NIPPON PRECISION CIRCUITS INC.

# SM8613AV

Laser Switching Driver IC

## OVERVIEW

The SM8613AV is a portable CD player laser diode (LD) driver IC. Conventional portable CD players use a fixed-current LD drive method, but this increases the power dissipation and limits battery life. The SM8613AV employs an intermittent LD driver duty operation to reduce the laser power dissipation, which greatly reduces the current consumption when reading data and extends battery driver life.

## FEATURES

- 2.3V low-voltage supply operation
- Intermittent-duty laser driver built-in (4-times speed read, 38MHz max. intermittent output)
- Laser switching frequency range: 8.6 to 38MHz
- Fixed-current drive/intermittent-duty drive switch function
- Intermittent current duty ratio adjust function
- Automatic power control (APC) function using luminosity-monitoring photodiode (PD)
- Low power dissipation
- Package: 16-pin VSOP (lead-free)

## APPLICATIONS

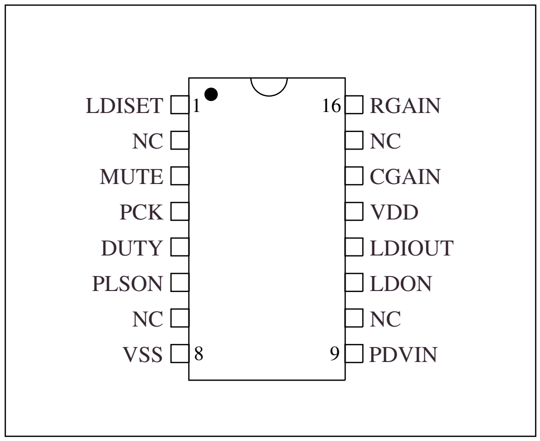
- Portable CD player

## ORDERING INFORMATION

| Device | Package |
|---|---|
| SM8613AV | 16-pin VSOP |

## PINOUT

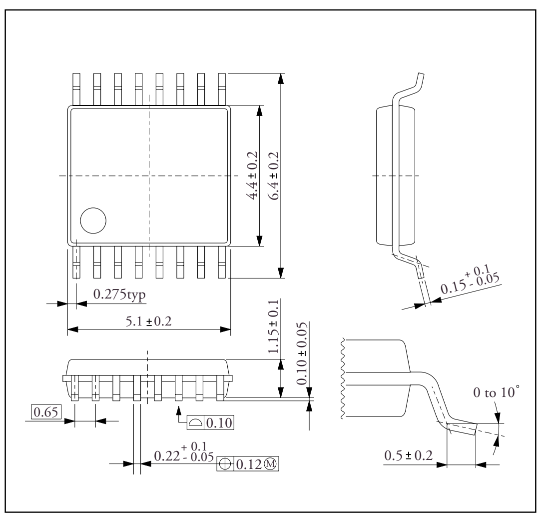
(Top view)



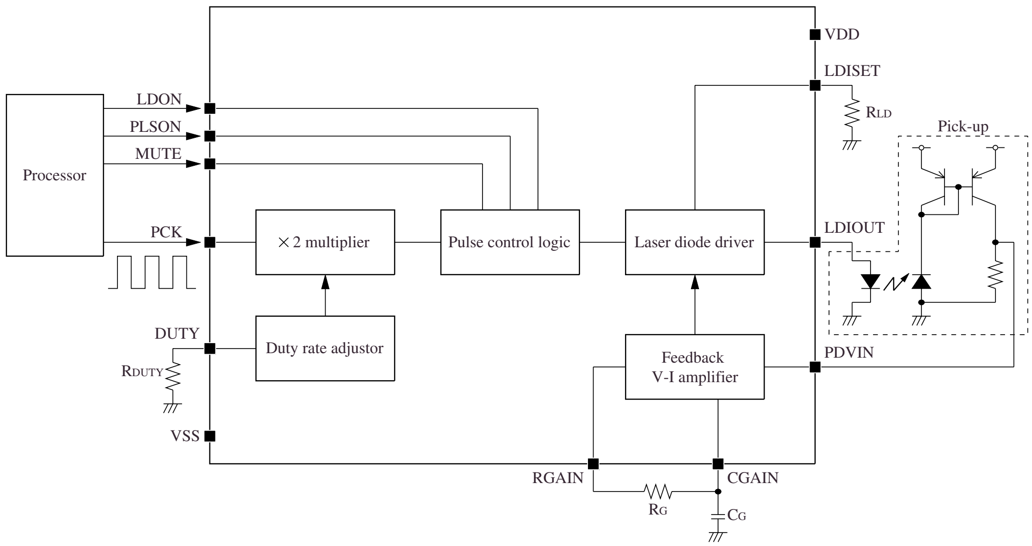

## PACKAGE DIMENSIONS

(Unit: mm)

Weight: 0.07g



# BLOCK DIAGRAM



## PIN DESCRIPTION

<table>
<tr><th>Number</th><th>Name</th><th>i/o</th><th>Description</th></tr>
<tr><td>1</td><td>LDISET</td><td>o</td><td>LD drive maximum current setting resistor connection</td></tr>
<tr><td>2</td><td>NC</td><td>–</td><td>No connection (must be open)</td></tr>
<tr><td>3</td><td>MUTE</td><td>ip</td><td>Intermittent-drive stop signal
<table>
<tr><th>MUTE</th><th>Laser drive state</th></tr>
<tr><td>L</td><td>LD intermittent drive control (PLSON = H)</td></tr>
<tr><td>H</td><td>LD constant-current drive</td></tr>
</table></td></tr>
<tr><td>4</td><td>PCK</td><td>i</td><td>Intermittent control reference pulse input</td></tr>
<tr><td>5</td><td>DUTY</td><td>o</td><td>Intermittent-duty ratio adjust resistor connection</td></tr>
<tr><td>6</td><td>PLSON</td><td>ip</td><td>Intermittent-drive control signal
<table>
<tr><th>PLSON</th><th>Laser drive state</th></tr>
<tr><td>L</td><td>LD constant-current drive</td></tr>
<tr><td>H</td><td>LD intermittent drive control</td></tr>
</table></td></tr>
<tr><td>7</td><td>NC</td><td>–</td><td>No connection (must be open)</td></tr>
<tr><td>8</td><td>VSS</td><td>–</td><td>Ground (0V DC)</td></tr>
<tr><td>9</td><td>PDVIN</td><td>i</td><td>Laser luminosity monitor voltage input</td></tr>
<tr><td>10</td><td>NC</td><td>–</td><td>No connection (must be open)</td></tr>
<tr><td>11</td><td>LDON</td><td>ip</td><td>LD drive current control signal
<table>
<tr><th>LDON</th><th>Laser drive state</th></tr>
<tr><td>L</td><td>LD drive stop control (sleep mode)</td></tr>
<tr><td>H</td><td>LD drive ON</td></tr>
</table></td></tr>
<tr><td>12</td><td>LDIOUT</td><td>o</td><td>LD drive current output</td></tr>
<tr><td>13</td><td>VDD</td><td>–</td><td>Supply voltage (2.5V DC)</td></tr>
<tr><td>14</td><td>CGAIN</td><td>o</td><td>APC frequency response control capacitor connection</td></tr>
<tr><td>15</td><td>NC</td><td>–</td><td>No connection (must be open)</td></tr>
<tr><td>16</td><td>RGAIN</td><td>o</td><td>APC loop gain control resistor connection</td></tr>
</table>

ip: Built-in pull-down resistor

# SPECIFICATIONS

## Absolute Maximum Ratings

| Parameter | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{DD}$ | – 0.5 to 7.0 | V |
| Input voltage | $V_{IN}$ | – 0.5 to $V_{DD}$ + 0.5 | V |
| Input current | $I_{IN}$ | – 3.0 to + 3.0 | mA |
| Operating temperature | $T_{OPR}$ | – 20 to 70 | °C |
| Storage temperature | $T_{STG}$ | – 40 to 125 | °C |
| Power dissipation | $P_W$ | 96 | mW |

## DC Electrical Characteristics

$V_{DD}$ = 2.5V, Ta = + 25 °C unless otherwise noted

| Parameter | Symbol | Condition | Rating | | | Unit | Test level |
|---|---|---|---|---|---|---|---|
| | | | min | typ | max | | |
| Guaranteed operating supply voltage | $V_{DD}$ | | 2.3 | 2.5 | 3.3 | V | I |
| Current consumption | $I_{DD1}$ | PDVIN–LDIOUT short, $R_{LDIOUT}$ = 4Ω, LDON = HIGH, Excluding LDIOUT current | 1.0 | 1.7 | 2.3 | mA | I |
| | $I_{DD2}$ | LDON = LOW | – | – | 30 | μA | I |

## Input Specifications

$V_{DD}$ = 2.5V, Ta = + 25 °C unless otherwise noted

| Parameter | Symbol | Condition | Rating | | | Unit | Test level |
|---|---|---|---|---|---|---|---|
| | | | min | typ | max | | |
| PCK HIGH-level voltage | $V_{IHPCK}$ | | $V_{DD} \times 0.7$ | – | – | V | I |
| PCK LOW-level voltage | $V_{ILPCK}$ | | – | – | $V_{DD} \times 0.3$ | V | I |
| PCK HIGH-level sink current | $I_{HPCK}$ | | – | – | 20 | μA | I |
| LDON HIGH-level voltage | $V_{IHLDON}$ | | $V_{DD} \times 0.7$ | – | – | V | I |
| LDON LOW-level voltage | $V_{ILLDON}$ | | – | – | $V_{DD} \times 0.3$ | V | I |
| LDON HIGH-level sink current | $I_{HLDON}$ | | – | – | 20 | μA | I |
| PLSON HIGH-level voltage | $V_{IHPLSON}$ | | $V_{DD} \times 0.7$ | – | – | V | I |
| PLSON LOW-level voltage | $V_{ILPLSON}$ | | – | – | $V_{DD} \times 0.3$ | V | I |
| PLSON HIGH-level sink current | $I_{HPLSON}$ | | – | – | 20 | μA | I |
| MUTE HIGH-level voltage | $V_{IHMUTE}$ | | $V_{DD} \times 0.7$ | – | – | V | I |
| MUTE LOW-level voltage | $V_{ILMUTE}$ | | – | – | $V_{DD} \times 0.3$ | V | I |
| MUTE HIGH-level sink current | $I_{HMUTE}$ | | – | – | 20 | μA | I |

## Electrical Characteristics

$V_{DD}$ = 2.5V, Ta = + 25 °C unless otherwise noted

| Parameter | Symbol | Condition | Rating | | | Unit | Test level |
|---|---|---|---|---|---|---|---|
| | | | min | typ | max | | |
| PCK minimum input frequency | $f_{PCKMIN}$ | | – | – | 4.3 | MHz | I |
| PCK maximum input frequency | $f_{PCKMAX}$ | | 19 | – | – | MHz | I |
| Intermittent current output frequency range | $f_{LD}$ | | 8.6 | – | 38 | MHz | I |
| LDON response time | $t_{LDON}$ | LDON = LOW to HIGH, I(LDIOUT) to 90%, $C_G$ = 6800pF | – | – | 110 | µs | II |
| PLSON, MUTE response time 1 | $t_{PLSON1}$ | PLSON = LOW to HIGH (MUTE: LOW), MUTE = HIGH to LOW (PLSON: HIGH), until the duty ratio stabilizes | – | – | 20 | µs | II |
| PLSON, MUTE response time 2 | $t_{PLSON2}$ | PLSON = HIGH to LOW (MUTE: LOW), MUTE = LOW to HIGH (PLSON: HIGH) | – | – | 25 | ns | II |
| LDIOUT maximum output current | $I_{LDMAX}$ | PDVIN = 0V | 40 | – | – | mA | I |
| LDIOUT intermittent current rise time | $t_{LDIR}$ | | – | – | 10 | ns | II |
| LDIOUT intermittent current fall time | $t_{LDIF}$ | | – | – | 10 | ns | II |
| LDISET voltage | $V_{LDISET}$ | 1/3$V_{DD}$ | 0.75 | 0.83 | 0.92 | V | I |
| PDVIN convergence voltage | $V_{PDVIN}$ | $R_G$ = 33kΩ, $V_{DD}$ = 2.5V, PDVIN–LDIOUT short, $R_{LDIOUT}$ = 20Ω | 145 | 160 | 175 | mV | I |
| PDVIN input impedance | $Z_{PDVIN}$ | | 1 | – | – | MΩ | II |
| APC loop cutoff frequency | $f_{APC}$ | $C_G$ = 6800pF | – | 25 | 100 | kHz | I |
| Minimum duty ratio | $DR_{MIN}$ | PCK = 4.3MHz, $R_{DUTY}$ = 15kΩ | 20 | – | 40 | % | I |
| Maximum duty ratio | $DR_{MAX}$ | PCK = 4.3MHz, $R_{DUTY}$ = 5kΩ | 55 | – | 85 | % | I |
| Minimum LD current ON time | $t_{LDION}$ | | – | 14 | – | ns | II |

Note 1) LDON has internal pull-down resistor.
Note 2) PLSON has internal pull-down resistor.
Note 3) MUTE has internal pull-down resistor.
Note 4) LDISET is in high-impedance state when LDON is HIGH.
Note 5) DUTY is in high-impedance state when LDON is HIGH.

## Test level description

| | |
|---|---|
| **Test level I** | 100% of devices tested at + 25°C |
| **Test level II** | Specifications guaranteed according to design and evaluation tests. |

# FUNCTIONAL DESCRIPTION

## LD Driver Control

The LD is controlled by the 3 logic-level signals on LDON, PLSON, and MUTE. When LDON is HIGH, the LD is in drive mode and the drive current is output on LDIOUT. When LDON is LOW (sleep mode), the LD drive mode stops (LDIOUT output current = 0mA).

Also when LDON is HIGH, LD intermittent drive mode operation occurs when PLSON is HIGH and MUTE is LOW.

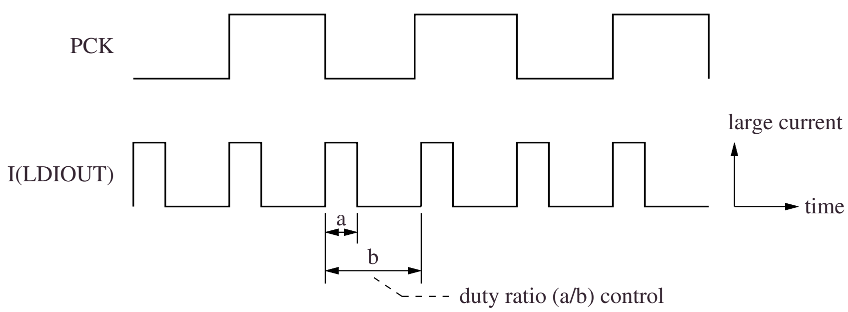
Table 1. Control signals and laser drive states

| LDON | PLSON | MUTE | Laser drive state |
|---|---|---|---|
| H | L | L | LDIOUT constant-current output |
| H | L | H | LDIOUT constant-current output |
| H | H | L | LDIOUT intermittent current output |
| H | H | H | LDIOUT constant-current output |
| L | × | × | LDIOUT = 0mA (sleep mode) |

Note) × : Don't care.

## Frequency Multiplier Function and LD Drive Current Duty Ratio Setting

The SM8613AV multiplies the PCK input frequency by 2, which is then used as the intermittent-drive reference frequency. The intermittent drive LD current ON time is shown in the following figure.




The intermittent current output from LDIOUT is automatically adjusted as the frequency changes to maintain the duty ratio almost constant. The intermittent current duty ratio is set by resistor $R_{DUTY}$ connected between DUTY and VSS pins, and is given by the following equation.

$$dutyratio = \left(1 - \frac{\frac{3}{2}V(DUTY)}{\frac{1}{2}VDD}\right) \times 100 = \frac{44[\mathrm{k}\Omega] - 2 \times R_{DUTY}}{R_{DUTY} + 44[\mathrm{k}\Omega]} \times 100\ [\%]$$

$$V(DUTY) = \frac{R_{DUTY}}{R_{DUTY} + 44[\mathrm{k}\Omega]} \times VDD\ [\mathrm{V}]$$

$R_{DUTY}$ : resistor connected to DUTY pin [kΩ]

## Laser Diode Drive Current Mid-value Set Function

The laser diode drive current mid-value can be adjusted by changing the resistance $R_{LD}$ connected between the LDISET and VSS pins. The laser diode drive current mid-value reference value $I_{LD0}$, given by the following equation, is set to the LDIOUT output current when the PDVIN voltage is in balance state (147 to 193mV). Note that the actual LDIOUT current may change due to feedback gain, and laser diode/photo diode tolerance variations.

If $R_G$ is not connected, the output current has no relationship to the reference current value, but is determined by the PDVIN convergence voltage.

$$I_{LD0} = I_{LDSET} \times 120 = \frac{40VDD}{R_{LD}} \ [\mathrm{A}]$$

$R_{LD}$ : LDISET connected resistor [Ω]

## APC Loop Gain Setting

The APC loop gain can be adjusted using an external resistor $R_G$. The gain set resistor, $R_G$, is connected between RGAIN and CGAIN. The PDVIN voltage to laser drive current open-loop gain is given approximately by the following equation.

$$Gm_{PDVIN} = 1.15 \times 10^{-4} R_G \ [\mathrm{S}]$$

ΔLDIOUT current /ΔPDVIN voltage ratio [S]
$R_G$ : RGAIN–CGAIN resistor [Ω]

If the external resistor $R_G$ is removed, the maximum gain Gm = 26 [S] is selected.

## APC Loop Cutoff Frequency Setting

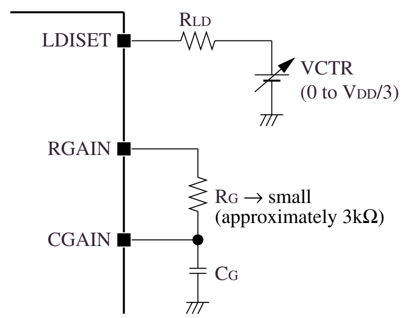
The APC loop cutoff frequency $f_{APC}$ is determined by the capacitor $C_G$ connected between CGAIN and VSS pins. The same result occurs if $C_G$ is connected between RGAIN and CGAIN pins.

$$f_{APC} = \frac{1}{2\pi 950 C_G} \ [\mathrm{Hz}]$$

## Laser APC Convergence Current External Signal Adjustment

The LD convergence current is determined by the internal bias voltage. However, if the APC loop gain resistor $R_G$ is small, the convergence current can be adjusted externally.

The convergence current is adjusted by the LDISET current, shown in the figure below. With VCTR in the range 0 to $1/3V_{DD}$, the LDISET current decreases with increasing VCTR, and the laser convergence current center point also decreases in response.



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