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# HA13532NT

Three-Phase Stepping Motor Control IC

# HITACHI

ADE-207-121A (Z)  
2nd Edition  
July 1996

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## Description

The HA13532NT is an IC for control a three-phase stepping motor.

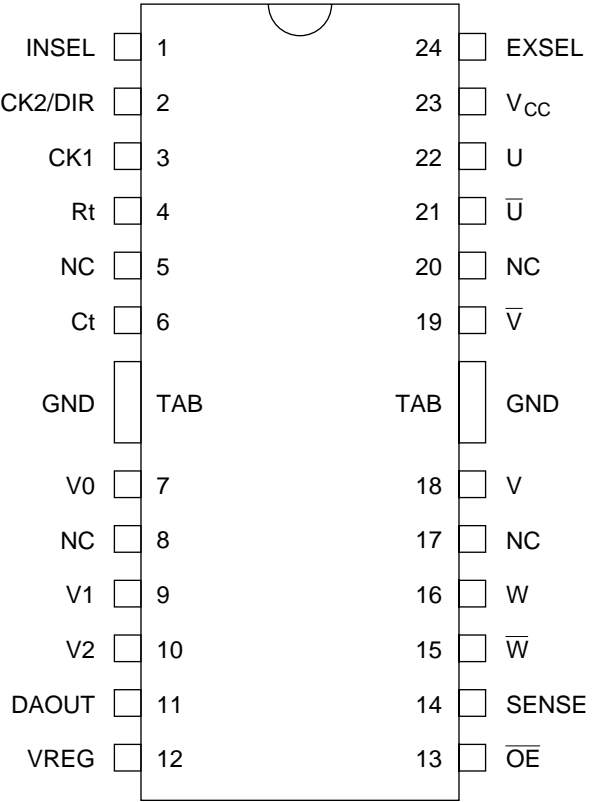
## Functions

- PWM current control
- Low-voltage inhibit (LVI)
- Three-bit D/A converter for current programming
- Motor on/off
- Selectable 2-phase or 2-3-phase exciting

## Features

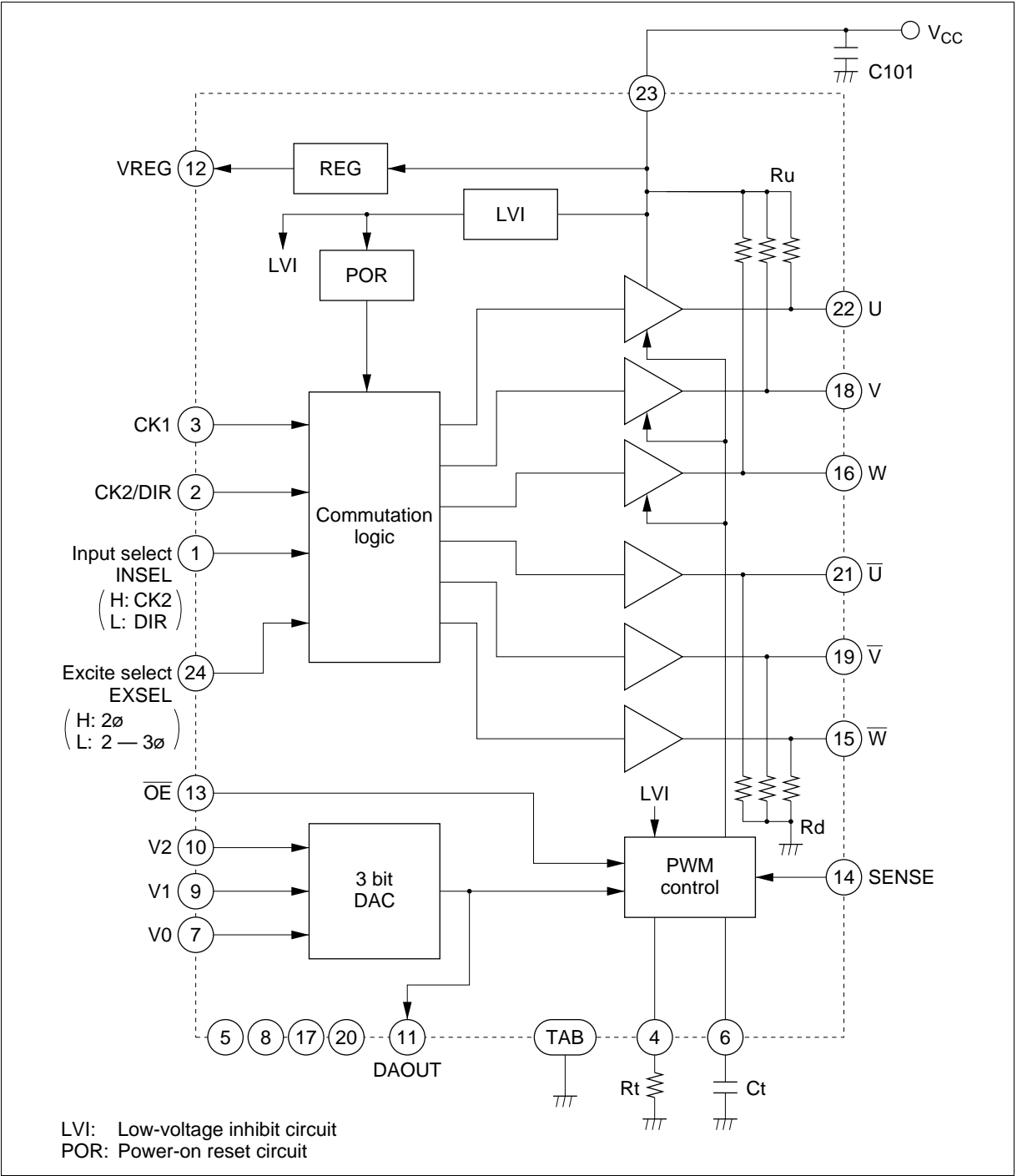
- Wide operating voltage range
- Few external components

Pin Arrangement



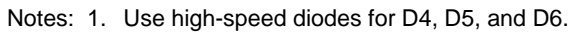
(Top view)

Block Diagram



Pin Description

| Pin No. | Pin Name        | Function  | Pin Voltage                 |
|---------|-----------------|---|-----------------------------|
| 1       | INSEL           | Selects pin 2 input: CK2 if high; DIR if low (see timing diagrams)                  | $V_{TH} = 2.5\text{ V typ}$ |
| 2       | CK2/DIR         | CK2 or DIR input (see timing diagrams)  | $V_{TH} = 2.5\text{ V typ}$ |
| 3       | CK1             | CK1 input (see timing diagrams)   | $V_{TH} = 2.5\text{ V typ}$ |
| 4       | Rt              | Reference value for 3-phase output current and Ct charge/discharge current          | 4.8 V typ                   |
| 5       | NC              | No connection   |                             |
| 6       | Ct              | Time constant for PWM carrier frequency   |                             |
| 7       | V0              | Voltage programming input to DAC (LSB)  | $V_{TH} = 2.5\text{ V typ}$ |
| 8       | NC              | No connection   |                             |
| 9       | V1              | Voltage programming input to DAC  | $V_{TH} = 2.5\text{ V typ}$ |
| 10      | V2              | Voltage programming input to DAC (MSB)  | $V_{TH} = 2.5\text{ V typ}$ |
| 11      | DAOUT           | DAC output  |                             |
| 12      | VREG            | Regulated output  | 4.8 V typ (@I = 2 mA)       |
| 13      | $\overline{OE}$ | Output enable: low enables PWM output phases U, V, and W; high gives high impedance | $V_{TH} = 2.5\text{ V typ}$ |
| 14      | SENSE           | Current feedback  | 0 V min, 5.0 V max          |
| 15      | $\overline{W}$  | Phase-W lower-arm output  |                             |
| 16      | W               | Phase-W upper-arm output  |                             |
| 17      | NC              | No connection   |                             |
| 18      | V               | Phase-V upper-arm output  |                             |
| 19      | $\overline{V}$  | Phase-U lower-arm output  |                             |
| 20      | $\overline{NC}$ | No connection   |                             |
| 21      | $\overline{U}$  | Phase-U lower-arm output  |                             |
| 22      | U               | Phase-U upper-arm output  |                             |
| 23      | V <sub>cc</sub> | Power supply  | 10 V min, 27.6 V max        |
| 24      | EXSEL           | Selects exciting mode: 2-phase if high; 2-3-phase if low (see timing diagrams)      | $V_{TH} = 2.5\text{ V typ}$ |



External Components

| Symbol   | Recommended Value                         | Purpose                                 | Notes |
|--|---|---|-------|
| Rnf  | $0.11\ \Omega \leq Rnf \leq 0.33\ \Omega$ | Current sensing                         | 1     |
| Rt   | 51 k $\Omega$                             | Reference current programming           | 2     |
| Ct   | 1000 pF                                   | Time constant for PWM carrier frequency | 3     |
| C <sub>101</sub>                                       | $\geq 0.1\ \mu\text{F}$                   | Power supply decoupling                 |       |
| C <sub>102</sub> , C <sub>103</sub> , C <sub>104</sub> | 0.01 $\mu\text{F}$                        | Penetration current control             | 4     |
| C <sub>105</sub>                                       | 1000 pF                                   | Current sensing filter                  |       |
| R <sub>101</sub>                                       | 750 $\Omega$                              |   |       |
| VR <sub>101</sub>                                      | 100 k $\Omega$                            | Motor current little adjustment         |       |

Notes: 1. The maximum motor drive current is:

$$I_{\text{max}} \approx \pm \frac{V_{\text{dac}} + V_{\text{offs}}}{R_{\text{nf}}} \tag{1}$$

where, V<sub>dac</sub>: DAC output voltage (see electrical characteristics)  
V<sub>offs</sub>: Offset voltage (see electrical characteristics)

2. The output sink current I<sub>osnk</sub>, output source current I<sub>osrc</sub>, and C<sub>t</sub> charge/discharge currents I<sub>ct+</sub> and I<sub>ct−</sub> are calculated as follows:  
where, set R<sub>t</sub> to be 2.5k $\Omega$  or higher.

$$I_{\text{osnk}} \approx \frac{50V_{\text{rt}}}{R_{\text{t}}} - \frac{V_{\text{be}}}{R_{\text{u}}} \tag{2}$$

$$I_{\text{osrc}} \approx \frac{50V_{\text{rt}}}{R_{\text{t}}} - \frac{V_{\text{be}}}{R_{\text{d}}} \tag{3}$$

$$I_{\text{ct+}}, I_{\text{ct−}} \approx \frac{V_{\text{rt}}}{R_{\text{t}}} \tag{4}$$

where, V<sub>rt</sub>: R<sub>t</sub> voltage (see electrical characteristics)  
R<sub>u</sub>: pull-up resistance (see electrical characteristics)  
R<sub>d</sub>: pull-down resistance (see electrical characteristics)  
V<sub>be</sub>: base-emitter voltage of driven transistor

3. The PWM carrier frequency f<sub>c</sub> is calculated as follows:

$$f_{\text{c}} \approx \frac{I_{\text{ct}}}{2C_{\text{t}} (V_{\text{cth}} - V_{\text{ctl}})} \tag{5}$$

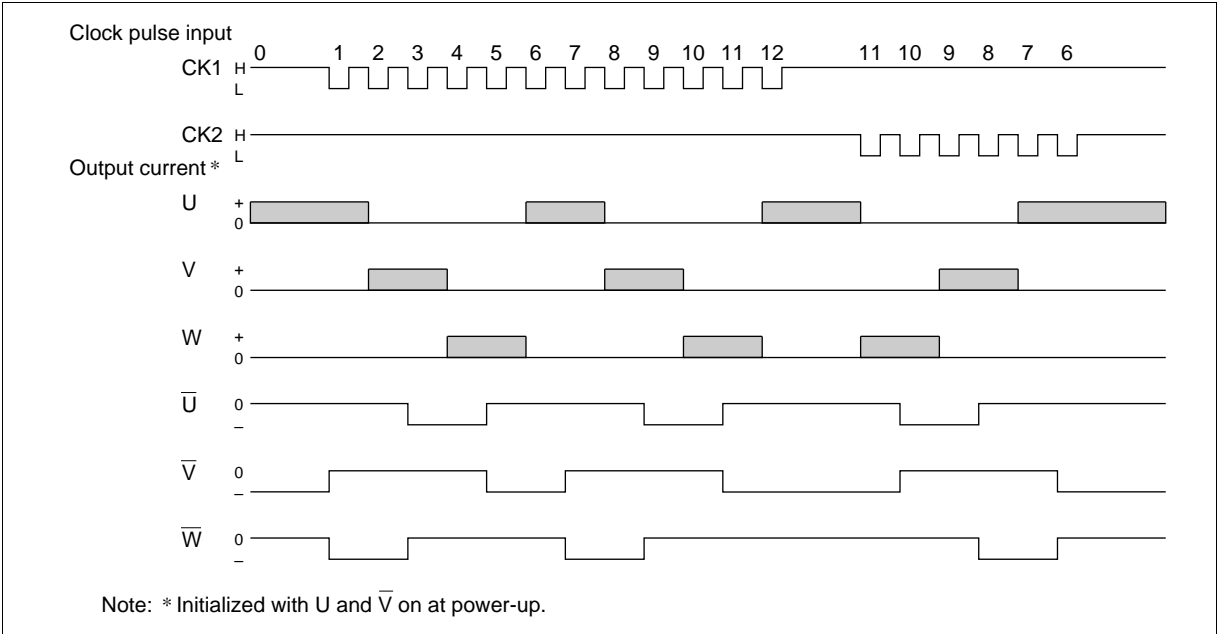
$$\approx \frac{V_{\text{rt}}}{2C_{\text{t}}R_{\text{t}} (V_{\text{cth}} - V_{\text{ctl}})} \tag{6}$$

where, V<sub>cth</sub>: C<sub>t</sub> high voltage (see electrical characteristics)  
V<sub>ctl</sub>: C<sub>t</sub> low voltage (see electrical characteristics)

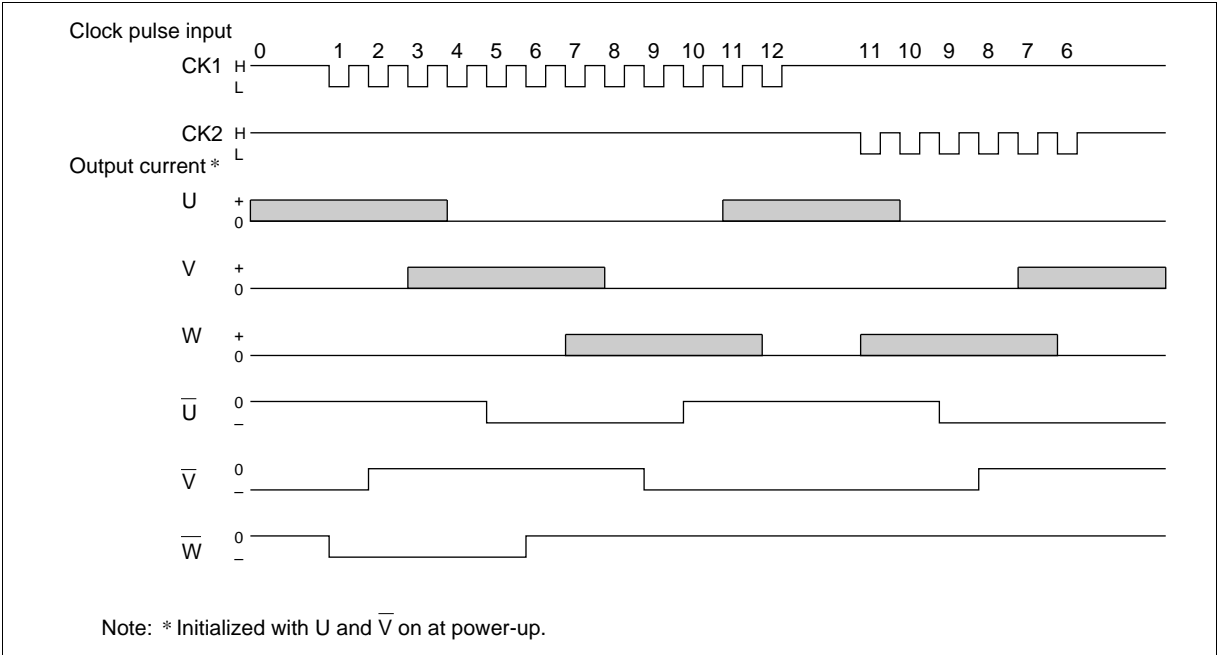
4. Values of C<sub>102</sub>, C<sub>103</sub>, C<sub>104</sub>, C<sub>105</sub>, R<sub>101</sub> are different from using power transistor

Timing Waveforms

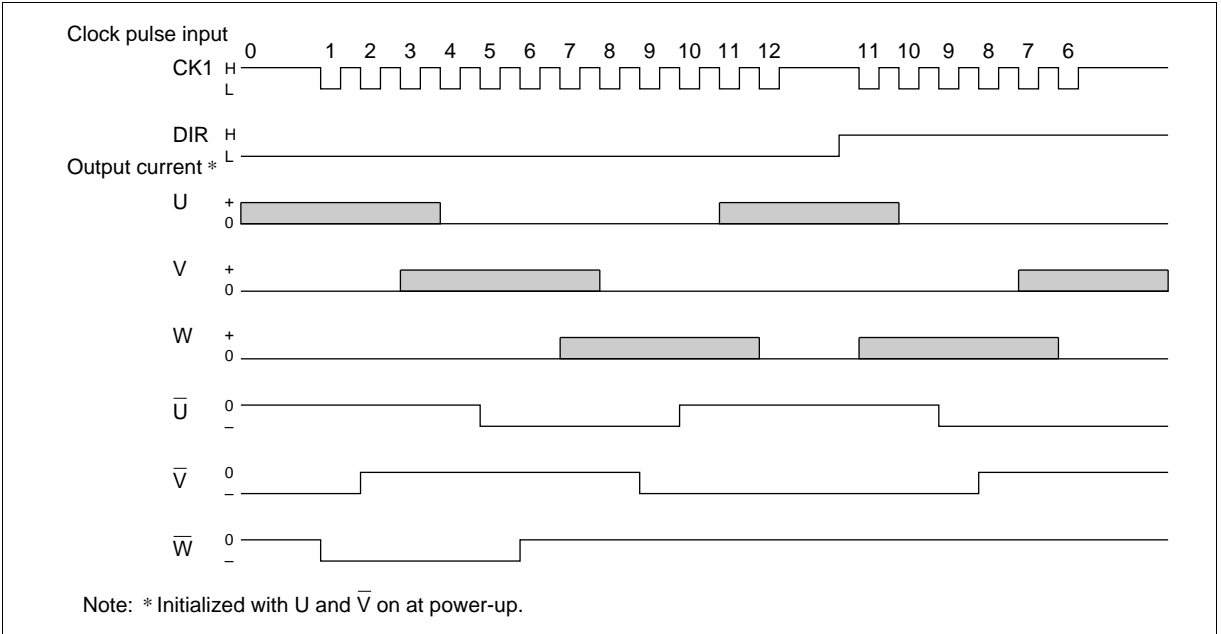
Two Clock Pulse Inputs, Two-Phase Exciting (INSEL High, EXSEL High)



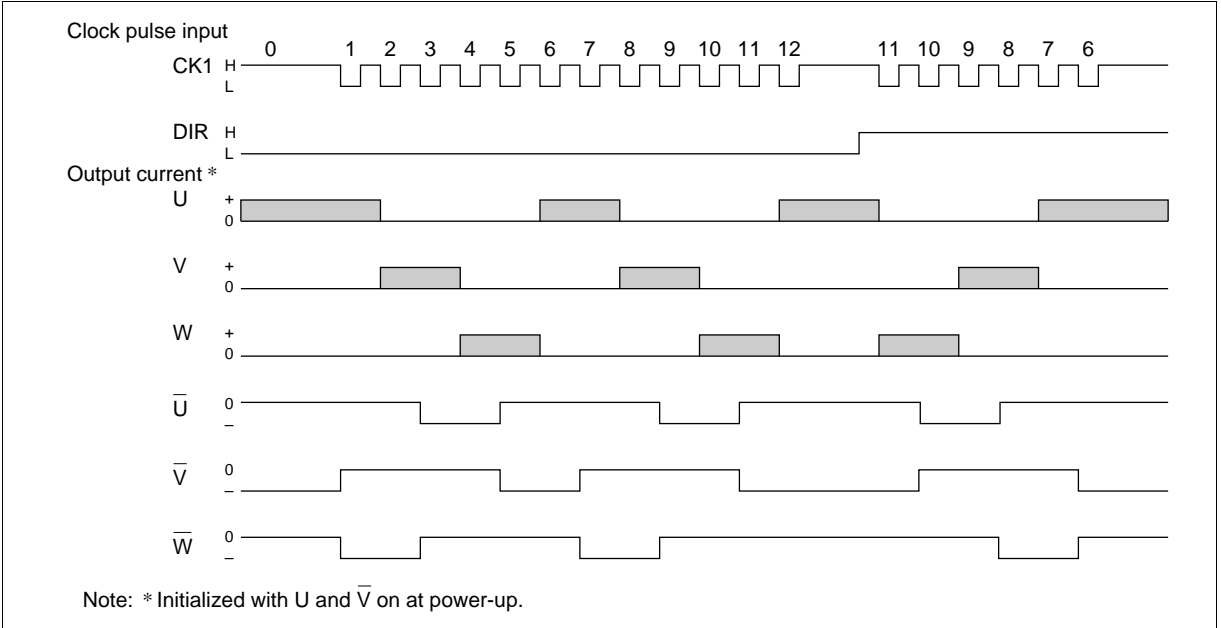
Two Clock Pulse Inputs, Two-Three-Phase Exciting (INSEL High, EXSEL Low)



One Clock Pulse Input, Two-Three-Phase Exciting (INSEL Low, EXSEL Low)

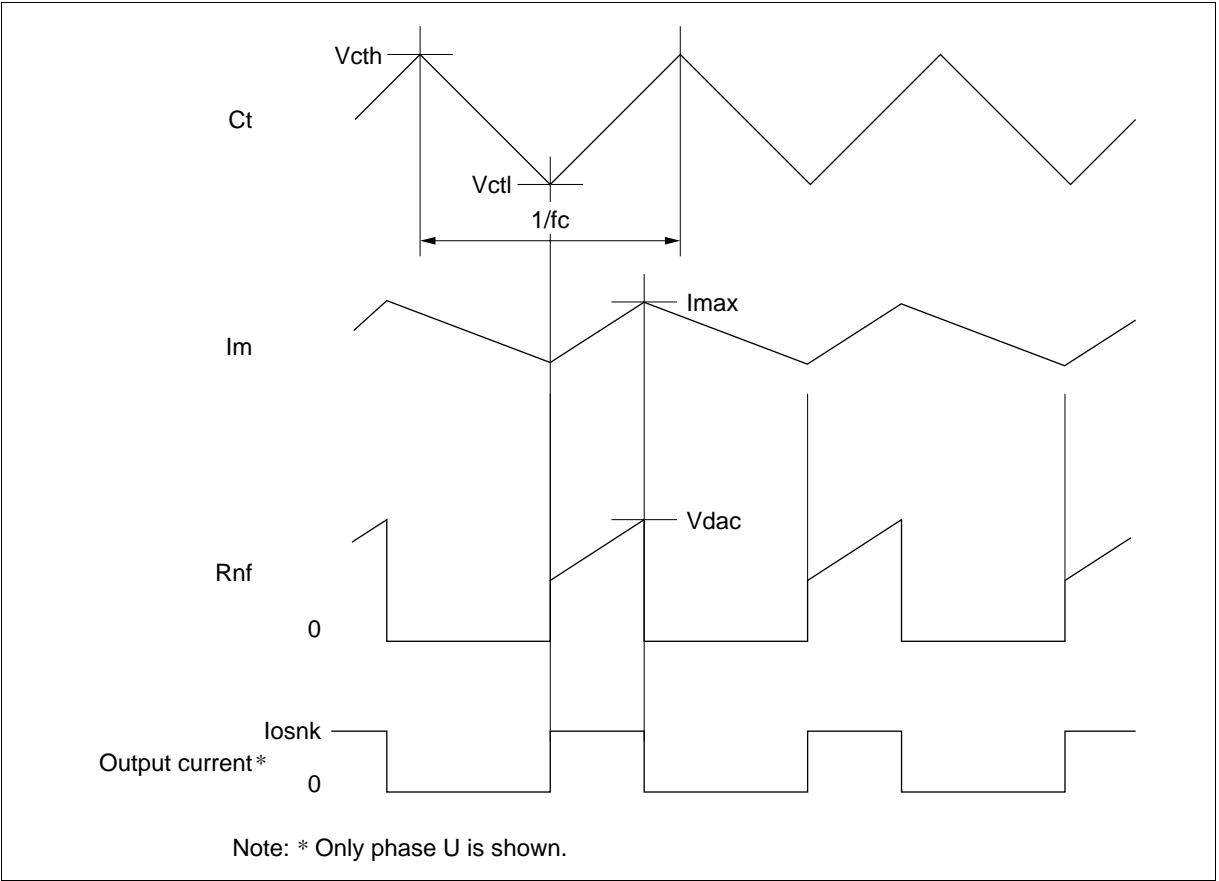


One Clock Pulse Input, Two-Phase Exciting (INSEL Low, EXSEL High)





PWM Control



Absolute Maximum Ratings

| Item                  | Symbol    | Rating      | Unit | Notes |
|-----------------------|-----------|-------------|------|-------|
| Power supply voltage  | $V_{cc}$  | 30          | V    | 1     |
| Input voltage         | $V_{in}$  | 7           | V    | 2     |
| Power dissipation     | $P_T$     | 910         | mW   | 3     |
| Operating temperature | $T_{opr}$ | -10 to +70  | °C   |       |
| Storage temperature   | $T_{stg}$ | -55 to +125 | °C   |       |
| Output current        | $I_{reg}$ | 2           | mA   |       |

- Notes:
- 1. The operating power supply voltage range is  $V_{cc} = 10\text{ V to }27.6\text{ V}$ .
  - 2. Applies to logic and DAC input pins.
  - 3. Permitted at  $T_a = 70^\circ\text{C}$ , if thermal resistance is as below:  
 $\theta_j - a \leq 60^\circ\text{C/W}$  (glass-epoxy board)

Electrical Characteristics (Ta = 25°C, V<sub>CC</sub> = 24 V)

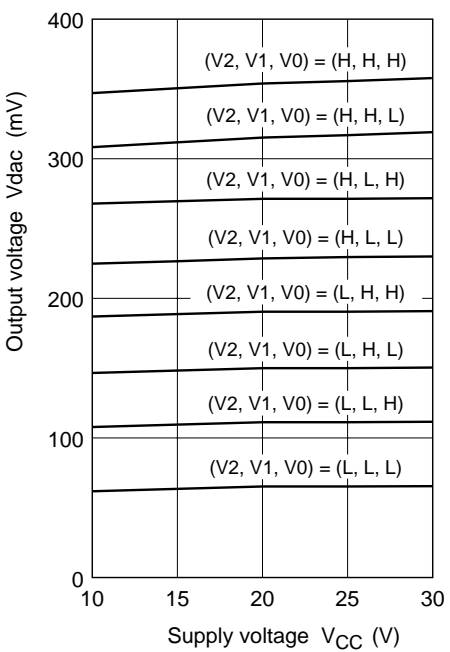
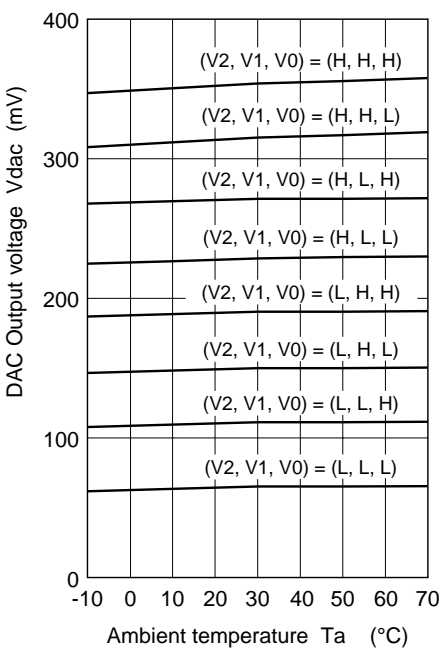
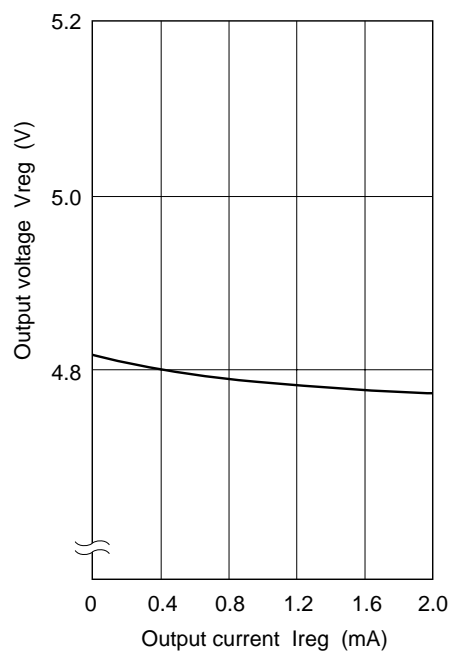
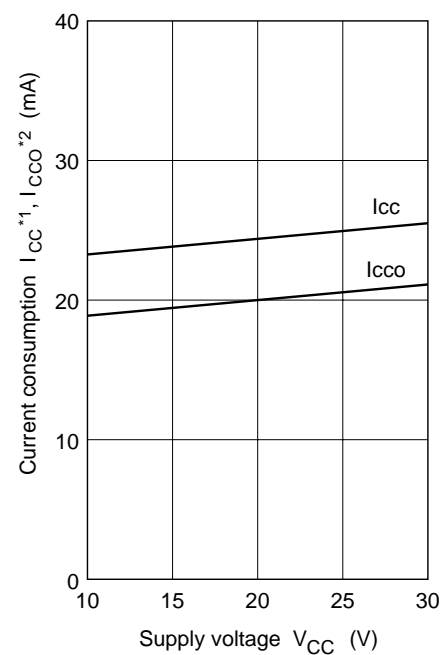
| Item                |                                  | Symbol            | Min  | Typ | Max  | Unit | Test Conditions   | Pins                   | Notes |
|---------------------|----------------------------------|-------------------|------|-----|------|------|---|------------------------|-------|
| Current consumption |                                  | I <sub>CCO</sub>  | —    | —   | 33   | mA   | V <sub>CC</sub> = 30 V, $\overline{\text{OE}}$ = H              | 23                     | 1     |
|                     |                                  | I <sub>CC</sub>   | —    | —   | 41   | mA   | V <sub>CC</sub> = 30 V, $\overline{\text{OE}}$ = L              |                        |       |
| REG                 | Output voltage                   | V <sub>reg</sub>  | 4.4  | 4.8 | 5.2  | V    | I <sub>reg</sub> = 2 mA   | 12                     |       |
|                     | Load regulation                  | ΔV <sub>reg</sub> | —    | —   | ±0.1 | V    | I <sub>reg</sub> = 0 mA to 2 mA                                 |                        |       |
| Logic               | Input current                    | I <sub>in</sub>   | −10  | —   | 1    | μA   | V <sub>in</sub> = 0 V to 7 V                                    | 1, 2, 3, 13, 24        |       |
|                     |                                  |                   | −1   | —   | 10   | μA   |   | 7, 9, 10               |       |
|                     | Low voltage level                | V <sub>il</sub>   | —    | —   | 1.35 | V    |   | 1, 2, 3, 7, 9, 10, 13, |       |
|                     | High voltage level               | V <sub>ih</sub>   | 3.65 | —   | —    | V    |   | 24                     |       |
| DAC                 | Outout voltage                   | V <sub>dac</sub>  | 200  | 230 | 260  | mV   | (V <sub>2</sub> , V <sub>1</sub> , V <sub>0</sub> ) = (H, L, L) | 11                     |       |
|                     |                                  |                   | 116  | 146 | 176  | mV   | (V <sub>2</sub> , V <sub>1</sub> , V <sub>0</sub> ) = (L, H, L) |                        |       |
|                     |                                  |                   | 75   | 105 | 135  | mV   | (V <sub>2</sub> , V <sub>1</sub> , V <sub>0</sub> ) = (L, L, H) |                        |       |
|                     |                                  |                   | 33   | 63  | 93   | mV   | (V <sub>2</sub> , V <sub>1</sub> , V <sub>0</sub> ) = (L, L, L) |                        |       |
| PWM control         | Input current                    | I <sub>sens</sub> | —    | —   | ±2   | μA   | V <sub>sens</sub> = 0 V to 5 V                                  | 14                     |       |
|                     | Offset voltage                   | V <sub>offs</sub> | —    | —   | ±10  | mV   |   |                        | 2     |
|                     | R <sub>t</sub> voltage           | V <sub>rt</sub>   | 4.4  | 4.8 | 5.2  | V    | R <sub>t</sub> = 51 kΩ  | 4                      |       |
|                     | C <sub>t</sub> change current    | I <sub>ct+</sub>  | 84   | 94  | 104  | μA   | R <sub>t</sub> = 51 kΩ, V <sub>ct</sub> 6 = 3.75 V              |                        |       |
|                     | C <sub>t</sub> discharge current | I <sub>ct−</sub>  | 84   | 94  | 104  | μA   | R <sub>t</sub> = 51 kΩ, V <sub>ct</sub> = 3.75 V                |                        |       |

Electrical Characteristics (Ta = 25°C, V<sub>CC</sub> = 24 V) (Cont)

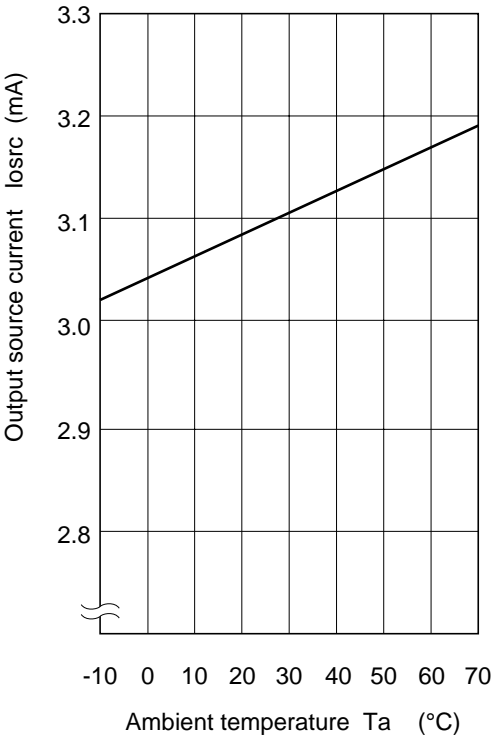
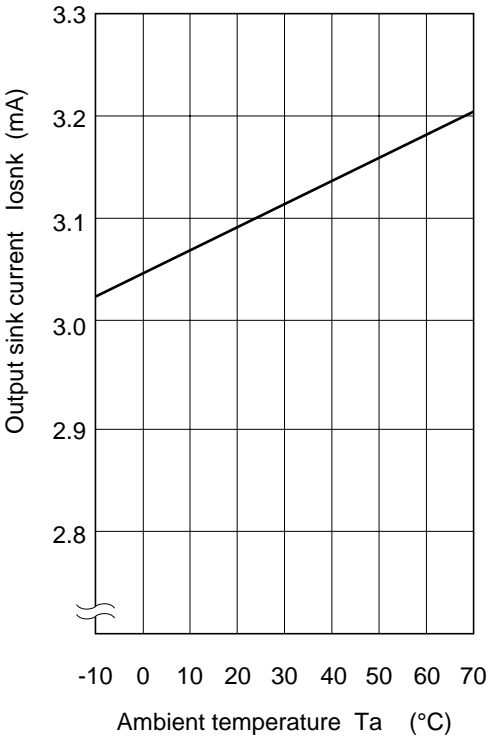
| Item           |                         | Symbol           | Min  | Typ  | Max  | Unit | Test Conditions  | Pins                   | Notes |
|----------------|-------------------------|------------------|------|------|------|------|--|------------------------|-------|
| PWM control    | Ct high voltage         | Vcth             | 4.3  | 4.8  | 5.3  | V    |  | 6                      | 3     |
|                | Ct low voltage          | Vctl             | 2.3  | 2.78 | 3.3  | V    |  |                        |       |
|                | Carrier frequency       | fc               | 18.6 | 23.3 | 28.0 | kHz  | Rt = 51 kΩ,<br>Ct = 1000 pF                              |                        |       |
| 3-pahse output | Output sink current     | Iosnk            | 2.0  | 3.1  | 4.2  | mA   | V <sub>O</sub> = V <sub>CC</sub> – 1.5 V, Rt = 51 kΩ     | 16, 18, 22             |       |
|                | Output source current   | Iosrc            | 2.0  | 3.1  | 4.2  | mA   | V <sub>O</sub> = 1.5 V, Rt = 51 kΩ                       | 15, 19, 21             |       |
|                | Output leakage current  | Ioff             | —    | —    | ±10  | μA   | V <sub>CC</sub> = 30 V, V <sub>O</sub> = V <sub>CC</sub> | 16, 18, 22             |       |
|                |                         |                  | —    | —    | ±10  | μA   | V <sub>CC</sub> = 30 V, V <sub>O</sub> = 0 V             | 15, 19, 21             |       |
|                | Pull-up resistance      | Ru               | 700  | 950  | 1200 | Ω    |  | 16, 18, 22             |       |
|                | Pull-down resistance    | Rd               | 700  | 950  | 1200 | Ω    |  | 15, 19, 21             |       |
|                | Transient response time | t <sub>phl</sub> | —    | —    | 6.0  | μs   |  | 15, 16, 18, 19, 21, 22 |       |
|                |                         | t <sub>plh</sub> | —    | —    | 6.0  | μs   |  |                        |       |
| LVI            | Operating voltage       | Vlvi             | 8.0  | —    | 10   | V    |  | 23                     |       |
|                | Hysteresis              | Vhys             | —    | 0.3  | —    | V    |  |                        |       |

Notes: 1. Measured with pins 12, 15, 16, 18, 19, 21, and 22 open.  
2. Offset between pins 11 and 14.  
3. See timing diagrams.

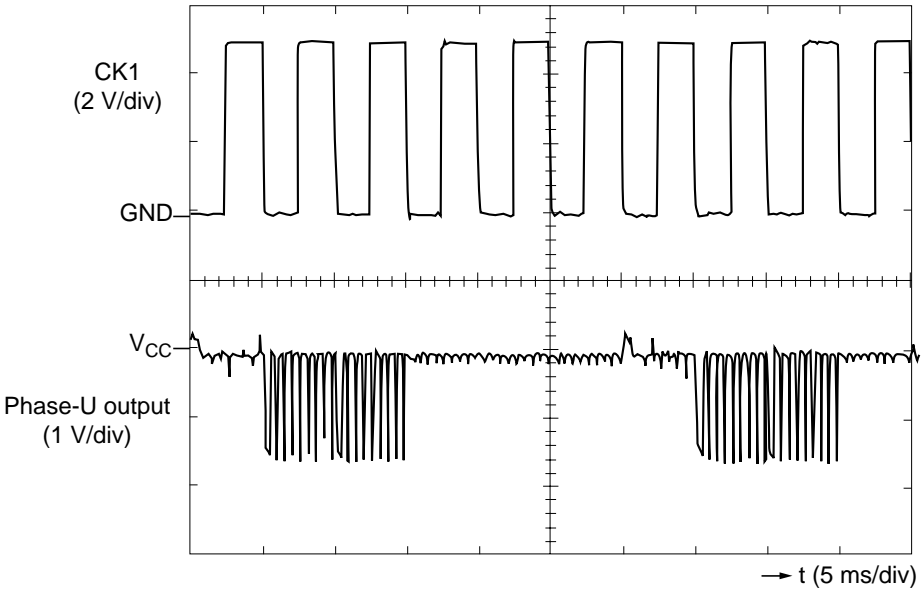
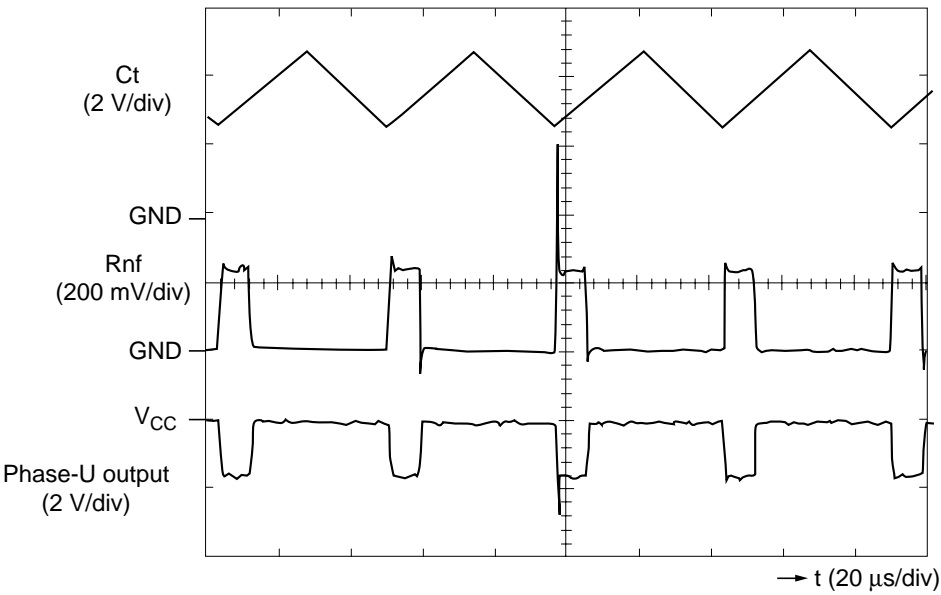
Reference Data



- Notes:
1.  $I_{osnk} + I_{osrc}$  is the current during three-channel output.
  2.  $I_{osnk}$  is the current during two-channel output.

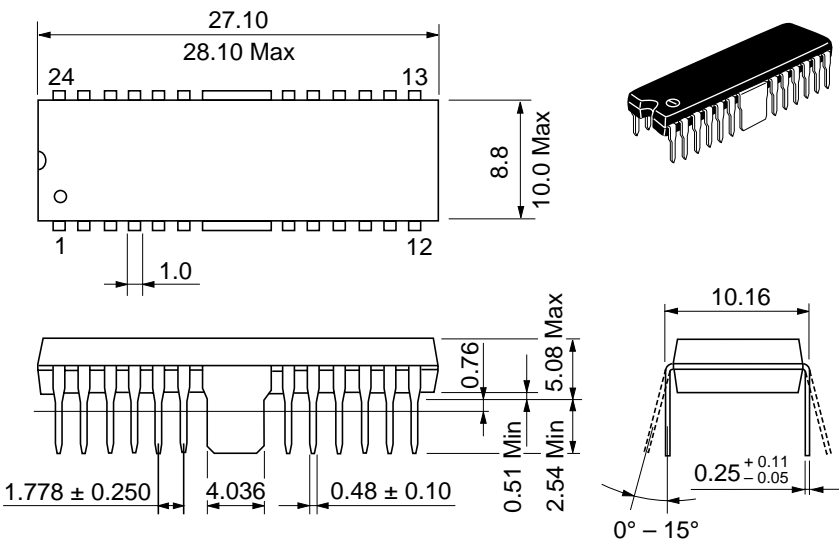


In-Circuit Waveform Characteristics



Package Dimensions

Unit: mm



|              |         |
|--------------|---------|
| Hitachi code | DP-24TS |
| EIAJ code    | —       |
| JEDEC code   | —       |

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