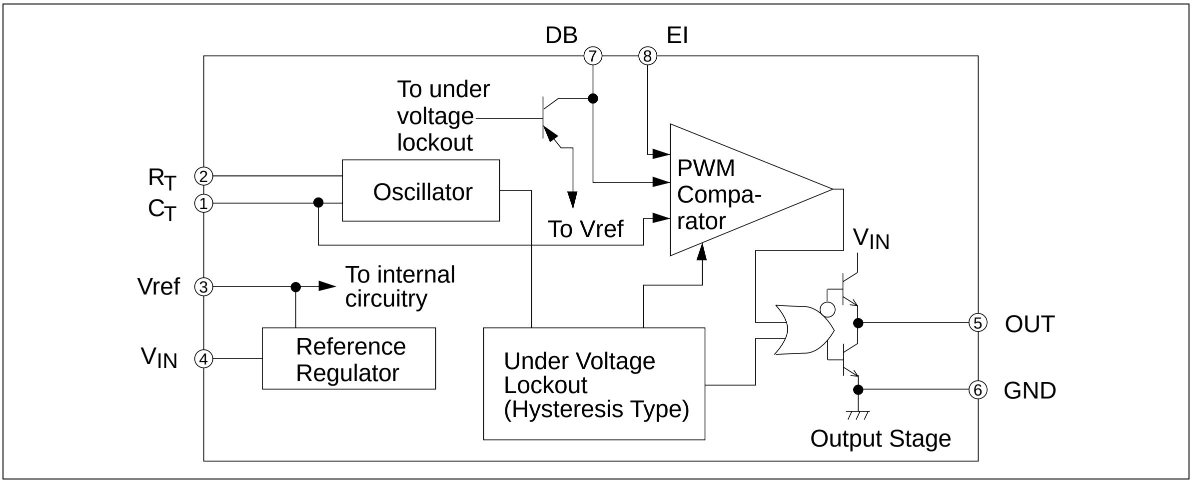


Table 1 Pin Function

Symbol	Pin Name
C_T	Timing capacitor
R_T	Timing resistor
Vref	Reference voltage
V_{IN}	Input voltage
EI	Error input
DB	Dead band
GND	Ground
OUT	Driver output

Block Diagram



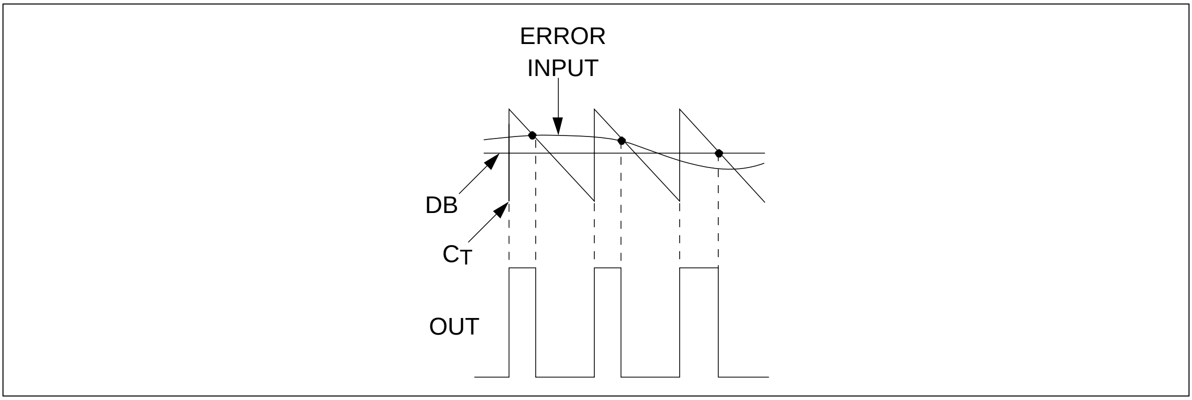


Figure 1 Waveform Timing

Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating	Unit	Notes
Power supply voltage	V_{IN}	+40	V	
Collector current (Push-pull)	I_O	20	mA	
Comparator input voltage	V_{COM}	Vref + 0.3	V	
R_T input current	I_{RT}	1	mA	
Power dissipation	P_T	680	mW	1, 2
Operation temperature range	Topr	–20 to +85	°C	
Storage temperature range	Tstg	–55 to 125	°C	

Notes: 1. Ta ≤ 45°C, if Ta > 45°C, derate by 8.3 mW/°C

2. Tjmax = θj–a • Pcmax + Ta (θj–a:Thermal resistance between junction and atmosphere at set board use)

The wiring density and the material of the set board must be chosen for thermal conductance of efficacy board.

Electrical Characteristics

HA16654APS/AFP (Ta = 25°C, V_{IN} = 20 V, C_T = 220 pF, R_T = 27 kΩ at f 500 kHz)

Voltage Reference

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Output voltage	Vref	4.75	5.00	5.25	V	
Line regulation	Line	—	—	100	mV	V_{IN} = 7.3 to 11 V
		—	10	25	mV	V_{IN} = 11 to 40 V
Load regulation	Load	—	5	16	mV	I_O = 0 to 10 mA
Temperature stability	V_{RTC}	—	–26	—	ppm/°C	
Short circuit current	I_{OS}	10	35	—	mA	Vref = 0 V

Oscillator

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Maximum frequency	f_{max}	500	—	—	kHz	C_T = 220 pF
Minimum frequency	f_{min}	—	—	100	kHz	C_T = 560 pF
Initial accuracy	f_{dev}	—	—	±10	%	
Voltage stability	f_{av}	—	–0.02	±1.0	kHz/V	V_{IN} = 11 to 40 V

PWM

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Maximum duty cycle	Du	80	—	—	%	
Duty cycle accuracy	Ddev	—	±1	±6	%	R_1 = 13 kΩ, R_2 = 39 kΩ
Input bias current	I_B	—	—	2.0	µA	V_{E1} = 4 V, V_{DB} = 0 V or V_{E1} = 0 V, V_{DB} = 4 V

Output Driver

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Sink current at Vin low	I_{OS}(Low)	0.6	1.5	—	mA	V_{IN} = 6 V, V_{OUT} = 0.4 V
Output low level	V_{OL}	—	0.86	1.4	V	I_O(sink) = 10 mA
Output high level	V_{OH}	V_{IN} – 2.2	—	—	V	I_O(source) = 10 mA
Output rising time	t_r	—	80	150	ns	Figure 3
Output falling time	t_f	—	40	100	ns	Figure 3
High level threshold	V_{THH}	9	10	11	V	UVL characteristics
Low level threshold	V_{THL}	7.3	8	9	V	UVL characteristics
Hysteresis width	V_{HRS}	1.5	2.0	2.5	V	UVL characteristics

Total Current

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Standby current	I_{CCS}	—	1.5	2.0	mA	Figure 2
Operation current	V_{CCL}	5.0	9.0	13.0	mA	R_1 = 13 kΩ, R2 = 29 kΩ, V_{IN} = 20 V Figure 2

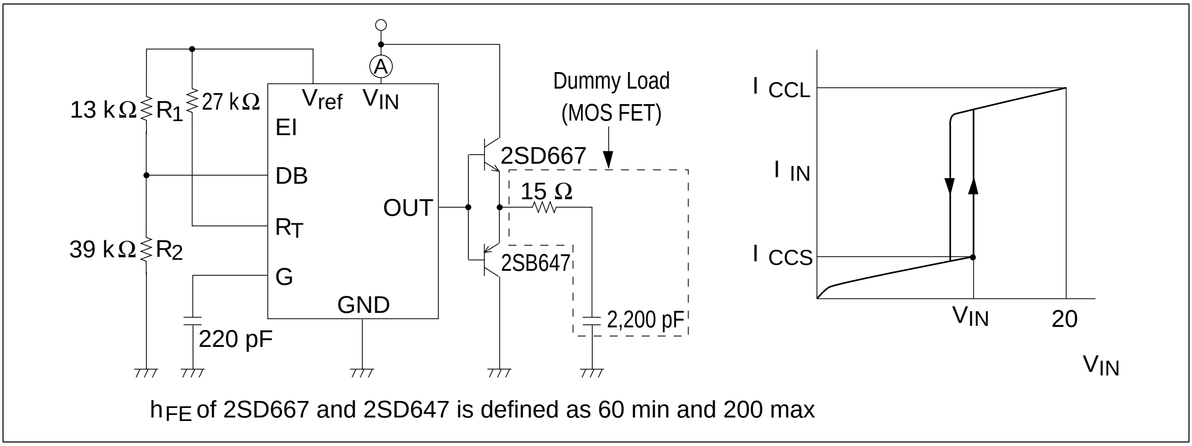


Figure 2 I_{CCS} • I_{CCL} Measurement Circuit

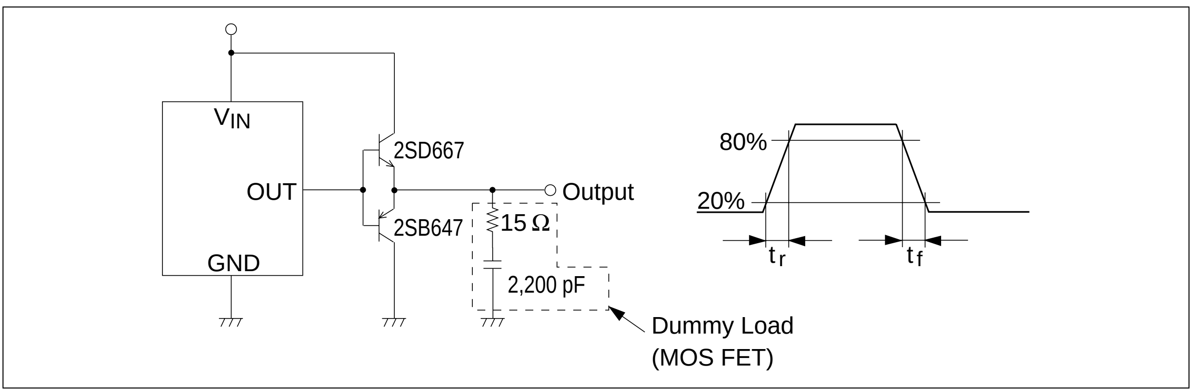


Figure 3 t_r , t_f Measurement Circuit

HA16664APS/AFP (Ta = 25°C, V_{IN} = 20 V, C_T = 560 pF, R_T = 82 kΩ at f 100 kHz)

Voltage Reference

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Output voltage	Vref	4.75	5.00	5.25	V	
Line regulation	Line	—	—	100	mV	V_{IN} = 7.3 to 11 V
		—	10	25	mV	V_{IN} = 11 to 40 V
Load regulation	Load	—	5	16	mV	I_O = 0 to 10 mA
Temperature stability	V_{RTC}	—	–26	—	ppm/°C	
Short circuit current	I_{OS}	10	35	—	mA	Vref = 0 V

Oscillator

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Maximum frequency	f_{max}	200	—	—	kHz	C_T = 220 pF
Minimum frequency	f_{min}	—	—	100	kHz	C_T = 560 pF
Initial accuracy	f_{dev}	—	—	±10	%	
Voltage stability	f_{av}	—	–0.02	±1.0	kHz/V	V_{IN} = 11 to 40 V

PWM Comparator

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Maximum duty cycle	Du	80	—	—	%	
Duty cycle accuracy	Ddev	—	±1.0	±6	%	R_1 = 11 kΩ, R_2 = 39 kΩ
Input bias current	I_B	—	—	2.0	µA	V_{EI} = 4 V, V_{DB} = 0 V or V_{EI} = 0 V, V_{DB} = 4 V

Output Driver

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Sink current at Vin low	I_{OS}(Low)	1.0	1.5	—	mA	V_{IN} = 6 V, V_{OUT} = 0.4 V
Output low level	V_{OL}	—	0.86	1.4	V	I_O(sink) = 10 mA
Output high level	V_{OH}	V_{IN} – 2.2	—	—	V	I_O(source) = 10 mA
Output rising time	t_r	—	80	300	ns	Figure 5
Output falling time	t_f	—	40	200	ns	Figure 5
High level threshold	V_{THH}	9	10	11	V	UVL characteristics
Low level threshold	V_{THL}	7.3	8	9	V	UVL characteristics
Hysteresis width	V_{HRS}	1.5	2.0	2.5	V	UVL characteristics

Total Current

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Standby current	I_{CCS}	—	1.5	2.0	mA	Figure 4
Operation current	V_{CCL}	3.0	5.0	7.0	mA	R_1 = 11 kΩ, R_2 = 39 kΩ, V_{IN} = 20 V Figure 4

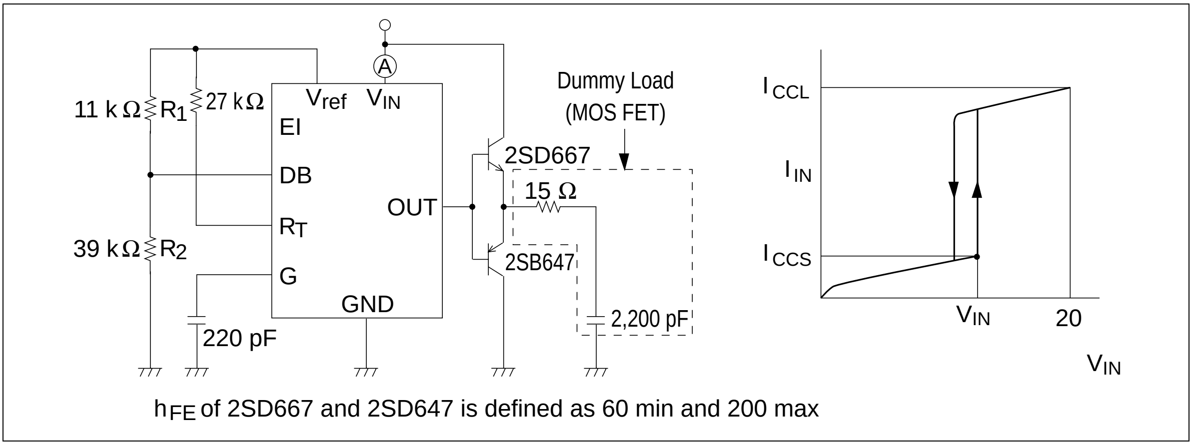


Figure 4 I_{CCS} • I_{CCL} Measurement Circuit

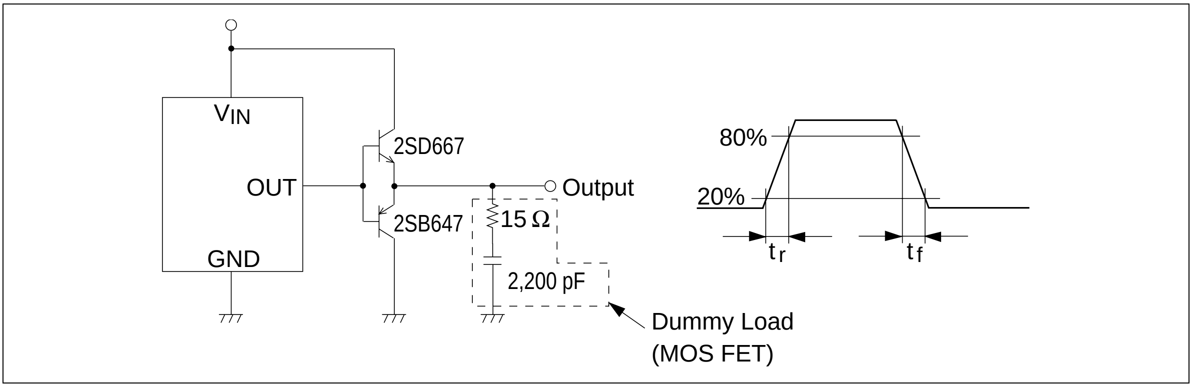
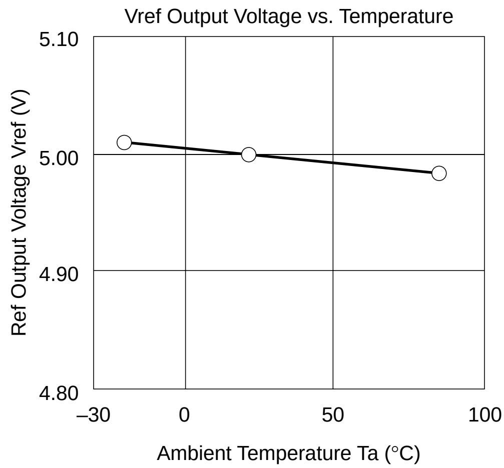
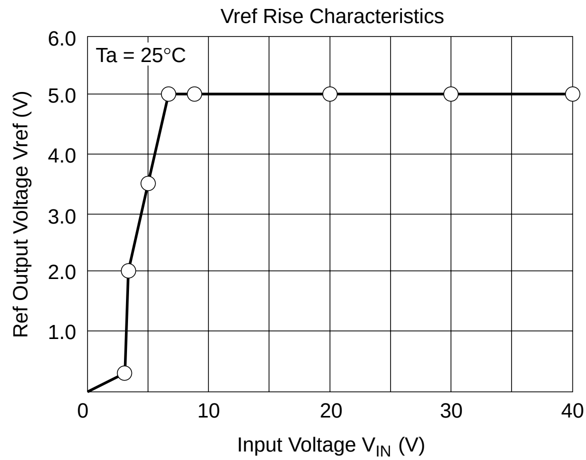
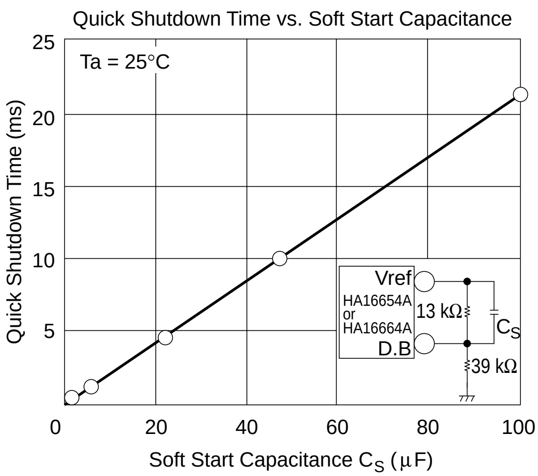


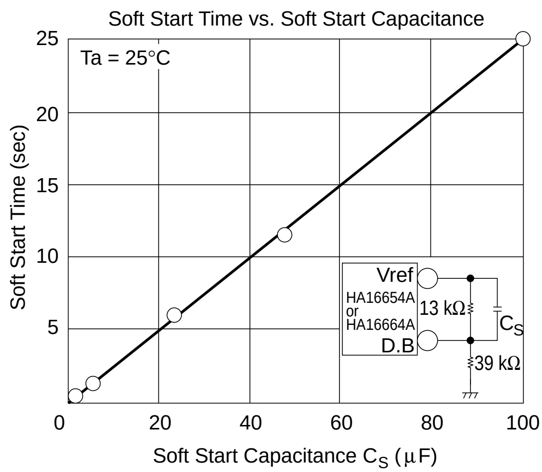
Figure 5 t_r • t_f Measurement Circuit

Characteristic Curves

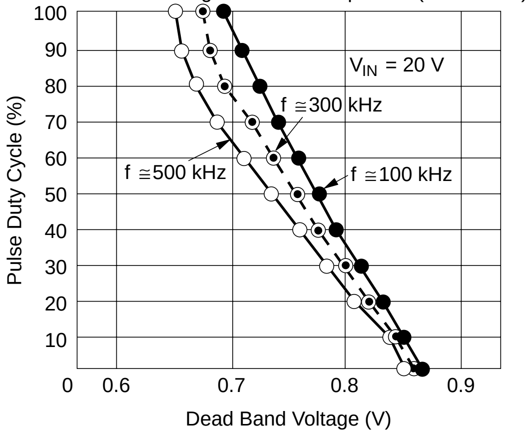




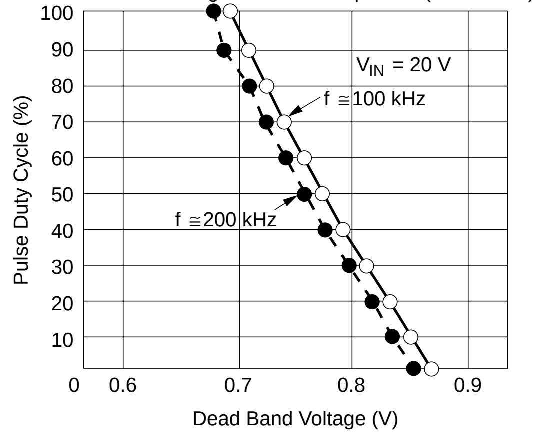




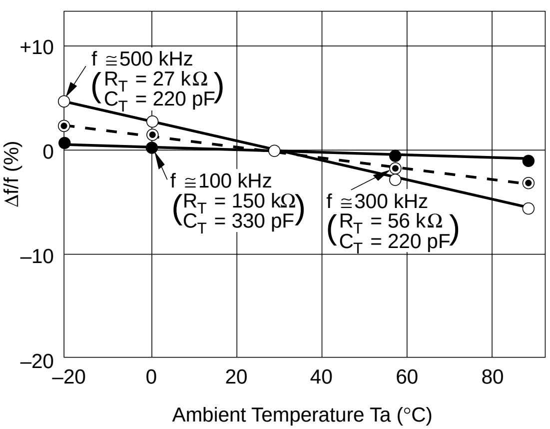
Pulse Duty Cycle vs.
Dead Band Voltage in PWM Comparator (HA16654A)



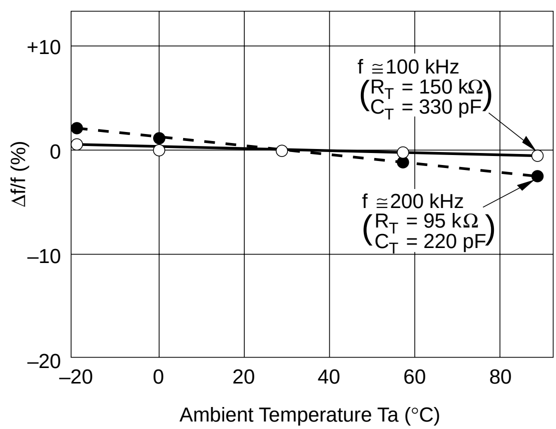
Pulse Duty Cycle vs.
Dead Band Voltage in PWM Comparator (HA16664A)



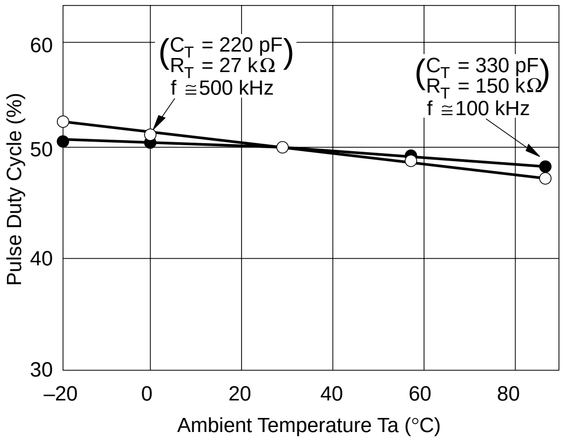
Δf/f vs. Ambient Temperature (HA16654A)



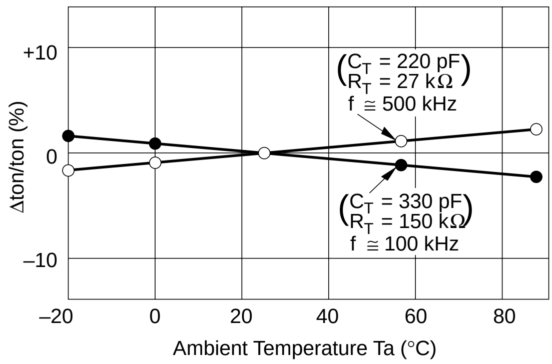
Δf/f vs. Ambient Temperature (HA16664A)



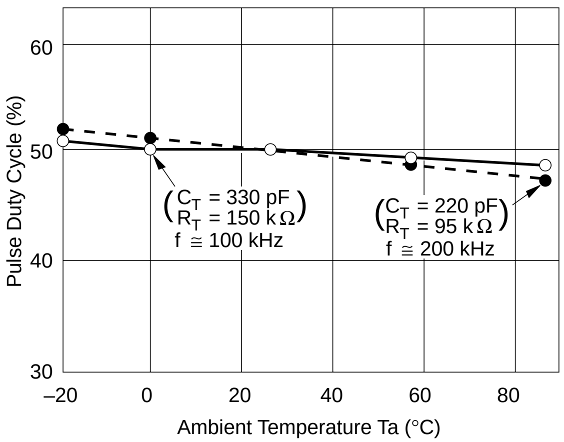
Pulse Duty Cycle vs. Ambient Temperature (HA16654A)



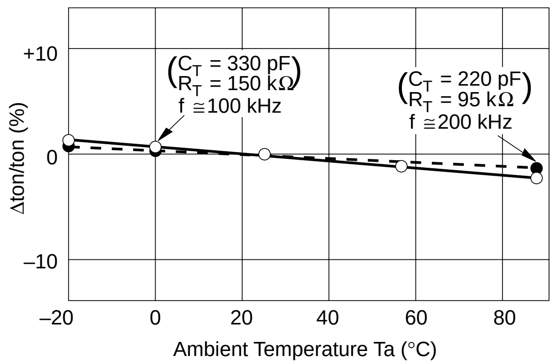
Δton/ton vs. Ambient Temperature (HA16654A)



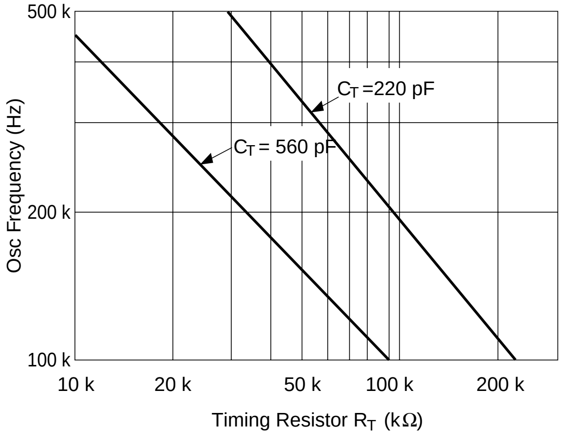
Pulse Duty Cycle vs. Ambient Temperature (HA16664A)



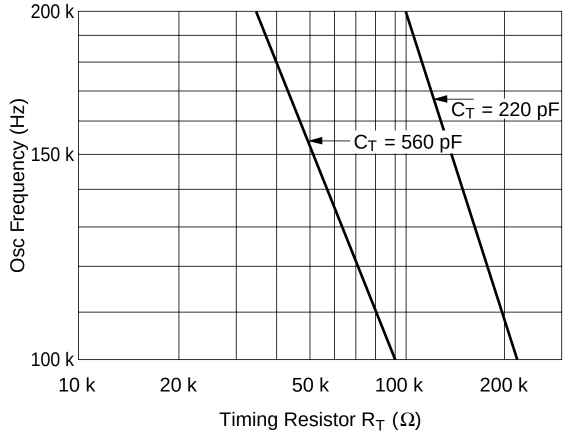
Δton/ton vs. Ambient Temperature (HA16664A)



OSC Frequency vs. Timing Resistor (HA16654A)



OSC Frequency vs. Timing Resistor (HA16664A)



Formula for the oscillation frequency f

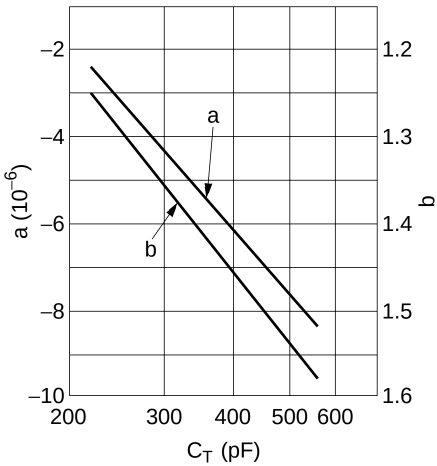
$$f = 1 / [\{C_T (R_T + 1 \times 10^3)(a \cdot R_T + b) / (Vref - V_{BE})\} + 100 \times 10^{-9}]$$

C_T : Timing capacitor (F)
R_T : Timing resistor (Ω)
Vref : Reference voltage 5.0 (V) (Typ)
V_{BE} : Base-emitter voltage 0.65 (V) (Typ)

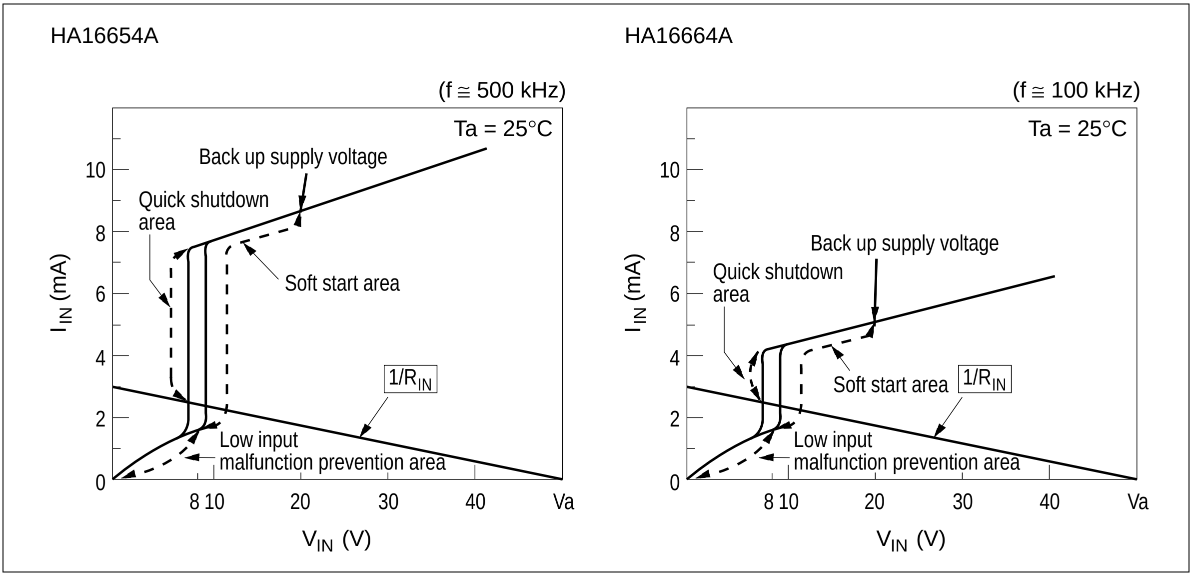
The following table show empirical values of a and b for different values of C_T.

C_T (pF)	a	b
220	-2.30×10^{-6}	1.247
560	-8.37×10^{-6}	1.575

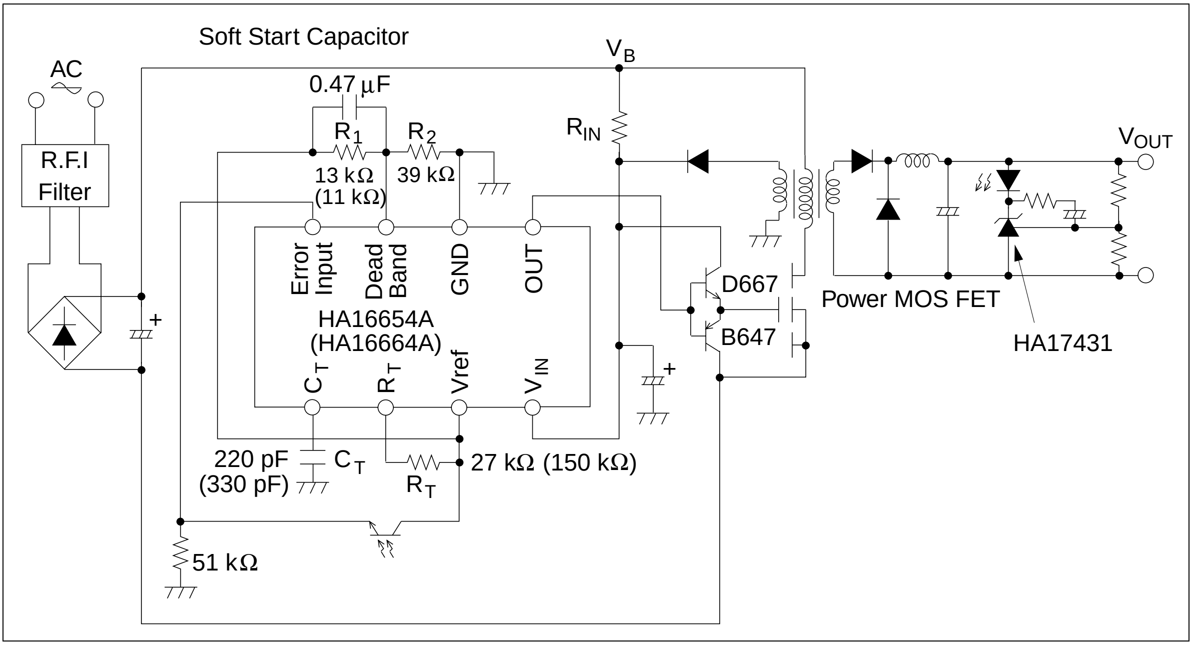
Also,
$f \approx 4.35 / (C_T \cdot R_T)$



V_{IN} Bias Point

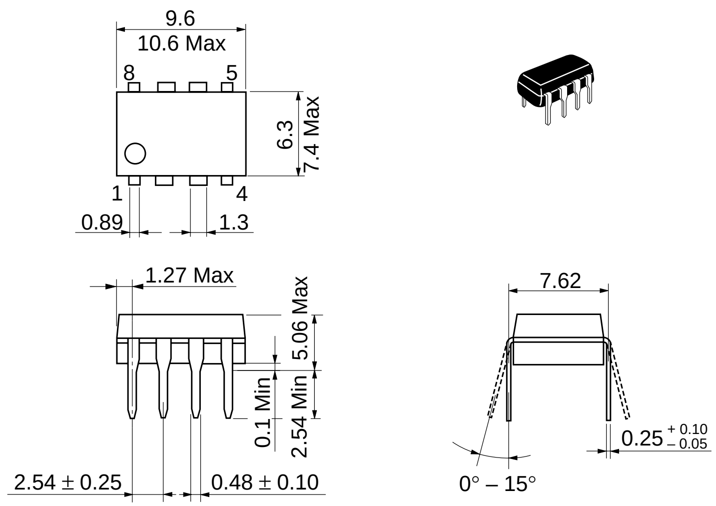


Primary Control Forward Converter System



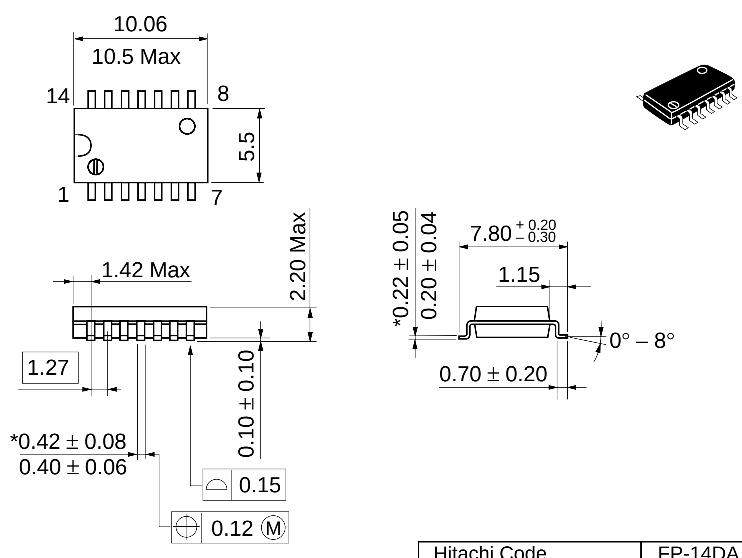
Package Dimensions

Unit: mm



Hitachi Code	DP-8
JEDEC	Conforms
EIAJ	Conforms
Mass (reference value)	0.54 g

Unit: mm



Hitachi Code	FP-14DA
JEDEC	—
EIAJ	Conforms
Mass (reference value)	0.23 g

*Dimension including the plating thickness
Base material dimension

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