# HA17524P/FP

Switching Regulator Controller

# HITACHI

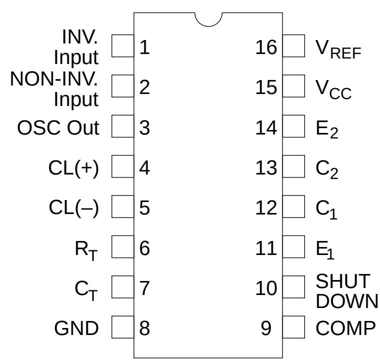
## Features

- 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)

## 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.

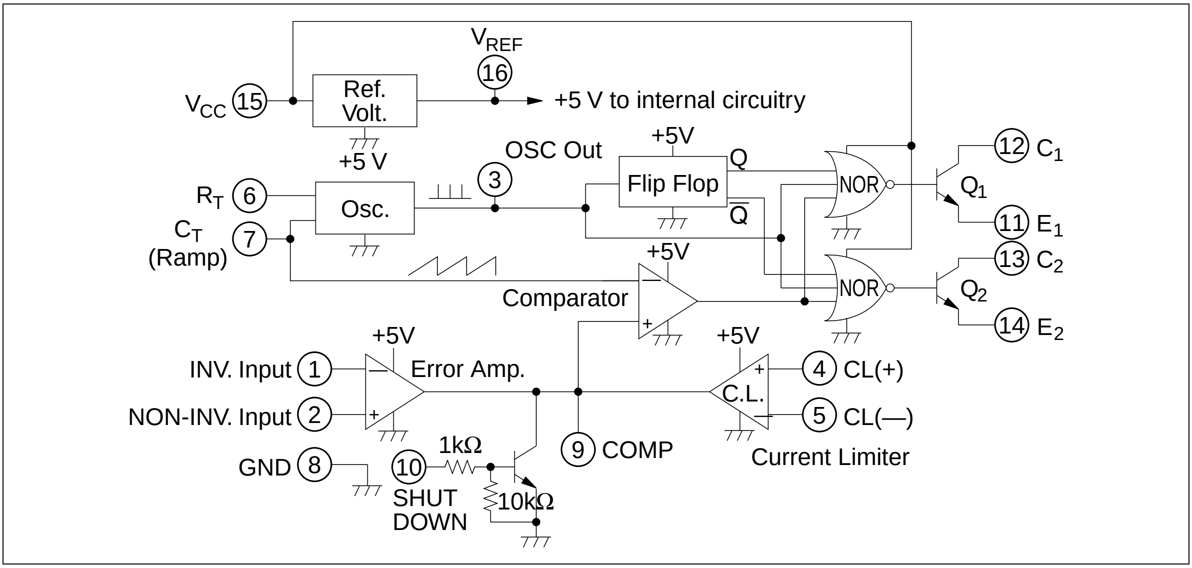



**Figure 1 HA17524 Block Diagram**

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.

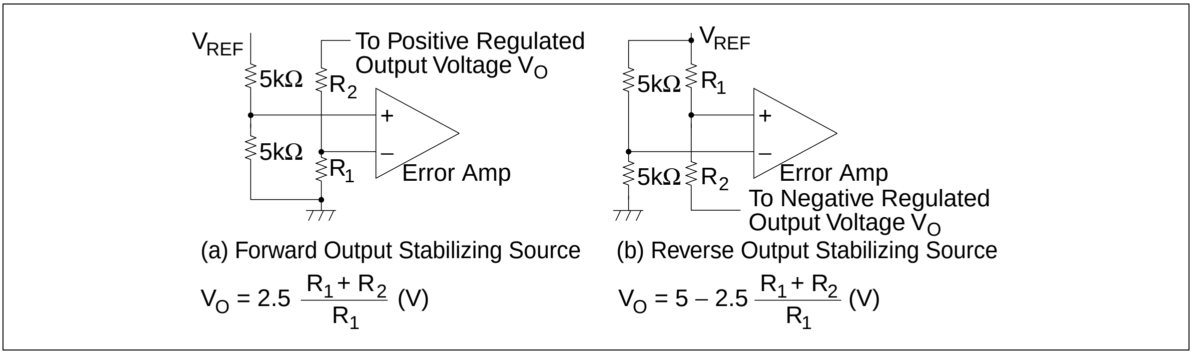



**Figure 2 Error Amplifier Biasing**

## 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

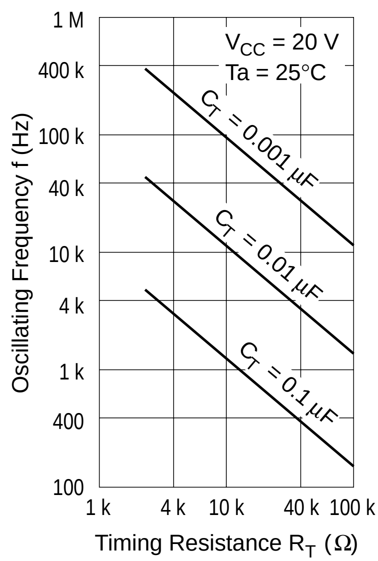



**Figure 3   Oscillating Frequency vs Timing Resistance**

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 $R_T$.

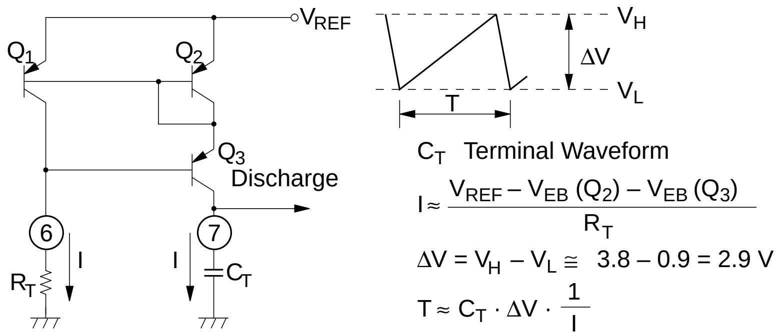



**Figure 4 Oscillating Circuit and $C_T$ Terminal Waveform**

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.

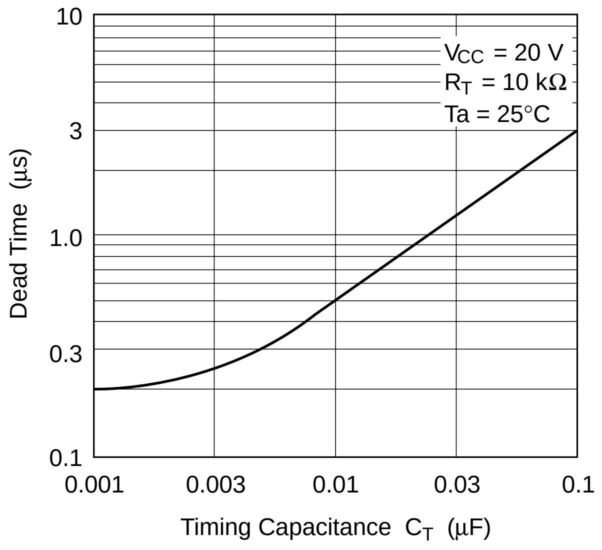



**Figure 5 Dead Time vs Timing Capacitance**

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.

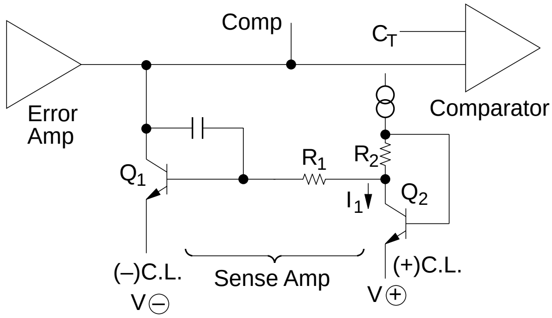
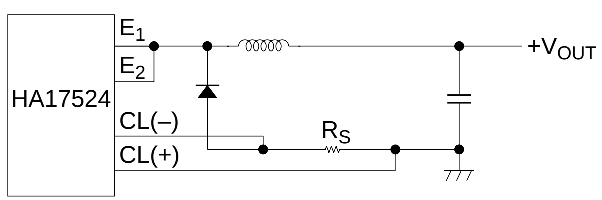



**Figure 6 Current Limiter Sense Amplifier**

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.




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

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

**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.

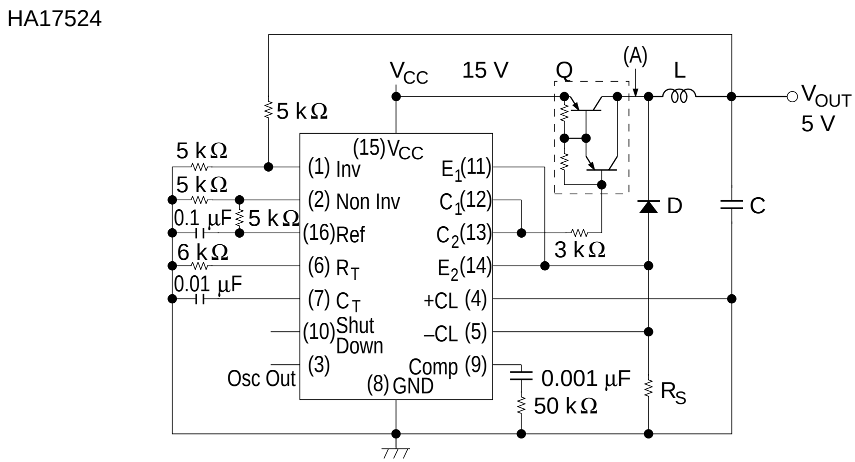



**Figure 8 Stepdown Voltage Type Chopper Switching Regulator**

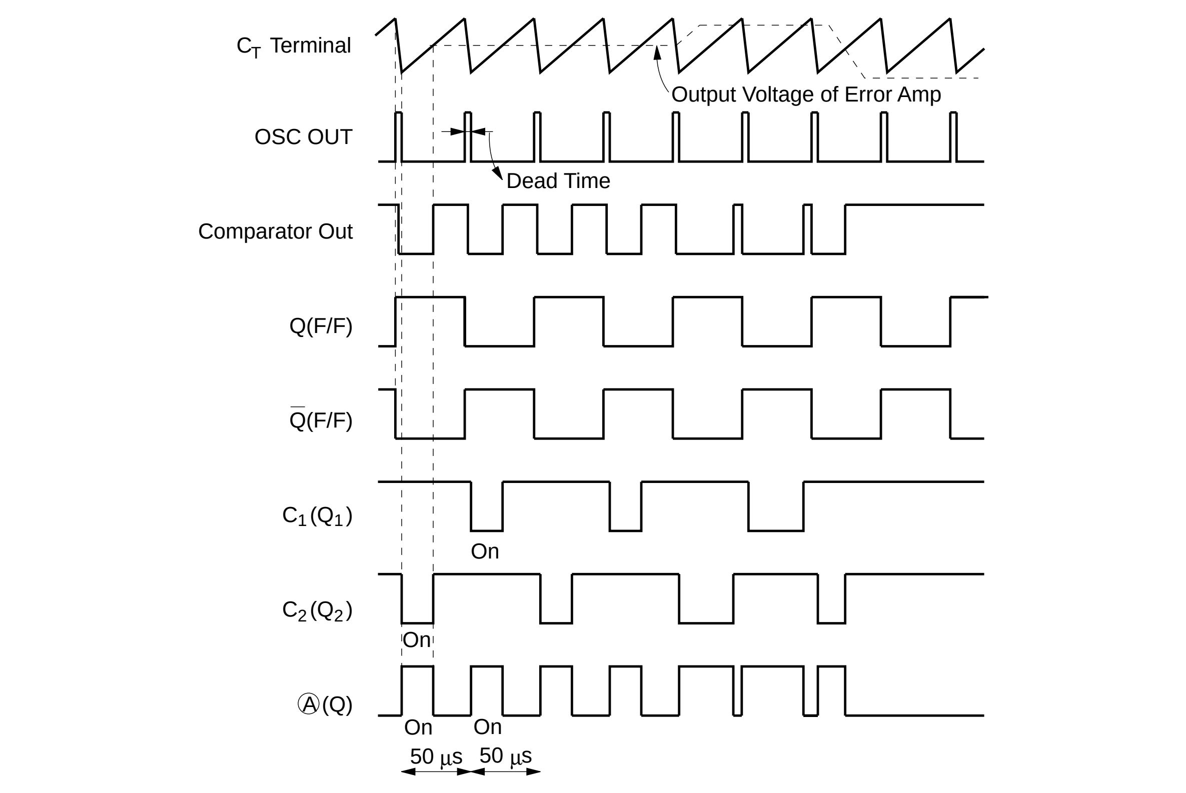



**Figure 9 Operating Waveforms**

## Circuit Applications

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

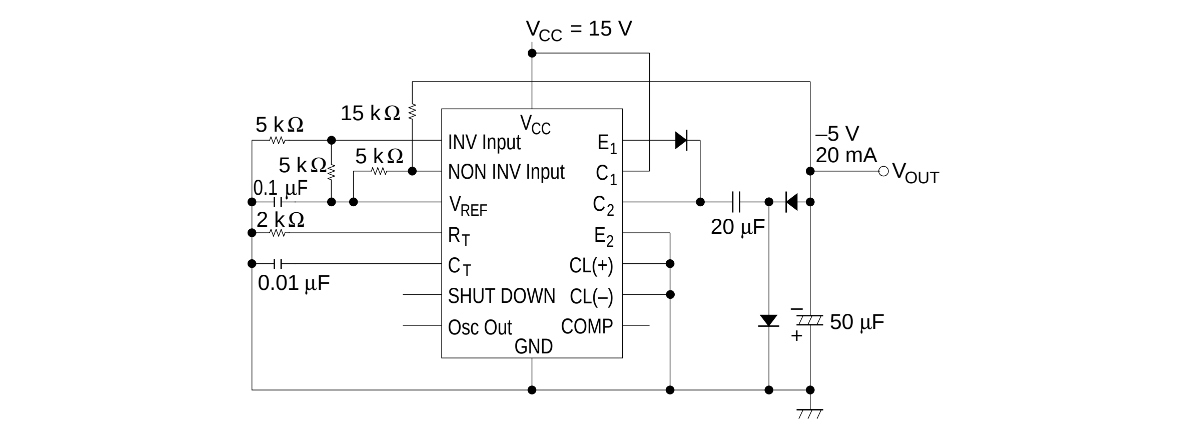



**Figure 10 Simple Polarity Conversion**

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

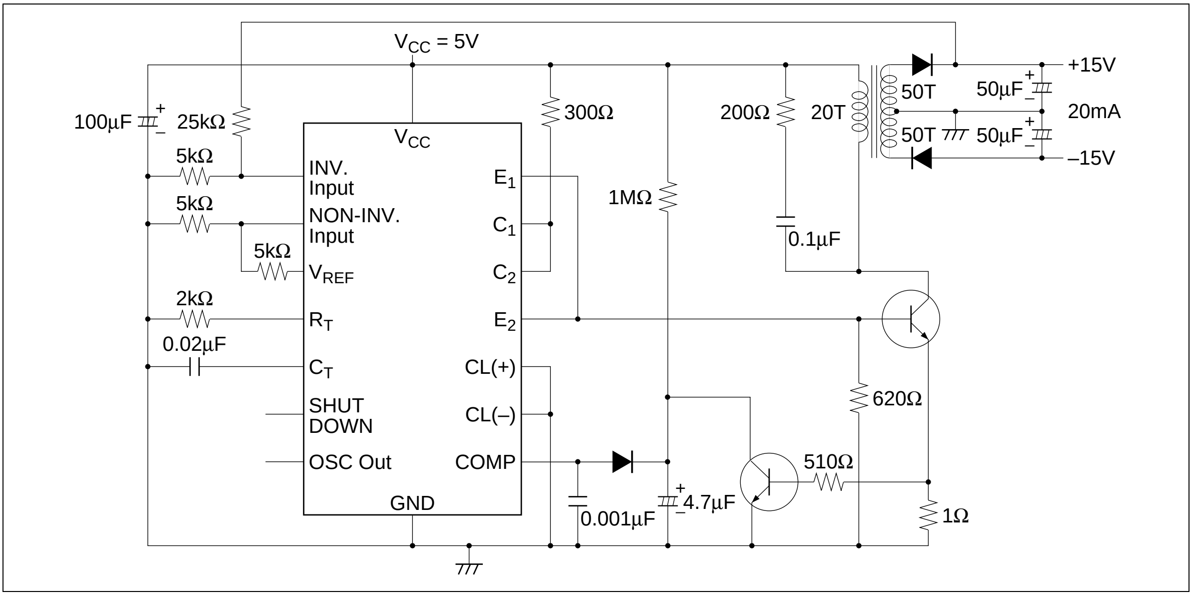



**Figure 11 Tracking Switching Regulator**

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.

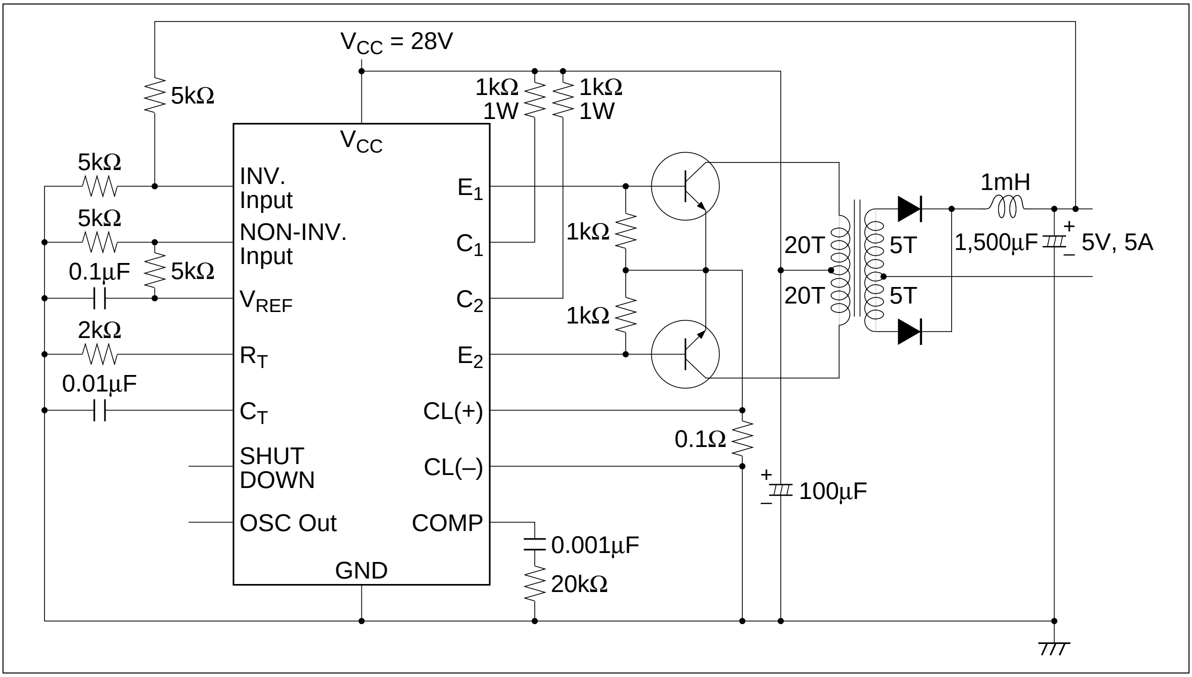



**Figure 12 Push-Pull Switching Regulator**

## 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)

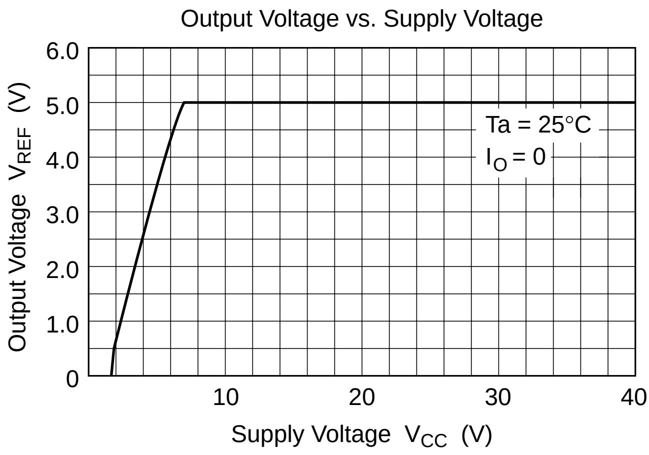
| Item | | Symbol | Min | Typ | Max | Unit | Test Conditions |
|---|---|---|---|---|---|---|---|
| Regulator | Output voltage | $V_{REF}$ | 4.6 | 5.0 | 5.4 | V | |
| | Input regulation | $\delta V_{OLine}$ | — | 10 | 30 | mV | $V_{CC}$ = 8 to 40 V |
| | Ripple rejection | $R_{REJ}$ | — | 66 | — | dB | f = 120 Hz |
| | Output regulation | $\delta V_{OLoad}$ | — | 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 | $\delta f_{Line}$ | — | — | 1.0 | % | $V_{CC}$ = 8 to 40 V |
| | | $\delta f/\delta Ta$ | — | 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 | |

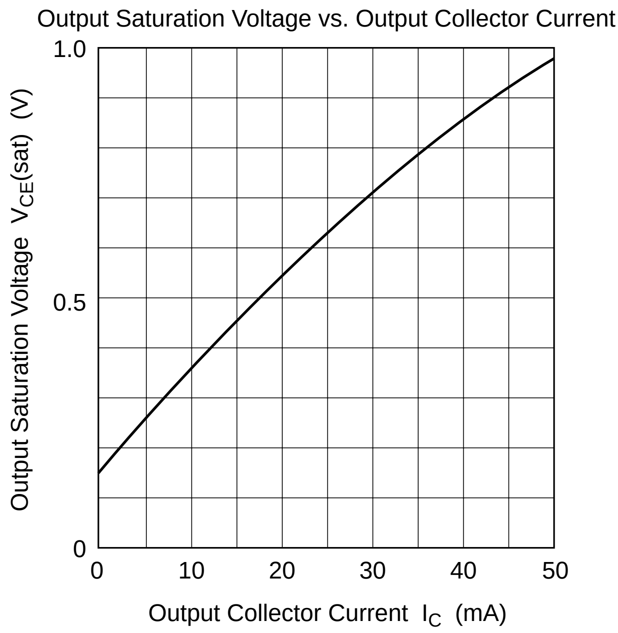
Note: Duration of the short-circuit should not exceed one second.

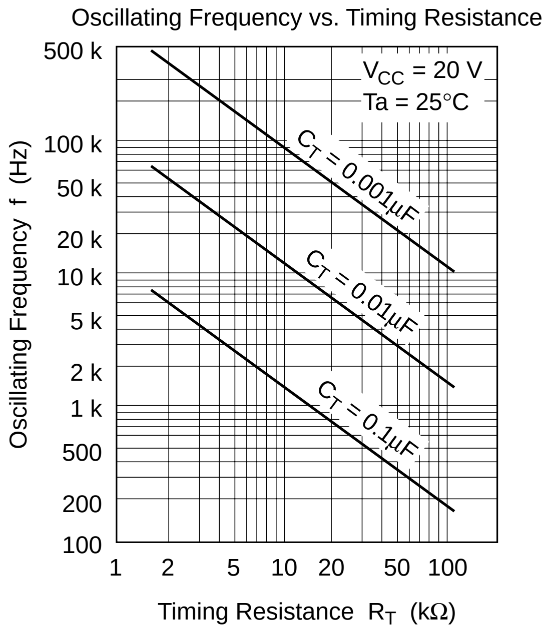
## **Electrical Characteristics** ($V_{CC}$ = 20 V, f = 20 kHz, Ta = 25°C) (cont)

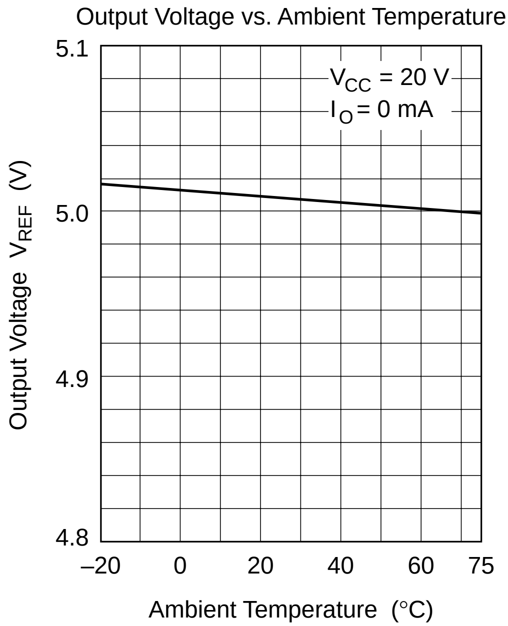
| Item | | Symbol | Min | Typ | Max | Unit | Test Conditions |
|---|---|---|---|---|---|---|---|
| Current limiter | Input voltage range | $V_{IS}$ | –0.7 to +1.0 | — | — | V | |
| | Sense voltage | $V_S$ | 180 | 200 | 220 | mV | V(Pin 9) = 2 V, Ta = 25°C V(Pin 2) – V(Pin 1) ≥ 50 mV |
| | Sensevoltage 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 |

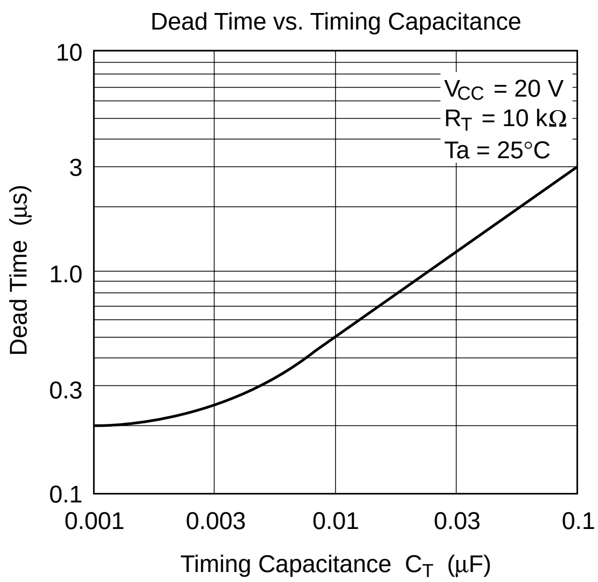
## Characteristic Curves



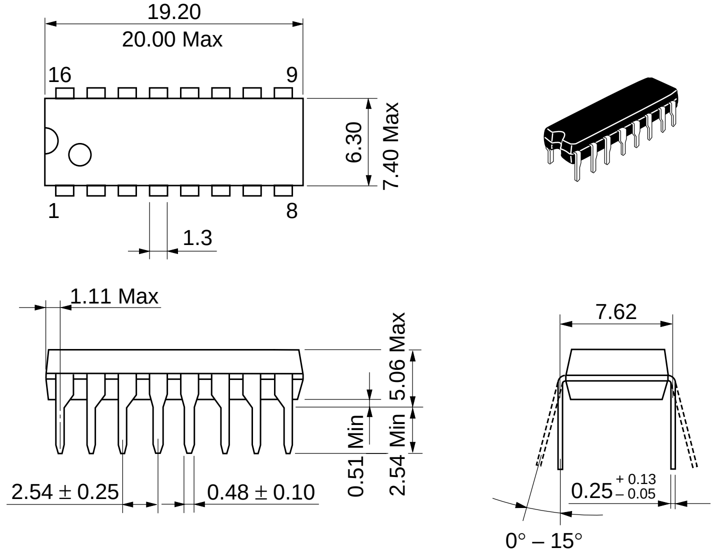

Oscillating Frequency vs. Timing Resistance
500 k
100 k
50 k
20 k
10 k
5 k
2 k
1 k
500
200
100
Oscillating Frequency f (Hz)
VCC = 20 V
Ta = 25°C
CT = 0.001µF
CT = 0.01µF
CT = 0.1µF
1
2
5
10
20
50
100
Timing Resistance RT (kΩ)


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


Dead Time vs. Timing Capacitance
$V_{CC}$ = 20 V
$R_T$ = 10 kΩ
Ta = 25°C
Dead Time (µs)
10
3
1.0
0.3
0.1
0.001
0.003
0.01
0.03
0.1
Timing Capacitance $C_T$ (µF)

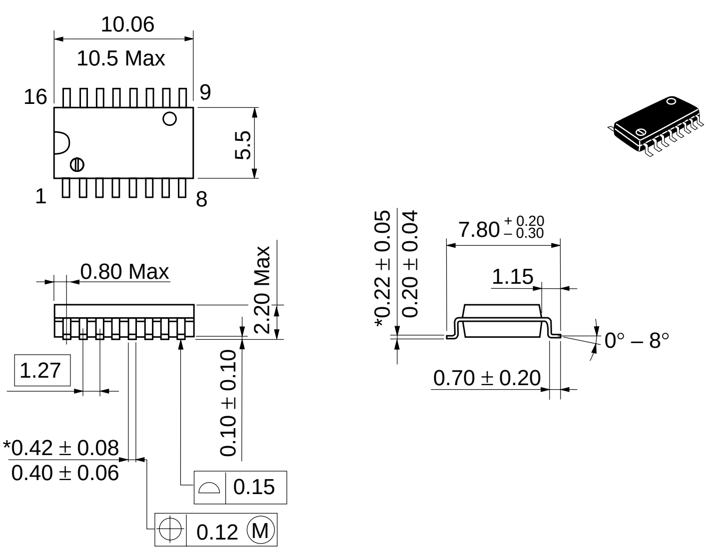
## Package Dimensions

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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