MITSUBISHI ⟨DIGITAL ASSP⟩
M66510P/FP

LASER-DIODE DRIVER

DESCRIPTION
The M66510 is a semiconductor laser diode driver that drives a semiconductor laser of the type whose cathode and the anode of monitor photodiode are connected to the stem.
Laser driving current of up to 120mA can be set by applying constant voltage from outside to drive the laser diode.
It operates from a 5V single power supply, allowing switching of laser driving current at a speed of 20M bits/sec.
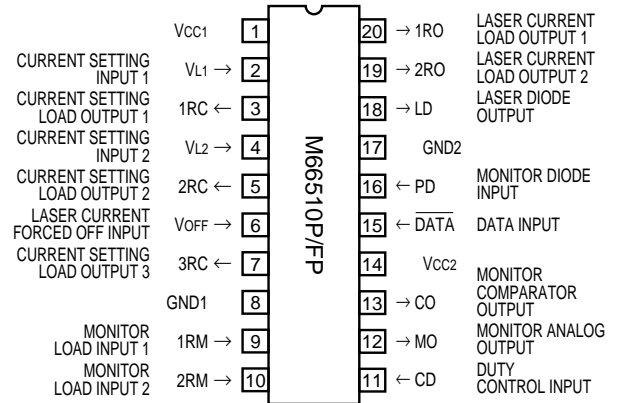*: Our semiconductor laser is of R type.

FEATURES
• Built-in two outputs for monitoring laser power (comparator output and analog output)
• With laser driving current forced off pin
• High-speed switching (20M bits/s)
• High driving current (120mA max.)
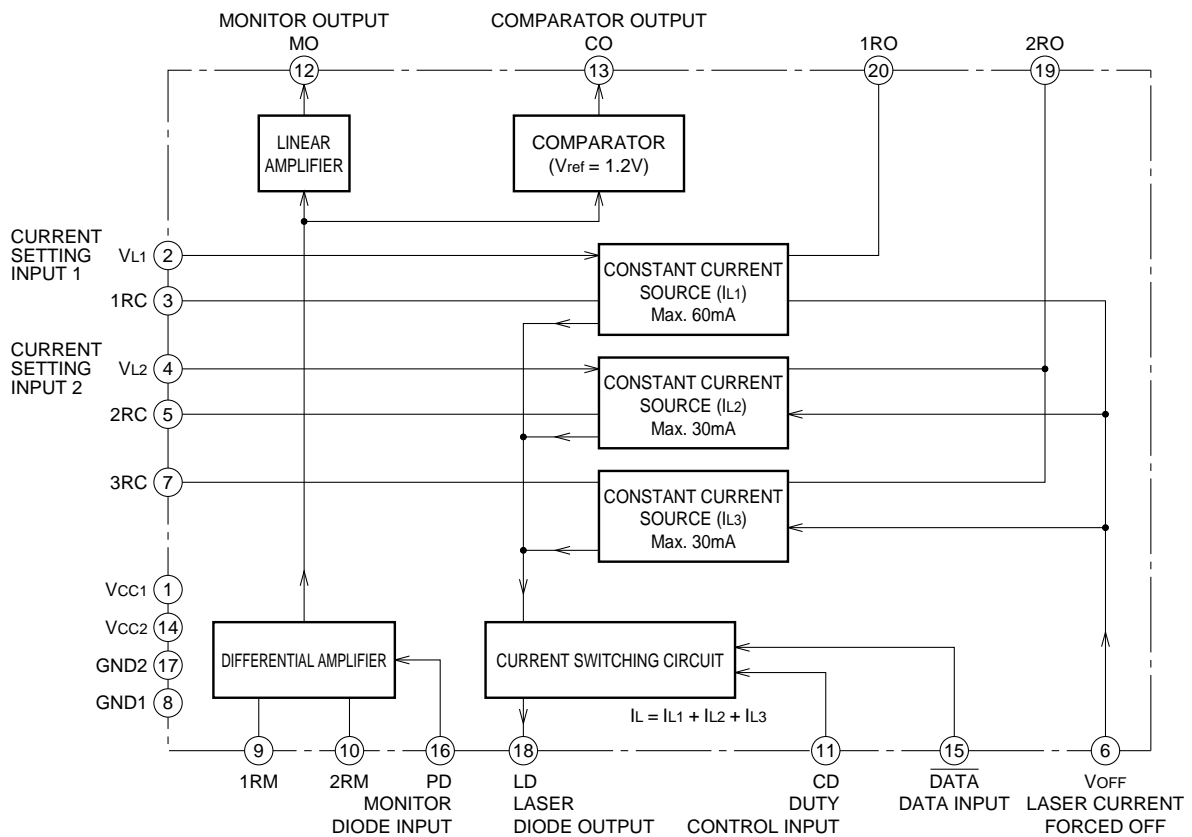• 5V single power supply

APPLICATION
Laser beam printer

PIN CONFIGURATION (TOP VIEW)

VCC1	1	20	→ 1RO LASER CURRENT LOAD OUTPUT 1
CURRENT SETTING INPUT 1	VL1 → 2	19	→ 2RO LASER CURRENT LOAD OUTPUT 2
CURRENT SETTING LOAD OUTPUT 1	1RC ← 3	18	→ LD LASER DIODE OUTPUT
CURRENT SETTING INPUT 2	VL2 → 4	17	GND2
CURRENT SETTING LOAD OUTPUT 2	2RC ← 5	16	← PD MONITOR DIODE INPUT
LASER CURRENT FORCED OFF INPUT	VOFF → 6	15	← DATA DATA INPUT
CURRENT SETTING LOAD OUTPUT 3	3RC ← 7	14	VCC2
	GND1 8	13	→ CO MONITOR COMPARATOR OUTPUT
MONITOR LOAD INPUT 1	1RM → 9	12	→ MO MONITOR ANALOG OUTPUT
MONITOR LOAD INPUT 2	2RM → 10	11	← CD DUTY CONTROL INPUT

Outline 20P4K

BLOCK DIAGRAM

VL1, 1RC: LASER CURRENT (IL1) SETTING PIN
VL2, 2RC: LASER CURRENT (IL2) SETTING PIN
3RC: LASER CURRENT (IL3) SETTING PIN
VCC1, GND1: IC INTERNAL ANALOG POWER SUPPLY PIN
VCC2, GND2: IC INTERNAL DIGITAL POWER SUPPLY PIN

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LASER-DIODE DRIVER

FUNCTION

The 66510 is a semiconductor laser diode driver that drives a semiconductor laser of the type (our R type) whose cathode and the anode of monitor photodiode are connected to the stem. Using the R type laser allows direct fixing the laser on a device for easy installation, thus improving its radiation efficiency.

Laser driving current is set by applying voltage from outside. The M66510 is equipped with two independent voltage applying pins to provide higher accuracy of setting the current value.

It is also equipped with a laser current forced off pin to prevent overcurrent from flowing into the laser diode at the power-ON time.

For detection of laser power, the monitor current of monitor photodiode built in the laser is converted into voltage by an external resistor to generate an analog output, and simultaneously the result of comparison with the internal reference voltage is output as TTL-level logic information.

PIN DESCRIPTIONS

Pin name	Name	Function
LD	Laser connecting pin	Connects the anode of semiconductor laser diode.
PD	Monitor diode connecting pin	Connects the cathode of monitor photodiode.
V_{L1}	Voltage input pin for I_{L1} setting	Voltage input for setting the output current (I_{L1}) of current source 1.
1RC	Load resistor connecting pin for I_{L1} setting	Connects I_{L1} setting load resistor between the pin and GND.
V_{L2}	Voltage input pin for I_{L2} setting	Voltage input for setting the output current (I_{L2}) of current source 2.
2RC	Load resistor connecting pin for I_{L2} setting	Connects I_{L2} setting load resistor between the pin and GND.
3RC	Load resistor connecting pin for I_{L3} setting	Connects I_{L3} setting load resistor between the pin and GND. If I_{L3} is not used, open the pin.
$\overline{DATA}$	Switching data input pin	Turns on the laser in the "L" position, and off in the "H" position.
1RM, 2RM	Monitor load resistor connecting pin	Connects between 1RM and 2RM the load resistor for converting monitor photodiode current into voltage.
MO	Monitor analog output pin	Analog output for monitoring laser power.
CO	Monitor comparator output pin	Comparator output for monitoring laser power.
V_{OFF}	Laser current forced off input pin	Turns off all current source circuits in the "L" position.
1RO	Load resistor connecting pin for laser current I_{L1}	Connects load resistor for laser current I_{L1} between 1RO pin and V_{CC}.
2RO	Load resistor connecting pin for laser current I_{L2}/I_{L3}	Connects load resistor for laser current I_{L2} and I_{L3} between 2RO pin and V_{CC}.
C_D	Duty compensating capacitor connecting pin	Connects duty compensating capacitor of optical output switch waveforms between the pin and GND. If duty compensation is not required, open the pin.
V_{CC1}	Power supply pin 1	Power supply for internal analog circuits. Connected to positive power supply (+5V).
V_{CC2}	Power supply pin 2	Power supply for internal digital circuits. Connected to positive power supply (+5V).
GND1	GND pin 1	GND for internal analog circuits.
GND2	GND pin 2	GND for internal digital circuits.

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DESCRIPTION OF OPERATION

1. Setting laser driving current

The M66510 is provided internally with three constant current sources I_{L1}, I_{L2} and I_{L3}, allowing setting of each independent output current.

The methods of setting I_{L1} to I_{L3} are given below in (1) to (3).

(1) Method of setting I_{L1}

I_{L1} is approximated by the V_{L1} pin input voltage and the resistor (RC1) connected between 1RC pin and GND as follows:

$$I_{L1}[mA] = 12 \times \frac{V_{L1}[V]}{RC1[k\Omega]}$$

However, $0 \le V_{L1} \le V_{CC} - 1.8V$, $I_{L1(max.)} = 60mA$

(2) Method of setting I_{L2}

I_{L2} is approximated by the V_{L2} pin input voltage and the resistor (RC2) connected between 2RC pin and GND as follows:

$$I_{L2}[mA] = 6 \times \frac{V_{L2}[V]}{RC2[k\Omega]}$$

However, $0 \le V_{L2} \le V_{cc} - 1.8V$, $I_{L2(max.)} = 30mA$

(3) Method of setting I_{L3}

I_{L3} is approximated by the internal reference voltage (V_{ref}) and the resistor (RC3) connected between 3RC pin and GND as follows:

$$I_{L3}[mA] = 10 \times \frac{V_{ref}[V]}{RC3[k\Omega]}$$

However, $V_{ref} = 1.2V$ (standard), $I_{L3(max.)} = 30mA$

Note: The expressions for setting I_{L1} to I_{L3} are typical. Actually, the set values fluctuate several % depending on IC lot dispersion or operating ambient temperature (See the ELECTRICAL CHARACTERISTICS).

2. Switching operation

The laser is turned on when $\overline{DATA}$ = "L". At this time, the laser driving current is $I_{L1} + I_{L2} + I_{L3}$.

The laser is turned off when $\overline{DATA}$ = "H". At this time, the laser driving current becomes almost 0 regardless of I_{L1} to I_{L3}.

3. Usage of V_{OFF} input

The current which flows into the laser becomes 0 when $\overline{DATA}$ = "H". And the laser is turned off but the internal current sources are active.

Contrarily, the internal current sources are turned off when V_{OFF} = "L". It is therefore possible to prevent overcurrent from flowing into the laser by setting V_{OFF} input to "L" until V_{CC} reaches 3.5V (standard) at the power-ON time, for example (See 6. Internal reset).

4. Laser power monitor operation

The M66510 outputs the information on monitor photodiode (PD) built in the laser from the MO and CO pins in the flow given below.

(1) The current equal to the PD current produced through emission of the laser flows into the resistor (RM) connected between 1RM and 2RM. The potential difference (V_M) produced on RM is converted into a level from GND by the internal differential amplifier.

(2) The V_M is output as an analog output from the MO pin through the buffer amplifier and compared to the internal reference voltage V_{ref} (1.2V standard) by the comparator. Then the result of comparison is output from the CO pin on the TTL level.

Condition	CO output
$V_M < V_{ref}$	"L"
$V_M > V_{ref}$	"H"

Monitor circuit schematic drawing
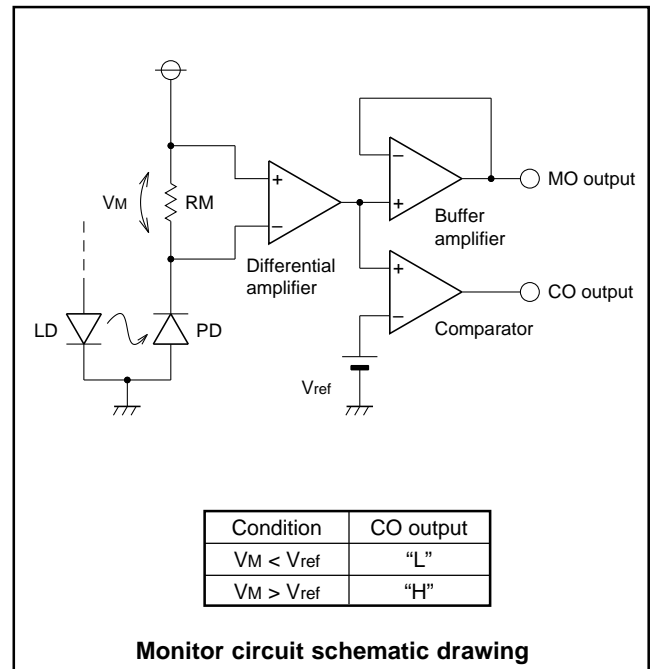
5. 1RO/2RO pin

The 1RO pin is used to connect the load resistor (RO1) for current source 1 (I_{L1}). The 2RO pin is used to connect the load resistor (RO2) for current sources 2 (I_{L2}) and 3 (I_{L3}). Connecting the load resistor between each pin and Vcc reduces IC internal power dissipation.

Set a resistance value so that each pin voltage does not go down to 3.5V or less. In other words, set a value such as meets the following expression:

$$RO1(RO2)[\Omega] \leq \frac{V_{CC} - 3.5[V]}{\text{Maximum load current [A] flowing into RO1(RO2)}}$$

Ex: When V_{CC} = 5V and maximum load current of each source is 60mA, RO1 and RO2 will be 25Ω or less.

6. Internal reset operation

The M66510 is provided with an internal reset circuit to prevent overcurrent from flowing into the laser at the power-ON time. The reset circuit operates within the range of V_{CC} < 3.5V (standard) to turn off all the current sources.

7. Vcc/GND pin

The power supply pins include V_{CC1}, V_{CC2}, GND1 and GND2, each of which is as follows in terms of internal circuit:

V_{CC1}/GND1: Connected to an analog circuit.
V_{CC2}/GND2: Connected to a digital circuit.

In actual wiring, pay attention to the following:

(1) Make wiring width as wide as possible. Avoid redundant wiring.
(2) Lay out an electrolytic capacitor for stabilizing voltage as close to V_{CC1}/GND1 as possible.
(3) Lay out a bypass capacitor as close to V_{CC2}/GND2 as possible.

Precaution for peripheral element wiring

Lay out the peripheral elements required for M66510 operation as close to M66510 as possible.

Method of calculating power dissipation

The power dissipation P of M66510 is given by the expression given below.

$P = I_{CC} \times V_{CC} + I_{(1RO)} \times (V_{(1RO)} - V_{(LD)}) + I_{(2RO)} \times (V_{(2RO)} - V_{(LD)}) + I_{OL(CO)} \times V_{OL(CO)}$

where,
$V_{(1RO)}$: 1RO pin voltage
$V_{(2RO)}$: 2RO pin voltage
$I_{(1RO)}$: 1RO pin load current
$I_{(2RO)}$: 2RO pin load current
$V_{(LD)}$: LD pin voltage
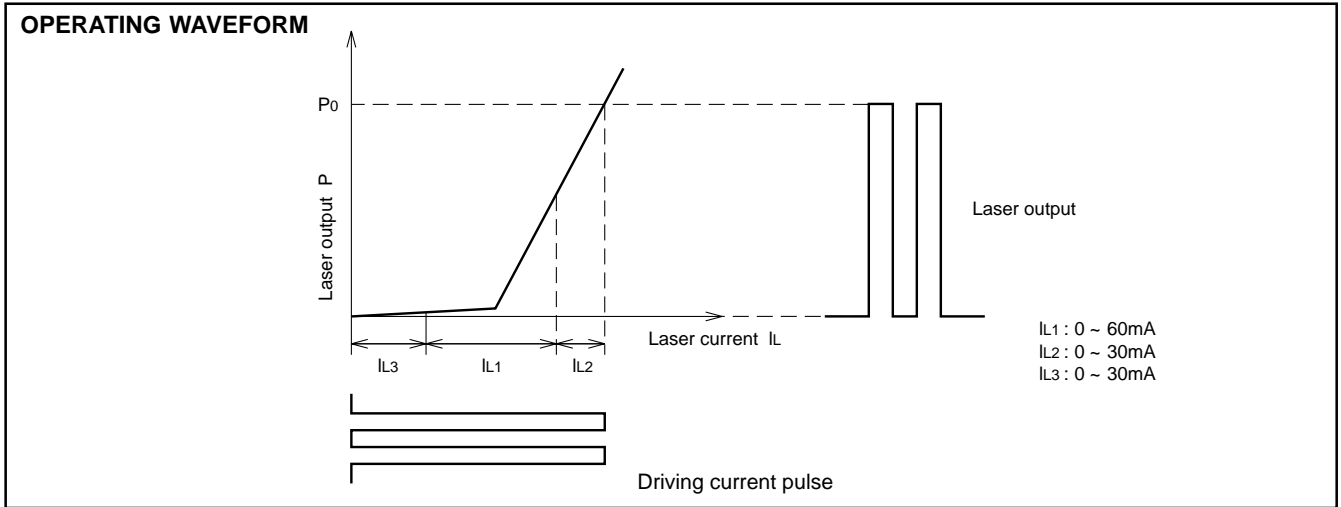$I_{OL(CO)}$: CO pin "L" output current
$V_{OL(CO)}$: CO pin "L" output voltage

For example, when V_{CC} = 5.25V, $V_{(1RO)}$ = $V_{(2RO)}$ = 3.5V, $I_{(1RO)}$ = $I_{(2RO)}$ = 60mA, $V_{(LD)}$ = 2.5V, $I_{OL(CO)}$ = 8mA and $V_{OL(CO)}$ = 0.5V, the power dissipation at the laser-ON/OFF time is as follows:

(1) Laser-ON time ($\overline{\text{DATA}}$ = "L", I_{CC}=26mA)
$P_{ON} = 26 \times 5.25 + 60 \times (3.5 - 2.5) + 60 \times (3.5 - 2.5) + 8 \times 0.5 = 260.5(mW)$
(2) Laser-OFF time ($\overline{\text{DATA}}$ = "H", I_{CC} = 44mA)
$P_{OFF} = 44 \times 5.25 + 0 + 0 + 8 \times 0.5 = 235(mW)$

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LASER-DIODE DRIVER

OPERATING WAVEFORM

Laser output P

P_0

Laser current I_L

I_{L3} I_{L1} I_{L2}

Laser output

I_{L1} : 0 ~ 60mA
I_{L2} : 0 ~ 30mA
I_{L3} : 0 ~ 30mA

Driving current pulse

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions		Ratings	Unit
V_{CC}	Supply voltage			−0.5 ~ +7.0	V
V_I	Input voltage	V_{L1}, V_{L2}		−0.3 ~ V_{CC}	V
		$\overline{DATA}$, V_{OFF}		−0.3 ~ + 7	
V_O	Output current	CO	When output is "H"	−0.3 ~ + 5.5	V
		1RO, 2RO		−0.3 ~ + 7	
I_{L1}	Output current 1			−90	mA
I_{L2}	Output current 2			−45	mA
I_{L3}	Output current 3			−45	mA
P_d	Power dissipation	DIP	IC unit, when T_a=25°C (Note 1)	1300	mW
		SOP	IC unit, when T_a=25°C (Note 2)	800	
T_{stg}	Storage temperature			−65 ~ 150	°C

Note 1: When $T_a \geq$ 25°C, do derating of 10.4mW/°C.
     2: When $T_a \geq$ 25°C, do derating of 6.4mW/°C.

RECOMMENDED OPERATINIG CONDITIONS

Symbol	Parameter	Conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{CC}	Supply voltage		4.75	5	5.25	V
I_{L1}	Output current 1				−60	mA
I_{L2}	Output current 2				−30	mA
I_{L3}	Output current 3				−30	mA
T_{opr}	Operating ambient temperature		−20		75	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 5V ± 5%, T_a = −20 ~ 75°C, unless otherwise noted)

Symbol	Parameter	Test pin	Test conditions	Min.	Typ.*	Max.	Unit
V_{IH}	"H" input voltage	$\overline{DATA}$, V_{OFF}		2			V
V_{IL}	"L" input voltage	$\overline{DATA}$, V_{OFF}				0.8	V
V_I	Upper limit of effective input voltage	V_{L1}, V_{L2}		V_{CC}−1.8	V_{CC}−1.4		V
V_{OH}	"H" output voltage	CO	I_{OH}=−400μA	2.7			V
V_{OL}	"L" output voltage	CO	I_{OL}=4mA			0.4	V
			I_{OL}=8mA			0.5	
V_{LD}	Operating supply voltage	LD		0		2.5	V
V_{OS}	Output offset voltage	MO	I_{MO}=±20μA, I_{PD}=0mA (Note 3)		30		mV
ΔV_M	Output voltage variance width	MO	I_{PD}=−0.2~2.0mA, I_{MO}=±20μA, RM=1kΩ (Note 4)		20		mV
		Temperature coefficient	RM=1kΩ, I_{PD}=−1.2mA		0.05		mV/°C
I_I	Input current	$\overline{DATA}$, V_{OFF}	V_I=2.7V			20	μA
			V_I=0.4V			−0.2	mA
		V_{L1}, V_{L2}	V_I=0~V_{CC}			±1	μA
V_{ref}	Reference voltage				1.2		V
		Temperature coefficient	T_a=−20~75°C		−1.1		mV/°C
			T_a=25~75°C		−0.7		
I_{L1}	Output current 1 (Note 5)	LD	V_{L1}=3V, RC1=560Ω, V_{LD}=2V		−62		mA
		Temperature coefficient			0.037		mA/°C
I_{L2}	Output current 2 (Note 5)	LD	V_{L2}=3V, RC2=560Ω, V_{LD}=2V		−31		mA
		Temperature coefficient			0.017		mA/°C
I_{L3}	Output current 3 (Note 5)	LD	RC3=360Ω, V_{LD}=2V		−31		mA
I_{OFF}	Off-state output current	LD	V_{OFF}=$\overline{DATA}$=2V		−0.2	−1	mA
			V_{OFF}=$\overline{DATA}$=0.8V		−1	−20	μA
I_{CC}	Supply current		V_{CC}=5.25V, V_{OFF}=4.5V, V_{L1}=V_{L2}=3.0V, RC1=RC2=560Ω, RC3=360Ω, 1RO, 2RO, LD open — $\overline{DATA}$=0V		17	26	mA
			$\overline{DATA}$=4.5V		30	44	

Note 3: I_{MO}: MO pin output current. I_{PD}: PD pin input current
   4: RM: Resistance connected between 1RM and 2RM pins.
   5: This indicates the input voltage – output current conversion characteristic. Use I_{L1} to I_{L3} within the range of limits of the recommended operating conditions.
   *: The standard value is given on V_{CC} = 5V and at T_a = 25°C. The items with T_a specified under test conditions are given on V_{CC} = 5V.
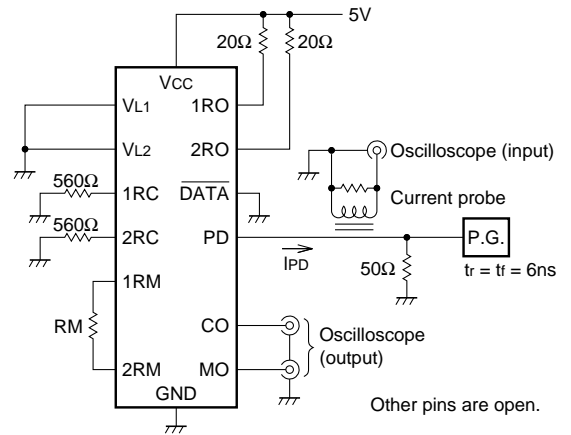
ELECTRICAL CHARACTERISTICS (V_{CC} = 5V, T_a = 25°C)

Symbol	Parameter	Test pin Input	Test pin Output	Test conditions	Min.	Typ.	Max.	Unit
f_{OP}	Operating frequency					20		Mbps
t_{RP1}	Circuit response time 1	V_{L1}/V_{L2} voltage	LD current	$I_{LD(L)}$=0mA, $I_{LD(H)}$=−60mA (Note 6)		4.5	7	μs
				$I_{LD(L)}$=−55mA, $I_{LD(H)}$=−65mA (Note 6)		0.5	2	
t_{RP2}	Circuit response time 2	PD current	MO voltage	$I_{PD(L)}$=0mA, $I_{PD(H)}$=−2mA, RM=1kΩ (Note 7)		7	10	μs
				$|\Delta I_{PD}|$=0.2mA, RM=1kΩ (Note 7)		1	3	
t_{RP3}	Circuit response time 3	PD current	CO voltage	$|\Delta I_{PD}|$=1mA (Note 7)		7	10	μs
				$|\Delta I_{PD}|$=0.2mA (Note 7)		0.5	2	
t_{ON}	Circuit ON time	V_{OFF} voltage	LD current	$I_{LD(H)}$=−60mA (Note 8)		3	5	μs
t_{OFF}	Circuit OFF time	V_{OFF} voltage	LD current	$I_{LD(H)}$=−60mA (Note 8)		0.5	2	μs

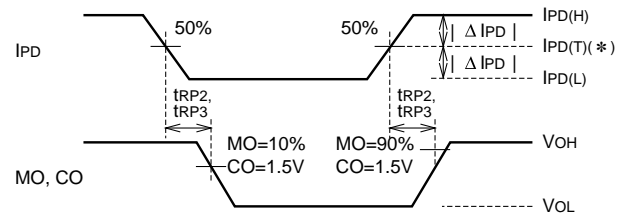MITSUBISHI ELECTRIC

NOTE 6: TEST CIRCUIT
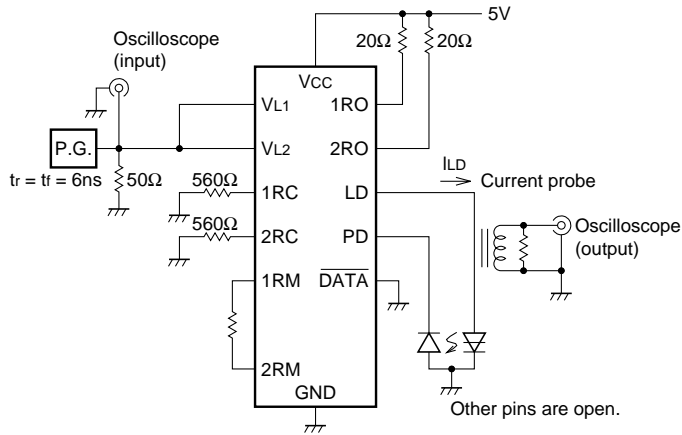
TIMING CHART

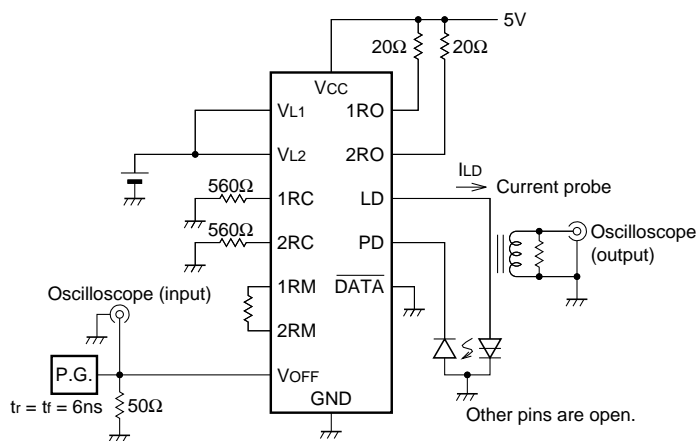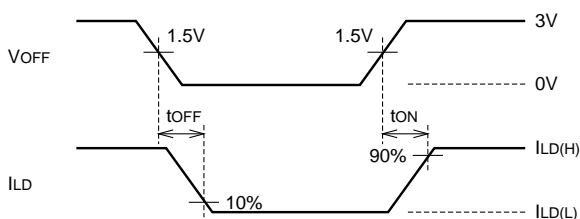

NOTE 7: TEST CIRCUIT
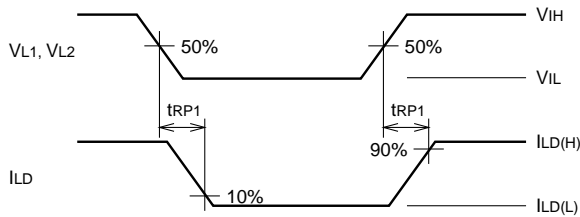
TIMING CHART

∗ : IPD when CO output is inverted.

NOTE 8: TEST CIRCUIT

TIMING CHART
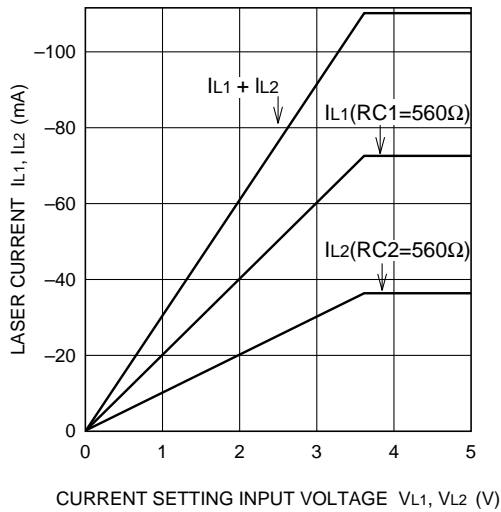
APPLICATION EXAMPLE
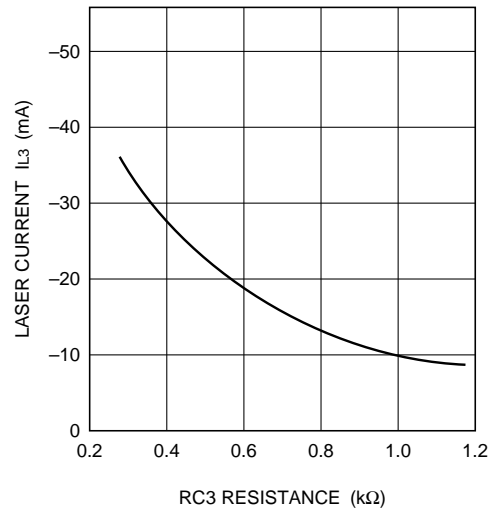
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LASER-DIODE DRIVER
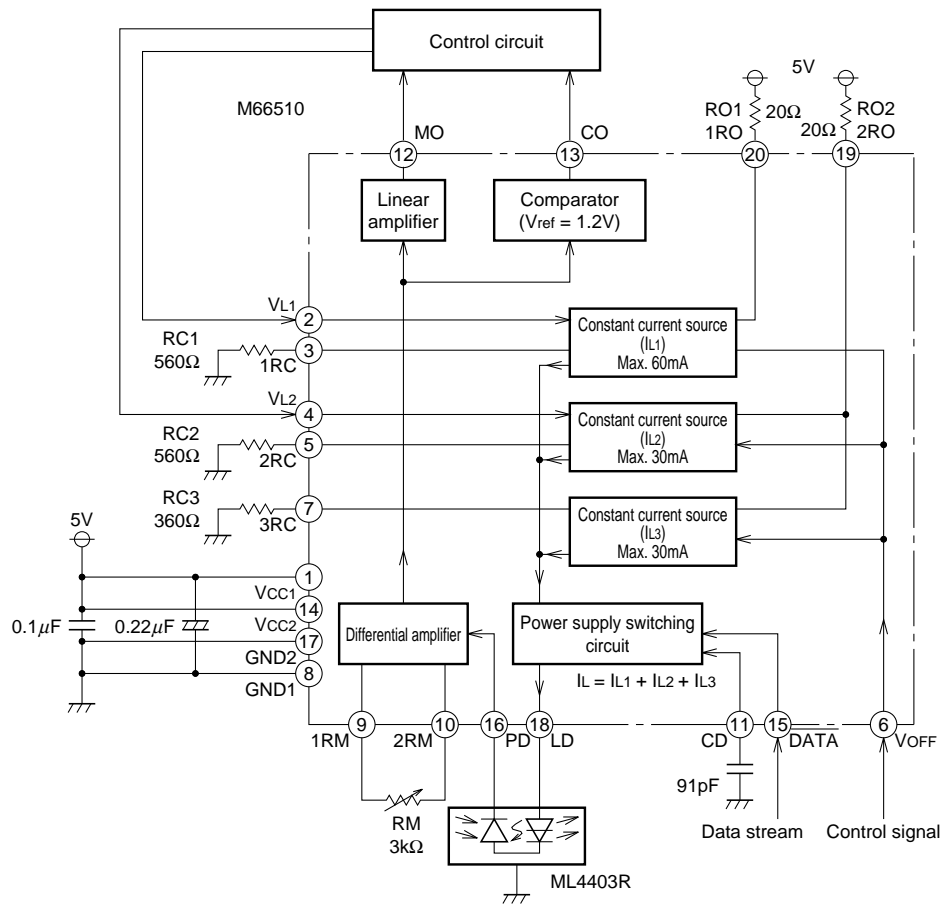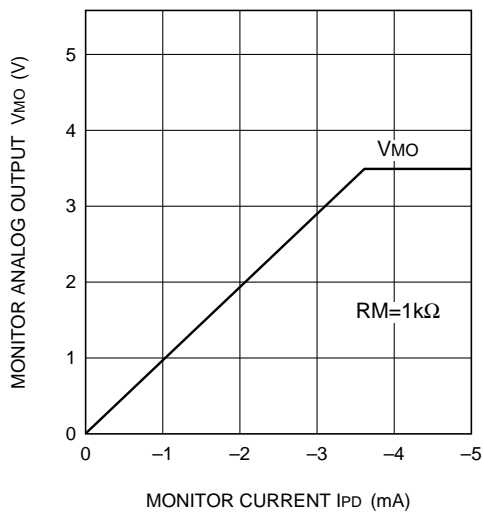
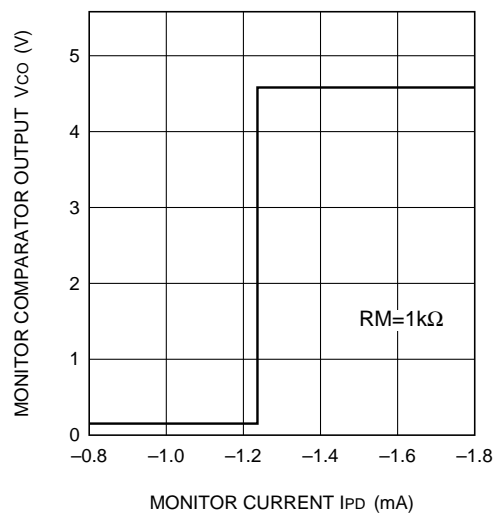## STANDARD CHARACTERISTICS (Vcc = 5V, Ta = 25°C)

LASER CURRENT - CURRENT SETTING VOLTAGE CHARACTERISTIC
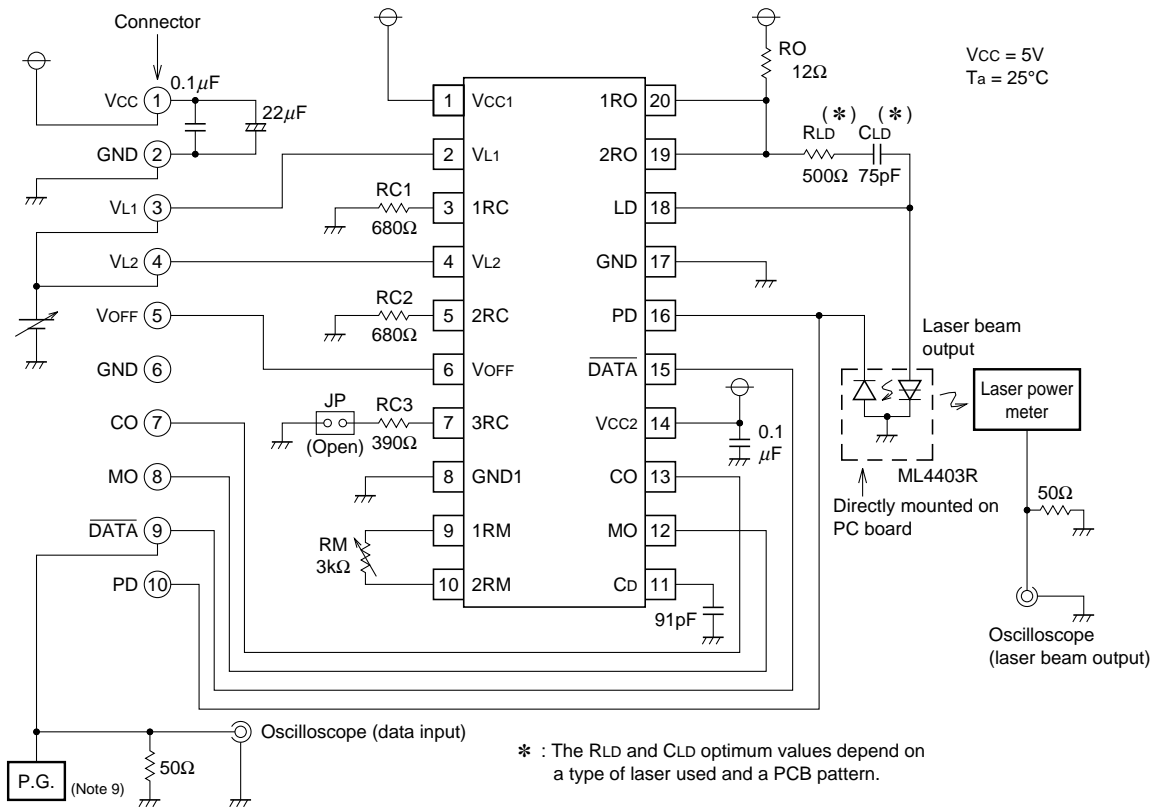
LASER CURRENT - RC3 RESISTANCE CHARACTERISTIC

MO OUTPUT - MONITOR CURRENT CHARACTERISTIC
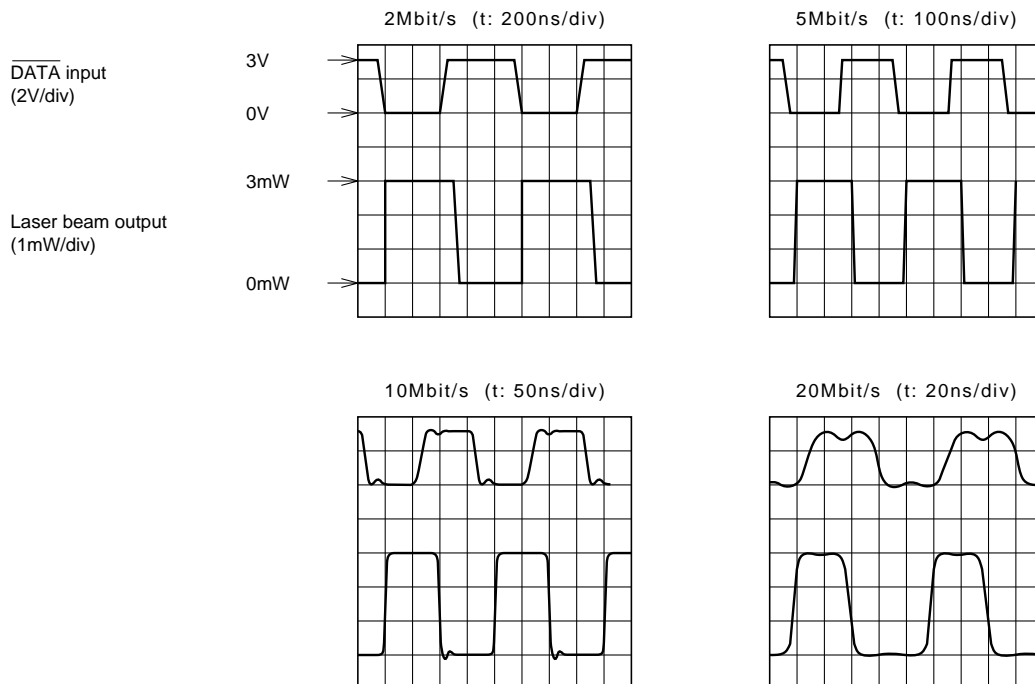
CO OUTPUT - MONITOR CURRENT CHARACTERISTIC

EVALUATION OF SWITCHING OPERATION WAVEFORM

EVALUATION CIRCUIT

Note 9: tr = tf = 6ns, VO = 3VP-p, duty = 50%

∗ : The RLD and CLD optimum values depend on
a type of laser used and a PCB pattern.

SWITCHING OPERATION WAVEFORM

Note: The delay from DATA input to laser beam output includes a measurement delay.

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