iC-VJ, iC-VJZ
LASER DIODE CONTROLLER

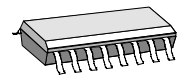
FEATURES

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

APPLICATIONS

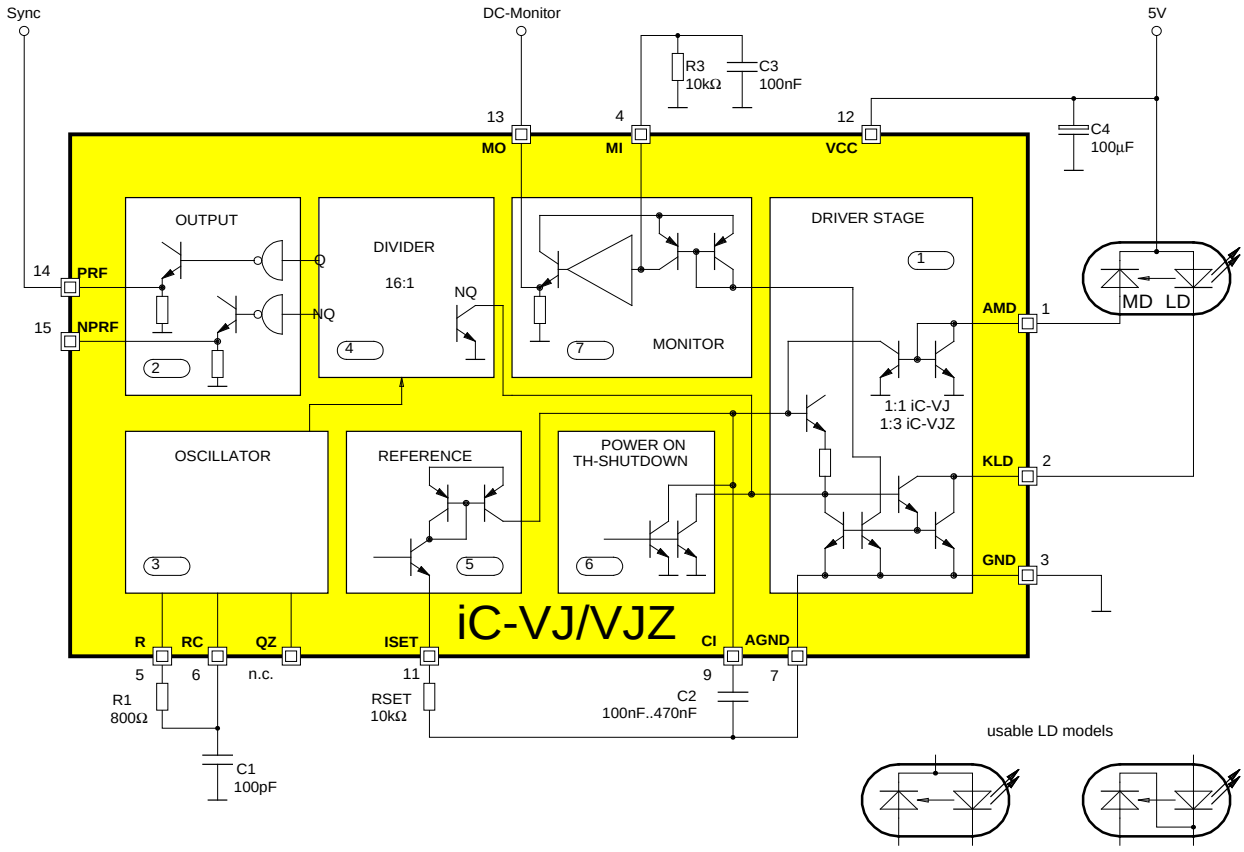
- ♦ Transmitter for laser light barriers from 1 to 200kHz

PACKAGES



iC-VJ, iC-VJZ
SO16N

BLOCK DIAGRAM



Rev A0

iC-Haus GmbH
Integrated Circuits
Am Kuemmerling 18, D-55294 Bodenheim

Tel +49-6135-9292-0
Fax +49-6135-9292-192
http://www.ichaus.com

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 nondestructive 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 protector as well as monitor and pulse repetition frequency outputs for synchronous control of a receiver circuit.

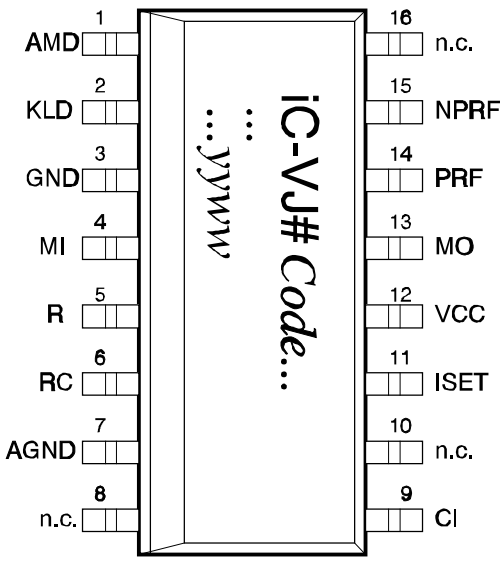
The laser power regulation is adapted to the laser diode used with an external resistor at ISET. The capacitor at CI determines the control time constants.
The oscillator operates with an external RC circuit in the range from about 10kHz to 4MHz. The generated pulse duty factor is a stable 1:1; the oscillator frequency is reduced to 1/16th by the integrated divider. A different IC model permits the oscillator to be wired with ceramic resonator or quartz, for example with a 3.2MHz quartz to generate a pulse repetition frequency of 200kHz.

An image of the laser diode current is output via MI. The MI connection is designed for the circuit with a low pass and then 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 analog levels (VCC/2 ± 0.75 Vpk) 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
1	AMD	Anode Monitor Diode
2	KLD	Cathode Laser Diode
3	GND	Ground
4	MI	Monitor Current Output
5	R	Oscillator Resistor (Optional: Terminal for Crystal Oscillator or Ceramic Resonator)
6	RC	Oscillator Capacitor
7	AGND	Analog Ground
8	n.c.	
9	CI	Capacitor Attachment
10	n.c.	
11	ISET	Set-up Resistor for the Laser Diode Power
12	VCC	5V Supply Voltage
13	MO	Monitor Voltage Output
14	PRF	Pulse Repetition Frequency Output
15	NPRF	Inverted PRF
16	n.c.	

ABSOLUTE MAXIMUM RATINGS

Values beyond which damage may occur; device operation is not guaranteed.

Item	Symbol	Parameter	Conditions	Fig.	Min.	Max.	Unit
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
G101	V(KLD)	Voltage at KLD	PRF= lo		0	6	V
G102	I(KLD)	Current in KLD	PRF= hi		-4	600	mA
G103	I(AMD)	Current in AMD			-4	4	mA
G201	I(PRF)	Current in PRF			-10	2	mA
G202	I(NPRF)	Current in NPRF			-10	2	mA
G301	I(R,RC)	Current in R, RC			-2	2	mA
G302	I(QZ)	Current in QZ	only for devices with pin QZ		-2	2	mA
G501	I(ISET)	Current at ISET			-2	2	mA
G701	I(MI)	Current in MI			-2	2	mA
G702	I(MO)	Current in MO			-2	2	mA
TG1	Tj	Junction Temperature			-40	150	°C
TG2	Ts	Storage Temperature			-40	150	°C
iC-VJZ with a monitor current range of 0.15..1.5mA Max. ratings for iC-VJ are valid with the following replacements:							
G103	I(AMD)	Current in AMD			-6	6	mA

THERMAL DATA

Operating Conditions: VCC= 5V ±10%

Item	Symbol	Parameter	Conditions	Fig.	Min.	Typ.	Max.	Unit
T1	Ta	Operating Ambient Temperature Range (extended temperature range on request)			-25		90	°C
T2	Rthja	Thermal Resistance Chip to Ambient	soldered on PCB, without special cooling				140	K/W

All voltages are referenced to ground unless otherwise noted.
All currents into the device pins are positive; all currents out of the device pins are negative.

ELECTRICAL CHARACTERISTICS

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

Item	Symbol	Parameter	Conditions	Tj °C	Fig.	Min.	Typ.	Max.	Unit
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)= 100mA, fosc= 3.2MHz ±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 Stage KLD, AMD									
101	Vs(KLD)	Saturation Voltage at KLD	PRF= hi, I(KLD)= 200mA					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)	iC-VJ: Voltage at AMD	I(AMD)= 500µA			0.5		1.5	V
105	tr	Current Rise Time in KLD	Imax(KLD)= 20..250mA, I(KLD): 10%→90%					150	ns
106	tf	Current Fall Time in KLD	Imax(KLD)= 20..250mA, I(KLD): 90%→10%					150	ns
107	CR1()av	iC-VJ: Mean Value for Current Ratio I(AMD) / I(ISET)	I(CI)= 0, closed control loop			0.8	1	1.2	
108	CR2()	iC-VJ: Current Ratio I(AMD) / I(CI)	V(CI)= 1..3.5V, ISET open			0.9	1	1.1	
Output PRF, NPRF									
201	Vav()	Average Value of Output Voltage	I(PRF,NPRF)= 0..-4mA			47.5	50	52.5	%VCC
202	Vpk()	Amplitude	I(PRF,NPRF)= 0..-4mA			625	750	875	mV
203	tpp()	Pulse/Pause Ratio				0.95	1.0	1.05	
204	j()	Jitter	VCC, fosc = const.					20	ns
205	tr()	Rise Time	CL()= 50pF, V(): 10%→90%					150	ns
206	tf()	Fall Time	CL()= 50pF, V(): 90%→10%					150	ns
Oscillator R, RC (Option: QZ)									
301	fosc	Oscillator Frequency	R1= 800Ω, C1= 100pF			2.64	2.9	3.19	MHz
302	fosc/f0	Frequency Drift	R×C= constant			0.85	1	1.15	
303	fosc(QZ)	Oscillator Frequency with Crystal Oscillator	Device with Pin QZ: 3.2MHz Quarz at QZ			2.88	3.2	3.52	MHz
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()	Current Ratio I(CI) / I(ISET)	V(CI)= 1..3.5V, I(AMD)= 0			0.9	1.0	1.1	
503	RSET	Permissible Resistor at ISET to AGND (Control Set-up Range)				2.7		50	kΩ

ELECTRICAL CHARACTERISTICS

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

Item	Symbol	Parameter	Conditions	Tj °C	Fig.	Min.	Typ.	Max.	Unit
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)= 300µA					1.5	V
606	Vs(CI)hi	iC-VJ: Saturation Voltage hi at CI	Vs(CI)hi= VCC-V(CI); RSET= 25kΩ, I(AMD)= 30µA			0.3			V
Monitor Outputs MI, MO									
701	Iav(MI)	Current in MI (Average Value)	R(MI)=10kΩ,C(MI)=100nF Iav(KLD)= 10..50mA			0.15	0.19	0.23	%I (KLD)
702	Iav(MI)	Current in MI (Average Value)	R(MI)=10kΩ,C(MI)=100nF Iav(KLD)= 50..125mA			0.12	0.19	0.26	%I (KLD)
703	I0(MI)	Leakage Current in MI	PRF= lo, V(MI)= 0V					3	µA
704	Vos (MO-MI)	Offset Voltage V(MO-MI)	V(MI)= 0.2..3.5V, R(MO)= 5kΩ			-30		30	mV
iC-VJZ with a monitor current range of 0.15..1.5mA Characteristics for iC-VJ are valid with the following replacements:									
104	V(AMD)	Voltage at AMD	I(AMD)= 1.5mA			0.5		1.5	V
107	CR1()av	Mean Value for Current Ratio I(AMD) / I(ISET)	I(CI)= 0, closed control loop			2.4	3	3.6	
108	CR2()	Current Ratio I(AMD) / I(CI)	V(CI)= 1..3.5V, ISET open			2.7	3	3.3	
606	Vs(CI)hi	Saturation Voltage hi at CI	Vs(CI)hi= VCC-V(CI); RSET= 25kΩ, I(AMD)= 90µA			0.3			V

DESCRIPTION OF FUNCTIONS

Laser Power Adjustment

The iC-VJ and iC-VJZ devices can be adapted to CW laser diodes from 2 to 40mW. 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 250mA minimal. In the event of a thermal overload due to an excessively high IC power loss, the driver turns 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 wiring it either to a resistor or a current source.
When wired to a current source, achieved for example by using an operational amplifier with current output (OTA), the laser power can also be modulated analog. In order to limit the current at pin ISET while turn-on the supply for the OTA circuity, however, the OTA output should be linked to the base point of RSET (instead of to AGND). The maximum current possible at ISET must be taken into consideration when dimensioning the capacitor C2.

Example iC-VJ: Laser diode with 5mW maximum optical output, monitor diode with 0.13mA/mW, average power 1mW (peak power 2mW; pulse duty ratio Twhi/T is 50%):
RSET is calculated as:

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

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

Example iC-VJZ: Laser diode with 5mW maximum optical output, monitor diode with 0.75mA at 3mW, average power 1mW (peak 2mW; pulse duty ratio Twhi/T is 50%):
For the average monitor current of 0.25mA the resistor RSET is calculated as:

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

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

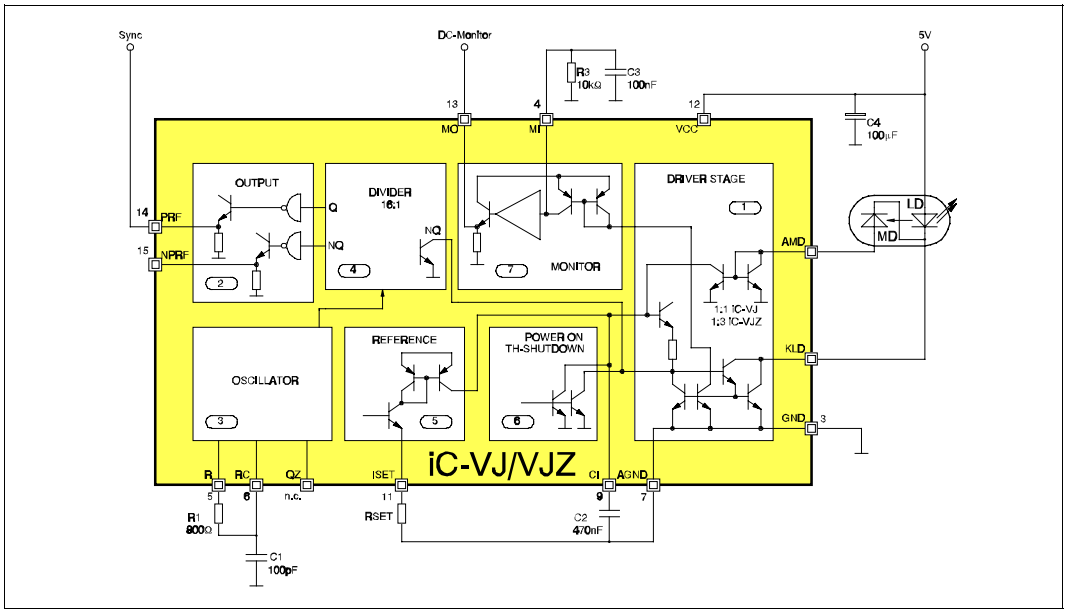


Fig. 1: Operation of a laser diode according to the example

Oscillator

The internal oscillator operates in the range approx. 10kHz to 4MHz in case of the RC circuit. This enables laser pulse repetition frequencies from 1 to 200kHz. Fig. 2 shows the resultant pulse repetition frequency as a function of the oscillator circuit.
Example: R1= 620Ω, C1= 82pF: f≈ 200kHz

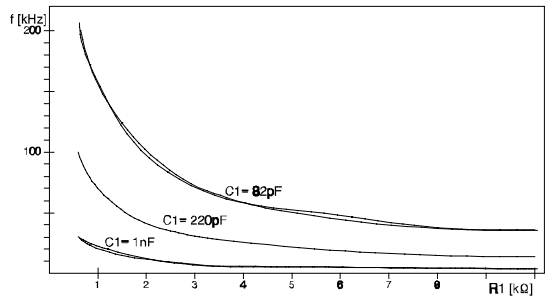


Fig 2: Pulse repetition frequency

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 declines.

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

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

Otherwise the charging of C2 during the pulse pauses (with I(ISET)= 1.22V / 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 following the starting flank.

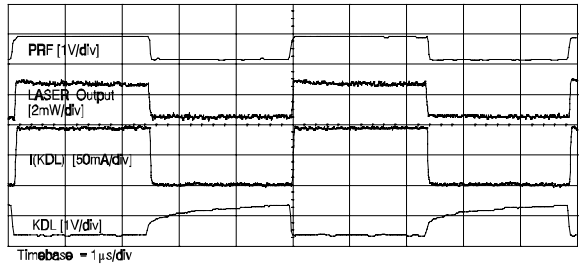


Fig. 3: Stabilized control with 200kHz pulse repetition frequency

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 after the starting flank, 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 synchronization.

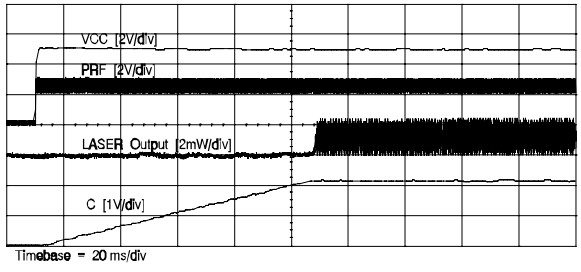


Fig. 4: Turn-on behavior
f=10kHz, RSET=10kΩ, C2=4.7µF

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:

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

Example:C2= 4.7µF, RSET= 10kΩ: $T_{on} \approx 96ms$

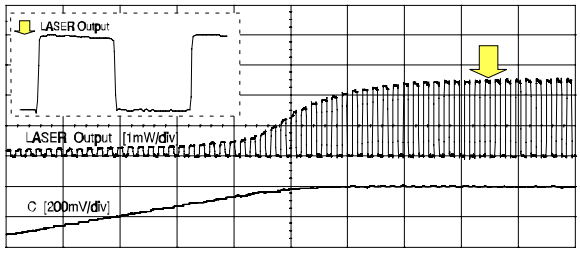


Fig. 5: Built-up transient of the averaging control

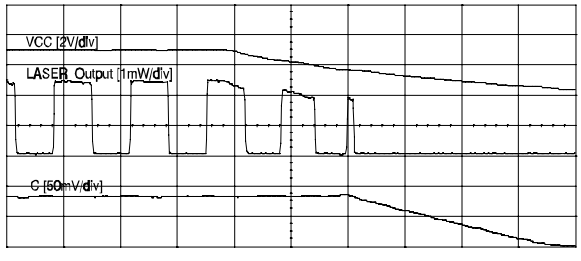


Fig. 6: Turn-off behavior

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

OPERATION OF A LASER DIODE VIA CABLE

It is recommended to connect a capacitor from 1nF up to 10nF across the laser diode in order to protect the laser diode against destruction due to ESD or build-up transients (Fig. 7). This capacitor should be placed close to the laser diode and not at the entry 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.

When the LD supply line is printed 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.

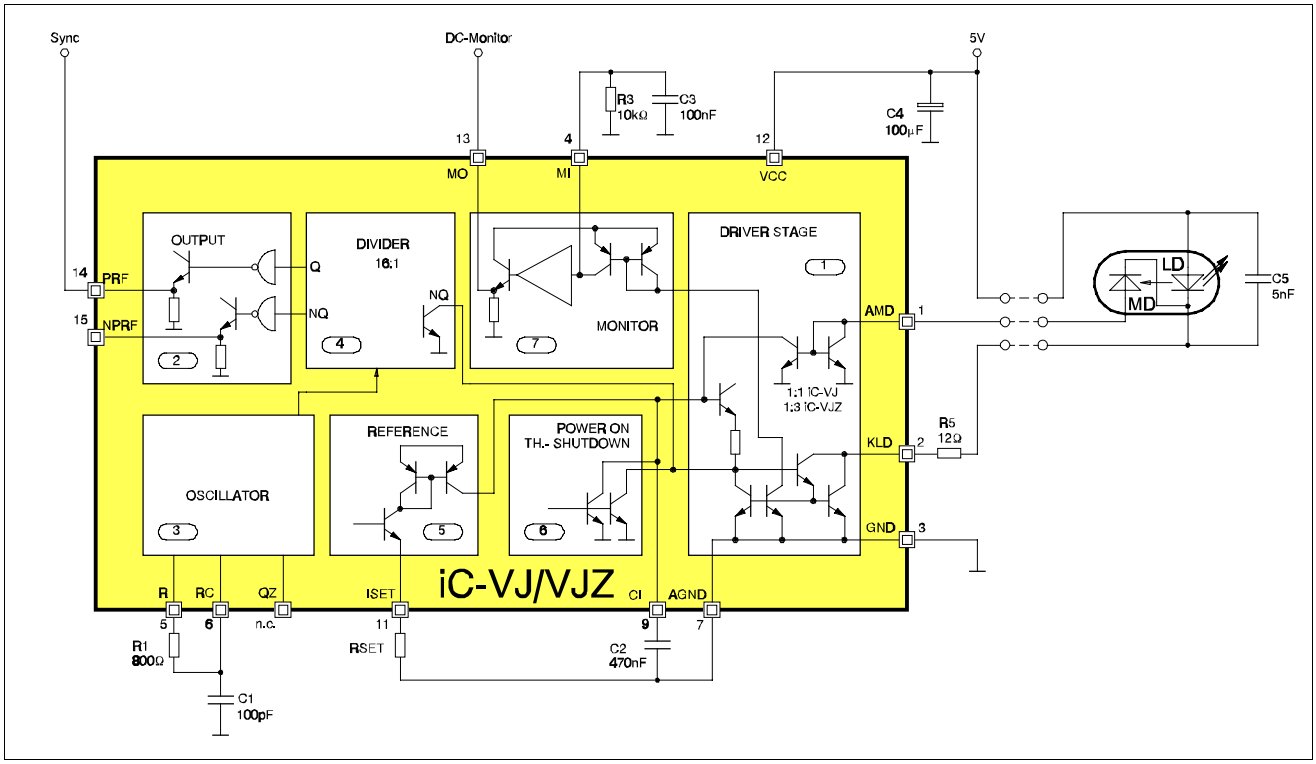


Fig. 7: Operation of a laser diode via cable

DEMO BOARD

The iC-VJ and iC-VJZ devices are equipped with a Demo Board for test purposes. The following figures show the wiring as well as the top and bottom layout of the test PCB.

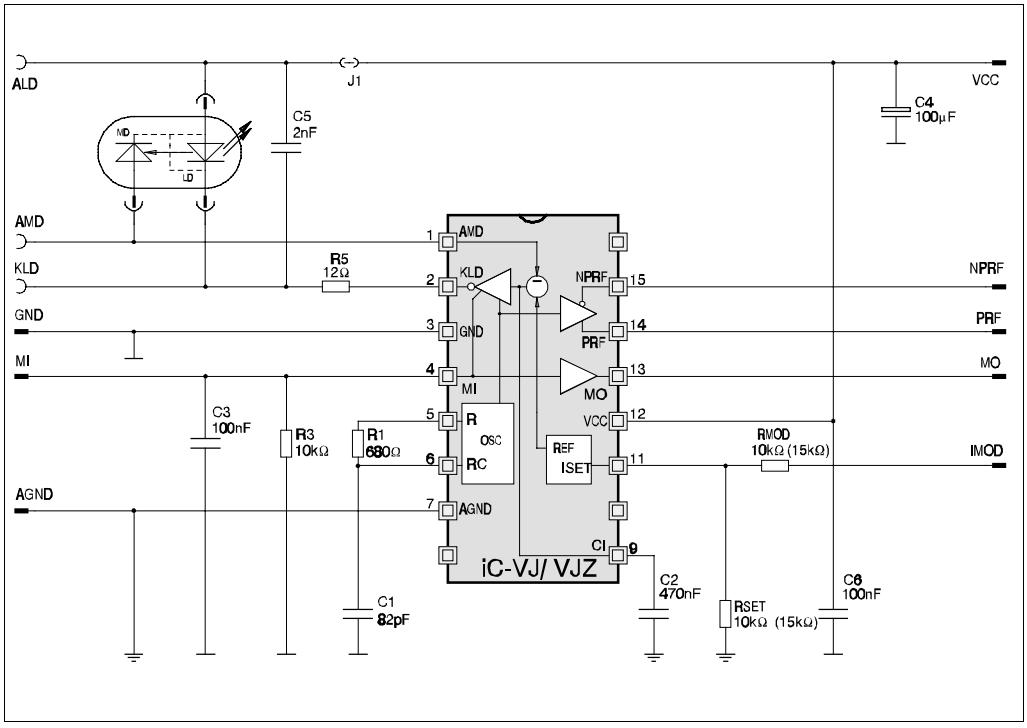


Fig. 8: Schematic diagram of the Demo Board

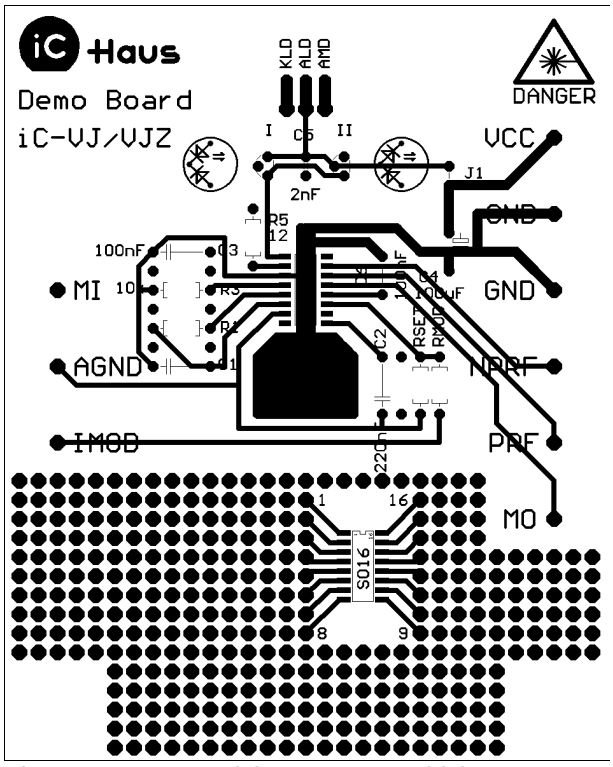


Fig. 9: Demo Board (components side)

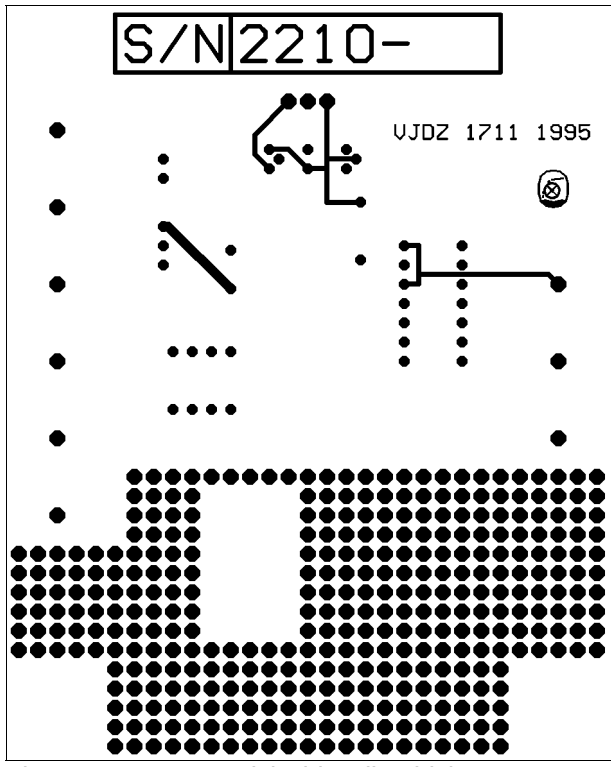


Fig. 10: Demo Board (solder dip side)

ORDERING INFORMATION

Type	Package	Order designation
iC-VJ VJ Demo Board	SO16N	iC-VJ-SO16N VJ Demo Board
iC-VJZ VJZ Demo Board	SO16N	iC-VJZ-SO16N VJZ Demo Board

For information about prices, terms of delivery, options for other case types, etc., please contact:

iC-Haus GmbH
Am Kuemmerling 18
D-55294 Bodenheim
GERMANY

Tel +49-6135-9292-0
Fax +49-6135-9292-192
http://www.ichaus.com