

# ELM186CxA 120mA laser diode driver

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## ■General description

ELM186CxA is a bipolar IC with APC drive circuit for laser diode(LD) applications. It can drive up to 120mA of LD forward current. Laser output power is controlled at constant value by a function of APC.

It consist of a band gap reference and an APC circuit. Laser power is adjusted by an external resistor which defines output laser power. ELM186CxA application circuit occupies only small area on PCB by SC-70-5 small package and a few external passive parts.

Four versions, ELM186C1A, ELM186C2A, ELM186C3A and ELM186C4A are prepared to drive all kinds of laser diode modules(LDMs) which have 4 combinations of each pin's polarity. All types of LDMs which have pins of LD cathode/LD anode and MD cathode/MD anode can be driven by a suitable version of ELM186CxA.

ELM186CxA consumes 0.6mA typ, and operates from 3.0V to 12.0V VCC.

## ■Features

- External adjustment for output laser power
- Internal voltage reference : Typ.1.25V
- Operation voltage : 3.0V to 12.0V
- Low power consumption : Typ.0.6mA
- LD drive current : Max.120mA
- Package : SC-70-5 (5 Pin)

## ■Application

- Laser pointers
- Laser levels
- Other LD applications

## ■Maximum absolute ratings

| Parameter                   | Symbol | Limit       | Unit |
|-----------------------------|--------|-------------|------|
| Operation voltage           | Vcc    | 13.0        | V    |
| Power dissipation           | Pd     | 300         | mW   |
| Operation temperature range | Top    | -40 to +85  | °C   |
| Storage temperature range   | Tstg   | -55 to +150 | °C   |

## ■Selection guide

ELM186CxA-x

| Symbol |                        |                                                                                  |
|--------|------------------------|----------------------------------------------------------------------------------|
| a      | Package                | C: SC-70-5                                                                       |
| b      | Pin configuration type | 1 : type1<br>2 : type2<br>3 : type3<br>4 : type4<br>(Refer to pin configuration) |
| c      | Product version        | A                                                                                |
| d      | Taping direction       | S, N: Refer to PKG file                                                          |

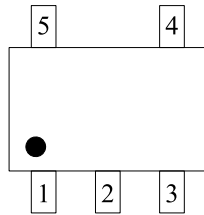
ELM186C x A - x  
↑ ↑ ↑ ↑  
a b c d

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## ■Pin configuration

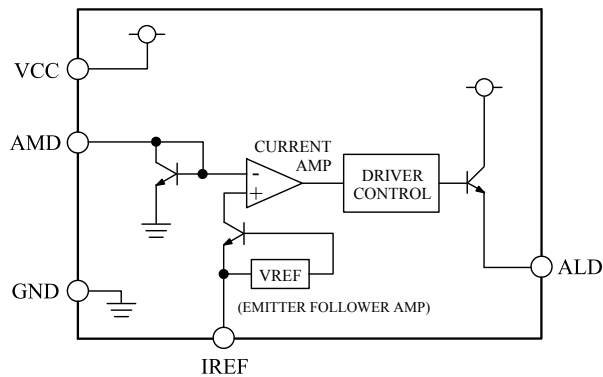
SC-70-5(TOP VIEW)



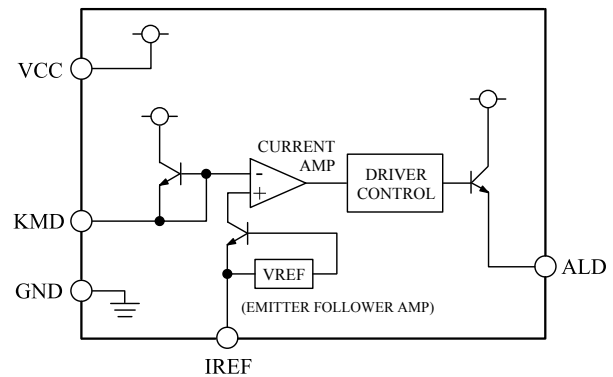
| Pin No. | Pin name  |           |           |           |
|---------|-----------|-----------|-----------|-----------|
|         | type1     | type2     | type3     | type4     |
|         | ELM186C1A | ELM186C2A | ELM186C3A | ELM186C4A |
| 1       | ALD       | ALD       | KLD       | KLD       |
| 2       | GND       | GND       | GND       | GND       |
| 3       | VCC       | VCC       | VCC       | VCC       |
| 4       | IREF      | IREF      | IREF      | IREF      |
| 5       | AMD       | KMD       | AMD       | KMD       |

## ■Block diagram

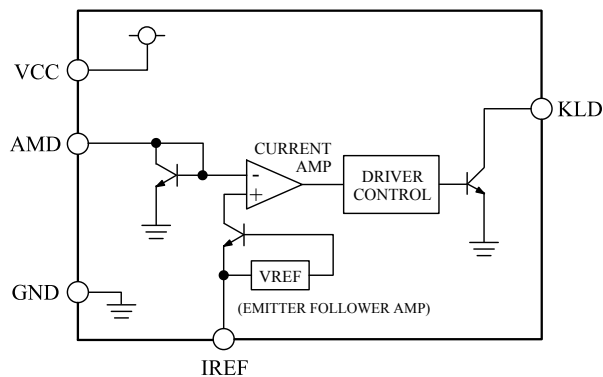
ELM186C1A



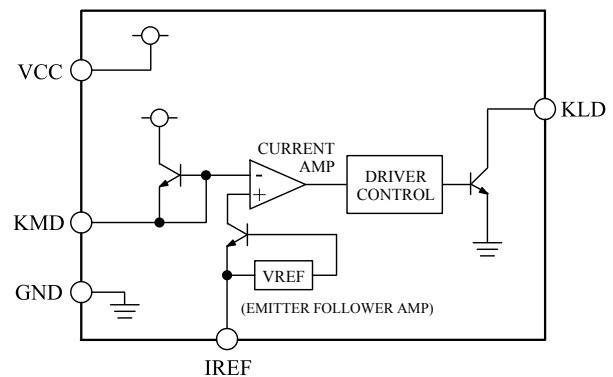
ELM186C2A



ELM186C3A



ELM186C4A



## Pin descriptions

| Pin Name | Function         | Description                                                                                                                                                                   |
|----------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ALD      | LD drive output  | Connect to anode of laser diodes. Emitter output of internal NPN transistor.                                                                                                  |
| KLD      | LD drive output  | Connect to cathode of laser diodes. Collector output of internal NPN transistor.                                                                                              |
| AMD      | MD current input | Connect to anode of monitor diode. Sinks photo current from monitor diode.                                                                                                    |
| KMD      | MD current input | Connect to cathode of monitor diode. Sources photo current to monitor diode.                                                                                                  |
| IREF     | Iref setting     | Connect an external resistor from IREF to GND. Emitter output of reference voltage source. The current at the resistor is copied to be a reference current for APC operation. |
| VCC      | Power input      | Power input of IC.                                                                                                                                                            |
| GND      | Ground           | Ground of IC.                                                                                                                                                                 |

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## Internal blocks and operation :

ELM186CxA consists of a reference voltage circuit, a reference current generator, a current operation circuit and a LD driving output transistor.

The reference current generator has a function to generate reference current for APC function defined by an external resistor at IREF pin. The current operational circuit controls output current to the LD in condition of flowing same current between the reference current and the photo current from a monitor diode's anode or cathode. The output transistor is a 120mA capable NPN bipolar transistor.

ELM186CxA has two types of output, ALD is an emitter output for LD anode drive and KLD is a collector output for LD cathode drive. Two photo current polarity inputs are prepared. AMD is connected to an anode of the monitor diode. KMD is connected to the cathode of monitor diode. AMD is a input pin to an anode of internal PN diode, and KMD is a input pin to a cathode of internal PN diode. Each diode works as a part of current mirrors.

ELM186CxA works as follows.

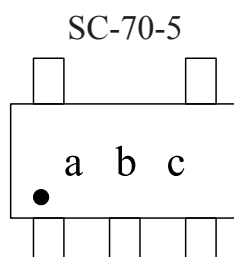
The reference current which defines output power of the LD is generated as a constant value by a band gap reference and a external resistor. The monitor current is proportional to the laser power. When ELM186CxA is in operation, the laser monitor current is compared with the reference current by a current operational amplifier. The difference current is magnified in very large amplitude. The amplified current is output to drive the laser diode. Consequently the output current is increased when the monitor current is smaller than the reference. And the output current is decreased when the monitor current is larger. Eventually the laser output is controlled in a constant power defined by the external resistor. The control error is caused from current gain of the amplifier. AMD/KMD current is recommended to be less than 1000 $\mu$ A. Since the reference voltage is approximately 1.25 V, the IREF pin resistance in that case is 1.25 k $\Omega$  or more.

## Electrical characteristics

VCC=+5V, Top=25°C, unless otherwise noted

| Parameter              | Symbol | Condition                            | Min.  | Typ. | Max. | Unit    |
|------------------------|--------|--------------------------------------|-------|------|------|---------|
| Operating voltage      | Vcc    |                                      | 3.0   |      | 12.0 | V       |
| Current consumption    | Icc    | Vcc=5.0V, Iref register=22k $\Omega$ | 0.3   | 0.6  | 1.2  | mA      |
| IREF reference voltage | Vref   | Vcc=5.0V, Iref register=22k $\Omega$ | 1.15  | 1.25 | 1.35 | V       |
| IREF current range     | Iref   |                                      |       | 50   |      | $\mu$ A |
| ALD output current     | Io_ald |                                      | -120  |      |      | mA      |
| KLD output current     | Io_kld |                                      |       |      | 120  | mA      |
| ALD leak current       | Il_ald |                                      |       |      | 1.0  | $\mu$ A |
| KLD leak current       | Il_kld |                                      | -1.0  |      |      | $\mu$ A |
| AMD input current      | Ii_amd |                                      |       | 50   | 1000 | $\mu$ A |
| KMD input current      | Ii_kmd |                                      | -1000 | -50  |      | $\mu$ A |

## Marking



| Symbol | Mark                                     | Content          |
|--------|------------------------------------------|------------------|
| a      | M                                        | Series : 186     |
| d      | 1 to 4                                   | Pin type display |
| c      | 0 to 9 and<br>A to Z ( I, O, X excepted) | Assembly lot No. |

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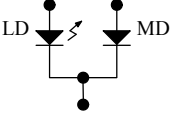
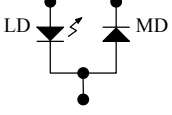
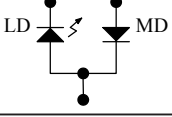
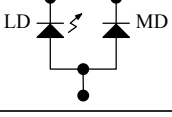
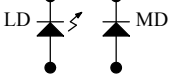
## ■Application circuits

LDMs are used in many LD applications. A LDM contain a laser diode and a monitor diode in one package. These two diodes are optically connected inside the package. The monitor diode is a PN diode generates photo current to measure photo power from the LD.

ELM186CxA can drive 4 kinds of laser diode modules(LDMs) having different polarity pins.

Each ELM186CxA can drive only corresponding polarity of laser diodes(LD) and monitor diodes(MD). Table1 shows ELM186CxA and laser diode modules (LDM) combinations.

Table 1 :

| No. | Laser diode module pins                                                                                              | Parts number of ELM186CxA            |
|-----|----------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1   |  : LD anode, common, MD anode       | ELM186C1A(Fig.2) or ELM186C3A(Fig.6) |
| 2   |  : LD anode, common, MD cathode     | ELM186C2A(Fig.4) or ELM186C4A(Fig.8) |
| 3   |  : LD cathode, common, MD anode    | ELM186C1A(Fig.1) or ELM186C3A(Fig.5) |
| 4   |  : LD cathode, common, MD cathode | ELM186C2A(Fig.3) or ELM186C4A(Fig.7) |
| 5   |  : Other LDM without a common pin | All ELM186CxA                        |

## LD anode driving applications

ELM186C1A and C2A are used when LD anode is driven. ALD is NPN emitter follower output. LD anode driving application only requires a resistor for output power definition. Only a noise absorbing capacitor at VCC is recommended.

Operation voltage is 5V or higher because it is necessary to have the sum of IC operation voltage and to LD forward voltage. LD anode drive has advantages on heat dissipation and fewer RC parts. The cases of LD modules can be directly grounded in Fig.1 for good heat dissipation.

ELM186C2A needs to have a compensation capacitor and a resistor at KMD pin for stable operation in Fig.3 and Fig4.

## LD anode driving application circuits Fig.1, Fig.2, Fig.3, Fig.4.

Fig.1

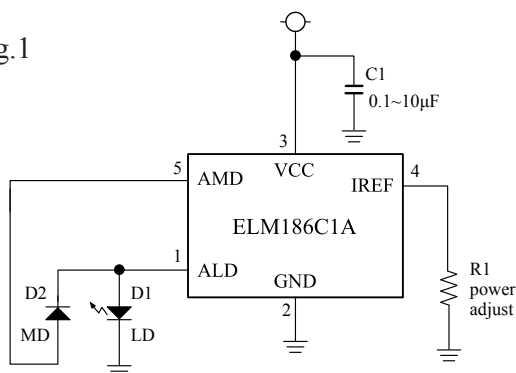
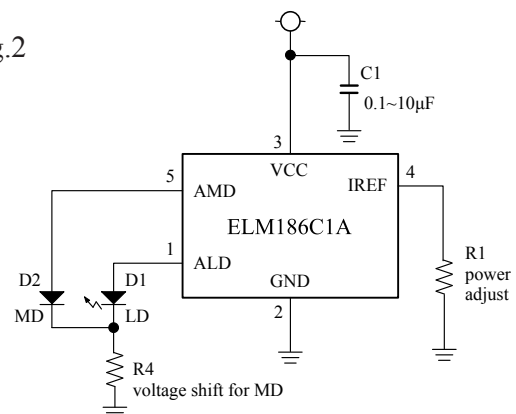


Fig.2



# ELM186Cx A 120mA laser diode driver

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Fig.3

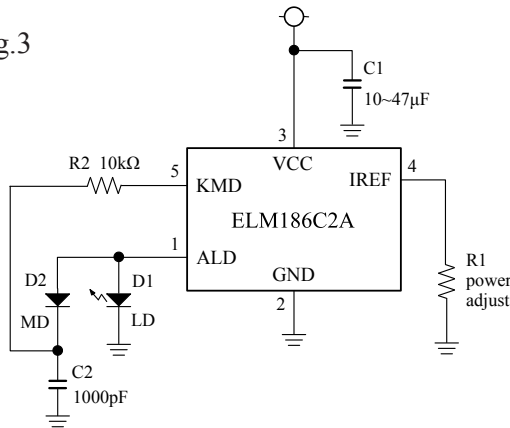
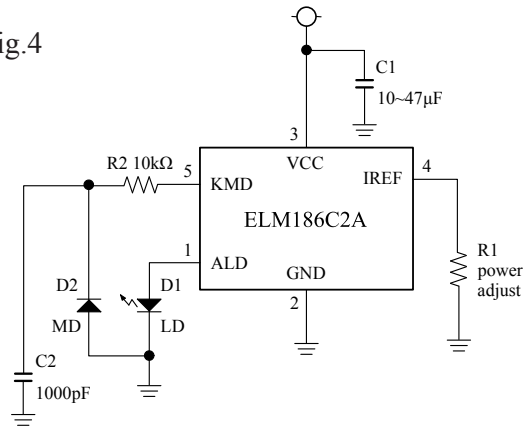


Fig.4



Method of determining circuit constants (Figures 1 to 4)

The laser diode module is assumed to have the characteristics of drive current  $I_F = 40\text{mA}$ , forward voltage  $V_F = 2.2\text{V}$ , and monitor current  $I_M = 100\mu\text{A}$  at the rated  $5\text{mW}$  operation.

In the case of Fig. 1:

Supply voltage  $V_{CC} = V_F + 3\text{V} = 5.2\text{V}$  or more, reference resistor  $R_1 = V_{REF} / I_M = 1.25\text{V} / 100\mu\text{A} = 12.5\text{k}\Omega$ , and supply capacitor  $C_1$  is  $0.1\mu\text{F}$  to  $10\mu\text{F}$ .

In the case of Fig.2 (Use a voltage drop of  $1\text{V}$  on  $R_4$  to reverse bias MD) :

Power supply voltage  $V_{CC} = V_F + 4\text{V} = 6.2\text{V}$  or more, reference resistance  $R_1 = V_{REF} / I_M = 1.25\text{V} / 100\mu\text{A} = 12.5\text{k}\Omega$ , voltage shift resistance  $R_4 = \text{shift voltage} / I_F = 1\text{V} / 40\text{mA} = 25\Omega$ , power supply capacitor  $C_1$  is  $0.1\mu\text{F}$  to  $10\mu\text{F}$ , optional for power stabilization.

In the case of Fig. 3 (Add  $R_2$  and  $C_2$  for APC stabilization):

Power supply voltage  $V_{CC} = V_F + 3\text{V} = 5.2\text{V}$  or more, reference resistance  $R_1 = V_{REF} / I_M = 1.25\text{V} / 100\mu\text{A} = 12.5\text{k}\Omega$ , stabilized CR is  $C = 1000\text{pF}$ ,  $R = 10\text{k}\Omega$ , power supply capacitor  $C_1$  is  $10\mu\text{F}$  to  $47\mu\text{F}$ , It is optional for power stabilization.

In the case of Fig. 4 (Add  $R_2$  and  $C_2$  for APC stabilization):

Power supply voltage  $V_{CC} = V_F + 3\text{V} = 5.2\text{V}$  or more, reference resistance  $R_1 = V_{REF} / I_M = 1.25\text{V} / 100\mu\text{A} = 12.5\text{k}\Omega$ , stabilized CR is  $C = 1000\text{pF}$ ,  $R = 10\text{k}\Omega$ , power capacitor  $C_1$  is  $10\mu\text{F}$  to  $47\mu\text{F}$ , It is optional for power stabilization.

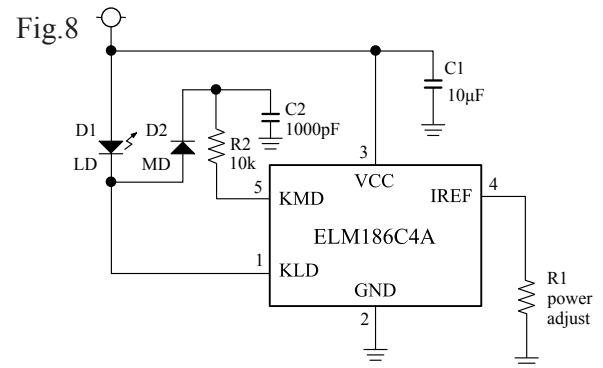
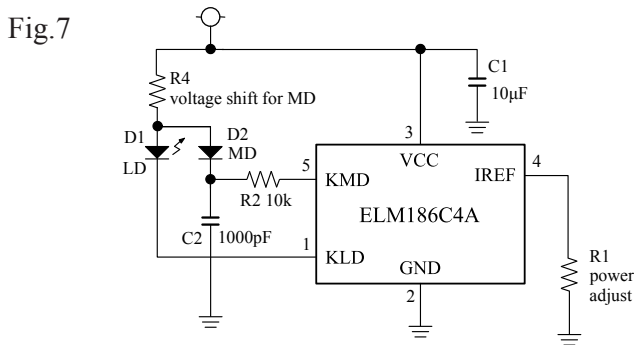
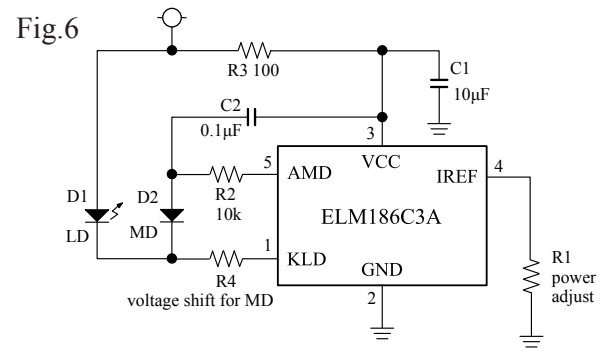
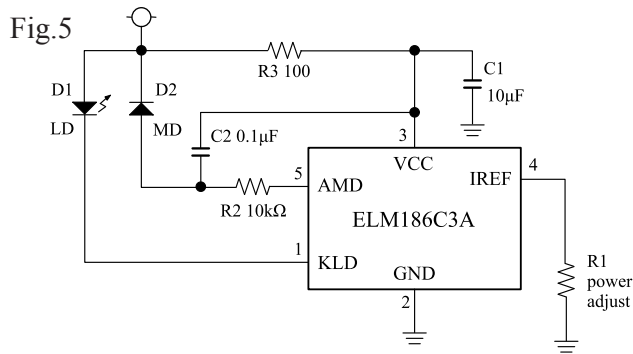
CR Example:  $R_1 = 12\text{k}\Omega$  ( $I_{ref} = 100\mu\text{A}$ ),  $R_2 = 10\text{k}\Omega$  to  $2\text{k}\Omega$ ,  $C_2 = 1000\text{pF}$ ,  $R_4 = 25\Omega$  ( $I_{ld} = 40\text{mA}$ )

## LD cathode driving applications

ELM186C3A and C4A are used when LD cathode is driven. KLD is NPN Collector output. Power supply voltage is possible to down till 3V(forward voltage of LD +0.5V). A decoupling CR network for VCC pin and a compensation CR network for AMD/KMD pin are needed to keep APC loop stability.

Decoupling CR filter's time constant is more than 1msec. Examples are  $100\Omega \times 10\mu\text{F}$  and etc. .

### LD cathode driving application circuits Fig.5, Fig.6, Fig.7, Fig.8.



CR example :  $R1=12k\Omega$  ( $I_{ref}=100\mu\text{A}$ ),  $C1=10\mu\text{F}$ ,  $C2=0.1\mu\text{F}$  (ELM186C3A),  $C2=1000\text{pF}$  (ELM186C4A),  $R2=10k\Omega$ ,  $R4=25\Omega$  ( $I_{ld}=40\text{mA}$ )

### Tips for PCB design:

Consider low thermal resistance on PCB layout design. Thermal vias are recommended on PCB.

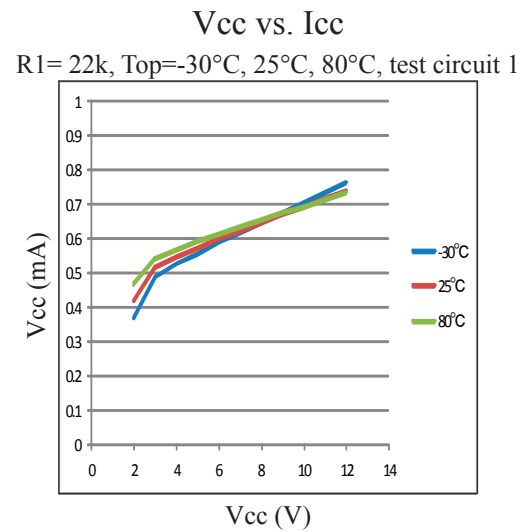
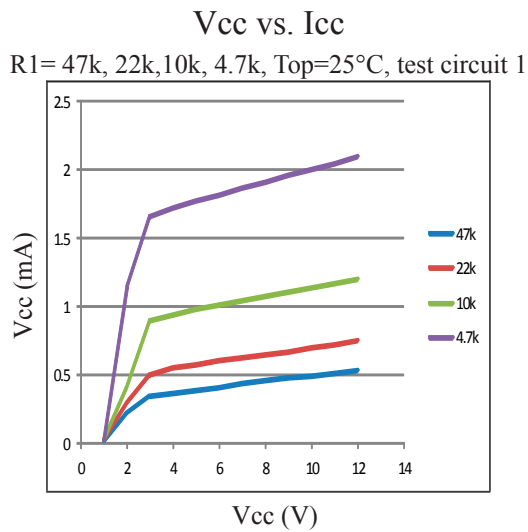
IREF pin to resistor connection should be a short line to reduce stray capacitance. Power lines to VCC and LD are branched at input point of PCB to prevent influence of voltage drops on power lines. Ground plane is strongly recommended to get lower ground impedance by using a multi layers PCB.

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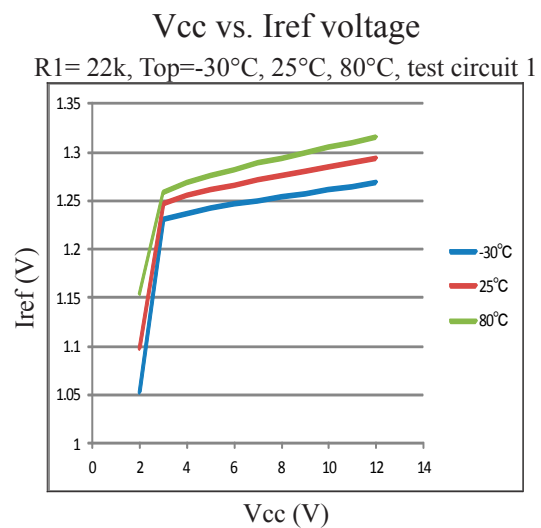
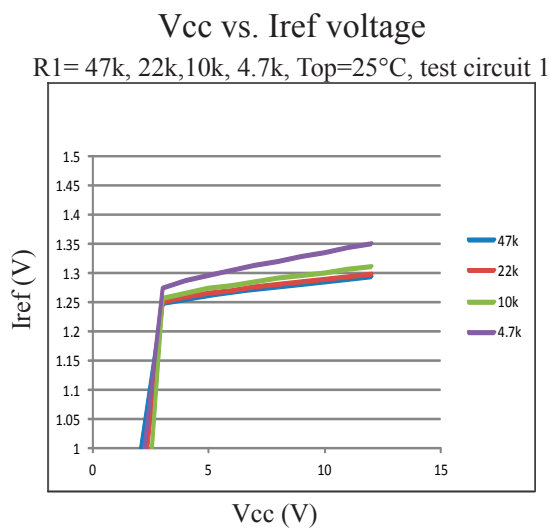
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## ■Electrical characteristics curves

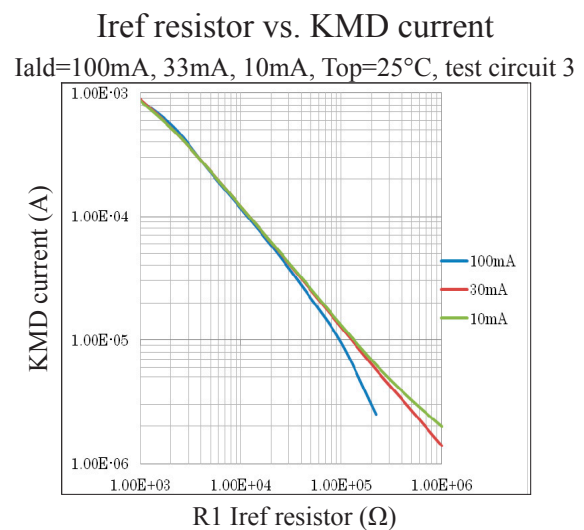
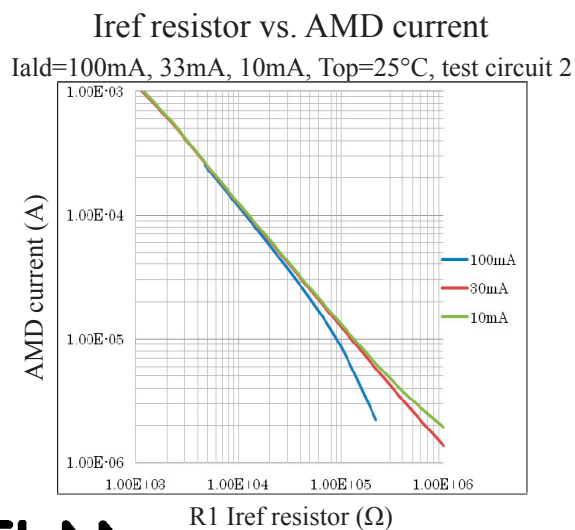
### 1. Power consumption



### 2. Voltage reference stability



### 3. LD drive characteristics

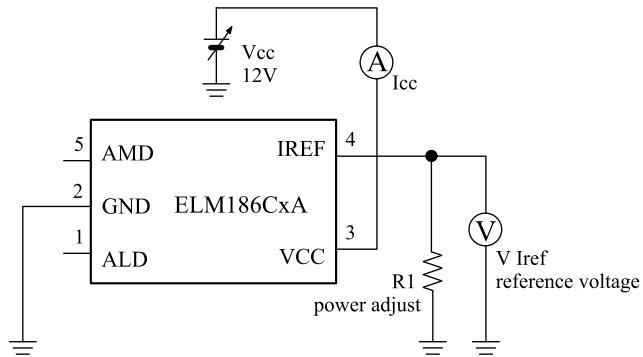


# ELM186CxA 120mA laser diode driver

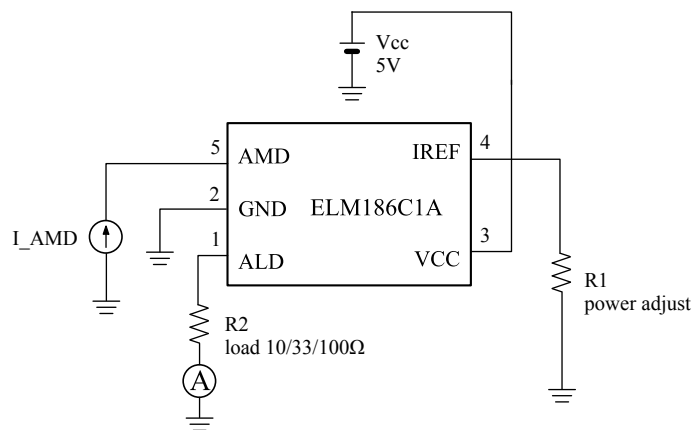
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## ■ Test circuits

### • Test circuit 1



### • Test circuit 2



### • Test circuit 3

