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LV8044LP

Bi-CMOS IC

6-channel Motor Driver IC for Digital Still Camera

Overview

The LV8044LP is a 6-channel motor driver IC for digital still camera.

Functions

- Two microstep drive H-bridge driver channels.
- Two microstep drive/PWM saturated drive switchable H-bridge driver channels.
- Two constant-current drive H-bridge driver channels.
- Drive mode switchable between 2-phase, 1-2 phase full torque, 1-2 phase, and 4W1-2 phase (channels 1, 2, 3, and 4).
- Microstep drive step advance controlled by a single step signal input (channels 1, 2, 3, and 4).
- Ability to set the hold current to one of four levels (channels 1, 2, 3, and 4).
- Ability to set the constant-current reference voltage to one of 16 levels from the serial data (channels 5 and 6).
- Eight-bit 3-wire serial control.
- Three on-chip photosensor driver circuits.

Specifications

Maximum Ratings at $T_a = 25^\circ\text{C}$

| Parameter | Symbol | Conditions | Ratings | Unit |
|-------------------------------|--------------|---|-------------|------------------|
| Power supply voltage 1 | V_M max | | 6.0 | V |
| Power supply voltage 2 | V_{CC} max | | 6.0 | V |
| Output peak current | I_O peak | Each CH $t_w \leq 10\text{ms}$, duty 20% | 600 | mA |
| Output continuous current | I_O max | Each CH | 400 | mA |
| Allowable power dissipation 2 | P_d max | With substrate * | 1.4 | W |
| Operating temperature | T_{opg} | | -20 to +85 | $^\circ\text{C}$ |
| Storage temperature | T_{stg} | | -55 to +150 | $^\circ\text{C}$ |

*: With 40mm × 50mm × 0.8mm glass epoxy substrate (four-layer substrate).

Caution 1) Absolute maximum ratings represent the value which cannot be exceeded for any length of time.

Caution 2) Even when the device is used within the range of absolute maximum ratings, as a result of continuous usage under high temperature, high current, high voltage, or drastic temperature change, the reliability of the IC may be degraded. Please contact us for the further details.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

ORDERING INFORMATION

See detailed ordering and shipping information on page 26 of this data sheet.

LV8044LP

Recommended Operating Conditions at Ta = 25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|------------------------------|-------------------|--------------|---------------------------|------|
| Power supply voltage range 1 | V _M | | 2.7 to 5.5 | V |
| Power supply voltage range 2 | V _{CC} | | 2.7 to 5.5 | V |
| Logic input voltage range | V _{IN} | | 0 to V _{CC} +0.3 | V |
| STEP frequency | F _{STEP} | STEP1, STEP2 | to 64 | KHz |
| PWM frequency | F _{PWM} | STEP3, STEP4 | to 100 | KHz |

Electrical Characteristics at Ta = 25°C, V_M = 5V, V_{CC} = 3.3V

| Parameter | Symbol | Conditions | Ratings | | | Unit | |
|---|---------------------------------|--|--|-------|-------|-------|---|
| | | | min | typ | max | | |
| Standby supply current | I _{STN} | ST = "L" | | | 1.0 | μA | |
| Motor supply current | I _M | ST = "H", PWM3 = PWM4 = "H", IN51 = IN61 = "H", no load | | 50 | 100 | μA | |
| Logic supply current | I _{CC} | ST = "H", PWM3 = PWM4 = "H", IN51 = IN61 = "H", no load | 2 | 3 | 4 | mA | |
| V _{CC} low-voltage cut voltage | V _{th} V _{CC} | | 2.1 | 2.35 | 2.6 | V | |
| Low-voltage hysteresis voltage | V _{th} HIS | | 100 | 150 | 200 | mV | |
| Thermal shutdown temperature | TSD | Design guarantee | 150 | 180 | 200 | °C | |
| Thermal hysteresis width | ΔTSD | Design guarantee | | 40 | | °C | |
| Microstep Driver (channels 1, 2, 3, and 4) | | | | | | | |
| Output on resistance | R _{on} | I _O = 400mA, Upper ON resistance | | 0.7 | 0.8 | Ω | |
| | R _{od} | I _O = 400mA, Lower ON resistance | | 0.5 | 0.6 | Ω | |
| Output leak current | I _O leak1 | | | | 1.0 | μA | |
| Diode forward voltage 1 | V _D 1 | I _D = -400mA | | 0.9 | 1.2 | V | |
| Logic pin input current | I _{in} L | V _{IN} = 0V (ST, STEP1, STEP2) | | | 1.0 | μA | |
| | I _{in} H | V _{IN} = 3.3V (ST, STEP1, STEP2) | 20 | 33 | 50 | μA | |
| Logic input "H" level voltage | V _{in} h | ST, STEP1, STEP2 | 2.5 | | | V | |
| Logic input "L" level voltage | V _{in} l | ST, STEP1, STEP2 | | | 1.0 | V | |
| Current selection reference voltage level | 4W1-2 phase | Vstep16 | Step 16 (Initial level: the channel 1 comparator level) | 0.185 | 0.200 | 0.215 | V |
| | | Vstep15 | Step 15 (Initial+1) | 0.185 | 0.200 | 0.215 | V |
| | | Vstep14 | Step 14 (Initial+2) | 0.185 | 0.200 | 0.215 | V |
| | | Vstep13 | Step 13 (Initial+3) | 0.176 | 0.193 | 0.206 | V |
| | | Vstep12 | Step 12 (Initial+4) | 0.170 | 0.186 | 0.200 | V |
| | | Vstep11 | Step 11 (Initial+5) | 0.162 | 0.178 | 0.192 | V |
| | | Vstep10 | Step 10 (Initial+6) | 0.154 | 0.171 | 0.184 | V |
| | | Vstep9 | Step 9 (Initial+7) | 0.146 | 0.163 | 0.176 | V |
| | | Vstep8 | Step 8 (Initial+8) | 0.129 | 0.148 | 0.159 | V |
| | | Vstep7 | Step 7 (Initial+9) | 0.113 | 0.131 | 0.143 | V |
| | | Vstep6 | Step 6 (Initial+10) | 0.097 | 0.115 | 0.127 | V |
| | | Vstep5 | Step 5 (Initial+11) | 0.079 | 0.097 | 0.109 | V |
| | | Vstep4 | Step 4 (Initial+12) | 0.062 | 0.079 | 0.092 | V |
| | | Vstep3 | Step 3 (Initial+13) | 0.044 | 0.06 | 0.074 | V |
| | | Vstep2 | Step 2 (Initial+14) | 0.024 | 0.04 | 0.054 | V |
| | Vstep1 | Step 1 (Initial+15) | 0.006 | 0.02 | 0.036 | V | |
| | 1-2 phase | Vstep16 | Step 16 (Initial level: the channel 1 comparator level) | 0.185 | 0.200 | 0.215 | V |
| | | Vstep8 | Step 8 (Initial+1) | 0.129 | 0.148 | 0.159 | V |
| | 1-2 phase (Full torque) | Vstep16 | Step 16 (Initial level: the channel 1 comparator level) | 0.185 | 0.200 | 0.215 | V |
| | | Vstep8 | Step 8 (Initial+1) | 0.185 | 0.200 | 0.215 | V |
| 2 phase | Vstep8 | Step 8 | 0.185 | 0.200 | 0.215 | V | |

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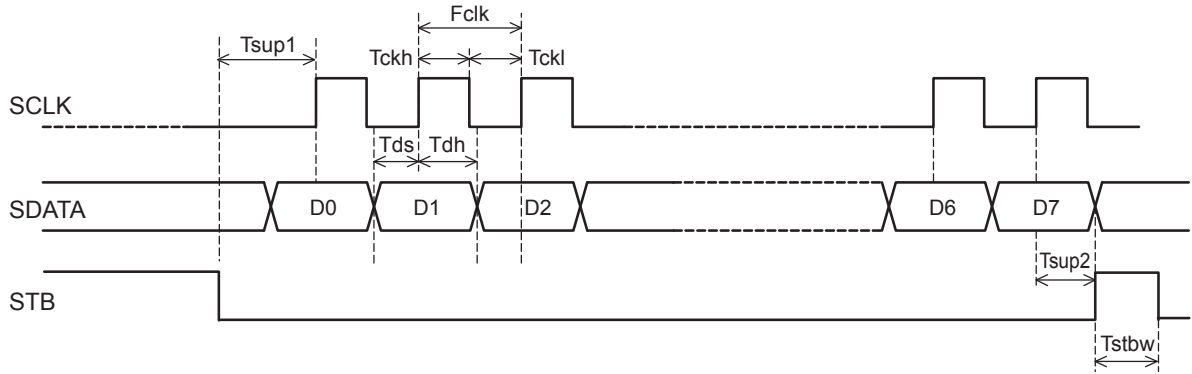
LV8044LP

Continued from preceding page.

| Parameter | Symbol | Conditions | Ratings | | | Unit |
|--|---------------------|--|---------|-------|-------|------|
| | | | min | typ | max | |
| Chopping frequency | fchop1 | | 104 | 130 | 156 | KHz |
| | fchop2 | | 52 | 65 | 78 | KHz |
| | fchop3 | | 160 | 200 | 240 | KHz |
| | fchop4 | | 80 | 100 | 120 | KHz |
| Current setting reference voltage | VSEN00 | (D5, D6) = (0, 0) | 0.185 | 0.200 | 0.215 | V |
| | VSEN01 | (D5, D6) = (0, 1) | 0.119 | 0.134 | 0.149 | V |
| | VSEN10 | (D5, D6) = (1, 0) | 0.085 | 0.100 | 0.115 | V |
| | VSEN11 | (D5, D6) = (1, 1) | 0.051 | 0.066 | 0.081 | V |
| Constant-Current Drive (channels 5 and 6) | | | | | | |
| Output on resistance | R _{on} | I _O = 400mA, Upper ON resistance | | 0.7 | 0.8 | Ω |
| | R _{on} | I _O = 400mA, Lower ON resistance | | 0.5 | 0.6 | Ω |
| Output leak current | I _O leak | | | | 1.0 | μA |
| Diode forward voltage 1 | V _D 1 | I _D = -400mA | | 0.9 | 1.2 | V |
| Logic pin input current | I _{in} L | V _{IN} = 0V, (IN51, IN52, IN61, IN62) | | | 1.0 | μA |
| | I _{in} H | V _{IN} = 3.3V, (IN51, IN52, IN61, IN62) | 20 | 33 | 50 | μA |
| Logic input "H" level voltage | V _{in} h | IN51, IN52, IN61, IN62 | 2.5 | | | V |
| Logic input "L" level voltage | V _{in} l | IN51, IN52, IN61, IN62 | | | 1.0 | V |
| Output constant current | I _{OUT} | R _{load} = 3Ω, R _F = 0.5Ω, Internal standard = 0.2V | 380 | 400 | 420 | mA |
| Current setting reference voltage | Vref0 | (D4, D5, D6, D7) = (0, 0, 0, 0) | 0.285 | 0.30 | 0.315 | V |
| | Vref1 | (D4, D5, D6, D7) = (1, 0, 0, 0) | 0.19 | 0.20 | 0.21 | V |
| | Vref2 | (D4, D5, D6, D7) = (0, 1, 0, 0) | 0.18 | 0.190 | 0.2 | V |
| | Vref3 | (D4, D5, D6, D7) = (1, 1, 0, 0) | 0.171 | 0.180 | 0.189 | V |
| | Vref4 | (D4, D5, D6, D7) = (0, 0, 1, 0) | 0.161 | 0.170 | 0.179 | V |
| | Vref5 | (D4, D5, D6, D7) = (1, 0, 1, 0) | 0.156 | 0.165 | 0.173 | V |
| | Vref6 | (D4, D5, D6, D7) = (0, 1, 1, 0) | 0.152 | 0.160 | 0.168 | V |
| | Vref7 | (D4, D5, D6, D7) = (1, 1, 1, 0) | 0.147 | 0.155 | 0.163 | V |
| | Vref8 | (D4, D5, D6, D7) = (0, 0, 0, 1) | 0.143 | 0.150 | 0.158 | V |
| | Vref9 | (D4, D5, D6, D7) = (1, 0, 0, 1) | 0.137 | 0.145 | 0.152 | V |
| | VrefA | (D4, D5, D6, D7) = (0, 1, 0, 1) | 0.133 | 0.140 | 0.147 | V |
| | VrefB | (D4, D5, D6, D7) = (1, 1, 0, 1) | 0.128 | 0.135 | 0.142 | V |
| | VrefC | (D4, D5, D6, D7) = (0, 0, 1, 1) | 0.123 | 0.130 | 0.137 | V |
| | VrefD | (D4, D5, D6, D7) = (1, 0, 1, 1) | 0.114 | 0.120 | 0.126 | V |
| | VrefE | (D4, D5, D6, D7) = (0, 1, 1, 1) | 0.104 | 0.110 | 0.116 | V |
| | VrefF | (D4, D5, D6, D7) = (1, 1, 1, 1) | 0.095 | 0.100 | 0.105 | V |
| Photo-sensor Drive Circuit | | | | | | |
| Output saturation voltage | V _{sat} | I _O = -20mA | | 0.09 | 0.12 | V |
| Serial Data Transfer Pin | | | | | | |
| Logic pin input current | I _{in} L | V _{IN} = 0V (SCLK, SDATA, STB) | | | 1.0 | μA |
| | I _{in} H | V _{IN} = 3.3V (SCLK, SDATA, STB) | 20 | 33 | 50 | μA |
| Logic input "H" level voltage | V _{in} h | SCLK, SDATA, STB | 2.5 | | | V |
| Logic input "L" level voltage | V _{in} l | SCLK, SDATA, STB | | | 1.0 | V |
| Minimum SCLK "H" pulse width | T _{ckh} | | 0.125 | | | μs |
| Minimum SCLK "L" pulse width | T _{ckl} | | 0.125 | | | μs |
| Minimum setup time (STB → SCLK rising edge) | T _{sup1} | | 0.125 | | | μs |
| Minimum setup time (SCLK rising edge → STB) | T _{sup2} | | 0.125 | | | μs |
| Minimum STB pulse width | T _{stbw} | | 0.125 | | | μs |
| Data setup time | T _{ds} | | 0.125 | | | μs |
| Data hold time | T _{dh} | | 0.125 | | | μs |
| Maximum SCLK frequency | F _{clk} | | | | 4 | MHz |

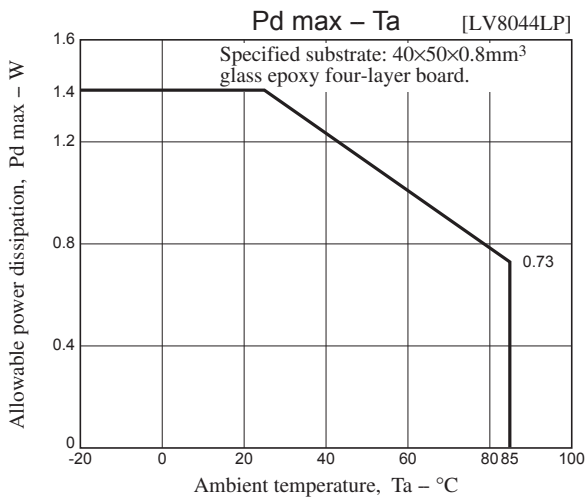
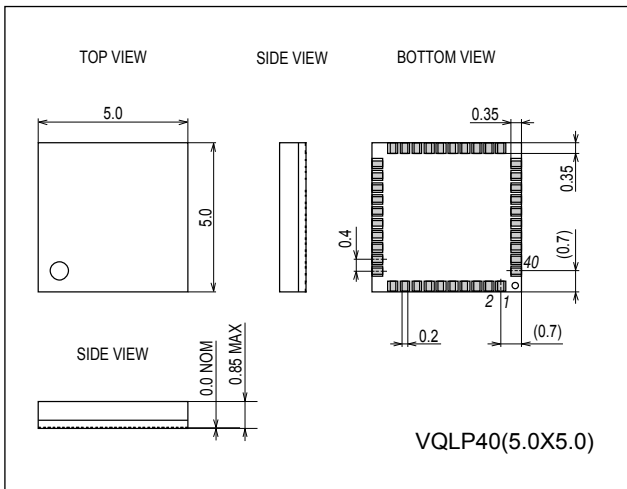
LV8044LP

Serial Input Switching Characteristics Timing Chart



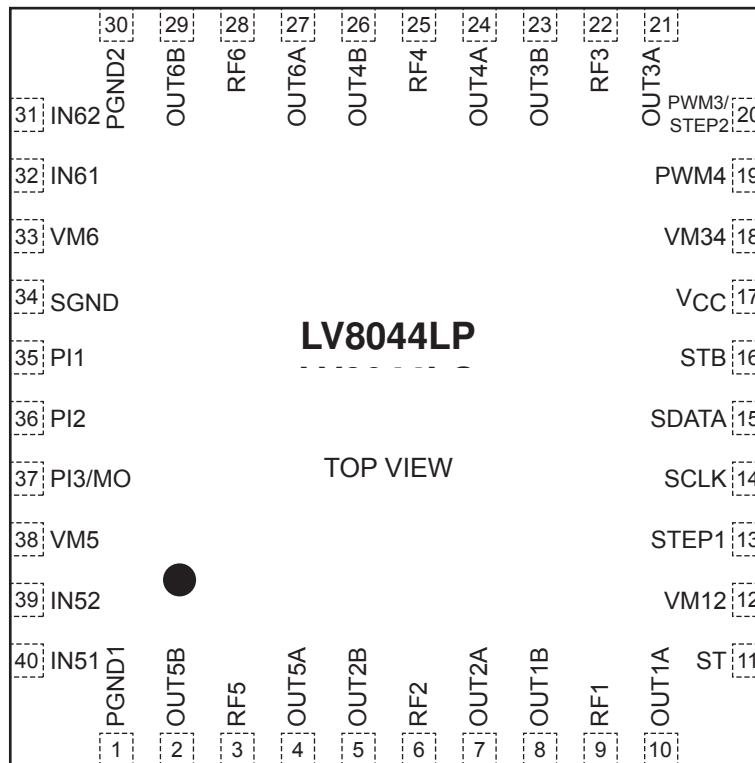
Package Dimensions

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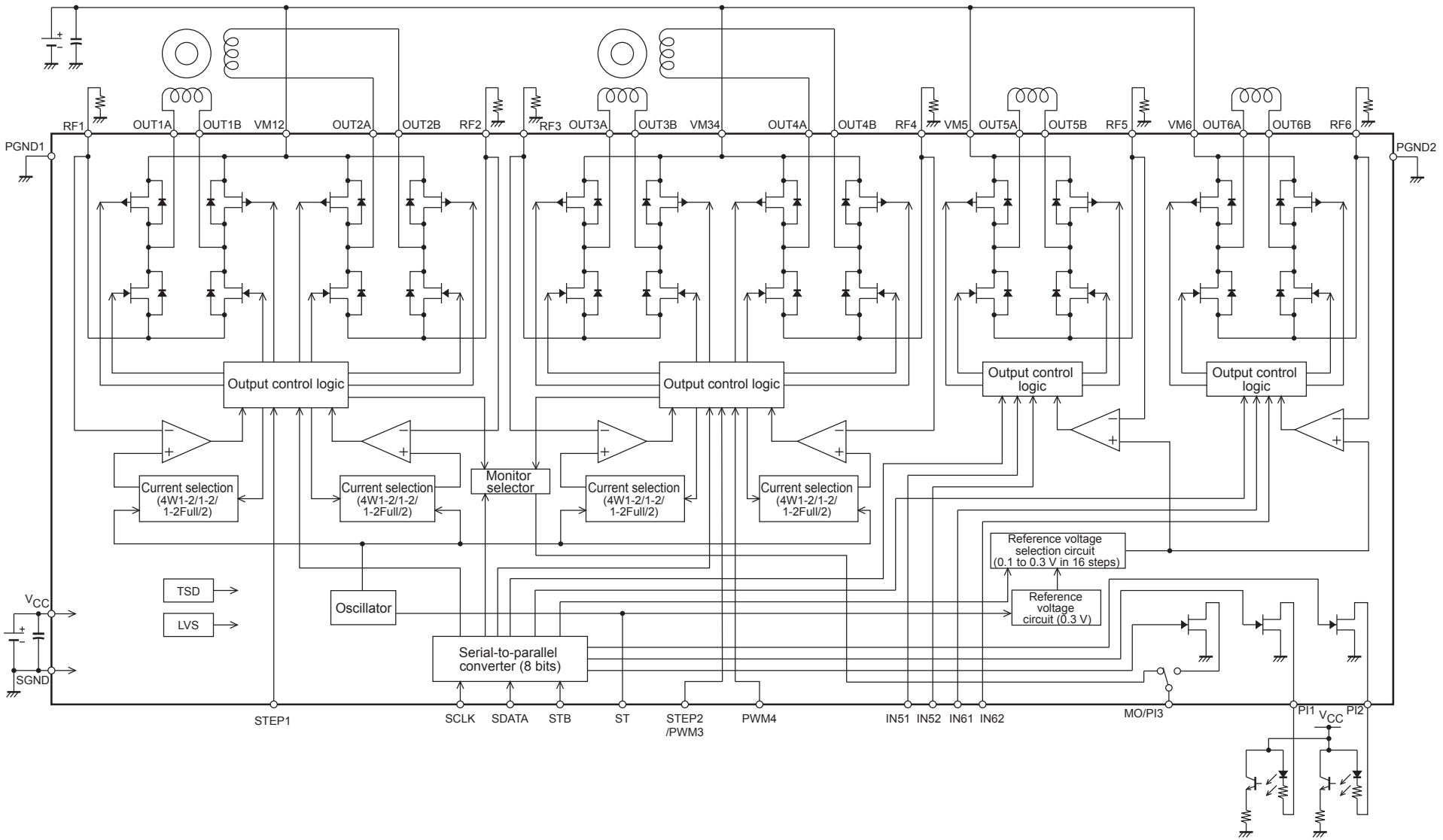


LV8044LP

Pin Assignment



The pin assignment of LV8044LP and LV8044LQ is the same.



LV8044LP

Pin Function

| Pin No. | Pin name | Function | Equivalent circuit | |
|---------|------------|--|--------------------|--|
| 13 | STEP1 | Channels 1/2 - STEP signal input | | |
| 20 | PWM3/STEP2 | 3ch PWM signal input / Channels 3/4 - STEP signal input | | |
| 19 | PWM4 | 4ch PWM signal input | | |
| 40 | IN51 | Channel 5 - Logic input 1 | | |
| 39 | IN52 | | | |
| 32 | IN61 | Channel 6 - Logic input 1 | | |
| 31 | IN62 | | | |
| 14 | SCLK | Serial data transfer clock input | | |
| 15 | SDATA | Serial data input | | |
| 16 | STB | Serial data latch pulse input | | |
| 11 | ST | Chip enable | | |
| 10 | OUT1A | 1ch OUTA output | | |
| 7 | OUT2A | 2ch | | |
| 21 | OUT3A | 3ch | | |
| 24 | OUT4A | 4ch | | |
| 4 | OUT5A | 5ch | | |
| 27 | OUT6A | 6ch | | |
| 8 | OUT1B | 1ch OUTB output | | |
| 5 | OUT2B | 2ch | | |
| 23 | OUT3B | 3ch | | |
| 26 | OUT4B | 4ch | | |
| 2 | OUT5B | 5ch | | |
| 29 | OUT6B | 6ch | | |
| 9 | RF1 | 1ch Current sensing resistor connection | | |
| 6 | RF2 | 2ch | | |
| 22 | RF3 | 3ch | | |
| 25 | RF4 | 4ch | | |
| 3 | RF5 | 5ch | | |
| 28 | RF6 | 6ch | | |
| 12 | VM12 | Channels 1/2 - Motor power supply | | |
| 18 | VM34 | Channels 3/4 - Motor power supply | | |
| 38 | VM5 | Channels 5 - Motor power supply | | |
| 33 | VM6 | Channels 6 - Motor power supply | | |
| 35 | PI1 | Photosensor drive output | | |
| 36 | PI2 | | | |

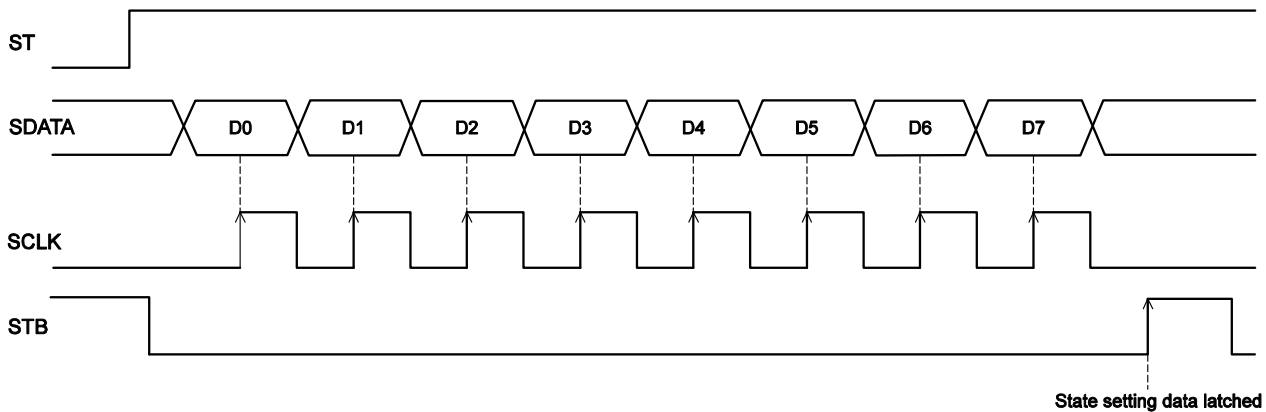
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| Pin No. | Pin name | Function | Equivalent circuit |
|---------|-----------------|---|--------------------|
| 37 | PI3/MO | Photosensor drive output 3/position detection monitor | |
| 17 | V _{CC} | Logic system power supply | |
| 1 | PGND1 | Channels 1/2/5 - Power system ground | |
| 30 | PGND2 | Channels 3/4/6 - Power system ground | |
| 34 | SGND | Signal system ground | |

Serial Data Input Specifications

1. Serial Data Input Setup



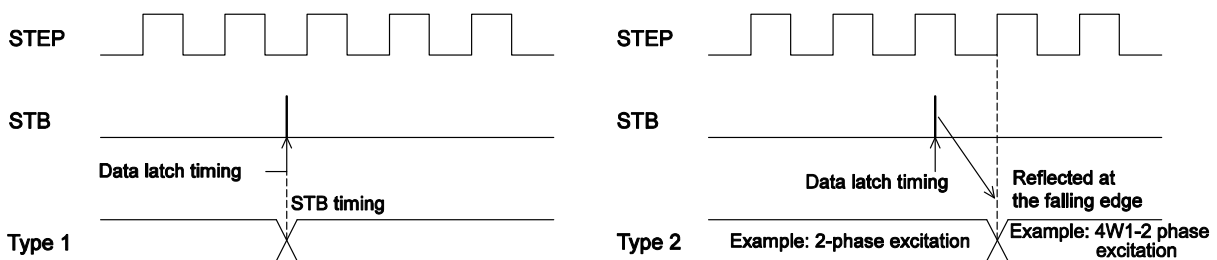
First set STB low and then input the SDATA and SCLK signals. The SCLK signal is not accepted when STB is high. SDATA inputs the data in the order D0, D1, ... D6, D7.

Data is transferred on the rising edge of SCLK and after all data has been transferred, all the data is latched on the rising edge of STB.

2. Timing with which the Serial Data Settings are Reflected in the Output

- STP timing mode (applies to microstep driver settings)
 - Type 1: The hold, reset, and enable settings, as well as the reference voltage setting are reflected at the same time as the STB signal data latch operation.
 - Type 2: The forward/reverse (FR) and the excitation setting mode (MS) setting that are set at STP setup are reflected in the output at the next clock rising edge after data latch.
- STB timing (applies to settings other than the above)

Type 1: The PWM driver, constant-current driver, PI, and other settings are reflected at the same time as the STB signal data latch operation.



LV8044LP

Serial Data Truth Table

Serial Logic Table (1)

| Input | | | | | | | Setting mode | Description | Remarks | Set channel | | | | | | PI | Serial data reflection timing | | | | | | | |
|-------|----|----|----|----|----|----|--------------|--|-------------------------|-------------|-----|-----|-----|-----|-----|----|-------------------------------|-------|-------|-----|--|--|--|--|
| D0 | D1 | D2 | D3 | D4 | D5 | D6 | | | | D7 | 1ch | 2ch | 3ch | 4ch | 5ch | | 6ch | STEP1 | STEP2 | STB | | | | |
| 0 | 0 | 0 | 0 | 0 | * | * | * | Channels 1 and 2 excitation mode selection | 2 phase | | ○ | ○ | | | | | | ○ | | | | | | |
| | | | 1 | 0 | * | * | * | | 1-2 phase (full torque) | | | | | | | | | | | | | | | |
| | | | 0 | 1 | * | * | * | | 1-2 phase | | | | | | | | | | | | | | | |
| | | | 1 | 1 | * | * | * | | 4W1-2 phase | | | | | | | | | | | | | | | |
| | | | * | * | 0 | 0 | * | Channels 1 and 2 current reference voltage selection | 100% (0.2V) | | | | | | | | | | | | | | | |
| | | | * | * | 1 | 0 | * | | 67% (0.134V) | | | | | | | | | | | | | | | |
| | | | * | * | 0 | 1 | * | | 50% (0.1V) | | | | | | | | | | | | | | | |
| | | | * | * | 1 | 1 | * | | 33% (0.066V) | | | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 0 | (Dummy data) | | | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 1 | | | | | | | | | | | | | | | | |
| 1 | 0 | 0 | 0 | * | * | * | * | 1/2ch energization direction | CW (Forward) | | ○ | ○ | | | | | | ○ | | | | | | |
| | | | 1 | * | * | * | * | | CCW (Reverse) | | | | | | | | | | | | | | | |
| | | | * | 0 | * | * | * | 1/2ch step hold | Cancel | | | | | | | | | | | | | | | |
| | | | * | 1 | * | * | * | | Hold | | | | | | | | | | | | | | | |
| | | | * | * | 0 | * | * | 1/2ch counter reset | Reset | | | | | | | | | | | | | | | |
| | | | * | * | 1 | * | * | | Cancel | | | | | | | | | | | | | | | |
| | | | * | * | * | 0 | * | 1/2ch output enable | Output OFF | | | | | | | | | | | | | | | |
| | | | * | * | * | 1 | * | | Output ON | | | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 0 | (Dummy data) | | | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 1 | | | | | | | | | | | | | | | | |

LV8044LP

Serial Logic Table (2)

| Input | | | | | | | Setting mode | Description | Remarks | Set channel | | | | | | PI | Serial data reflection timing | | | | | | |
|-------|----|----|----|----|----|----|--------------------------------------|---|---|---|---------------|-----|-----|-----|-----|----|-------------------------------|-------|-------|-----|--|---|---|
| D0 | D1 | D2 | D3 | D4 | D5 | D6 | | | | D7 | 1ch | 2ch | 3ch | 4ch | 5ch | | 6ch | STEP1 | STEP2 | STB | | | |
| 0 | 1 | 0 | 0 | 0 | * | * | * | 3/4ch excitation mode selection | 2 phase | | | | | | | | | | | | | | |
| | | | 1 | 0 | * | * | * | | 1-2 phase (full torque) | | | | | | | | | | | | | | |
| | | | 0 | 1 | * | * | * | | 1-2 phase | | | | | | | | | | | | | ○ | |
| | | | 1 | 1 | * | * | * | | 4W1-2 phase | | | | | | | | | | | | | | |
| | | | * | * | * | 0 | 0 | * | 3/4ch current reference voltage selection | 100% (0.2V) | | | | | | | | | | | | | |
| | | | * | * | * | 1 | 0 | * | | 67% (0.134V) | | | | ○ | ○ | | | | | | | | |
| | | | * | * | * | 0 | 1 | * | | 50% (0.1V) | | | | | | | | | | | | | |
| | | | * | * | * | 1 | 1 | * | | 33% (0.066V) | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 0 | 3/4ch Channels 3 and 4 saturation/microstep selection | PWM | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 1 | | Microstep | | | | | | | | | | | | | ○ |
| 1 | 1 | 0 | 0 | 0 | * | * | * | 3ch energization direction (Saturated mode) | OFF | | | | | | | | | | | | | | |
| | | | 1 | 0 | * | * | * | | OUT3A → OUT3B | | | | | | | | | | | | | | |
| | | | 0 | 1 | * | * | * | | OUT3B → OUT3A | | | | ○ | | | | | | | | | | |
| | | | 1 | 1 | * | * | * | | Brake | | | | | | | | | | | | | | |
| | | | * | * | * | 0 | 0 | * | 4ch energization direction (Saturated mode) | OFF | | | | | | | | | | | | | |
| | | | * | * | * | 1 | 0 | * | | OUT4A → OUT4B | | | | | | | | | | | | | |
| | | | * | * | * | 0 | 1 | * | | OUT4B → OUT4A | | | | | ○ | | | | | | | | ○ |
| | | | * | * | * | 1 | 1 | * | | Brake | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 0 | 3/4ch PWM DECAY (Saturated mode) | Brake | | | | | | | | | | | | | |
| | | | * | * | * | * | * | 1 | | Standby mode | | | | ○ | ○ | | | | | | | | |
| | | | | | | 0 | * | * | * | 3/4ch energization direction (Microstep mode) | CW (Forward) | | | | | | | | | | | | |
| | | | | | | 1 | * | * | * | | CCW (Reverse) | | | | | | | | | | | | ○ |
| | | | | | | * | 0 | * | * | 3/4ch step hold (Microstep mode) | Cancel | | | | | | | | | | | | |
| | | | | | | * | 1 | * | * | | Hold | | | | | | | | | | | | |
| | | | | | | * | * | 0 | * | 3/4ch counter reset (Microstep mode) | Reset | | | | ○ | ○ | | | | | | | |
| | | | | | | * | * | 1 | * | | Cancel | | | | | | | | | | | | ○ |
| | | | * | * | * | 0 | 3/4ch output enable (Microstep mode) | Output OFF | | | | | | | | | | | | | | | |
| | | | * | * | * | 1 | | Output ON | | | | | | | | | | | | | | | |
| | | | * | * | * | * | (Dummy data) | | | | | | | | | | | | | | | | |
| | | | * | * | * | 1 | | | | | | | | | | | | | | | | | |

LV8044LP

Serial Logic Table (4)

| Input | | | | | | | Setting mode | Description | Remarks | Set channel | | | | | | PI | Serial data reflection timing | | |
|-------|----|----|----|----|----|----|--------------|--|------------------|-------------|-----|-----|-----|-----|-----|----|-------------------------------|-------|-------|
| D0 | D1 | D2 | D3 | D4 | D5 | D6 | | | | D7 | 1ch | 2ch | 3ch | 4ch | 5ch | | 6ch | STEP1 | STEP2 |
| 0 | 1 | 1 | 0 | * | * | * | * | Photo-sensor drive 1 | OFF | | | | | | | | | | |
| | | | 1 | * | * | * | * | | ON | | | | | | | | | | |
| | | | * | 0 | * | * | * | Photo-sensor drive 2 | OFF | | | | | | | | | | |
| | | | * | 1 | * | * | * | | ON | | | | | | | | | | |
| | | | * | * | 0 | * | * | Photo-sensor drive 3 (When PI3 output selected) | OFF | | | | | | | | | | |
| | | | * | * | 1 | * | * | | ON | | | | | | | | | | |
| | | | * | * | * | 0 | * | (Dummy data) | | | | | | | | | | | |
| | | | * | * | * | 1 | * | | | | | | | | | | | | |
| | | | * | * | * | * | 0 | (Dummy data) | | | | | | | | | | | |
| | | | * | * | * | * | 1 | | | | | | | | | | | | |
| 1 | 1 | 1 | 0 | * | * | * | * | PI3/MO select | PI3 Output | | | | | | | | | | |
| | | | 1 | * | * | * | * | | MO output | | | | | | | | | | |
| | | | * | 0 | * | * | * | MO output channel selection (When MO output selected) | 1/2ch | | | | | | | | | | *3 |
| | | | * | 1 | * | * | * | | 3/4ch | | | | | | | | | | |
| | | | * | * | 0 | * | * | MO output position | Initial position | | | | | | | | | | *4 |
| | | | * | * | 1 | * | * | | 1-2 phase | | | | | | | | | | |
| | | | * | * | * | 0 | 0 | Chopping frequency setting | 130KHz | | | | | | | | | | |
| | | | * | * | * | 1 | 0 | | 65KHz | | | | | | | | | | |
| | | | * | * | * | 0 | 1 | | 200KHz | | | | | | | | | | |
| | | | * | * | * | 1 | 1 | | 100KHz | | | | | | | | | | |



Notes

- *1: This serial data is only accepted when the IN51/IN52 pulse inputs are in the Low/Low states, respectively. It is ignored at all other times.
- *2: This serial data is only accepted when the IN61/IN62 pulse inputs are in the Low/Low states, respectively. It is ignored at all other times.
- *3: When D4 = 1, MO is only output if microstep mode is selected for channels 3 and 4. In PWM mode, this output is held fixed at the high level.
- *4: The MO output can be specified to be the 1-2 phase position only in 4W1-2 phase excitation mode. In all other excitation modes, the MO output position becomes the initial position regardless of the serial data values.

LV8044LP

Channels 1 and 2 Driver Circuit (Microstep drive stepping mode driver)

STEP1 Pin Function

| Input | | Operating mode |
|-------|---|----------------------|
| ST | STEP1 | |
| Low | * | Standby mode |
| High |  | Excitation step feed |
| High |  | Excitation step hold |

Excitation Mode Setting (D0 = 0, D1 = 0, D2 = 0)

| D3 | D4 | Excitation mode | Initial position | |
|----|----|------------------------------------|------------------|-------|
| | | | 1ch | 2ch |
| 0 | 0 | 2 phase excitation | 100% | -100% |
| 1 | 0 | 1-2 phase excitation (full torque) | 100% | 0% |
| 0 | 1 | 1-2 phase excitation | 100% | 0% |
| 1 | 1 | 4W1-2 phase excitation | 100% | 0% |

The initial state at power on is the initial position for each excitation mode when the counter is reset.

Reference Voltage Setting Serial Data: (D0 = 0, D1 = 0, D2 = 0)

| D5 | D6 | Current setting reference voltage (When microstep is 100%) |
|----|----|--|
| 0 | 0 | 0.2V |
| 1 | 0 | 0.134V |
| 0 | 1 | 0.1V |
| 1 | 1 | 0.066V |

The output current setting reference voltage can be switched between four levels with the serial data. This setting is useful for saving power in the motor powered hold state.

Calculating the Set Current

Since the reference voltage can be modified (0.2, 0.134, 0.1, and 0.66V) with the serial data, the output current can be set with the reference voltage and the resistor RF connected between the RF pin and ground.

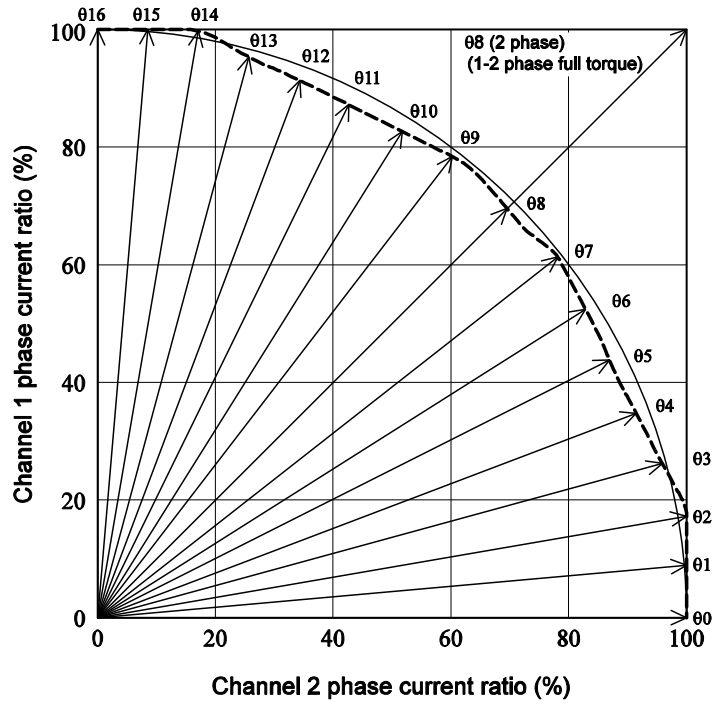
$$I_{OUT} = (<reference\ voltage> \times <set\ current\ ratio>) / <RF\ resistor\ value>$$

Example: If the reference voltage is 0.2 V, the set current ratio is 100%, and the RF resistor value is 1Ω, then the output current will be that shown below.

$$I_{OUT} = 0.2V \times 100\% / 1\Omega = 200mA$$

LV8044LP

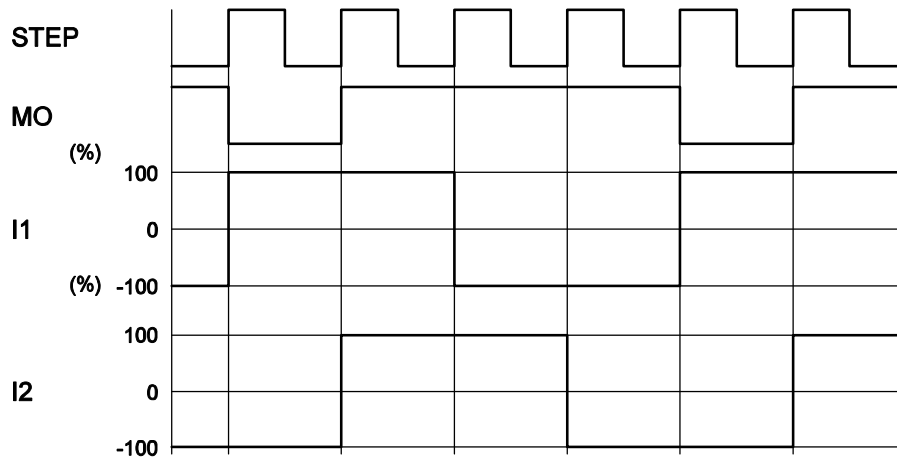
Output Current Vector Locus (With one step normalized to 90 degrees)



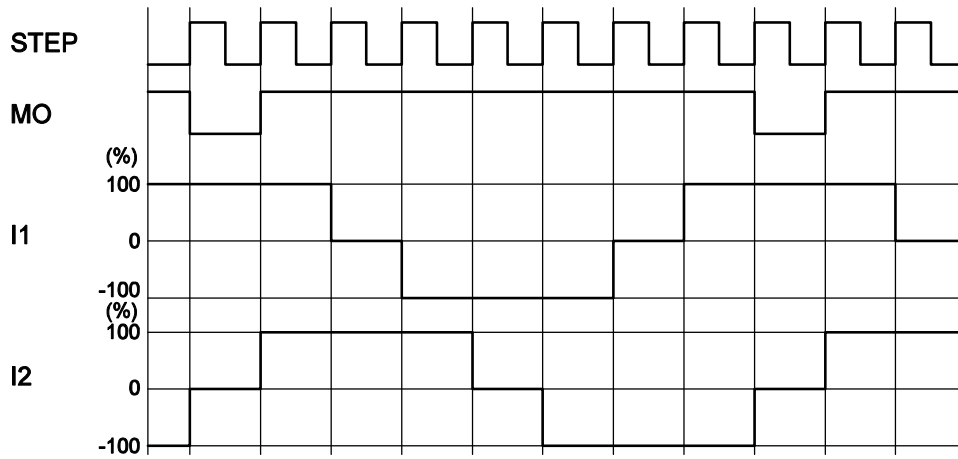
Set Current Ratios in the Different Excitation Modes

| STEP | 4W1-2 phase (%) | | 1-2 phase (%) | | 1-2 phase full torque (%) | | 2 phase (%) | |
|----------|-----------------|------|---------------|------|---------------------------|-----|-------------|-----|
| | 1ch | 2ch | 1ch | 2ch | 1ch | 2ch | 1ch | 2ch |
| theta 00 | 0 | 100 | 0 | 100 | 0 | 100 | | |
| theta 01 | 10 | 100 | | | | | | |
| theta 02 | 20 | 100 | | | | | | |
| theta 03 | 30 | 96.5 | | | | | | |
| theta 04 | 39.5 | 93.0 | | | | | | |
| theta 05 | 48.5 | 89 | | | | | | |
| theta 06 | 57.5 | 85.5 | | | | | | |
| theta 07 | 65.5 | 81.5 | | | | | | |
| theta 08 | 74.0 | 74.0 | 74.0 | 74.0 | 100 | 100 | 100 | 100 |
| theta 09 | 81.5 | 65.5 | | | | | | |
| theta 10 | 85.5 | 57.5 | | | | | | |
| theta 11 | 89 | 48.5 | | | | | | |
| theta 12 | 93.0 | 39.5 | | | | | | |
| theta 13 | 96.5 | 30 | | | | | | |
| theta 14 | 100 | 20 | | | | | | |
| theta 15 | 100 | 10 | | | | | | |
| theta 16 | 100 | 0 | 100 | 0 | 100 | 0 | | |

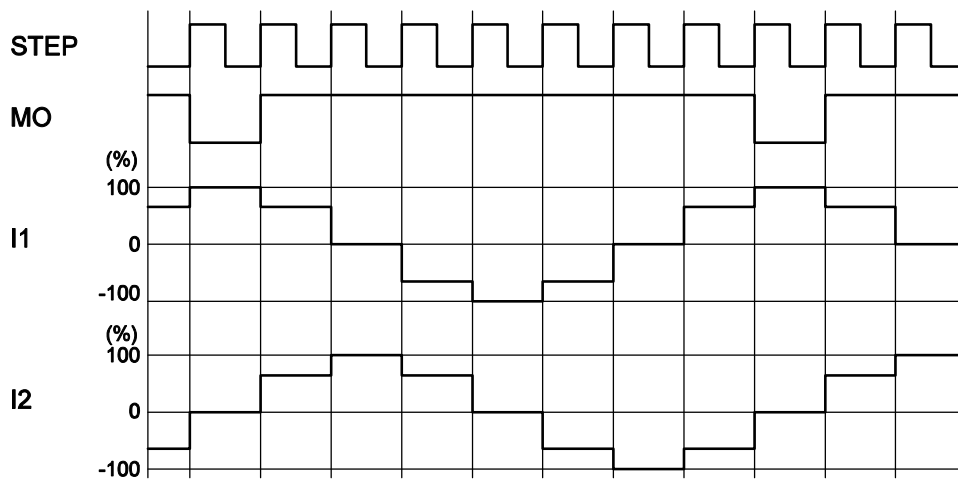
2 Phase Excitation (CW mode)



1-2 Phase Excitation full torque (CW mode)

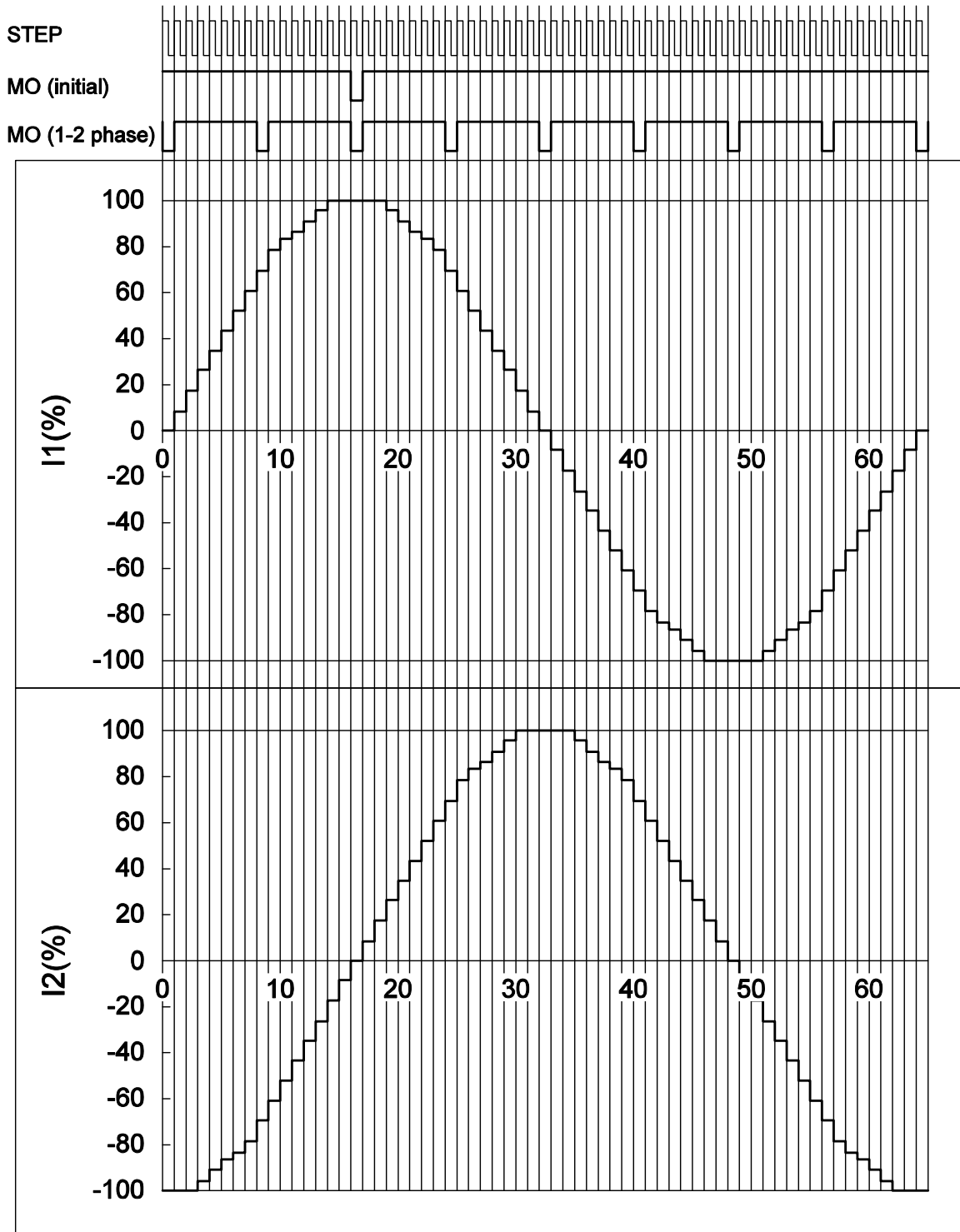


1-2 Phase Excitation (CW mode)



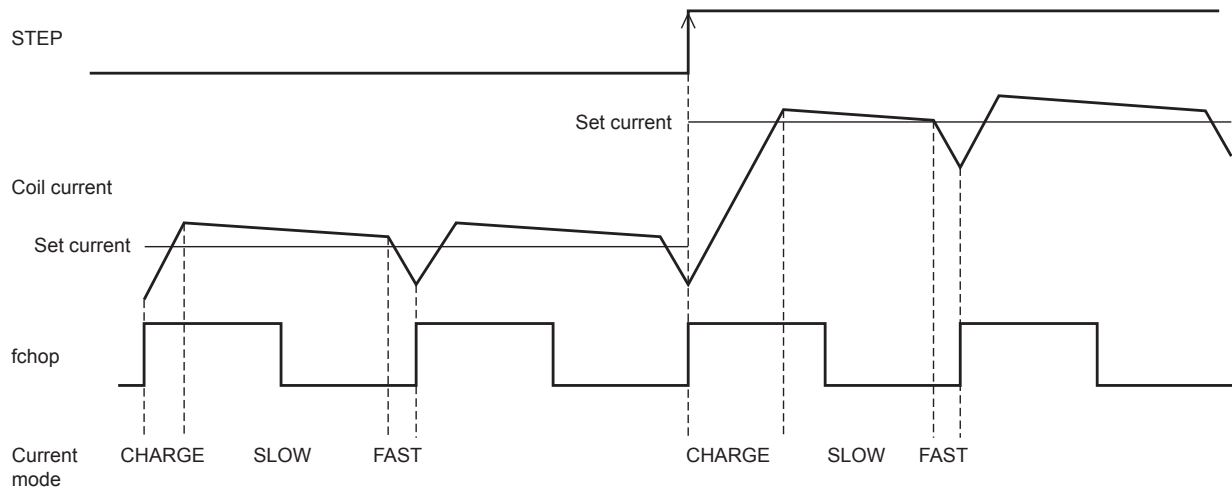
LV8044LP

4W1-2 Phase Excitation (CW mode)

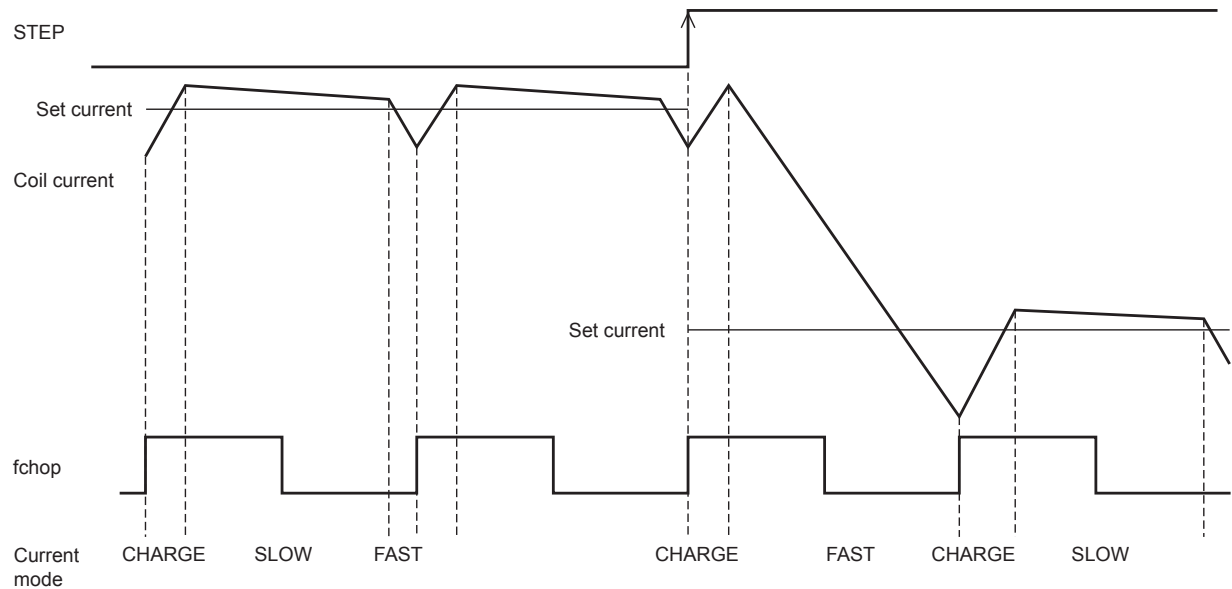


Current Control Operation Specifications

- Sine wave increasing direction



- Sine wave decreasing direction



Each of the current modes operates with the follow sequence.

- The IC enters charge mode when the chopping oscillation starts. (A period of charge mode is forcibly present in 1/8 of the period, regardless of which of the coil current (ICOIL) and the set current (IREF) is larger.)
- In charge mode, the coil current (ICOIL) and the set current (IREF) are compared.

If an $ICOIL < IREF$ state exists during the charge period:

The IC operates in charge mode until $ICOIL \geq IREF$. After that, it switches to slow decay mode and then switches to fast decay mode in the last 1/8 of the period.

If no $ICOIL < IREF$ state exists during the charge period:

The IC switches to fast decay mode and the coil current is attenuated with the fast decay operation until the end of the chopping period.

The above operation is repeated. Normally, in the sine wave increasing direction the IC operates in slow (+fast) decay mode, and in the sine wave decreasing direction the IC operates in fast decay mode until the current is attenuated and reaches the set value and the IC operates in slow decay mode.

LV8044LP

Chopping Frequency Setting (D6 and D7 in the serial data)

This IC integrates an internal oscillator circuit and allows the chopping frequency used in constant-current control to be switched with the serial data (111***, D6, D7) setting.

| Data D6 | Data D7 | Chopping frequency |
|---------|---------|--------------------|
| 0 | 0 | 130KHz |
| 1 | 0 | 65KHz |
| 0 | 1 | 200KHz |
| 1 | 1 | 100KHz |

Monitor Output Setting (Serial data bits D3, D4, and D5)

The signal output from the PI3/MO pin can be switched with the serial data (111, D3, ****) setting.

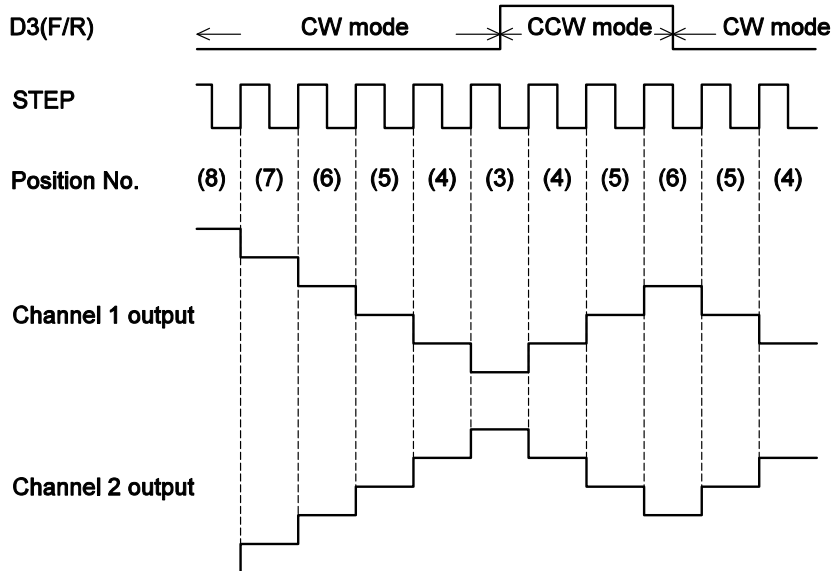
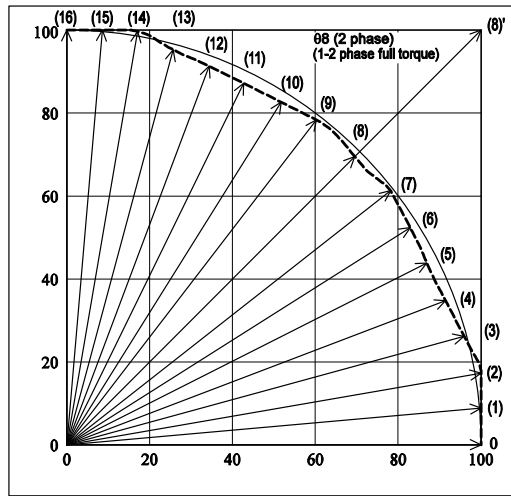
| Data D3 | PI3/MO pin output |
|---------|--|
| 0 | Photosensor drive output 3 |
| 1 | Stepping position detection monitor output |

It is also possible to select which of channels 1 and 2 or channels 3 and 4 are output from the monitor pin with the serial data (111*, D4, D5, **) setting. The MO output position used to detect the driver excitation position in microstepping drive mode can also be switched. The state MO = Low is output at the output position.

| Data D4 | Data D5 | Channels 1 and 2 excitation mode | Channels 3 and 4 excitation mode | MO output |
|---------|---------|------------------------------------|------------------------------------|---|
| 0 | 0 | 2 phase excitation | | Channels 1 and 2 monitor/initial position |
| 0 | 1 | | | Channels 1 and 2 monitor/initial position |
| 0 | 0 | 1-2 phase excitation (full torque) | | Channels 1 and 2 monitor/initial position |
| 0 | 1 | | | Channels 1 and 2 monitor/initial position |
| 0 | 0 | 1-2 phase excitation | | Channels 1 and 2 monitor/initial position |
| 0 | 1 | | | Channels 1 and 2 monitor/initial position |
| 0 | 0 | 4W1-2 phase excitation | | Channels 1 and 2 monitor/initial position |
| 0 | 1 | | | Channels 1 and 2 monitor/1-2 phase position |
| 1 | 0 | | 2 phase excitation | Channels 3 and 4 monitor/initial position |
| 1 | 1 | | | Channels 3 and 4 monitor/initial position |
| 1 | 0 | | 1-2 phase excitation (full torque) | Channels 3 and 4 monitor/initial position |
| 1 | 1 | | | Channels 3 and 4 monitor/initial position |
| 1 | 0 | | 1-2 phase excitation | Channels 3 and 4 monitor/initial position |
| 1 | 1 | | | Channels 3 and 4 monitor/initial position |
| 1 | 0 | | 4W1-2 phase excitation | Channels 3 and 4 monitor/initial position |
| 1 | 1 | | | Channels 3 and 4 monitor/1-2 phase position |
| 1 | 0 | | PWM drive mode | Output held fixed at the high level |
| 1 | 1 | | | Output held fixed at the high level |

LV8044LP

Basic Set Current Step Switching (STEP pin) and Forward/Reverse Switching (D3 in the serial data) Operations



The IC internal D/A converter advances by 1 bits on the rising edge of the input step pulse.

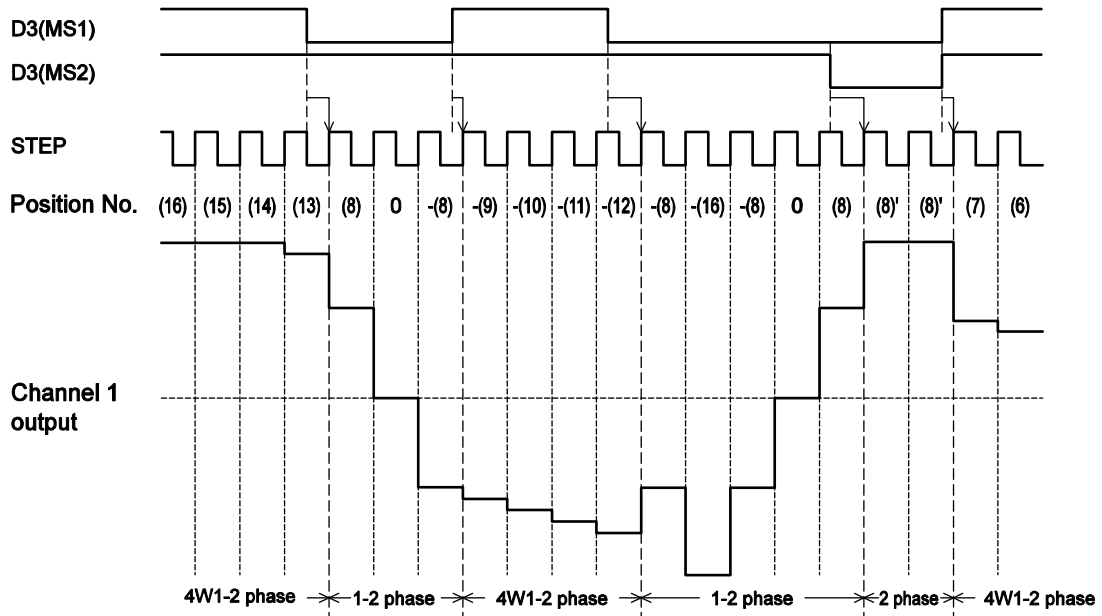
The CW/CCW mode can be switched with the serial data (100, D3, ****) setting. The operation progresses with the position number decreasing in CW mode and increasing in CCW mode.

In CW mode, the channel 2 current phase is delayed by 90 degrees relative to the channel 1 current.

In CCW mode, the channel 2 current phase is advanced by 90 degrees relative to the channel 1 current.

LV8044LP

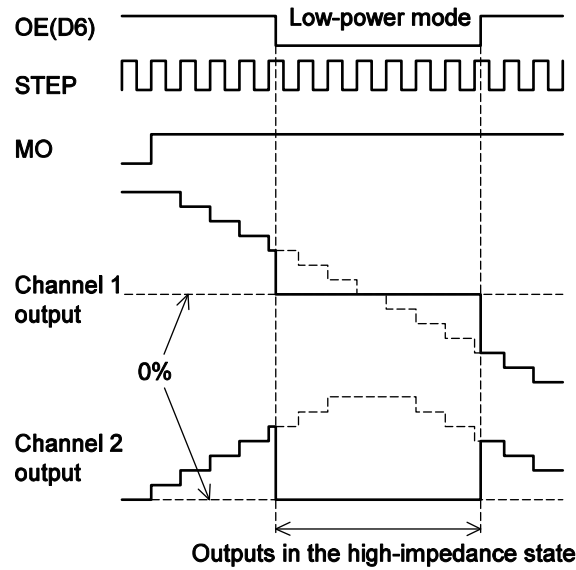
Excitation Mode Switching During Operation (D3 and D4 in the serial data)



If the excitation mode is switched when power is applied to the motor, the operation follows the sequence shown below. (CW mode)

| Before excitation mode switching | | Step position after excitation mode switching | | | |
|----------------------------------|-------------|---|-----------|---------------------|---------|
| Excitation mode | Position | 4W1-2 phase | 1-2 phase | 2 phase full torque | 2 phase |
| 4W1-2 phase | (16) | / | (8) | (8)' | (8)' |
| | (15) to (9) | | (8) | (8)' | (8)' |
| | (8) | | 0 | 0 | (8)' |
| | (7) to (1) | | (8) | (8)' | (8)' |
| | 0 | | -(8) | -(8)' | -(8)' |
| 1-2 phase | (16) | (15) | / | (8)' | (8)' |
| | (8) | (7) | | 0 | (8)' |
| | 0 | -(1) | | -(8)' | -(8)' |
| 2 phase full torque | (16) | (15) | (8) | / | (8)' |
| | (8)' | (7) | 0 | | (8)' |
| | 0 | -(1) | -(8) | | -(8)' |
| 2 phase | (8)' | (7) | 0 | 0 | / |

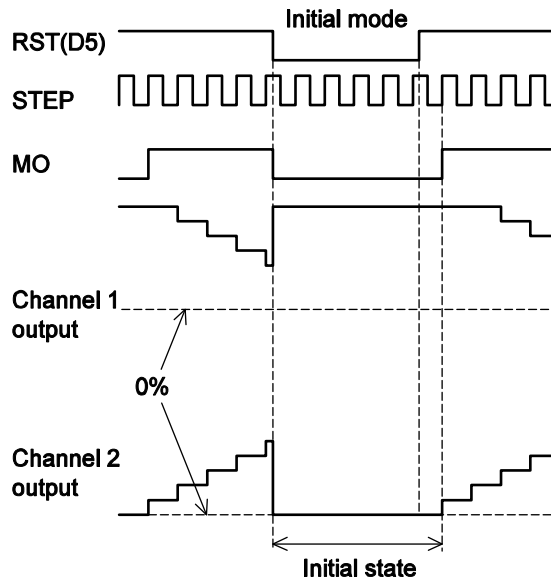
Output Enable Function (D6 in the serial data)



When the OE bit in the serial data, D6 (100, ***, D6, *), is set to 0, the output is turned off and set to the high-impedance state at the rise of STB.

Since, however, the internal logic circuits operate in this state, the position number will be advanced if a step input is applied. Therefore, when the OE bit (D6) is returned to 1, a level according to the position number advanced by the step input will be output.

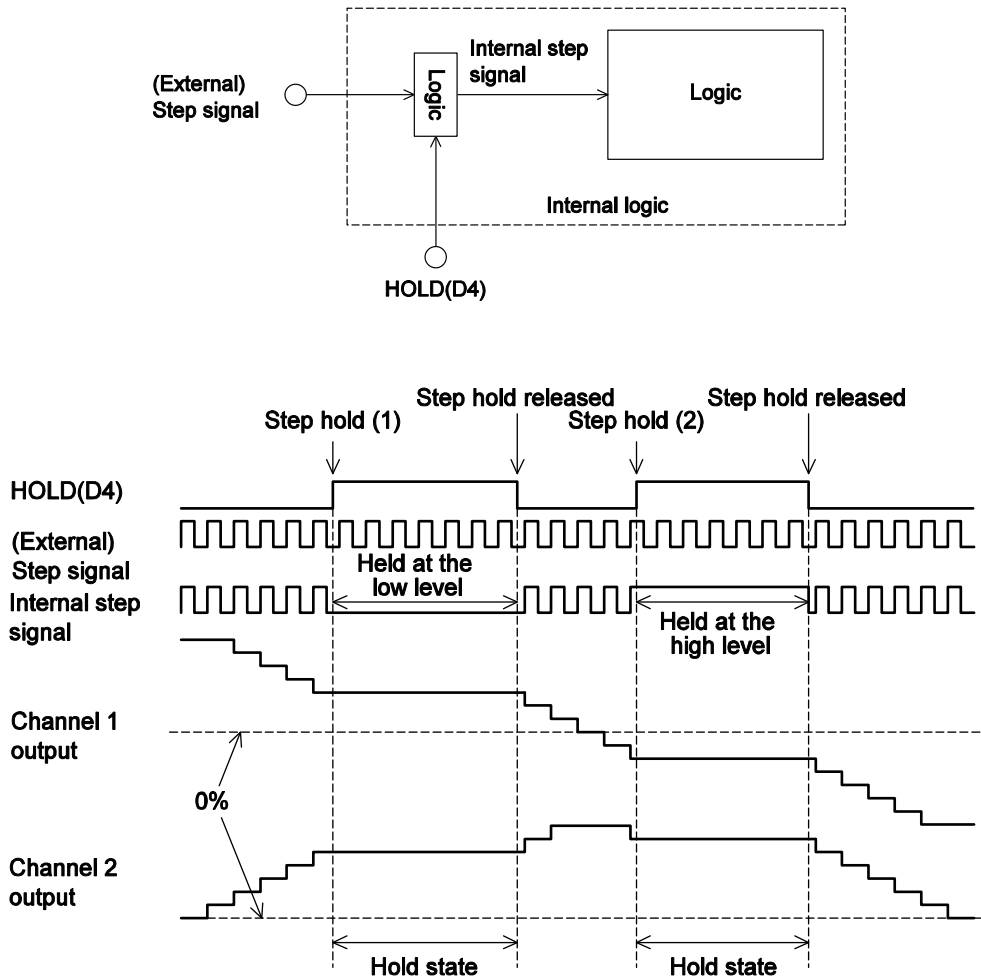
Counter Reset Function (D5 in the serial data)



When the reset bit in the serial data, D5 (100, **, D5, **), is set to 0, the output goes to the initial state at the rise of STB and the MO output goes low.

Then, when the reset bit (D5) is next set to 1, the position number will advance at the next step input.

Step Hold Function (D4 in the serial data)



When the hold bit in the serial data, D4 (100, *, D4, ***), is set to 1, the external step state at that time is held without change as the internal step state.

Since the (external) step state is low at the timing of the step hold operation (1) in the figure, the internal step state is held at the low level, and since the (external) step state is high at the timing of the step hold operation (1), the internal step state is held at the high level.

When the hold data (D) is set to 0, the internal state is synchronized with the external step signal.

The output is held at the state at the point where the step hold was applied and after the step hold is released, it advances with the timing of the next step input (rising edge).

As long as the IC is in the hold state, the position number does not advance even if external step pulses are applied.

LV8044LP

Channels 3 and 4 Driver Circuit (Saturated drive/microstep drive)

Driver Mode Setting (D0 = 0, D1 = 1, D2 = 0)

| D7 data value | Drive mode | Pin functions | Notes |
|---------------|-----------------|---------------|--|
| 0 | Saturated drive | PWM3 | Used as the channel 3 PWM input pin |
| 1 | Microstep drive | STEP2 | Used as the channels 3 and 4 excitation step input pin |

The channels 3 and 4 driver circuit can be switched between the following operating modes by bit D7 in the serial data (010, ****, D7).

- (1) Two saturated mode driver channels
- (2) One microstep drive stepping motor driver channel

Microstep Drive Stepping Motor Driver

The basic functionality provided is identical to that of the channels 1 and 2 stepping motor driver. See section 10-2 for details on the serial data settings.

PWM Saturated Mode Driver

Channel 3 Truth Table (PWM mode: D0 = 1, D1 = 1, D2 = 0)

| Input | | | | | Output | | Operating mode |
|-------|------|----|----|----|--------|-------|-------------------------|
| ST | PWM3 | D3 | D4 | D7 | OUT3A | OUT3B | |
| Low | * | * | * | * | OFF | OFF | Standby mode |
| High | Low | 0 | 0 | * | OFF | OFF | Output off |
| High | Low | 1 | 0 | * | High | Low | CW (forward) |
| High | Low | 0 | 1 | * | Low | High | CCW (reverse) |
| High | Low | 1 | 1 | * | Low | Low | Brake |
| High | High | * | * | 0 | Low | Low | SLOW DECAY (brake) |
| High | High | * | * | 1 | OFF | OFF | FAST DECAY (output off) |

Channel 4 Truth Table (PWM mode: D0 = 1, D1 = 1, D2 = 0)

| Input | | | | | Output | | Operating mode |
|-------|------|----|----|----|--------|-------|-------------------------|
| ST | PWM4 | D5 | D6 | D7 | OUT4A | OUT4B | |
| Low | * | * | * | * | OFF | OFF | Standby mode |
| High | Low | 0 | 0 | * | OFF | OFF | Output off |
| High | Low | 1 | 0 | * | High | Low | CW (forward) |
| High | Low | 0 | 1 | * | Low | High | CCW (reverse) |
| High | Low | 1 | 1 | * | Low | Low | Brake |
| High | High | * | * | 0 | Low | Low | SLOW DECAY (brake) |
| High | High | * | * | 1 | OFF | OFF | FAST DECAY (output off) |

*: Don't care

Channels 5 and 6 Driver Circuit (Constant-current drive)

Output Function

When the channels 5 and 6 driver circuit is used to drive an actuator, it can be controlled either from the serial data or from the IN51, IN52, IN61, and IN62 parallel signals.

When the parallel input signals IN51 (IN61)/IN52 (IN62) are in the low/low state (note that since these inputs are pulled down internally in the IC, the open/open state can also be used), the output mode will be determined by the serial data.

If the parallel input signals are in any state other than the above, the serial data will be ignored and the output mode will be determined by the parallel inputs.

Truth Table (Channel 5: D0 = 0, D1 = 0, D2 = 1)

| Parallel input | | Serial data | | Outputs | | Mode |
|----------------|------|-------------|----|---------|-------|---------------|
| IN51 | IN52 | D3 | D4 | OUT5A | OUT5B | |
| Low | Low | 0 | 0 | OFF | OFF | Standby mode |
| | | 1 | 0 | High | Low | CW (forward) |
| | | 0 | 1 | Low | High | CCW (reverse) |
| | | 1 | 1 | Low | Low | Brake |
| High | Low | * | * | High | Low | CW (forward) |
| Low | High | * | * | Low | High | CCW (reverse) |
| High | High | * | * | Low | Low | Brake |

Truth Table (Channel 6: D0 = 0, D1 = 0, D2 = 1)

| Parallel input | | Serial data | | Outputs | | Mode |
|----------------|------|-------------|----|---------|-------|---------------|
| IN61 | IN62 | D5 | D6 | OUT6A | OUT6B | |
| Low | Low | 0 | 0 | OFF | OFF | Standby mode |
| | | 1 | 0 | High | Low | CW (forward) |
| | | 0 | 1 | Low | High | CCW (reverse) |
| | | 1 | 1 | Low | Low | Brake |
| High | Low | * | * | High | Low | CW (forward) |
| Low | High | * | * | Low | High | CCW (reverse) |
| High | High | * | * | Low | Low | Brake |

*: Don't care

Constant-Current Control

Reference Voltage Setting (D0 = 1, D1 = 0, D2 = 1, D3 = 0 (channel 5) or D3 = 1 (channel 6))

| D4 | D5 | D6 | D7 | Current setting reference voltage |
|----|----|----|----|-----------------------------------|
| 0 | 0 | 0 | 0 | 0.300V |
| 1 | 0 | 0 | 0 | 0.200V |
| 0 | 1 | 0 | 0 | 0.190V |
| 1 | 1 | 0 | 0 | 0.180V |
| 0 | 0 | 1 | 0 | 0.170V |
| 1 | 0 | 1 | 0 | 0.165V |
| 0 | 1 | 1 | 0 | 0.160V |
| 1 | 1 | 1 | 0 | 0.155V |
| 0 | 0 | 0 | 1 | 0.150V |
| 1 | 0 | 0 | 1 | 0.145V |
| 0 | 1 | 0 | 1 | 0.140V |
| 1 | 1 | 0 | 1 | 0.135V |
| 0 | 0 | 1 | 1 | 0.130V |
| 1 | 0 | 1 | 1 | 0.120V |
| 0 | 1 | 1 | 1 | 0.110V |
| 1 | 1 | 1 | 1 | 0.100V |

The constant-current setting for channels 5 and 6 can be set individually for each channel.
 (When D3 is 0, channel 5 is set, and when D3 is 1, channel 6 is set.)

The constant-current output value is set by the constant-current reference voltage set with the serial data and the value of the resistor (referred to as "RF" here) connected to the RF5 or RF6 pin.
 The formula below is used to calculate the constant-current output value.

$$\langle \text{Constant-current output level} \rangle = \langle \text{current setting reference voltage} \rangle / \langle \text{RF resistor} \rangle$$

