

iC-VJ, iC-VJZ

LASER DIODE CONTROLLER

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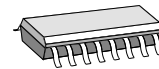
FEATURES

- ◆ Laser diode driver of up to 250 mA
- ◆ Averaging control of laser power
- ◆ Protective functions to prevent destruction of laser diode
- ◆ Laser-current monitor with current or voltage output
- ◆ Integrated RC oscillator up to 4 MHz
- ◆ Integrated 16:1 divider for pulse generation in the kHz range
- ◆ Stable 1:1 pulse duty ratio
- ◆ Simple adjustment of the laser power via external resistor
- ◆ Soft-start at power-on
- ◆ Complementary pulse repetition frequency output for ECL level
- ◆ Shutdown in case of overtemperature
- ◆ Single 5 V power supply
- ◆ Very few external components
- ◆ **iC-VJ** for laser diodes with 50 to 500 μ A monitor current
- ◆ **iC-VJZ** for laser diodes with 0.15 to 1.5 mA monitor current

APPLICATIONS

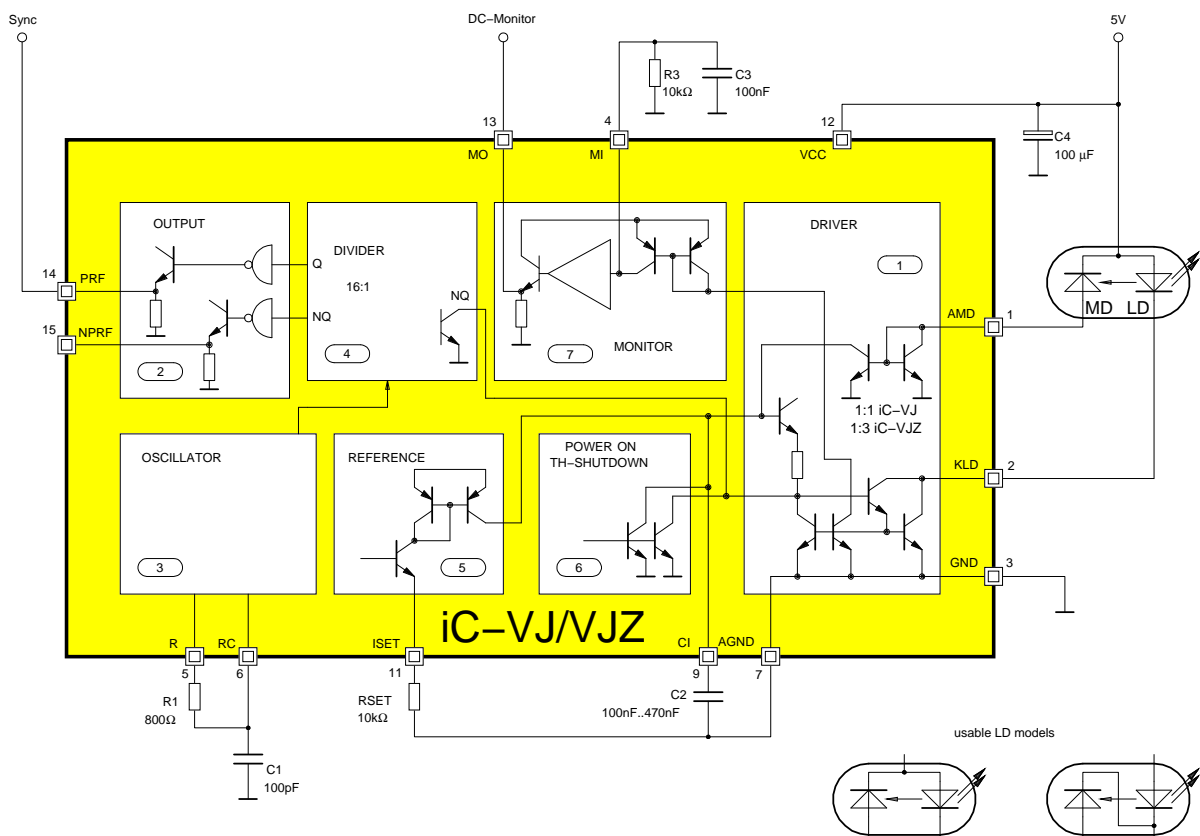
- ◆ Transmitter for laser light barriers from 1 to 200 kHz

PACKAGES



SO16N

BLOCK DIAGRAM



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iC-VJ, iC-VJZ

LASER DIODE CONTROLLER



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DESCRIPTION

The devices iC-VJ and iC-VJZ are control ICs for laser diodes. Control to the average of the laser current and integrated protective functions ensure safe operation of the sensitive semiconductor laser. All required functions for the pulse operation of a CW laser are integrated: a power driver and monitor amplifier for direct connection of the laser diode, an oscillator for pulse repetition frequency generation, a start-up and temperature protection as well as monitor and pulse repetition frequency outputs for synchronous control of a receiver circuit.

The laser power control is adapted to the laser diode used with an external resistor at ISET. The capacitor at CI determines the control time constants.

The oscillator operates with an external RC circuit in the range from about 10 kHz to 4 MHz. The gener-

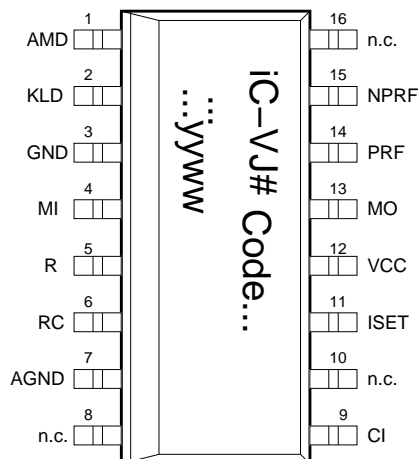
ated pulse duty factor is a stable 1:1; the oscillator frequency is reduced to 1/16th by the integrated divider.

An image of the laser diode current is output via MI. Output MI when connected with a low pass filter forms a voltage proportional to the average laser current. This voltage is output to MO via the integrated voltage follower and is thus available for any applications. The Outputs PRF and NPRF supply the pulse repetition frequency complementarily to analogue levels ($V_{CC}/2 \pm 0.75 V_{pk}$) to be able to activate high-speed ECL logic of a receiver circuit.

The IC contains protective diodes against ESD destruction, a thermal shutdown, plus a start-up circuit for the laser diode driver to protect the laser diode when the supply voltage is switched on.

PACKAGES SO16N to JEDEC Standard

PIN CONFIGURATION SO16N (top view)



PIN FUNCTIONS

No. Name Function

No.	Name	Function
1	AMD	Anode Monitor Diode
2	KLD	Cathode Laser Diode
3	GND	Ground
4	MI	Monitor Current Output
5	R	Oscillator Resistor
6	RC	Oscillator Capacitor
7	AGND	Analogue Ground
8	n.c.	
9	CI	Averaging Capacitor
10	n.c.	
11	ISET	Set-up Resistor for the Laser Diode Power
12	VCC	5 V Supply Voltage
13	MO	Monitor Voltage Output
14	PRF	Pulse Repetition Frequency Output
15	NPRF	Inverted PRF
16	n.c.	

ABSOLUTE MAXIMUM RATINGS

Beyond these values damage may occur; device operation is not guaranteed.

Item No.	Symbol	Parameter	Conditions	Fig.			Unit
					Min.	Max.	
G001	VCC	Supply Voltage			0	6	V
G002	I(AGND)	Current in AGND			-4	4	mA
G003	I(CI)	Current in CI			-4	4	mA
G004	V(KLD)	Voltage at KLD	PRF = lo		0	6	V
G005	I(KLD)	Current in KLD	PRF = hi		-4	600	mA
G006	I(AMD)	Current in AMD	iC-VJ iC-VJZ		-4	4	mA
					-6	6	mA
G007	I(PRF)	Current in PRF			-10	2	mA
G008	I(NPRF)	Current in NPRF			-10	2	mA
G009	I(R,RC)	Current in R, RC			-2	2	mA
G010	I(ISET)	Current at ISET			-2	2	mA
G011	I(MI)	Current in MI			-2	2	mA
G012	I(MO)	Current in MO			-2	2	mA
G013	Tj	Junction Temperature			-40	150	°C
G014	Ts	Storage Temperature			-40	150	°C

THERMAL DATA

Operating Conditions: VCC = 5V ±10%

Item No.	Symbol	Parameter	Conditions	Fig.				Unit
					Min.	Typ.	Max.	
T01	Ta	Operating Ambient Temperature Range (extended temperature range on request)			-25		90	°C
T02	Rthja	Thermal Resistance Chip to Ambient	soldered on PCB, without special cooling				140	K/W

All voltages are referenced to ground unless otherwise stated.

All currents into the device pins are positive; all currents out of the device pins are negative.

ELECTRICAL CHARACTERISTICS

Operating Conditions: VCC = 5 V ±10%, RSET = 5...50 kΩ, iC-VJ: I(AMD) = 50...500 μA, iC-VJZ: I(AMD) = 0.15...1.5 mA; Tj = -25...125 °C, unless otherwise stated.

Item No.	Symbol	Parameter	Conditions	Tj °C	Fig.				Unit	
						Min.	Typ.	Max.		
Total Device										
001	VCC	Permissible Supply Voltage Range at VCC				4.5		5.5		V
002	Iav(VCC)	Supply Current in VCC (average value)	Iav(KLD) = 100 mA, fosc = 3.2 MHz ±20%, I(PRF, NPRF) = 0					50		mA
003	tp(KLD-PRF)	Pulse Edge Delay I(KLD) to V(PRF)	PRF(hi ↔ lo), I(50%):V(50%)			-70		70		ns
004	tp(KLD-NPRF)	Pulse Edge Delay I(KLD) to V(NPRF)	NPRF(hi ↔ lo), I(50%):V(50%)			-70		70		ns
Driver KLD, AMD										
101	Vs(KLD)	Saturation Voltage at KLD	PRF = hi, I(KLD) = 200 mA					1.5		V
102	I0(KLD)	Leakage Current in KLD	PRF = lo, V(KLD) = VCC					10		μA
103	I(KLD)	Current in KLD	I(AMD) = 0			250				mA
104	V(AMD)	Voltage at AMD	iC-VJ: I(AMD) = 500 μA iC-VJZ: I(AMD) = 1.5 mA			0.5		1.5		V
105	tr	Current Rise Time in KLD	I _{max} (KLD) = 20...250 mA, I(KLD): 10% → 90%					150		ns
106	tf	Current Fall Time in KLD	I _{max} (KLD) = 20...250 mA, I(KLD): 90% → 10%					150		ns
107	CR1(I _{av})	Average Value for Current Ratio I(AMD) / I(ISET)	I(CI) = 0, closed control loop; iC-VJ iC-VJZ			0.8 2.4	1 3	1.2 3.6		
108	CR2(I)	Current Ratio I(AMD) / I(CI)	V(CI) = 1...3.5 V, ISET open; iC-VJ iC-VJZ			0.9 2.7	1 3	1.1 3.3		
Output PRF, NPRF										
201	Vav()	Average Value of Output Voltage	I(PRF, NPRF) = 0...-4 mA			47.5	50	52.5		%VCC
202	Vpk()	Amplitude	I(PRF, NPRF) = 0...-4 mA			625	750	875		mV
203	tpp()	Pulse/Pause Ratio				0.95	1	1.05		
204	j()	Jitter	VCC, fosc = const.					20		ns
205	tr()	Rise Time	CL() = 50 pF, V(): 10% → 90%					150		ns
206	tf()	Fall Time	CL() = 50 pF, V(): 90% → 10%					150		ns
Oscillator R, RC										
301	fosc	Oscillator Frequency	R1 = 800 Ω, C1 = 100 pF			2.64	2.9	3.19		MHz
302	fosc/f0	Frequency Drift	R × C = constant			0.85	1	1.15		
Divider										
401	Div	Division Factor fosc / PRF						16		
Reference ISET										
501	V(ISET)	Reference Voltage		27		1.20	1.22	1.27		V V
502	CR(I)	Current Ratio I(CI) / I(ISET)	V(CI) = 1...3.5 V, I(AMD) = 0			0.9	1	1.1		
503	RSET	Permissible Resistor at ISET to AGND (Control Set-up Range)				2.7		50		kΩ
Power-on and Thermal Shutdown										
601	VCCon	Turn-on Threshold VCC				3.0		4.1		V
602	VCChys	Hysteresis				300		450		mV
603	Toff	Thermal Shutdown Threshold				125		150		°C
604	Thys	Thermal Shutdown Hysteresis				10				°C
605	Vs(CI)lo	Saturation Voltage lo at CI in case of undervoltage	VCC = 0...VCCon – VCChys, I(CI) = 300 μA					1.5		V

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ELECTRICAL CHARACTERISTICS

Operating Conditions: $V_{CC} = 5V \pm 10\%$, $R_{SET} = 5...50\text{ k}\Omega$, iC-VJ: $I(AMD) = 50...500\ \mu\text{A}$,
iC-VJZ: $I(AMD) = 0.15...1.5\ \text{mA}$; $T_j = -25...125\ ^\circ\text{C}$, unless otherwise stated.

Item No.	Symbol	Parameter	Conditions	Tj °C	Fig.				Unit
						Min.	Typ.	Max.	
606	Vs(CI)hi	Saturation Voltage hi at CI	$V_{s(CI)hi} = V_{CC} - V(CI)$, $R_{SET} = 25\ \text{k}\Omega$; iC-VJ: $I(AMD) = 30\ \mu\text{A}$ iC-VJZ: $I(AMD) = 90\ \mu\text{A}$			0.3			V
Monitor Outputs MI, MO									
701	Iav(MI)	Current in MI (Average Value)	$R(MI) = 10\ \text{k}\Omega$, $C(MI) = 100\ \text{nF}$, $I_{av}(KLD) = 10...50\ \text{mA}$			0.15	0.19	0.23	% I(KLD)
702	Iav(MI)	Current in MI (Average Value)	$R(MI) = 10\ \text{k}\Omega$, $C(MI) = 100\ \text{nF}$, $I_{av}(KLD) = 50...125\ \text{mA}$			0.12	0.19	0.26	% I(KLD)
703	I0(MI)	Leakage Current in MI	$PRF = I_0$, $V(MI) = 0\ \text{V}$					3	μA
704	Vos(MO-MI)	Offset Voltage V(MO – MI)	$V(MI) = 0.2...3.5\ \text{V}$, $R(MO) = 5\ \text{k}\Omega$			-30		30	mV

DESCRIPTION OF FUNCTIONS

Laser Power Adjustment

The iC-VJ and iC-VJZ devices can be adapted to CW laser diodes from 2 to 40 mW. Models can be used in which the cathode of the monitor diode is connected to the anode or the cathode of the laser diode.

The driver output, pin KLD, permits laser diode currents of up to 250 mA. In the event of a thermal overload due to excessive high power dissipation, the driver is turned off.

The pin ISET is used for the adjustment to the sensitivity of the monitor diode and to set the desired optical laser power. The setpoint for the average control of the monitor diode current is preset at this pin, by connecting it either to a resistor or a current source.

When connected to a current source, by means of an operational amplifier with current output (OTA) for example, the laser power can also be modulated. In order to limit the current at pin ISET when turning on the supply for the OTA, however, the OTA output should be connected to the base point of RSET.

The maximum current possible at ISET must be taken into consideration when dimensioning the capacitor C2.

Example iC-VJ

Laser diode with 5 mW maximum optical output, monitor diode with 0.13 mA/mW, average power 1 mW (peak power 2 mW; pulse duty ratio T_{whi} / T is 50%).

RSET is calculated as:

$$RSET = \frac{CR1 * V(ISET)}{I(AMD)} = \frac{1 * 1.22 V}{0.13 mA} \approx 9.4 k\Omega$$

with the Electrical Characteristics No. 501 for V(ISET) and with No. 107 for current ratio CR1.

Example iC-VJZ

Laser diode with 5 mW maximum optical output, monitor diode with 0.75 mA at 3 mW, average power 1 mW (peak 2 mW; pulse duty ratio T_{whi} / T is 50%).

For the average monitor current of 0.25 mA the resistor RSET is calculated as:

$$RSET = \frac{CR1 * V(ISET)}{I(AMD)} = \frac{3 * 1.22 V}{0.25 mA} \approx 14.6 k\Omega$$

with the Electrical Characteristics No. 501 for V(ISET) and with No. 107 (iC-VJZ) for current ratio CR1.

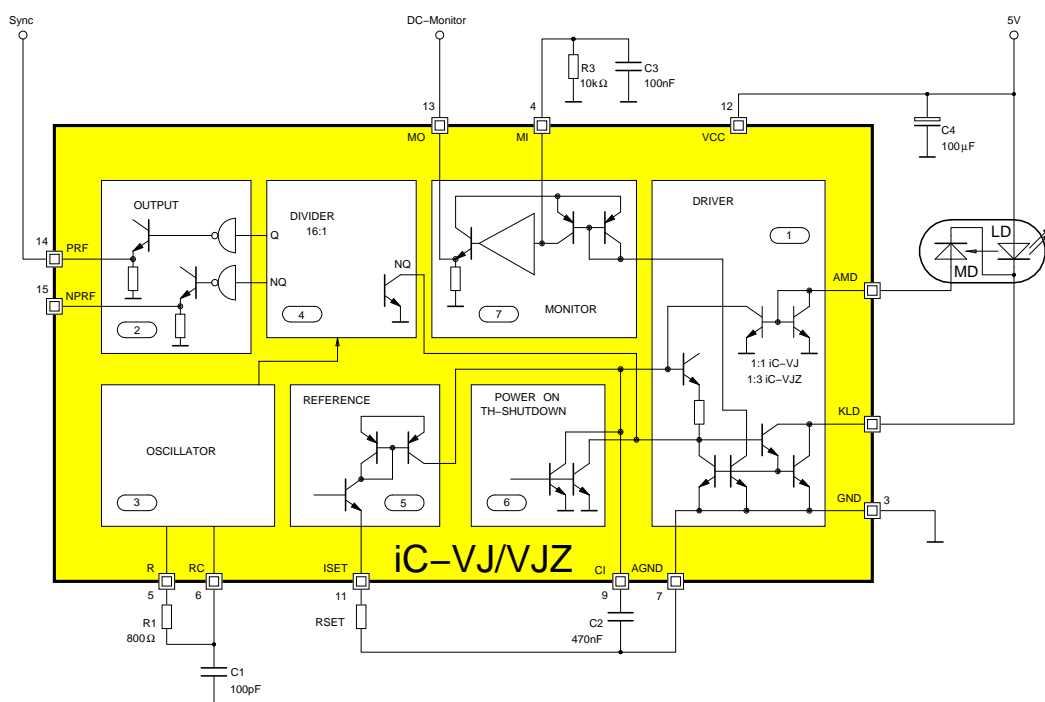


Figure 1: Operation of a laser diode according to the example

Oscillator

The internal oscillator operates in the range approx. 10 kHz to 4 MHz. This enables laser pulse repetition frequencies from 1 to 200 kHz. Fig. 2 shows the pulse repetition frequency as a function of the oscillator circuit.

Example

R1 = 620 Ω, C1 = 82 pF: f ≈ 200 kHz

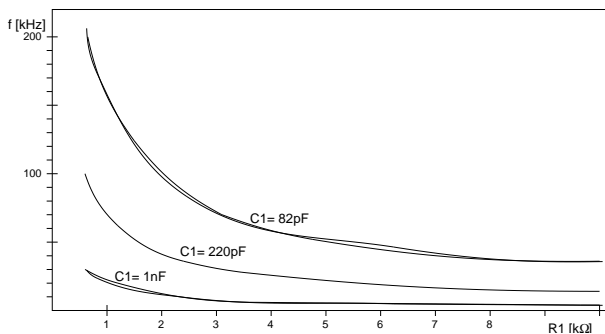


Figure 2: Pulse repetition frequency

Averaging Control

The control of the average optical laser power requires the external capacitor C2 at pin CI. This capacitor is used for averaging and must be adjusted to the selected pulse repetition frequency and the charging current preset with RSET. The ratios are linear in both cases, i.e. C2 must be increased in size proportionally as the pulse repetition frequency slows or resistance RSET decreases.

$$C2 \geq \frac{440 * I(ISET)}{f * V(ISET)} = \frac{440}{f * RSET}$$

Example

Frequency 10 kHz, RSET = 10 kΩ: C2 ≈ 4.7 μF

Otherwise the charging of C2 during the pulse pauses (with I(ISET) = 1.22 V / RSET) will result in excessive mean value potential at pin CI and the laser diode may be destroyed with the next pulse. C2 is correctly dimensioned when the current through the laser diode and the optical output signal do not show any overshooting on the rising edge.

In steady-state condition, signals will then appear at the IC pins as shown in Fig. 3. In this case the laser pulse exhibits a minimal overshoot on the rising edge, but this can be tolerated. The increase in the current in KLD and the laser pulse follow directly after the signal at the divider output PRF. The outputs PRF and NPRF are used for receiver synchronisation.

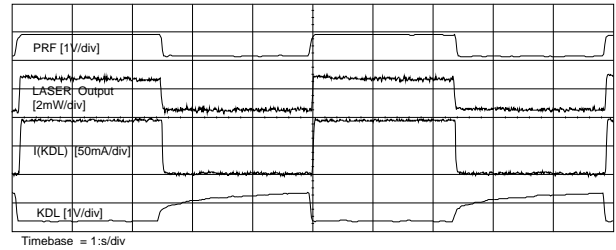


Figure 3: Settled control with 200 kHz pulse repetition frequency

Turn-on and Turn-off Behavior

Capacitor C2 also determines the starting time from switching on the supply voltage VCC to steady-state laser pulse operation. The values of C2 which are necessary higher for low pulse repetition frequencies increase this starting time to several milliseconds (Fig. 4). The following applies for estimating the starting time:

$$T_{on} \approx \frac{2.5 V * C2}{I(ISET)} = \frac{2.5 V * C2 * RSET}{1.22 V}$$

Example

C2 = 4.7 μF, RSET = 10 kΩ: T_{on} ≈ 96 ms

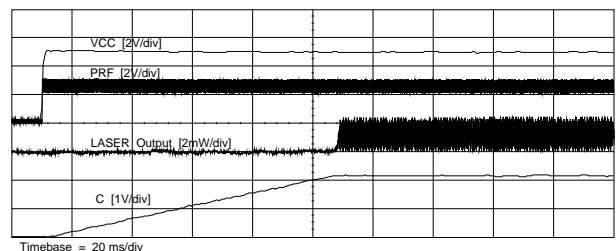


Figure 4: Turn-on behavior f = 10 kHz, RSET = 10 kΩ, C2 = 4.7 μF

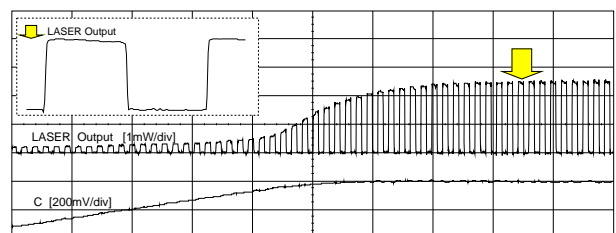


Figure 5: Settling of the averaging control

For high pulse repetition frequencies (200 kHz) and low C2 values (220 nF) and for RSET = 10 kΩ the averaging control achieves its operating point after 3.5 ms. Fig. 5 shows the turn-on, Fig. 6 the turn-off behavior, here in case of undervoltage.

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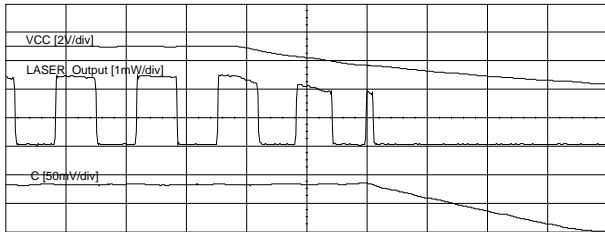


Figure 6: Turn-off behavior

up transients (Fig. 7). This capacitor should be placed close to the laser diode and not at the start of the LD supply line.

An approx. 12Ω series resistor at pin KLD reduces the iC power consumption and damps possible resonances of the load circuit caused by the inductive LD supply line. This resistor is useful for many applications, also for those which do not operate via cable.

Operation of a laser diode via cable

It is recommended to connect a capacitor from 1 nF up to 10 nF across the laser diode in order to protect the laser diode against destruction due to ESD or build-

When the LD supply line is laid out on the PCB, the forward path VCC should be arranged in parallel with, i.e. be close to the return path to KLD, even when the line is only a few centimeters in length.

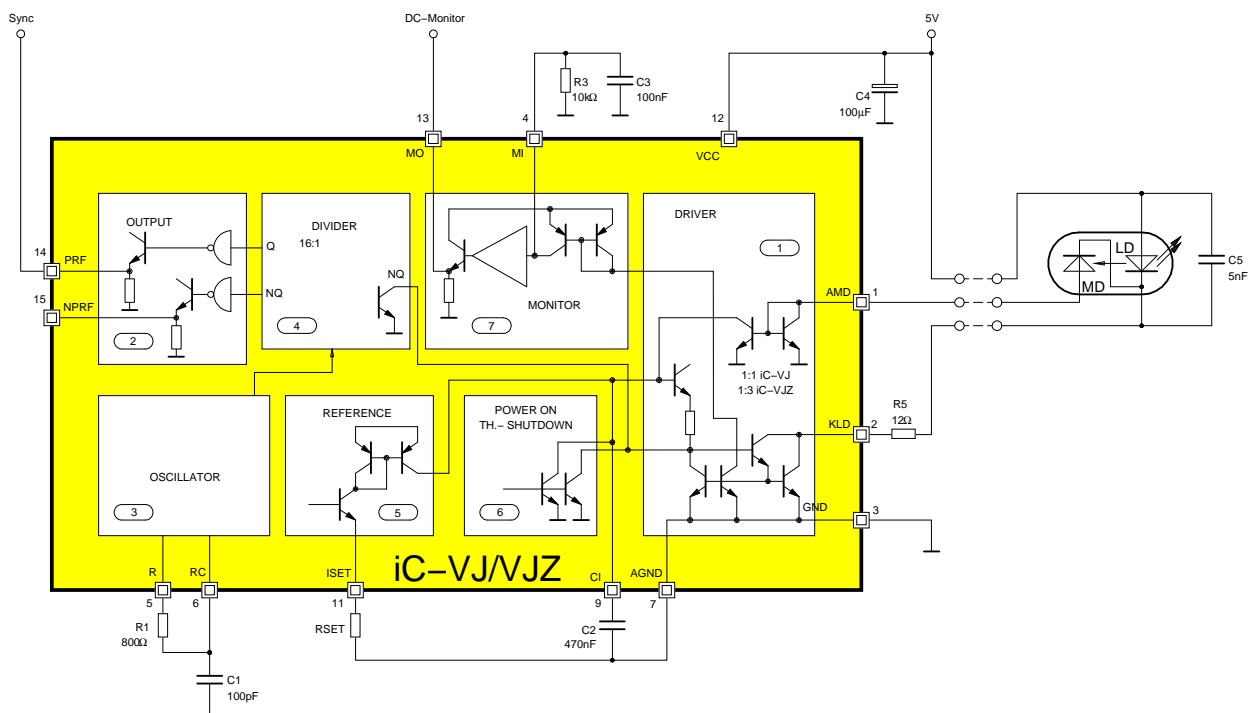


Figure 7: Operation of a laser diode via cable

EVALUATION BOARD

For the devices iC-VJ/VJZ a Demo Board is available for test purposes. The following figures show the schematic diagram and the component side of the test PCB.

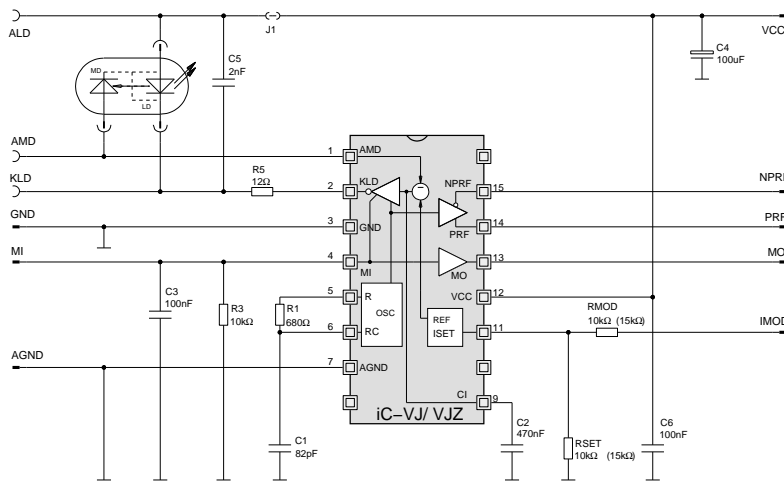


Figure 8: Schematic diagram of the Demo Board

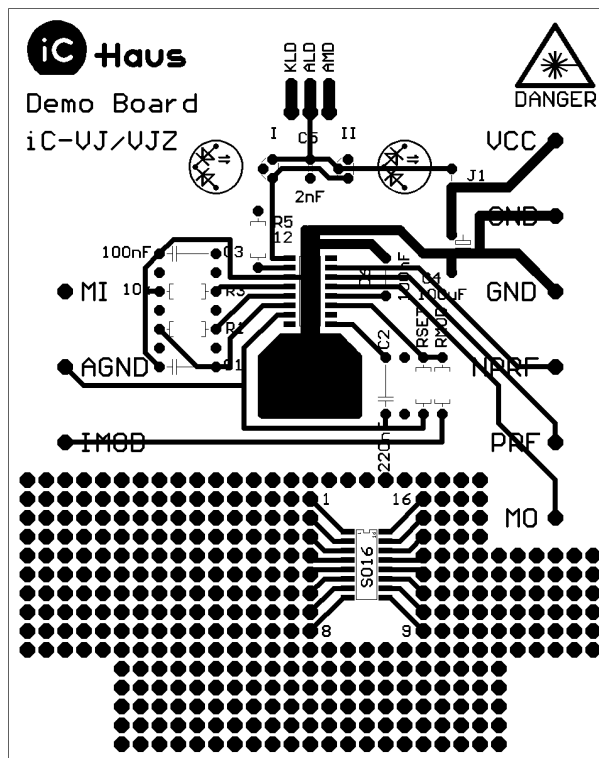


Figure 9: Demo Board (components side)

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ORDERING INFORMATION

Type	Package	Order Designation
iC-VJ Demo Board	SO16N	iC-VJ SO16N iC-VJ EVAL VJD
iC-VJZ Demo Board	SO16N	iC-VJZ SO16N iC-VJZ EVAL VJD