HA17524P/FP

Switching Regulator Controller

HITACHI

ADE-204-058 (Z)
Rev. 0
Dec. 2000

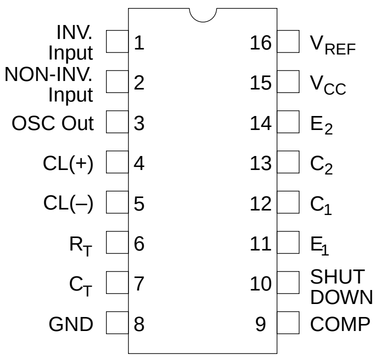
Features

- Pulse width modulation (PWM)
- Wide oscillation frequency range: 450 kHz(typ)
- Low quiescent current: 5 mA typ
- Good line regulation (0.2% typ) and load regulation (0.4% typ)
- Independent output stages for 2 channels
- Wide external circuit applications including single-end and push-pull method
- Reference power source output stage and switching output stage include current limiting protection circuit.

Ordering Information

Type No.	Package
HA17524P	16 pin dual in line plastic(DP-16)
HA17524FP	16 pin flat plastic (FP-16DA)

Pin Arrangement



(Top View)

Hitachi semiconductor

Functional Description

Principals of HA17524 Operation

The HA17524 switching regulator circuit, using pulse width modulation (PWM), is constructed as shown in figure 1.

Timing resistances R_T and timing capacitance C_T control the oscillation frequency. C_T is charged by a constant current generated by R_T. Ramp signals (saw-tooth waves) at the C_T terminal generated by this oscillator is available for reference input signal to comparator which control the pulse width.

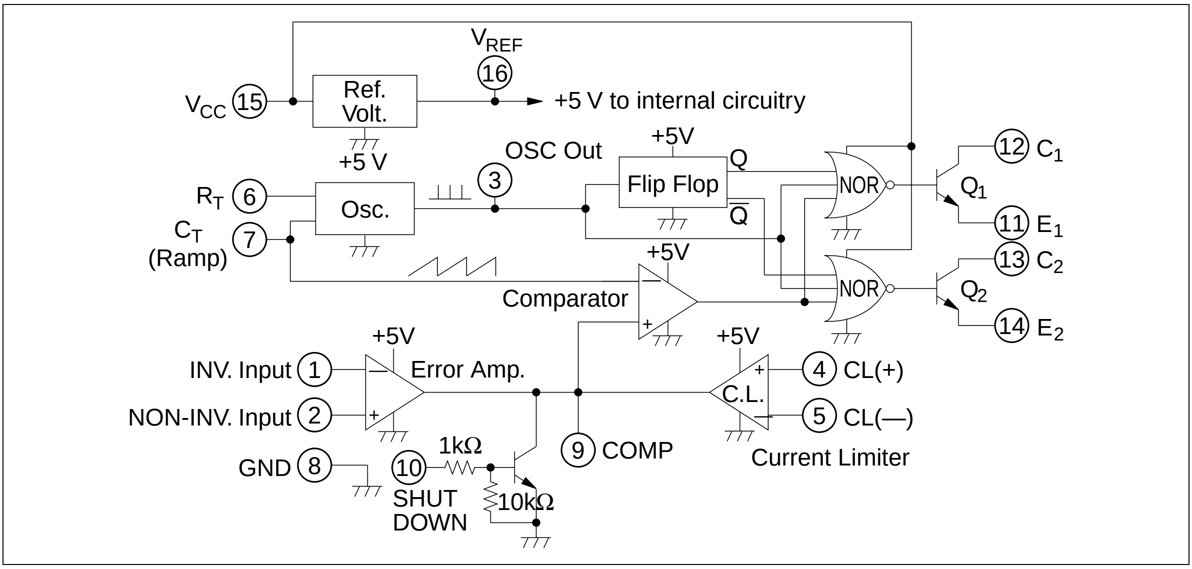


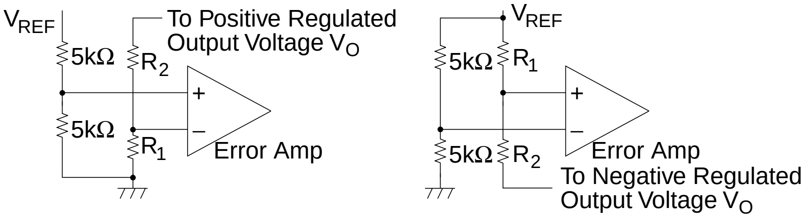
Figure 1 HA17524 Block Diagram

The reference voltage connects to the non-inverted or inverted input terminal of the error amplifier via resistance divider (figure 2).

The output voltage from the error amplifier is compared with the ramp signal capacitance C_T (figure 1). The comparator can provide a signal with modulated pulse width.

This signal, then, controls output transistors Q_1 and Q_2, making an open loop to stabilize output voltage.

Outputs form the error amplifier the current limiter, and the shut-down circuit are connected together at the comparator, so that an input signal from any one of these circuits can break the output stage.



(a) Forward Output Stabilizing Source

$$V_O = 2.5\ \frac{R_1 + R_2}{R_1}\ (V)$$

(b) Reverse Output Stabilizing Source

$$V_O = 5 - 2.5\ \frac{R_1 + R_2}{R_1}\ (V)$$

Figure 2 Error Amplifier Biasing

Blocks Description

Oscillator: The oscillation frequency f is calculated from the following equations. Figure 3 shows one example.

$f \quad 1.15/(R_T \bullet C_T)$

R_T = 1.8k to 100 k Ω

C_T = 0.001µ to 0.1 µF

f = 140 Hz to 500 kHz

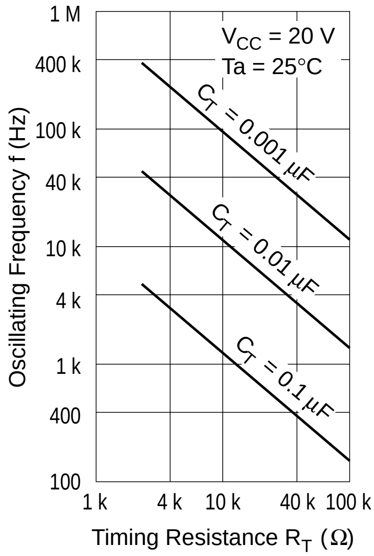


Figure 3 Oscillating Frequency vs Timing Resistance

Then the ramp wave shown in figure 4 is available at pin 7, C_T terminal, since C_T is charged by the constant current I generated by R_T.

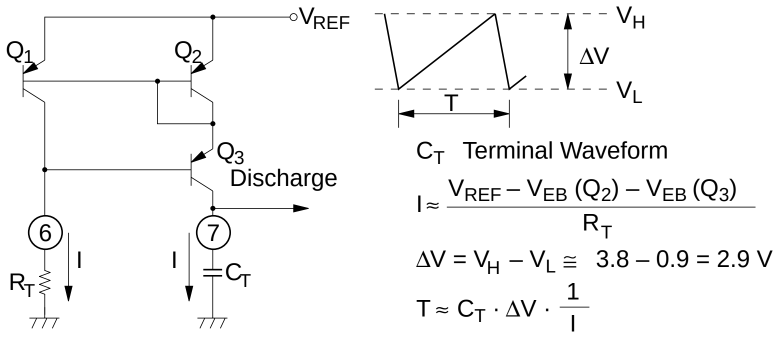


Figure 4 Oscillating Circuit and C_T Terminal Waveform

The oscillator output pulse signal is used as the flip flop clock pulse and as switching pulses for the output transistors, synchronous to the clock pulse.

The pulse-widths which can be controlled by the timing capacitor C_T as shown in figure 5, increases output dead time.

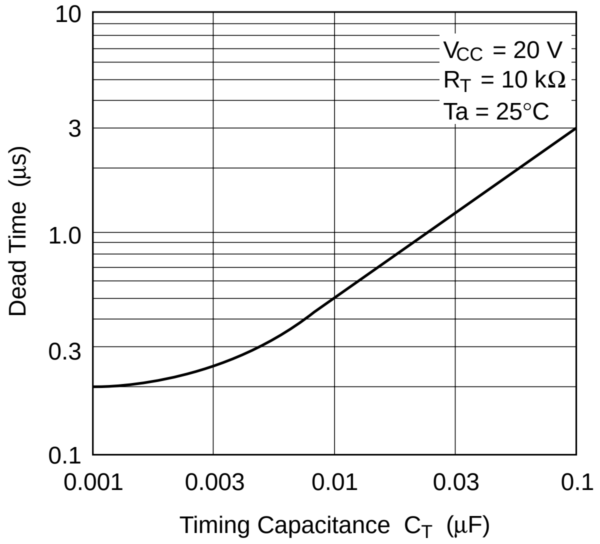


Figure 5 Dead Time vs Timing Capacitance

Reference Voltage: The built-in regulator (reference voltage: V_{REF} = 5 ±0.4 V) can be used as a reference power supply for the error amplifier, which determines output voltage (V_{OUT}). It is also connected as a bias source for another circuits in IC.

Error Amplifier: Figure 2 shows error amplifier biasing, applied input voltage must be set within the range of common-mode input voltage (1.8 V to 3.4 V). Inserting a resistor and capacitor between phase compensation terminal (pin 9) and GND in series provides phase compensation.

Current Limiter: The sense amplifier threshold voltage (V_S) for the current limiter is:

$$V_S = V_{BE}(Q\ ) + I_1R_2 - V_{BE}(Q_2)$$

$$= I_1R_2$$

$$= 200\ \text{mV typ}$$

At the current limiter sense amp shown in figure 6, when $V^+ - V^-$ 200 mV, Q_1 turns on, phase compensation terminal becomes low and the output switching element is cut off.

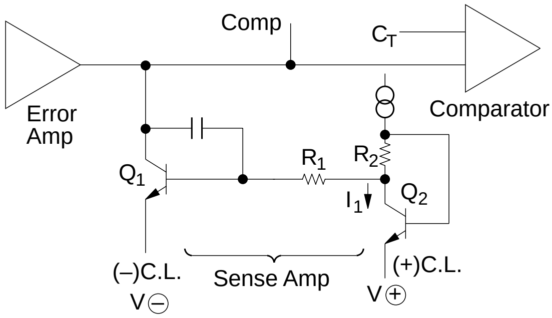
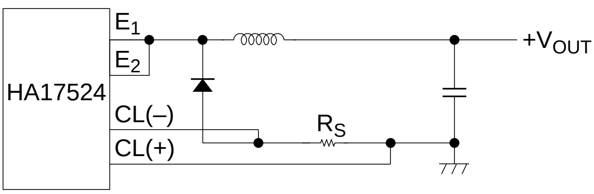


Figure 6 Current Limiter Sense Amplifier

Figure 7 shows an example of detecting current limit. The input voltage range is –0.7 V to +1.0 V; The current limit detection output is provided from GND line.



$$I_{OS} = \frac{V_S}{R_S}$$

V_S = 200 mV

Figure 7 Current Limit Detector Example Operating Waveforms

Operating Waveforms

Figure 9 shows operating waveforms at every part, when stepdown voltage type chopper switching regulator (figure 8) is used. Operating condition are as follows: f = 20 kHz, V_{OUT} = 5 V. At the output section, two channels are connected in parallel. Operating waveforms inside the IC are also shown.

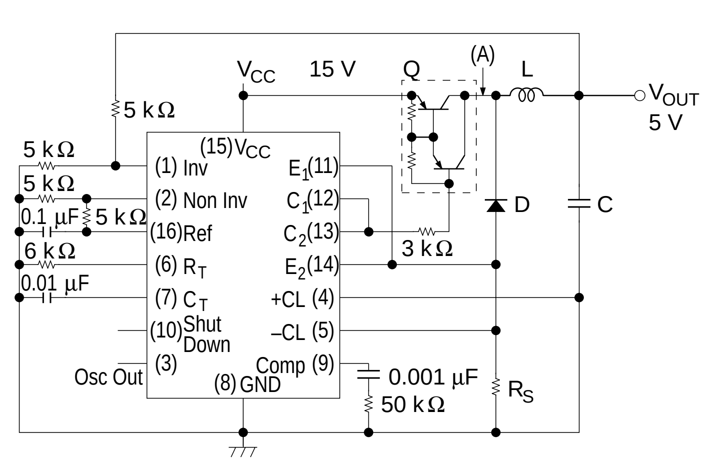


Figure 8 Stepdown Voltage Type Chopper Switching Regulator

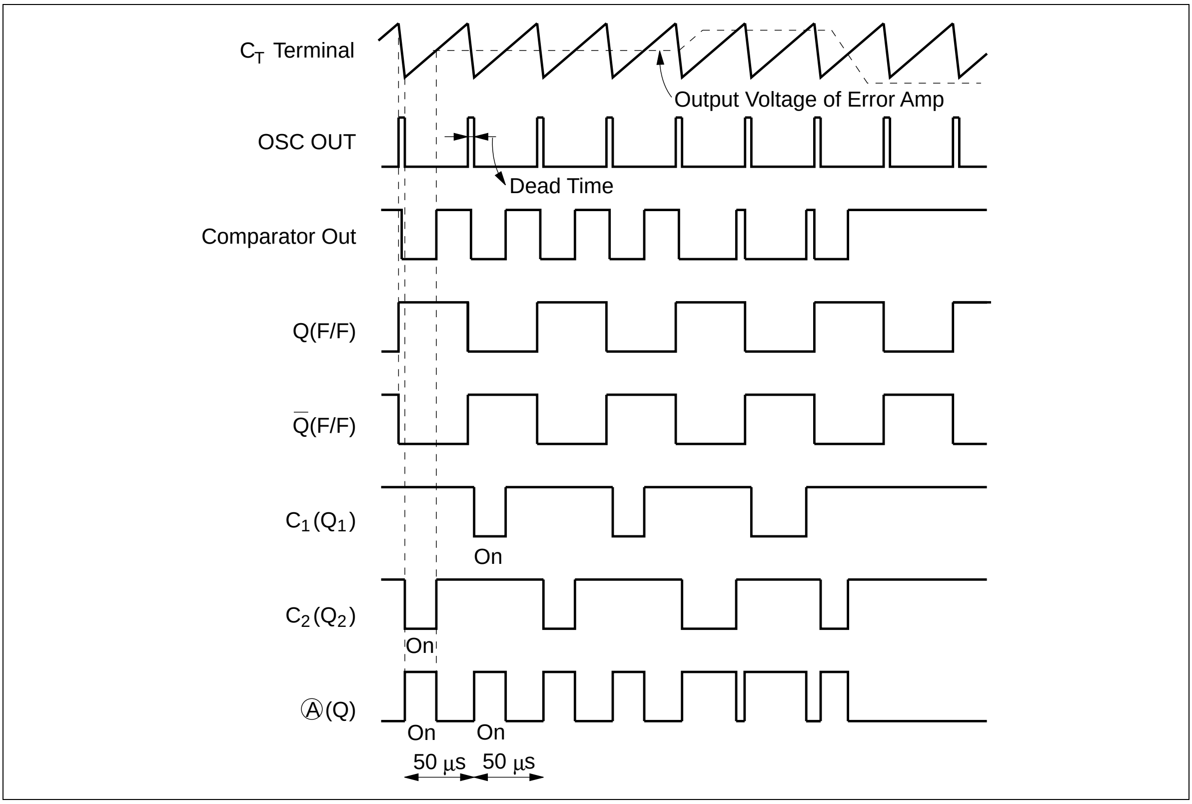


Figure 9 Operating Waveforms

Circuit Applications

Simplified inverting Regulator: Figure 10 shows the circuit configuration of HA17524 inverting regulator for light load (V_{OUT} = –5 V)

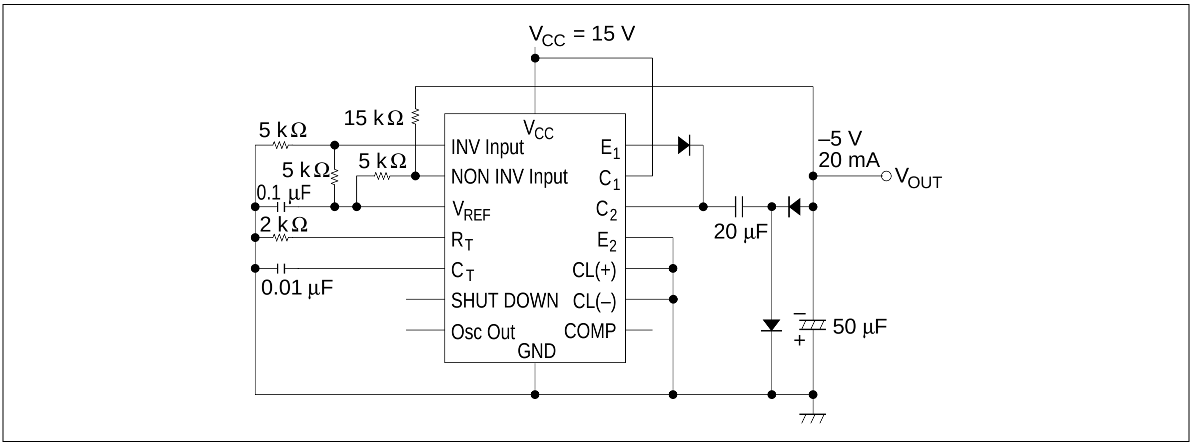


Figure 10 Simple Polarity Conversion

Tracking Switching Regulator: Figure 11 shows the circuit configuration of a tracking regulator that uses a transformer. (V_{OUT} = ±15 V)

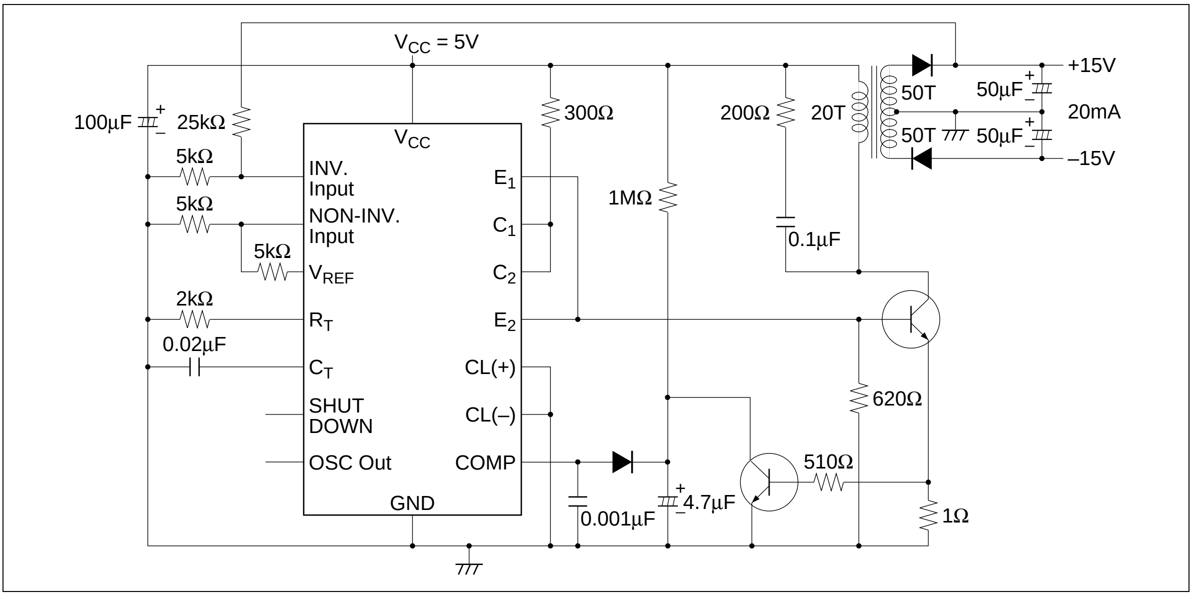


Figure 11 Tracking Switching Regulator

Push Pull Switching Regulator: Figure 12 shows the circuit configuration of push-pull switching regulator that uses transformer. This system is suited for high power. Output transistors inside HA17524 can drive external switching transistors.

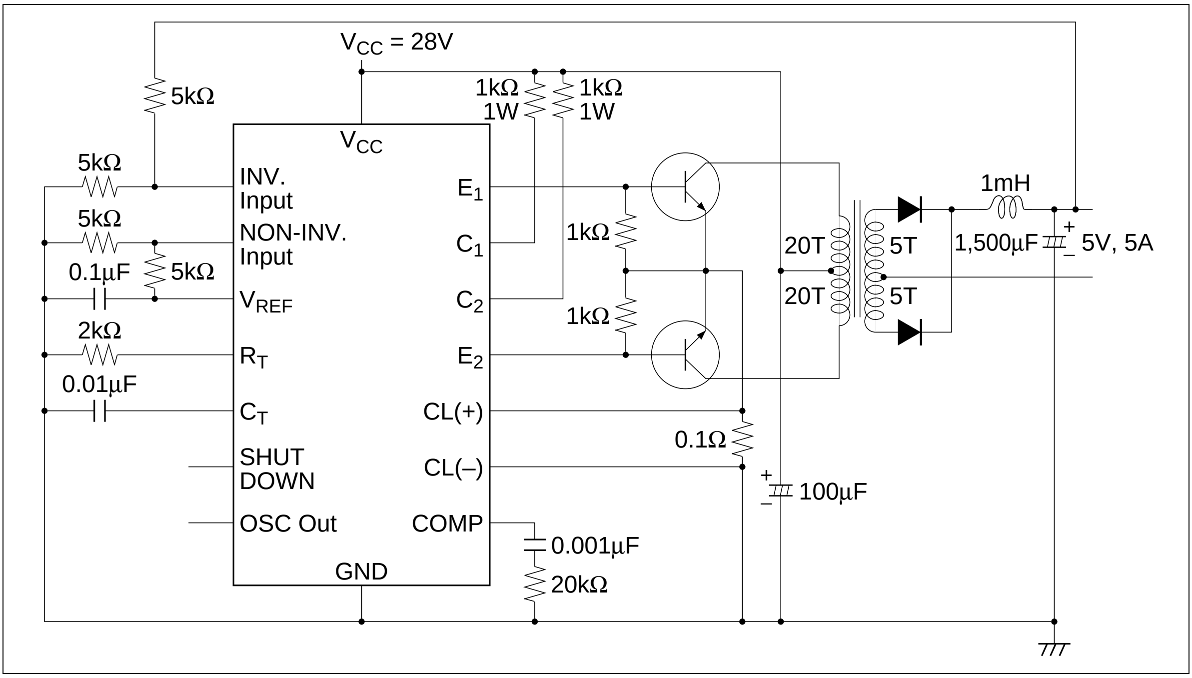


Figure 12 Push-Pull Switching Regulator

Note

Compared with conventional series regulators, switching regulators generate high frequency noise by switching current quickly. To reduce noise

1. As a general rule, insert line filter to reduce noise at the input.
2. To reduce noise at the output:
    a. Twist output wiring together.
    b. Do not bundle power source and output wiring.
    c. Insert capacitor should be inserted at the load side.
    d. Ground the power frame.

3. When choosing external parts (external switching transistor, diode, coil, etc) consider their capacitance and characteristics.

Absolute Maximum Ratings (Unless otherwise specified, Ta = +25°C)

Item	Symbol	Rating	Unit	Note
Supply voltage	V_{CC}	40	V	1, 2
Collector output current	I_C	100	mA	
Reference output current	I_{REF}	50	mA	
Current through C_T terminal	I_{CT}	5	mA	
Continuous total power dissipation	P_T	600	mW	3
Operating free-air temperature range	Topr	–20 to +75	°C	
Storage temperature range	Tstg	–55 to +125	°C	

Notes: 1. With respect to network ground terminal

2. The reference voltage can be given by connecting the V_{CC} and 5 V reference output pins both to the supply voltage. In this configuration, V_{CC} = 6 V max.
3. HA17524P: Value at Ta ≤ 52.7°C, If Ta > 52.7°C, derate by 8.3 mV/°C

Electrical Characteristics (V_{CC} = 20 V, f = 20 kHz, Ta = 25°C)

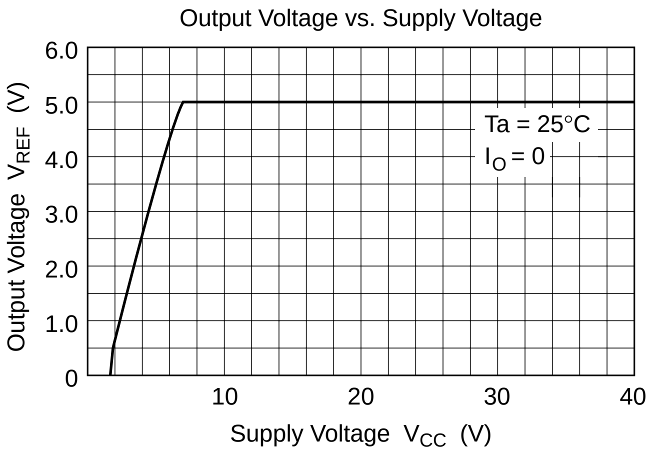
Item		Symbol	Min	Typ	Max	Unit	Test Conditions
Regulator	Output voltage	V_{REF}	4.6	5.0	5.4	V	
	Input regulation	δV_{OLine}	—	10	30	mV	V_{CC} = 8 to 40 V
	Ripple rejection	R_{REJ}	—	66	—	dB	f = 120 Hz
	Output regulation	δV_{OLoad}	—	20	50	mV	Iout = 0 to 20 mA
	Output voltage change with output temperature	$\delta V_O / \delta Ta$	—	0.3	1.0	%	Ta = 0 to +70°C
			—	0.4	1.36	%	Ta = –20 to +75°C
	Short-circuit output current (Note)	I_{OS}	—	100	—	mA	V_{REF} = 0
Error amplifier	Input offset voltage	V_{IO}	—	2	10	mV	V_{IC} = 2.5 V
	Input bias current	I_I	—	2	10	µA	V_{IC} = 2.5 V
	Open-loop voltage gain	A_{VD}	—	60	—	dB	
	Common-mode input voltage range	V_{CM}	1.8 to 3.4	—	—	V	Ta = 25°C
	Common-mode Rejection ratio	CMR	—	70	—	dB	
	Unity-gain bandwidth	BW	—	3	—	MHz	
	Output swing	V_{OPP}	0.5	—	3.8	V	
Oscillator	OSC frequency	f	—	450	—	kHz	C_T = 0.001 µF, R_T = 2 kΩ
	Standard deviation of frequency	Δ f	—	5	—	%	V_{CC} = 8 to 40 V, R_T = 1.8 to 100 kΩ, C = Const
	Frequency stability	δf_{Line}	—	—	1.0	%	V_{CC} = 8 to 40 V
		δf/δTa	—	5.0	10	%	Ta = 0 to +70°C
			—	5.0	13.6	%	Ta = –20 to +75°C
	Output amplitude	$V_{3(peak)}$	—	3.5	—	V	Pin 3
	Output pulse width	T_P	—	0.5	—	µs	C_T = 0.01 µF, Pin 3
Comparator	Maximum duty cycle	Dmax	45	—	—	%	
	Threshold voltage	Vth 0	—	1.0	—	V	Duty cycle = 0
		Vth max	—	3.5	—	V	Duty cycle = max
	Input bias current	I_I	—	–1	—	µA	

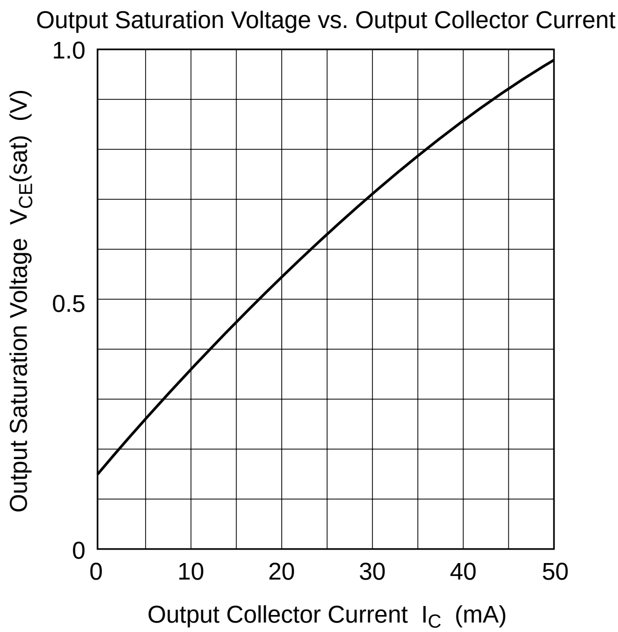
Note: Duration of the short-circuit should not exceed one second.

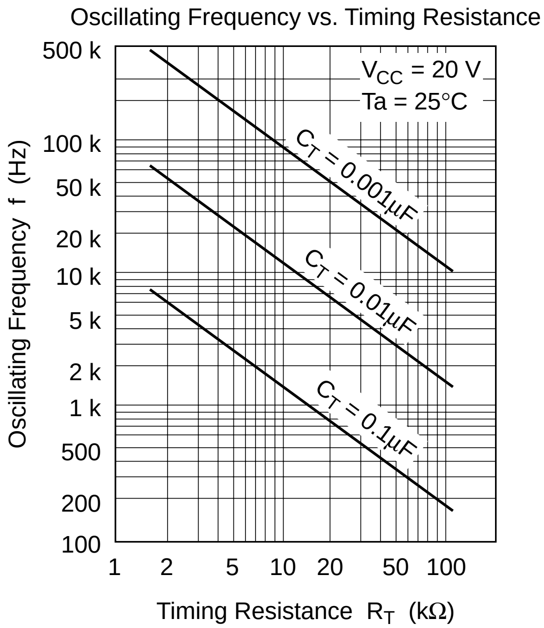
Electrical Characteristics (V_{CC} = 20 V, f = 20 kHz, Ta = 25°C) (cont)

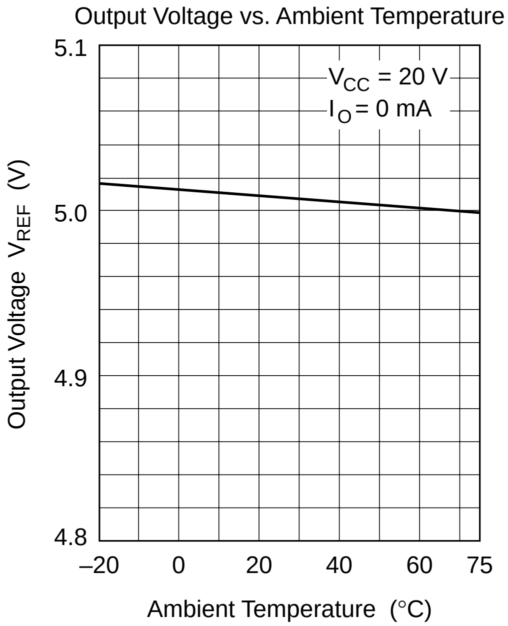
Item		Symbol	Min	Typ	Max	Unit	Test Conditions
Current limiter	Input voltage range	V_{IS}	–0.7 to +1.0	—	—	V	
	Sense voltage	V_S	180	200	220	mV	V(Pin 9) = 2 V, Ta = 25°C V(Pin 2) – V(Pin 1) ≥ 50 mV
	Sensevoltage change with temperature	$\delta V_S/\delta Ta$	—	0.2	—	mV/°C	Ta = –20 to +75°C
Output	Collector-emitter breakdown voltage	V_{CE}	40	—	—	V	
	Collector off-state current	I_{Leak}	—	0.01	50	µA	V_{CE} = 40 V
	Collector-emitter saturation voltage	$V_{CE(sat)}$	—	1	2	V	I_C = 50 mA
	Emitter output voltage	V_E	17	18	—	V	V_{CC} = 20 V, I_E = –250 µA
	Rise time	tr	—	0.2	—	µs	R_C = 2 kΩ
	Fall time	tf	—	0.1	—	µs	
Total device	Standby current	I_{ST}	—	5.0	10	mA	V_{CC} = 40 V, V_2 = 2 V, Pins 1, 4, 7, 8, 9, 11, 14grounded, All other pins open

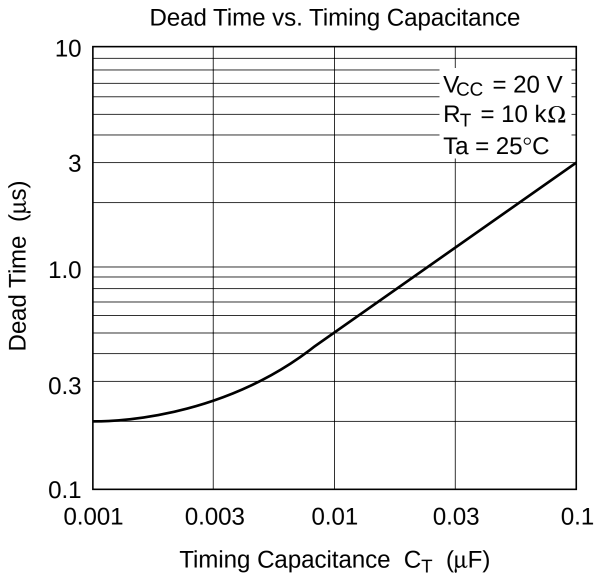
Characteristic Curves





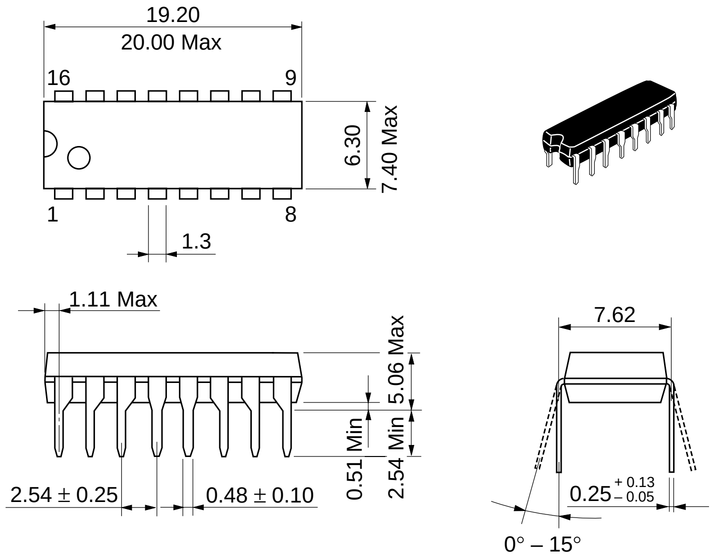

Oscillating Frequency vs. Timing Resistance
VCC = 20 V
Ta = 25°C
CT = 0.001µF
CT = 0.01µF
CT = 0.1µF
500 k
100 k
50 k
20 k
10 k
5 k
2 k
1 k
500
200
100
Oscillating Frequency f (Hz)
1
2
5
10
20
50
100
Timing Resistance RT (kΩ)


Output Voltage vs. Ambient Temperature
VCC = 20 V
IO = 0 mA
5.1
5.0
4.9
4.8
Output Voltage VREF (V)
–20
0
20
40
60
75
Ambient Temperature (°C)


Dead Time vs. Timing Capacitance
VCC = 20 V
RT = 10 kΩ
Ta = 25°C
10
3
1.0
0.3
0.1
Dead Time (µs)
0.001
0.003
0.01
0.03
0.1
Timing Capacitance CT (µF)

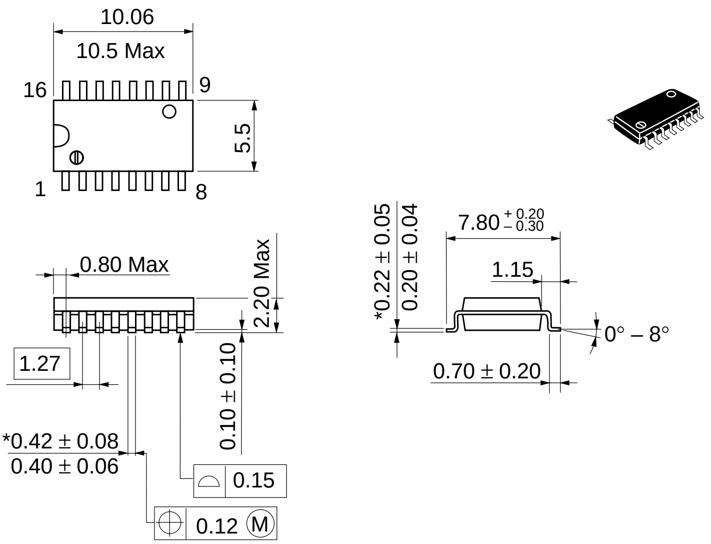
Package Dimensions

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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