iC-WJ, iC-WJZ
LASER DIODE DRIVER

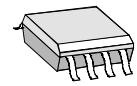
FEATURES

- ♦ Laser diode driver for continuous and intermittent operation (CW to 300kHz) up to 250mA
- ♦ Averaging control of laser power
- ♦ Simple adjustment of the laser power via external resistor
- ♦ Adjustable watchdog at the switching input to protect the laser diode
- ♦ Smooth starting after power-on
- ♦ Driver shutdown in the case of overtemperature and undervoltage
- ♦ Single 5V supply
- ♦ Simple circuitry
- ◊ **iC-WJ** for laser diodes with 50..500µA monitor current
- ◊ **iC-WJZ** for laser diodes with 0.15..1.5mA monitor current

APPLICATIONS

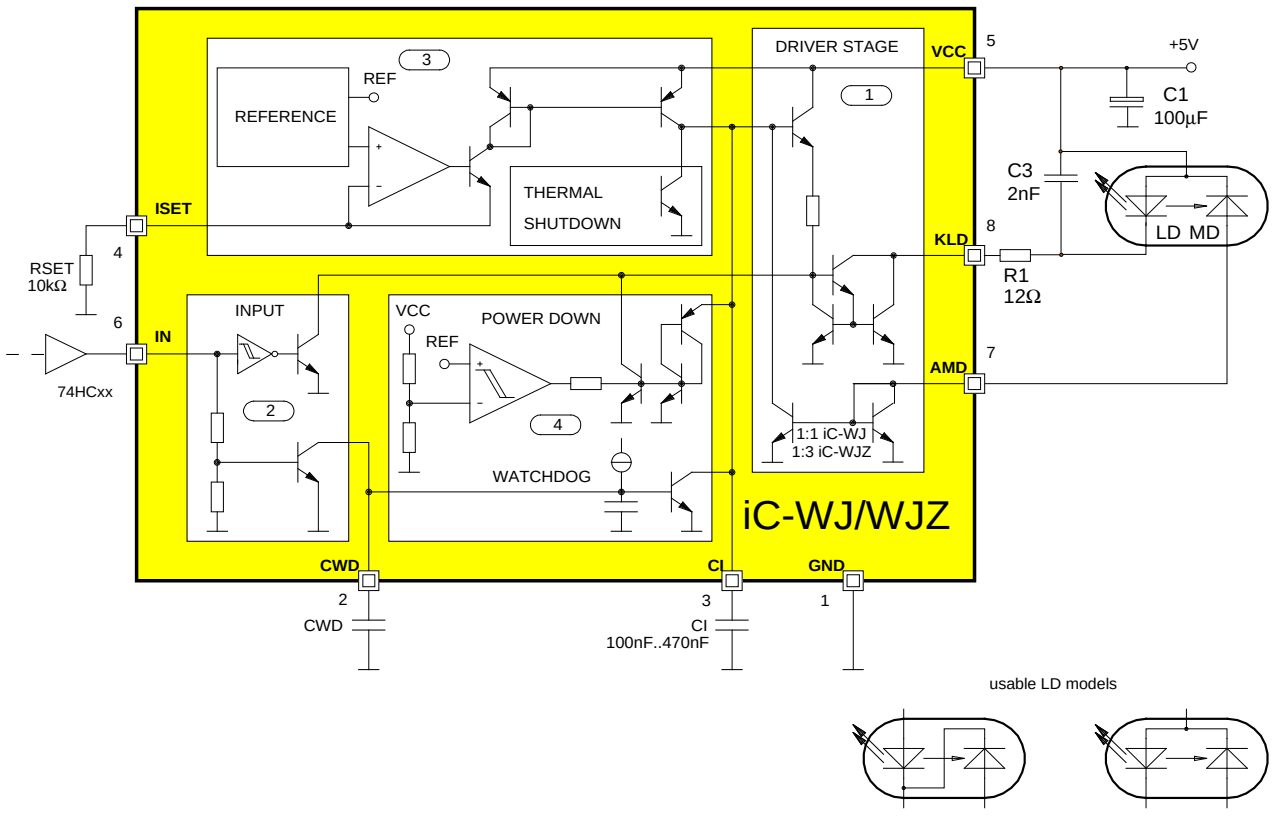
- ♦ Driver with protective functions for CW laser diodes

PACKAGES



iC-WJ, iC-WJZ
SO8

BLOCK DIAGRAM



Rev A1

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DESCRIPTION

The iC-WJ and iC-WJZ devices are driver ICs for laser diodes in continuous and intermittent operation up to 300kHz. The laser diode is activated via switching input IN. A control to the mean value of the optical laser power and integrated protective functions ensure nondestructive operation of the sensitive semiconductor laser.

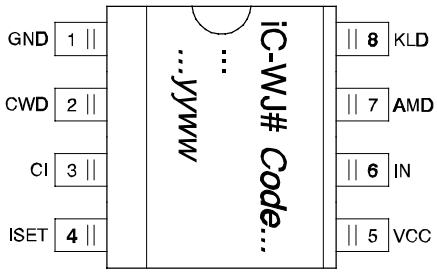
The IC contains protective diodes to prevent destruction due to ESD, a protective circuit to guard against overtemperature and undervoltage and a starting circuit for the laser diode driver to protect the laser diode when switching on the supply voltage.

An external resistor at ISET is employed to adapt the power control to the laser diode being used. The capacitor at CI determines the recovery time constants and the starting time.

A watchdog circuit monitors the switching input IN. If IN remains low longer than preset by the capa-citor at CWD, the capacitor of the power control is discharged at pin CI. This ensures that the current through the laser diode during the next high pulse at input IN is not impermissibly high.

PACKAGES SO8 to JEDEC Standard

PIN CONFIGURATION SO8
(top view)



PIN-FUNKTIONEN

No.	Name	Function
1	GND	Ground
2	CWD	Capacitor for Watchdog
3	CI	Capacitor for Power Control
4	ISET	Attachment for RSET
5	VCC	5V Supply Voltage
6	IN	Input
7	AMD	Anode Monitor Diode
8	KLD	Cathode Laser Diode

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
G101	I(CI)	Current in CI			-4	4	mA
G102	V(KLD)	Voltage at KLD	IN= lo		0	6	V
G103	I(KLD)	Current in KLD	IN= hi		-4	600	mA
G104	I(AMD)	Current in AMD			-4	4	mA
G201	I(IN)	Current in IN			-10	2	mA
G301	I(ISET)	Current in ISET			-2	2	mA
G401	I(CWD)	Current in CWD	IN= lo		-2	2	mA
EG1	Vd()	ESD Susceptibility at CWD, CI, ISET, IN, AMD, KLD	MIL-STD-883, HBM 100pF discharged through 1.5kΩ			2	kV
TG1	Tj	Junction Temperature			-40	150	°C
TG2	Ts	Storage Temperature			-40	150	°C
iC-WJZ with a monitor current rating of 0.15..1.5mA Max. ratings for iC-WJ are valid with the following replacements:							
G104	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	surface mounted 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= 2.7..27kΩ,iC-WJ: I(AMD)= 50..500µA,
iC-WJZ: 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				4.5		5.5	V
002	Iav(VCC)	Supply Current in VCC (average value)	Iav(KLD)= 100mA, f(IN)= 200kHz ±20%					15	mA
003	tp(IN-KLD	Delay Time Pulse Edge V(IN) to I(KLD)	IN(hi←→lo), V(50%):I(50%)			65		135	ns
004	Vc()lo	Clamp Voltage lo at VCC, IN, AMD, KLD, CI, CWD, ISET	I()= -2mA, other pins open			-1.5		-0.3	V
005	Vc()hi	Clamp Voltage hi at IN, AMD, KLD, GND, CI, CWD, ISET	Vc()hi= V()-VCC; I()= 2mA, other pins open			0.3		1.5	V
Driver Stage									
101	Vs(KLD)	Saturation Voltage at KLD	IN= hi, I(KLD)= 200mA					1.3	V
102	I0(KLD)	Leakage Current in KLD	IN= lo, V(KLD)= VCC					10	µA
103	I(KLD)	Current in KLD	IN= hi, I(AMD)= 0	-25 27 70 125		225 250 250 250	250		mA mA mA mA
104	V(AMD)	iC-WJ: Voltage at AMD	I(AMD)= 500µA			0.5		1.5	V
105	tr	Current Rise Time in KLD	Imax(KLD)= 20..250mA, Ip(): 10%→90%					100	ns
106	tf	Current Fall Time in KLD	Imax(KLD)= 20..250mA, Ip(): 90%→10%					100	ns
107	K/KL	Control Tolerance K= I(AMD) × RSET	VCC steady KL= constant for each lot			0.95	1	1.05	
108	CR1()	iC-WJ: Current Ratio I(AMD) / I(ISET)	I(CI)= 0, closed control			0.8	1	1.2	
109	CR2()	iC-WJ: Current Ratio I(AMD) / I(CI)	V(CI)= 1..3.5V, ISET open			0.9	1	1.1	
Input IN									
201	Vt()hi	Threshold hi		 -25 27 70 125		1.60	 1.84 1.87 1.88 1.91	2.20	V V V V V
202	Vt()lo	Threshold lo		 -25 27 70 125		1.58	 1.76 1.78 1.79 1.81	2.10	V V V V V
203	Vt()hys	Hysteresis		 -25 27 70 125		10	 80 90 90 100	190	mV mV mV mV mV
204	Rin	Pull-Down Resistor	V(IN)= -0.3..VCC+0.3V			4		16	kΩ
205	V0()	Open-loop Voltage	I(IN)= 0					0.1	V

ELECTRICAL CHARACTERISTICS

Operating Conditions: VCC= 5V ±10%, RSET= 2.7..27kΩ,iC-WJ: I(AMD)= 50..500µA,
iC-WJZ: I(AMD)= 0.15..1.5mA, Tj= -25..125°C, unless otherwise noted.

Item	Symbol	Parameter	Conditions	Tj °C	Fig.	Min.	Typ.	Max.	Unit
Input IN (continued)									
206	Vtwd()	Threshold for Watchdog		-25 27 70 125		2.4 2.0 1.5 1.0		3.2 2.8 2.3 1.8	V V V V
Reference und Thermal Shutdown									
301	V(ISET)	Voltage at ISET		 27		1.20	 1.22	1.27	V V
302	CR()	Current Ratio I(CI) / I(ISET)	V(CI)= 1..3.5V, I(AMD)= 0			0.9	1	1.1	
303	RSET	Permissible Resistor at ISET (Control Set-up Range)				2.7		50	kΩ
304	Toff	Thermal Shutdown Threshold				125		150	°C
305	Thys	Thermal Shutdown Hysteresis				10		40	°C
Power-Down and Watchdog									
401	VCCon	Turn-on Threshold VCC		 27		3.5	 3.8	4.3	V V
402	VCCoff	Undervoltage Threshold at VCC				3.2		3.7	V
403	VCChys	Hysteresis	VCChys= VCCon-VCCoff	 27		300	 400	450	mV mV
404	Vs(CI)of	Saturation Voltage at CI in case of Undervoltage	I(CI)= 300µA, VCC < VCCoff					1.6	V
405	Vs(CI)wd	Saturation Voltage at CI for IN= lo	I(CI)= 300µA, t(IN= lo) > tp (*)					1.5	V
406	Isc(CWD)	Pull-Up Current at CWD	V(CWD)= 0, IN= lo			3		15	µA
407	tpmin	Min. Activation Time for Watchdog	IN= lo, CWD open			10		45	µs
408	Kwd (*)	Constant for Calculating the Watchdog Activation Time	IN= lo			0.19	0.38	0.57	µs/pF
iC-WJZ with a monitor current rating of 0.15..1.5mA Characteristics for iC-WJ are valid with the following replacements:									
104	V(AMD)	Voltage at AMD	I(AMD)= 1.5mA			0.5		1.5	V
108	CR1()	Current Ratio I(AMD) / I(ISET)	I(CI)= 0, closed control			2.4	3	3.6	
109	CR2()	Current Ratio I(AMD) / I(CI)	V(CI)= 1..3.5V, ISET open			2.7	3	3.3	

(*): tp = (C(CWD) × Kwd) + tpmin (see Applications Information)

APPLICATIONS INFORMATION

Laser Power Adjustment

The iC-WJ and iC-WJZ 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 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 averaging control of the monitor diode current is preset at this pin.

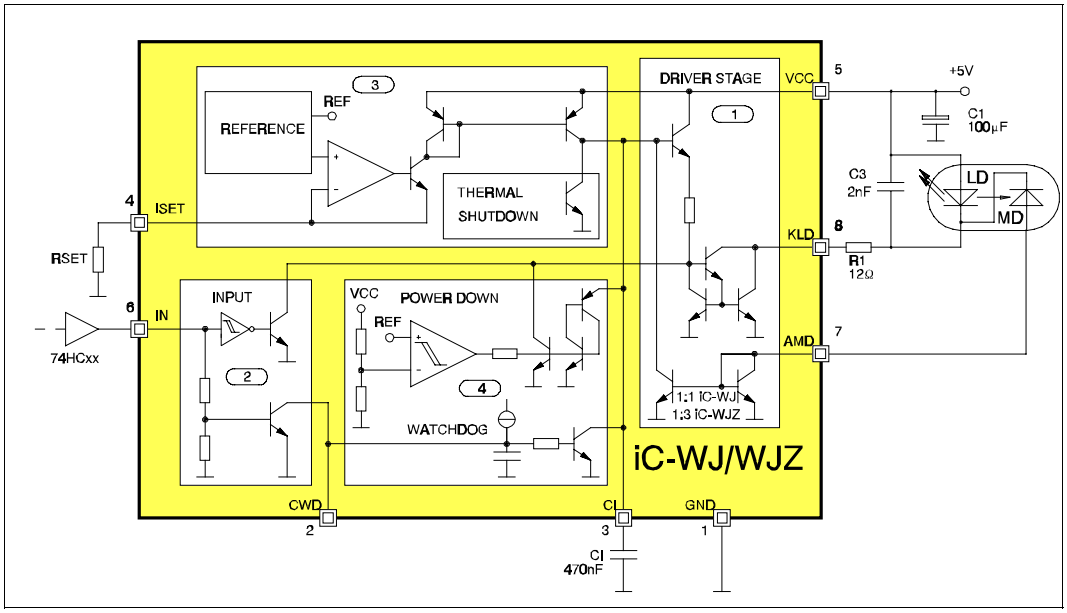


Fig. 1: Operation of a laser diode according to the example

To calculate the current required at ISET, the average optical laser power is to determine:

$$P_{av} = P_{peak} \times \frac{t_{whi}}{T}$$ with peak value P_{peak} and pulse/period duration t_{whi}/T

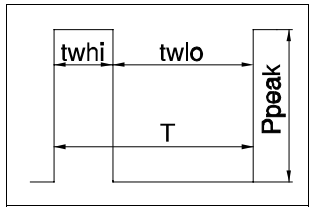


Fig. 2

Example iC-WJ: Laser diode with 5mW maximum optical output, monitor diode with 0.13mA/mW, pulse duty factor set to 20% with P_{peak}= 5mW:
The resultant average optical power is 1mW and the average monitor diode current is 0.13mA. The resistor RSET is calculated as:

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

with the Electrical Characteristics No. 301 for V(ISET) and with No. 108 for current ratio CR1

Example iC-WJZ: Laser diode with 5mW maximum optical output, monitor diode with 0.75mA at 3mW, CW operation (pulse duty factor 100%) with P_{cw}= 1mW:
For the monitor diode current of 0.25mA the resistor RSET is calculated as:

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

with Electrical Characteristics No. 301 for V(ISET) and with No. 108 (iC-WJZ) for current ratio CR1

Averaging control

The control of the average optical laser power requires a capacitor 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. the capacitor CI must be increased in size proportionally as the pulse repetition frequency slows or the current from ISET increases:

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

Example: Pulse repetition frequency 100kHz, RSET= 10kΩ:
CI= 440nF, chosen 470nF

Otherwise the charging of the capacitor CI during the pulse pauses (with I(ISET)= 1.22 V/RSET) will create an excessive mean value potential and may destroy the laser diode during the next pulse. The capacitor CI is correctly dimensioned when the current through the laser diode and the optical output signal do not show any overshooting following the starting flank.
In steady-state condition and for a pulse duty factor of 50% (pulse/pause 1:1), signals as shown in Fig. 3 are present at the IC pins.
Fig. 4 shows the corresponding signals for a pulse duty factor of 20%. The influence of the pulse duty factor on the peak value of the monitor current proportional to the laser current is apparent. The average kept constant by the control (RSET unchanged) means a peak value increased by the factor 2.5. The pulse duty factor for which RSET was dimensioned should there fore be kept constant if at all possible.

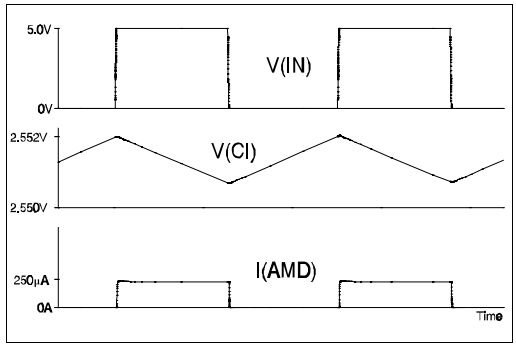


Fig. 3: Steady-state averaging control, f(IN)= 100kHz (1:1), CI= 470nF, RSET= 10kΩ

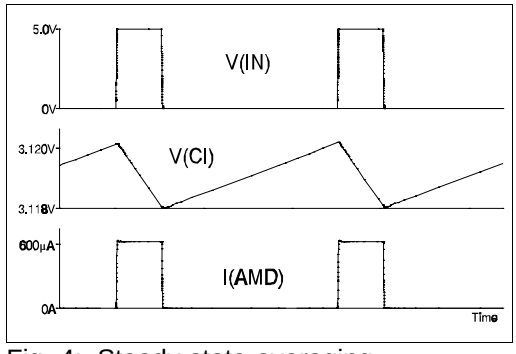


Fig. 4: Steady-state averaging, f(IN)= 100kHz (1:4), CI= 470nF, RSET= 10kΩ

Turn-on and turn-off behavior

Capacitor CI also determines the starting time from switching on the supply voltage VCC to steady-state laser pulse operation or after a discharge of CI by the watchdog. The following applies for estimating the starting time (Fig. 5):

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

Example: CI= 470nF, RSET= 10kΩ:
$T_{on} \approx 9.6$ms

Figure 6 shows a detailed view of the start of laser operation; Figure 7 shows the shut-down behavior. The decline in the voltage at CI and the absence of the laser pulses are signs that the undervoltage detector is active.

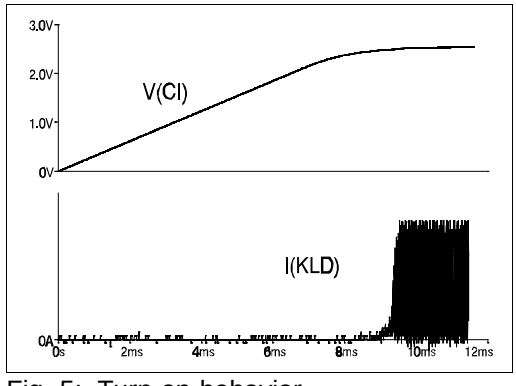


Fig. 5: Turn-on behavior, f(IN)= 100kHz (1:1), CI= 470nF, RSET= 10kΩ

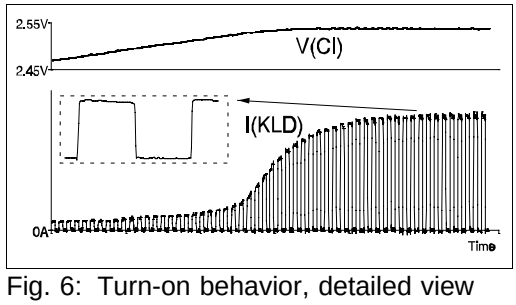


Fig. 6: Turn-on behavior, detailed view f(IN)= 100kHz (1:1), CI= 470nF, RSET= 10kΩ

Watchdog

In order for the watchdog to function correctly, the input IN must be activated with a CMOS output (e.g. with an HCMOS gate: see Fig. 1).

The watchdog ensures that the capacitor CI is discharged during protracted pulse pulses at IN. During the pulse pauses the potential at CI increases by ΔV (Fig. 3):

$$\Delta V = \frac{I\,(ISET) \times t_{wlo}}{CI}$$

The discharge of capacitor CI by the watchdog protects the laser diode from being destroyed by an excessive turn-on current during the next pulse.

The capacitor CWD should be dimensioned such that the response time t_p of the watchdog is slightly longer than the pulse pause t_{wlo} of the input signal. As a result, the watchdog is just short of being activated.

For response times t_p longer than t_{pmin} applies:

$$CWD = \frac{t_p - t_{pmin}}{K_{wd}}$$

with t_{pmin} and K_{wd} from Electrical Characteristics No. 407, 408

Figure 8 shows the signal curves during normal operation, without the watchdog being activated. The potential at CWD rises during pulse pauses but does not reach the watchdog activation threshold.

Figure 9 shows the watchdog behavior when the input frequency is reduced from 100kHz to 10kHz. The pulse pauses are longer than the watchdog's response time. The watchdog begins to discharge the capacitor CI current limited. The remaining charge time during the pulse pauses before further watchdog intervention is not sufficient to maintain the initial potential at CI. The potential is thus gradually reduced until it reaches the saturation voltage $Vs(CI)_{wd}$ (Electrical Characteristics No. 405).

The watchdog therefore protects the laser diode from destruction when the input signal change in such a manner that the capacitor CI is not longer adequate for averaging.

Furthermore, the intervention of the watchdog permits long pulse pauses and activation of the laser diode with pulse packets.

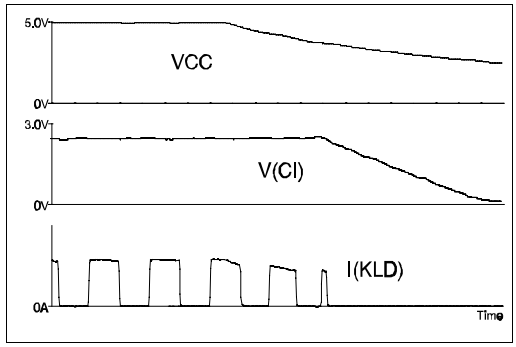


Fig. 7: Turn-off behavior,
f(IN)= 100kHz (1:1),
CI= 470nF, RSET= 10kΩ

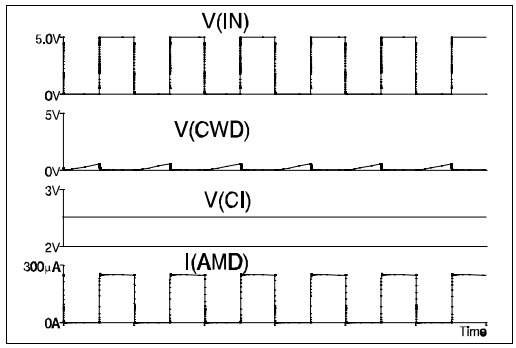


Fig. 8: Watchdog, CWD open,
f(IN)= 100kHz (1:1),
CI= 470nF, RSET= 10kΩ

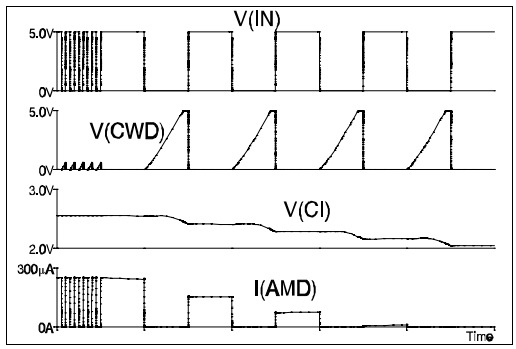


Fig. 9: Watchdog, CWD open,
f(IN)= 100kHz → 10kHz (1:1),
CI= 470nF, RSET= 10kΩ

CW OPERATION

In case of CW operation, the input IN can be connected to the power supply VCC. The pin CWD may be unloaded, because the capacitor for the watchdog is not necessary. The capacitor CI for the averaging control can be reduced to 100nF.

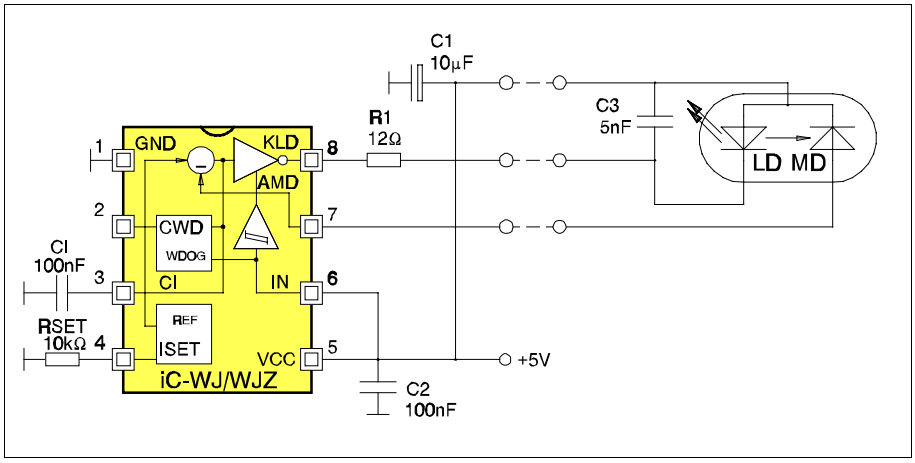


Fig. 10: CW operation via cable

Operation of 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. 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.

Analog modulation during CW operation

The modulation cut-off frequency is determined by the capacitor CI as well as by the operating point set with the resistor RSET. With CI= 100nF and RSET= R2= 10kΩ the cut-off frequency is approx. 40kHz, with CI= 22nF and the same resitor value of about 230kHz.

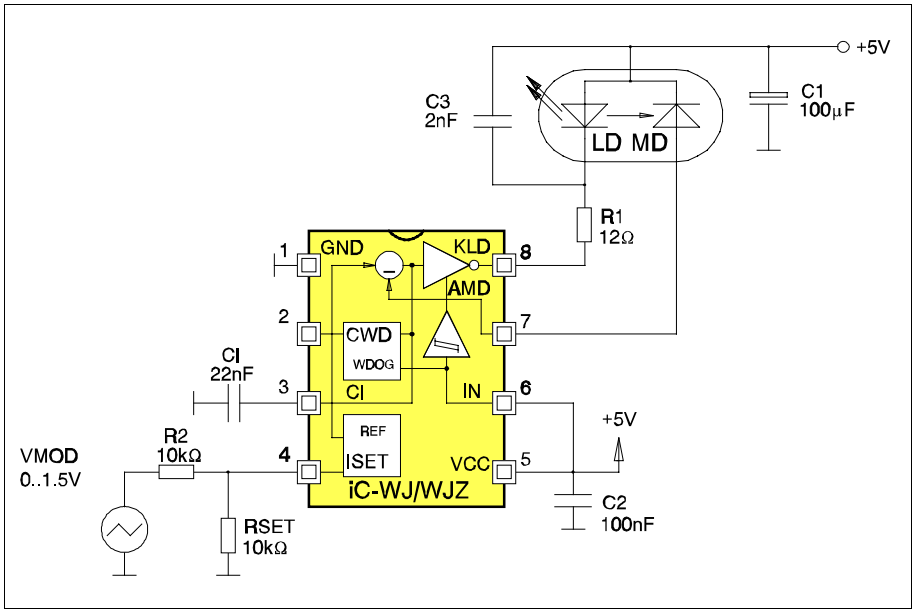


Fig. 11: Analog modulation during CW operation

The laser power can also be modulated by adapting a current source, e.g. by using an operational amplifier with a current output (OTA). To limit the current at pin ISET while turning on the power supply for the OTA circuitry, however, the OTA output should be linked to the base point of RSET (instead of to GND). The maximum current possible at ISET must be taken into consideration when dimensioning the capacitor CI.

CW operation with a laser diode current of up to 2A

Using the circuitry in Figure 12 the current capability can be increased. Laser diodes with a common cathode cannot be used here. The laser diode operating voltage must not be lower than 1.5V.

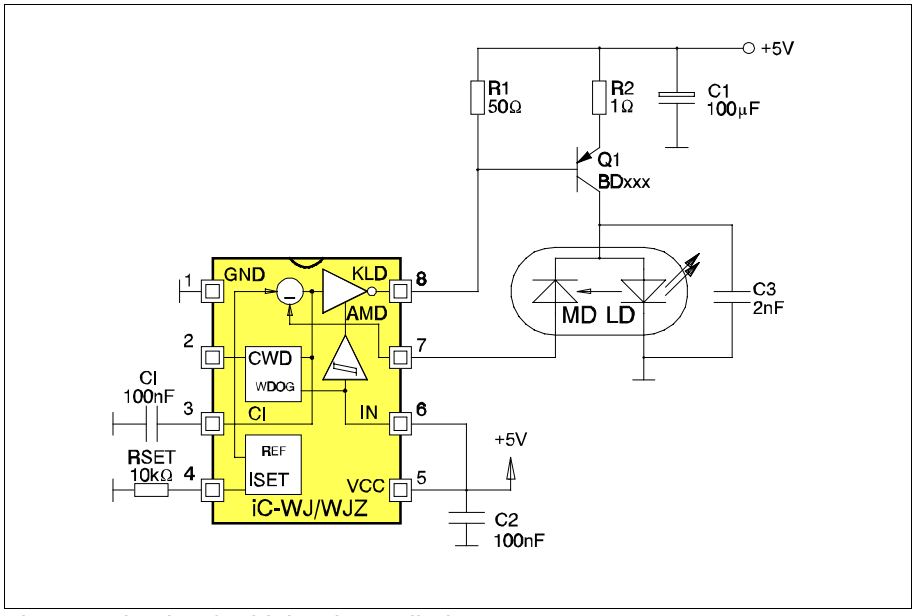


Fig. 12: Circuitry for higher laser diode currents

PC BOARD LAYOUT

The ground connections of the external components CI, CWD and RSET have to be directly connected at the IC with the GND terminal.

DEMO BOARD

The iC-WJ/WJZ/WJB 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.

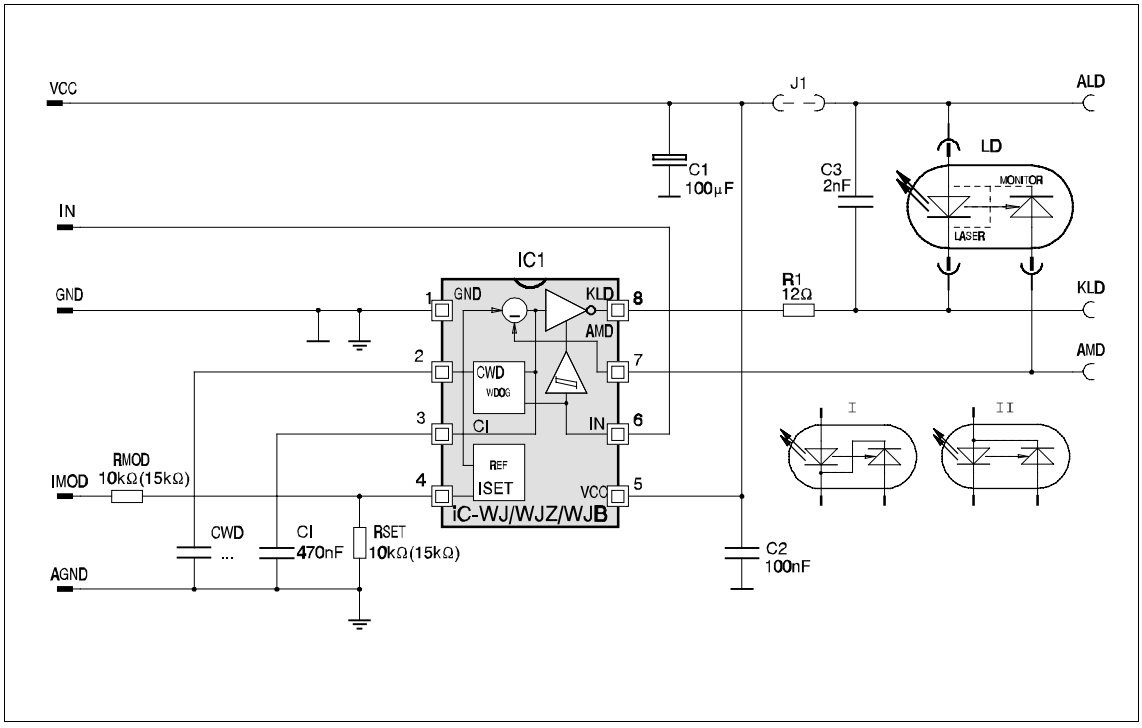


Fig. 13: Schematic diagram of the Demo Board

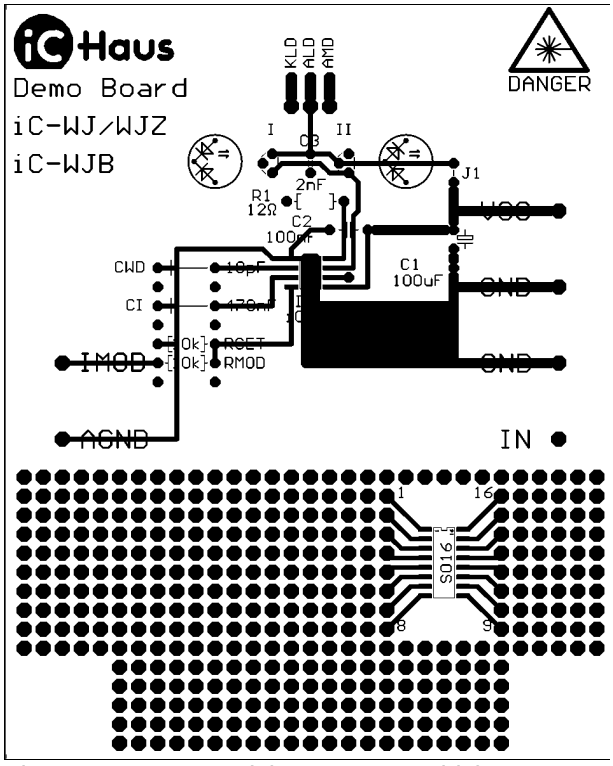


Fig. 14: Demo Board (components side)

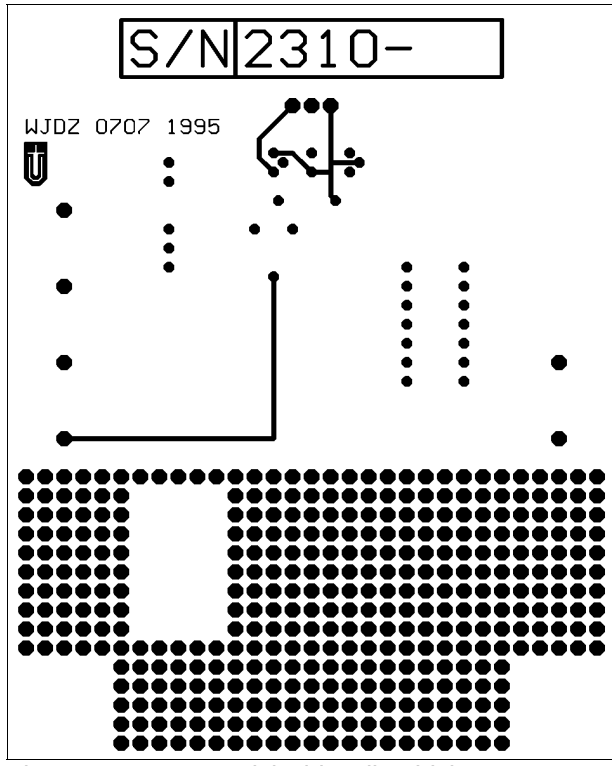


Fig. 15: Demo Board (solder dip side)

ORDERING INFORMATION

Type	Package	Order designation
iC-WJ WJ Demo Board	SO8	iC-WJ-SO8 WJ Demo Board
iC-WJZ WJZ Demo Board	SO8	iC-WJZ-SO8 WJZ Demo Board

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

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