neoplascontrol

Q-macs

Q-MACS Basic

QUANTUM CASCADE LASER MEASUREMENT AND CONTROL SYSTEM

Operating Manual

Version 10 (06/2009)

Q-MACS Basic

(**Q**uantum Cascade Laser **M**easurement **A**nd **C**ontrol **S**ystem)

Operating Manual

DECLARATION OF CONFORMITY

We, the neoplas control GmbH declare that the product is in conformity with standards:

IEC 61010-1 / 02.2001

DIN EN 61326 / 05.2004

Classifications and Restrictions:

For continuous, controlled operation in industry environments (class A).

SAFETY INSTRUCTION

The crossed out wheelie bin means that within the European Union the product must be taken to separate collection of waste at the end of product's life-time. Do not dispose these products as unsorted municipal waste.

This product is capable to operate quantum cascade lasers. These devices are specified as class 1 or 3R lasers. Follow the detailed instructions of the laser manufacturer.

This mark points to an important information which should be studied by the user very carefully. This includes information about limitations of the devices and warnings.

Table of Contents

1 Introduction

Q-MACS was designed for driving the QCL's from Alpes Lasers SA. However, the Q-MACS electronics is capable of driving QCL's from other manufacturers as well, like the encapsulated SPECDILAS® from LASER COMPONENTS and similar ones from nanoplus on a TO-8 cap and the QCL from the Fraunhofer IAF on a c-mount. When combined with a PC or a Laptop with PCI extension card, matching software like TDLWintel[1] and an optical board the Q-MACS can be used to build a powerful absorption spectroscopy system. In addition, Q-MACS is useful for other applications e.g. for free space communication.

The main features of Q-MACS are:

- Compactness and robustness
- Applicability in laboratory and industrial environments
- 100% compatible with the versatile spectroscopy software package TDLWintel[1]

---

[1] TDLWintel is software developed by Aerodyne Research, Inc. (http://www.aerodyne.com/)

2   Safety Instructions

2.1   General

Please read the following instructions carefully. They will help you to avoid damaging the Q-MAC System, the quantum cascade laser or other related components.

Before using any QCL for the first time, its data sheet should be read and carefully interpreted and all operating limits should be noted or determined to prevent damage or destruction of the devices. If there are unresolved questions regarding the operational limits of a laser it is very strongly recommended that these be clarified before using Q-MACS to drive the QCL.

To avoid potential damages of the QCL check before starting that:

- **The QCL voltage is turned to zero and switched off.**

- **All digital inputs are connected to appropriate devices.**

- **All analogue inputs are connected properly and in the right parameter range.**

2.2   Safety Hints for QCL's

A comprehensive overview covering general questions on quantum cascade lasers can be found in the appendix or on the FAQ sites of the QCL suppliers.

Besides the wavelength the main operating parameters of QCL's are as follows:

- Pulse repetition rate (trigger frequency)
- Pulse width
- Duty cycle (quotient of pulse repetition rate/pulse width)
- QCL current (average current, peak current)
- QCL voltage
- QCL temperature

Pulse repetition rate

The pulse repetition rate is the frequency of the single pulses which drive the QCL. It is determined by the external or internal trigger ($f_{Trigger}$).

Pulse width

During the pulse a current is flowing through the quantum cascade laser. Due to the ohmic drop the QCL is heated, the temperature and therefore the emitted wavelength is increasing. This effect can be used for spectroscopic purposes. Typically, two kinds of pulse width are commonly used in the field of absorption spectroscopy. Short pulses (less than 20ns) are well suited to the inter pulse mode preferred by TDLWintel, longer pulses (longer than 100ns) are needed for the intra pulse mode and higher temporal resolution.

Duty cycle

The duty cycle is defined as the ratio of the pulse width to the pulse period. It determines, together with the peak QCL current and the DC bias current, the thermal stress imposed on the QCL.

$$duty\_cycle = \frac{t_{Pulse}}{\dfrac{1}{f_{Trigger}}} = \frac{t_{Pulse}}{T_{Trigger}}$$

QCL current

It is necessary to distinguish between the average and the peak currents. The Q-MACS Supply only provides the output of the average current through the laser. Data sheets from QCL suppliers present in addition charts with peak currents. To get initial information on the peak current it is necessary to know the duty cycle to get a precise average current for the QCL.

Note: Each QCL currently available is a unique device. Therefore, each QCL should be checked for its operational parameters before it is used for the first time.

$$i_{QCL_{average}} = i_{QCL_{peak}} * duty\_cycle$$

Note: Using TDLWintel and the QCL in the inter pulse mode requires a DC bias current (or ramp) to the QCL. This current can easily be much larger than the average current resulting from the short current pulses driving the laser (peak current; $i_{QCL_{peak}}$)!

QCL voltage

In contrast to other laser drivers the QCL voltage of Q-MACS is variable and the current is the result of the impedance of QCL device.

3 Parts

3.1 General Description

The Q-MAC System is designed as a cost effective, simple, compact and user friendly system that can be integrated into optical systems in laboratories and industrial environments. The components are:

- Q-MACS head
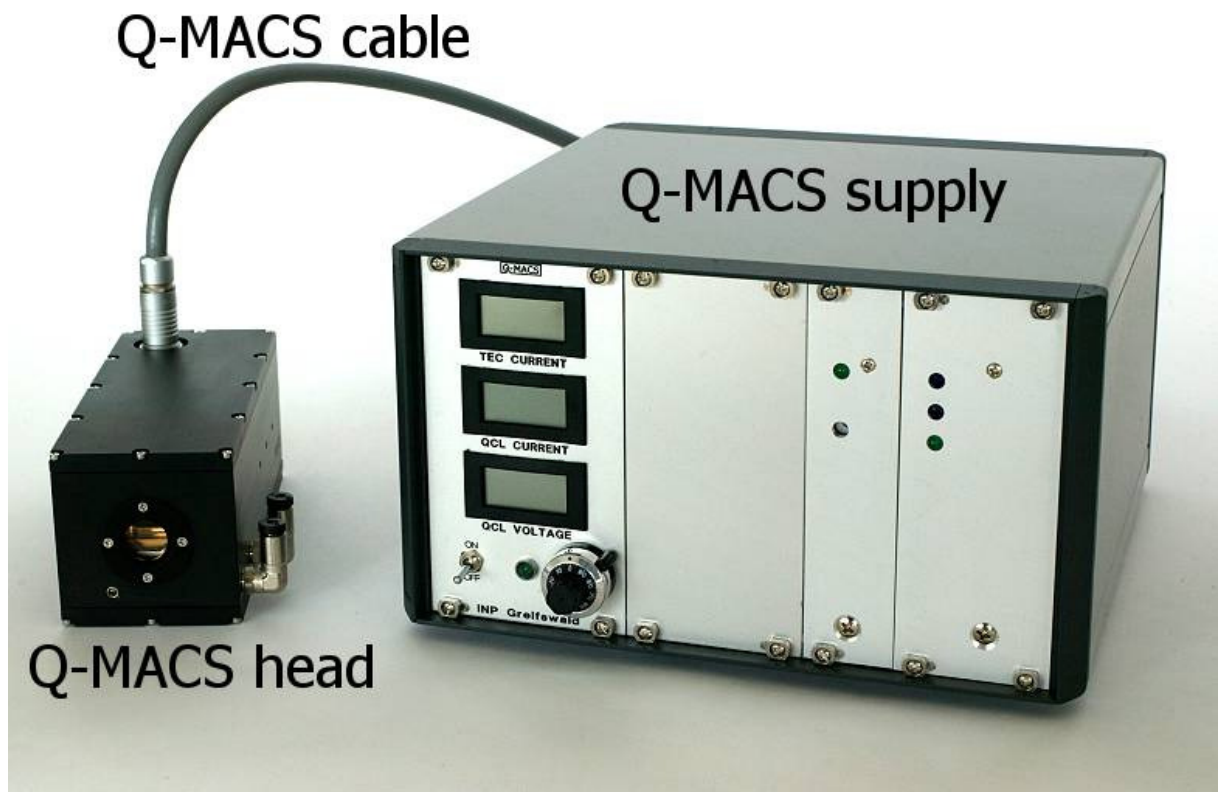
- Q-MACS supply
- Q-MACS cable

Figure 1: Components of the Q-MAC System

The two main parts of the Q-MACS Basic, the head and the supply, are connected via a shielded cable. The head includes all electronics necessary to drive the QCL. The supply is needed for setting the operating parameters and producing the supply voltages for the electronics. Both ends of the Q-MACS cable are easy to connect.

3.2 Q-MACS head

3.2.1 Overview

In addition to the QCL, the Q-MACS head houses the thermo-electrical heat sink, a temperature controller board and a pulse amplifier board. The head is equipped with an infrared transparent KBr or ZnSe window. The window can be easily replaced. Figure 2 shows a detailed view of the Q-MACS head without the electronic boards and without the QCL chip.
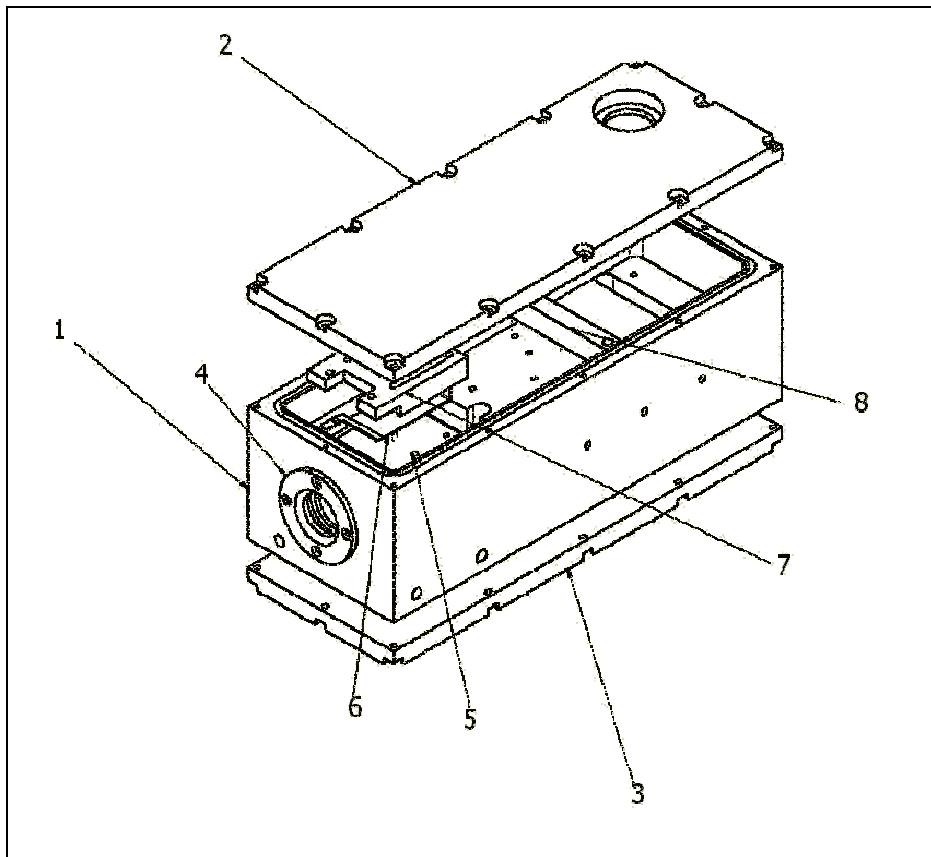

Figure 2: Q-MACS head exploded view

1. body
2. upper cover plate
3. bottom cover plate
4. window holder
5. QCL holder and heat sink
6. contact clip
7. contact holder (finger plate)
8. electronic board holder

The standard QCL holder was developed for mounting Alpes Lasers QCL's. Fittings for water tubes allow the Q-MACS head to be cooled or thermo stabilized if necessary. M4- threads on both sides of the body can be used to mount the Q-MACS head. In addition, a modified base cover can be supplied to hold the Q-MACS head in an alternative way.

3.2.2 Installing the QCL

For mounting or replacing of the QCL it is necessary to loosen the two M 2.5 screws holding the fingerplate as shown in Figure 3.
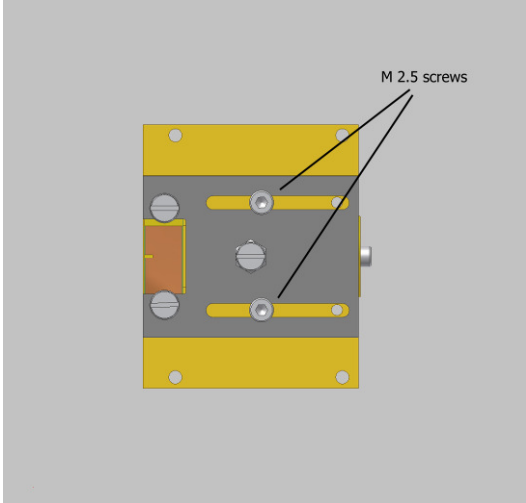

Figure 3: QCL installation (top view)

The ribbon cable will lift the fingerplate to the bolt head of the M 2.5 screws as shown in Figure 4**.**
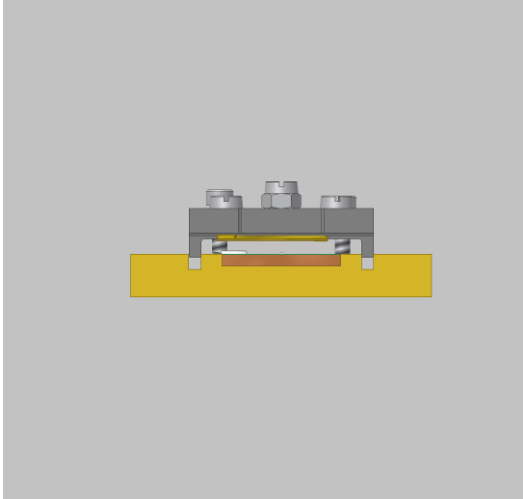

Figure 4: Raised fingerplate (front view)

The contact holder can now be moved back and the QCL becomes accessible and ready to be replaced. The fingerplate works like a slide on the holder (Figure 5). In this way no rotation, in particular of the QCL chip, is possible, since the slides of the contact holder are guided through the slot. With appropriate handling of the Q-MACS laser holder no free parts can touch the QCL itself.
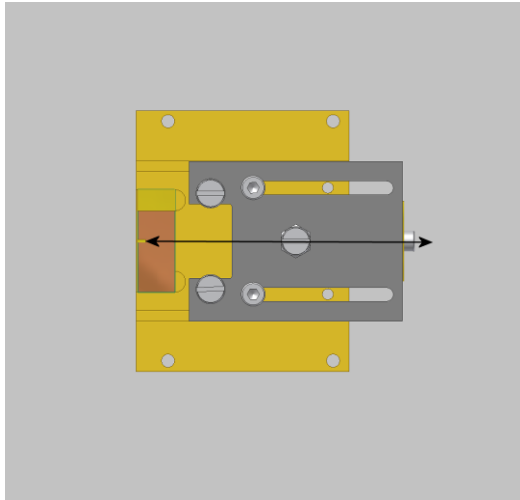
Figure 5: Sliding fingerplate

Only appropriate tools like precision tweezers should be used to replace or handle the QCL.

⚠️ Note: After installing a QCL it is vital to check the combination holder-QCL-fingerplate for electrical contact to avoid short circuits and/or open circuits. This will help to reduce time-consuming troubleshooting.

We recommend replacing the air in the head with dry nitrogen to avoid water vapor inside.

Figure 6: Example for dry nitrogen filling procedure

3.2.3 Temperature protective circuits

The electronic boards in the Q-MACS head provide three independent electronic components, two of them are NTC's, and one is a bimetallic switch. The NTC's are placed in the QCL holder (cold side of TEC) and on the bottom of the body under the TEC. Each of them will switch off the temperature controller electronics if the temperature rises above 57°C.

The bimetallic switch protects the pulse amplifier board against temperatures higher than 50°C. In this case the pulse width IC will be switched off and the QCL will receive no pulses.

3.3 Q-MACS supply

3.3.1 General

The Q-MACS supply was developed as a standard 19- inch rack system with 3 sub units for easy integration into any application. The supply contains

- power supplies for the single functional units
- three LC displays (TEC current, QCL current, QCL voltage)
- a switch for the QCL voltage
- a potentiometer for setting the QCL voltage manually and
- an electronics board

In principle the operating parameters can be set in two different ways: internally and externally. While the internally generated parameters are controlled via the front panel, external remote control of the supply can be achieved either via BNC's or two 68 pin connectors on the back of the supply.

3.3.2 Front panel

3.3.2.1 Description

The Q-MACS supply (figure 6) houses a variable power supply (1) providing the QCL voltage, a second power supply (2) which generates the 15V operational voltage for the electronic boards in the Q-MACS head, a printed circuit and the front panel (3) which displays the main operational parameters.
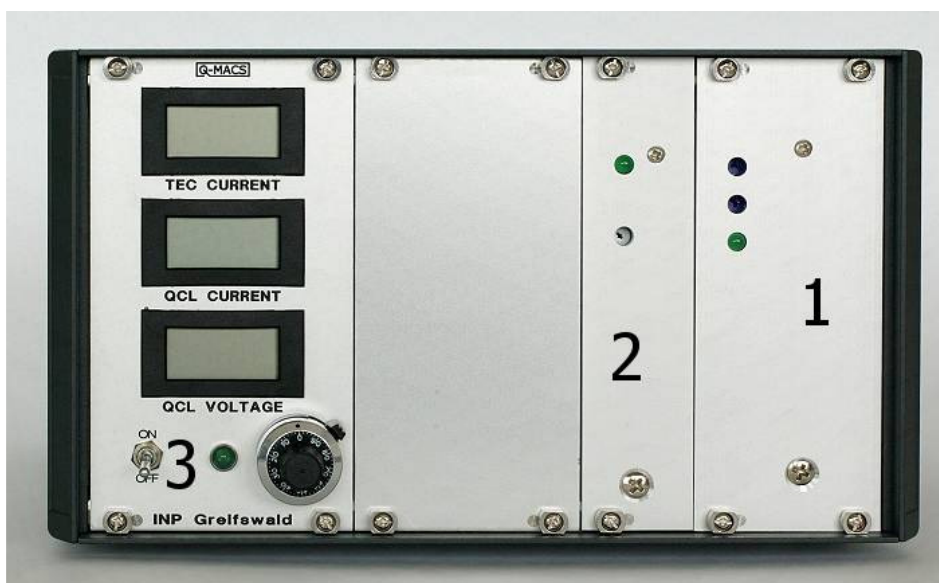

Figure 7: Q-MACS supply front panel

3.3.2.2 QCL voltage supply

This variable supply provides a maximum QCL voltage of 15V. Higher voltages are available on request. Two ways of setting the output voltage are possible:

a) using the potentiometer on the front panel (internal)

b) using an auxiliary voltage between 0…5V (external)

a) or b) can be selected by a switch: **Set QCL** on the back of the supply. For security reasons the output QCL voltage is displayed on the front regardless of the position of the main voltage switch on the front panel. This gives the user the opportunity of checking if the QCL voltage is appropriate for the operating parameters before switching on.

In case of using an auxiliary voltage the resulting QCL voltage is:

$$V_{QCL} = \frac{V_{out\,max}}{5V} \bullet V_{aux}$$

A green LED on the QCL voltage supply (1) indicates the operation. Note that the brightness of the LED directly follows the output voltage. In particular, this means that the LED will be dark if the QCL voltage is set near 0. If the QCL voltage is close to the maximum, the LED illuminates bright green.

115V operation: If the Q-MACS power supply is to be powered by an 115V line one jumper and the fuse of the QCL voltage supply must be changed.

3.3.2.3 15V-Supply

The 15V-Supply (2) is used to provide the power for the temperature controller circuit, for the thermoelectric element and for the digital part of the electronic circuit. The output voltage is stabilized to 15V and the maximum current can be as high as 6.6A. A green LED indicates the status in a similar way to the QCL voltage supply LED.

115V operation: This supply is equipped with a wide range input. This means no further re-configuration is necessary to operate this supply at 115V.

3.3.2.4 Display panel

This panel provides some important information about the status of the main operating parameters for the basic handling of Q-MACS. Three LCD modules are placed in this field, together with the ON/OFF switch for the QCL voltage, a LED which shows if the QCL power supply is on (ON/OFF switch on) and a high precision potentiometer.

LCD modules

TEC current

It displays the current through the thermoelectric element in A with a resolution of 10mA.

> Note: If the current stays over 1A for a long period sufficient cooling of the warm side of the Peltier element must be provided to avoid overheating or damage to the element.

QCL current

This module measures the average current through the QCL. This means the summation of the pulsed average current and DC bias current. The resolution is 0.1mA.

QCL voltage

The QCL voltage is displayed independent of the status of the main voltage switch. This feature is implemented to avoid potential malfunction or damage of the QCL due to excess voltage. The display module provides a 20V range with a resolution of 10mV.

ON/OFF switch

This switch separates the programmable power supply from the QCL and cannot be remote controlled.

3.3.3 Rear panel

3.3.3.1 Description

The connections are gathered into two groups on the back of the Q-MACS supply. The first group contains the power input module with fuses and the ON/OFF rocker switch, the second the connectors like the BNC, D-Sub's and AMP plus the toggle switches.

3.3.3.2 Fused power inlet module

The Q-MACS supply is provided with two default 1A- slow-blow fuses for 230V/50Hz operation, a filter and a rocker switch.

⚠️ Note: Each device which is directly connected to the power inlet module is itself protected by own fuses.

⚠️ Note: For 115V/60Hz operation replace the 1A fuses with 2.5A fuses.

3.3.3.3 Connector panel

Figure 8 shows the rear panel of the Q-MACS supply.
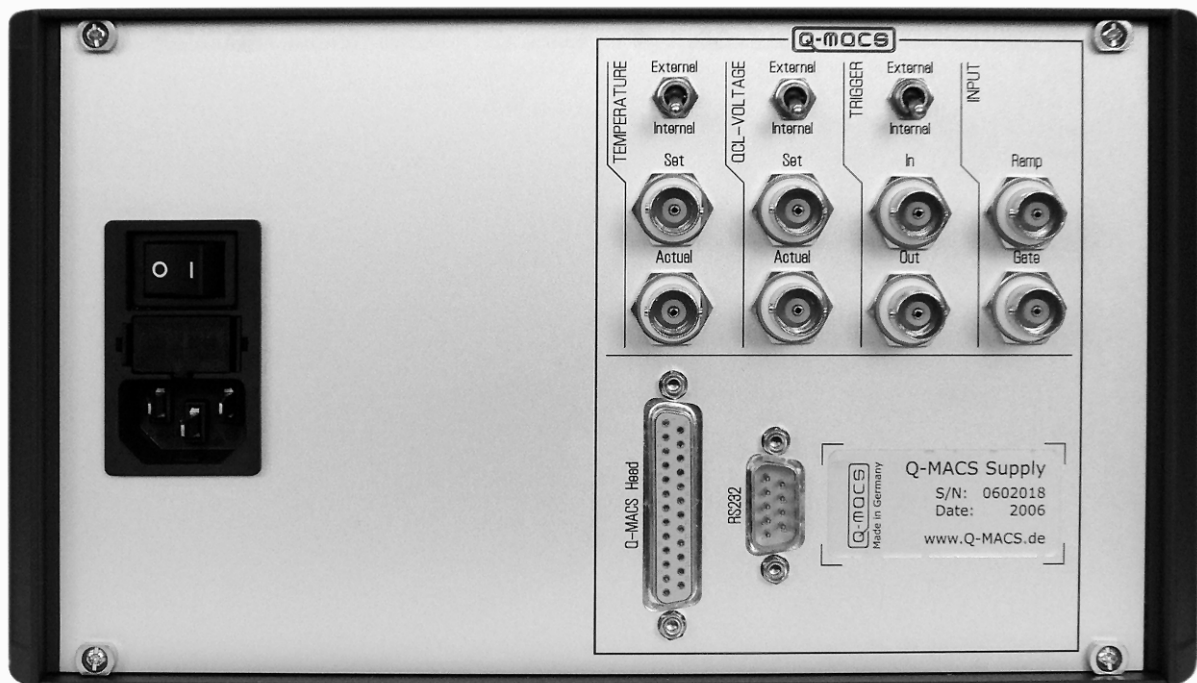

Figure 8: Q-MACS supply rear panel

3.4   Q-MACS cable

The connection between the Q-MACS head and the Q-MACS supply is made with a 20 core shielded 2.50m long cable which provides a male 25 pole D-Sub on the supply side and a 20 pole Fischer connector (S104Z092-130+) on the head side.

For safety reasons it is recommended that the D-Sub connector is secured with its screws.

4 Getting started

4.1 General

This chapter presents an overview of the two main pulsed operation modes and how to use Q-MACS in combination with TDLWintel to drive both modes.

4.2 Basic setup

For a basic setup a light source (1) and a detector (5) is absolutely necessary independent of which mode is used. An example of a basic setup is shown in Figure 9. Off- axis- parabolic mirrors (2, 4) are used to couple the beam. To get a much more compact setup a lens can be used instead of the OAP. A reference gas cell (3) is placed in the middle of the optical path between the OAPs.
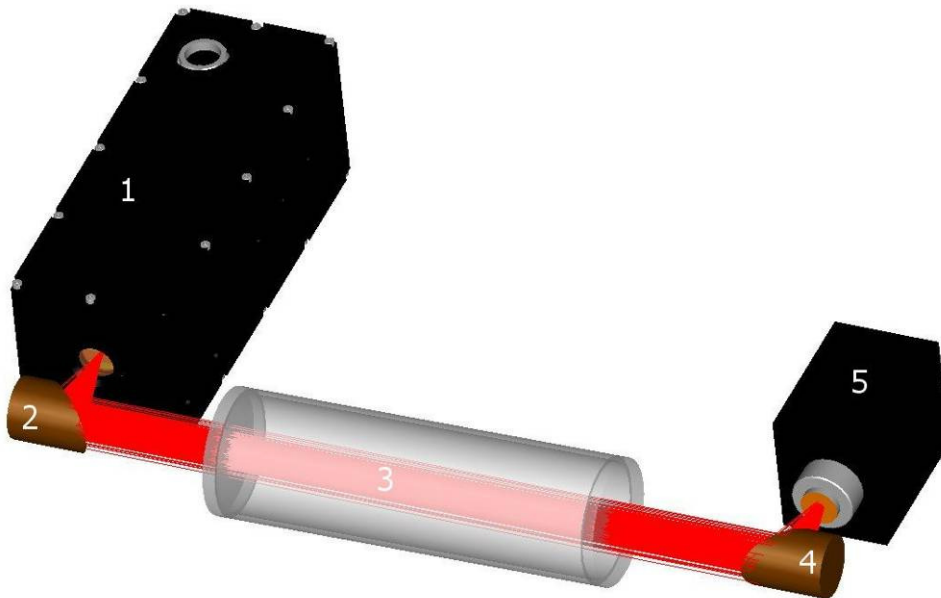

Figure 9: Basic setup

Q-MACS (1), OAPs (2, 4), reference gas cell (3) and TE cooled detector (5)

4.3 Inter pulse mode

The inter pulse mode is the combination of a pulsed quantum cascade laser driven with a constant pulse width, a duty cycles less then 1% and a DC ramp to tune the laser. The principle is shown in Figure 10. Pulse widths between 12ns and 20ns were usually used and lead to sufficient results.
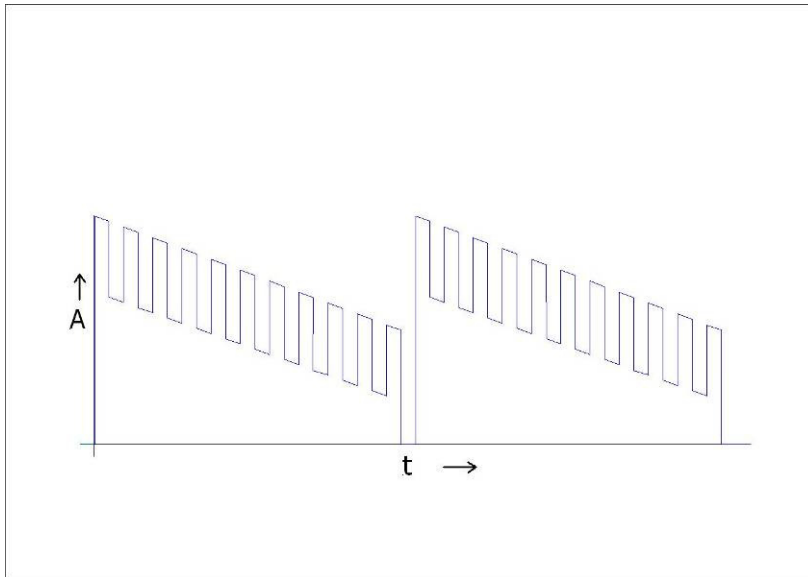
Figure 10: Principle of the inter pulse mode

The parts which are necessary for the inter pulse mode are shown in Figure 11. Besides the Q-MACS the setup includes the following components:

- a trigger signal source (e.g. function generator)
- a gate signal source (e.g. function generator)
- a ramp signal source (e.g. function generator)
- a signal source for the temperature set point (variable power supply)
- a voltmeter to display the current temperature
- a detector
- an oscilloscope
- either a PC or laptop
- either an etalon or reference gas cell

Figure 11: Setup for inter pulse mode operation

4.4 Intra pulse mode

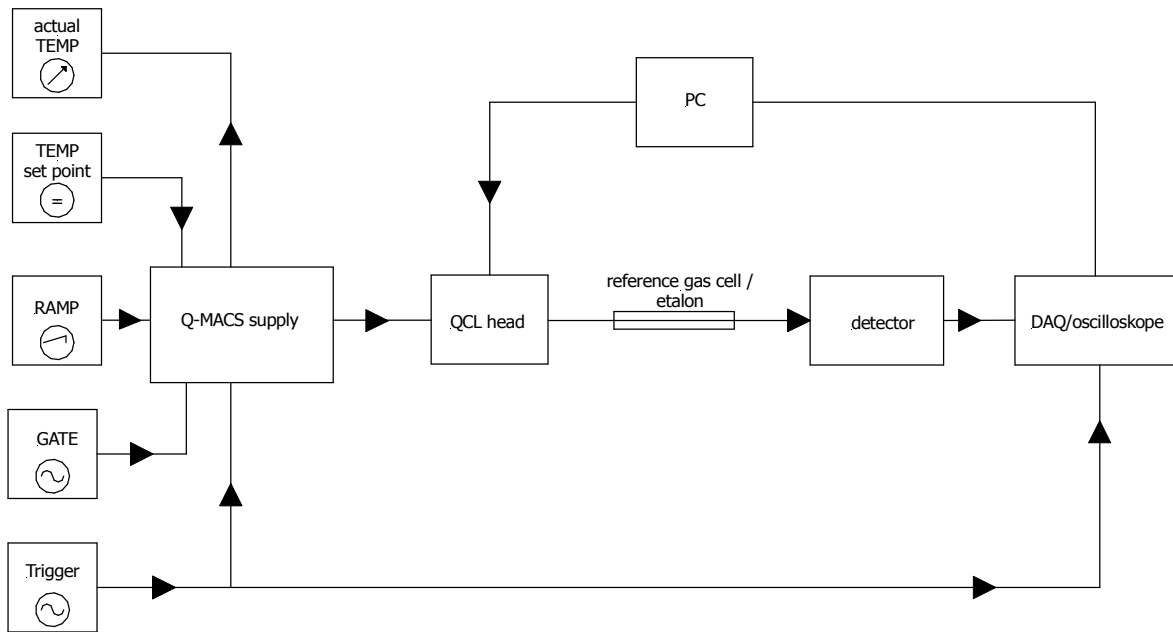The principle of the intra pulse mode is shown in Figure 12. It needs less hardware and uses the pulse length for tuning the laser. The emission wavelength of the QCL is tuned by the temperature change caused by the current flowing during the pulse (typically 100ns and longer).
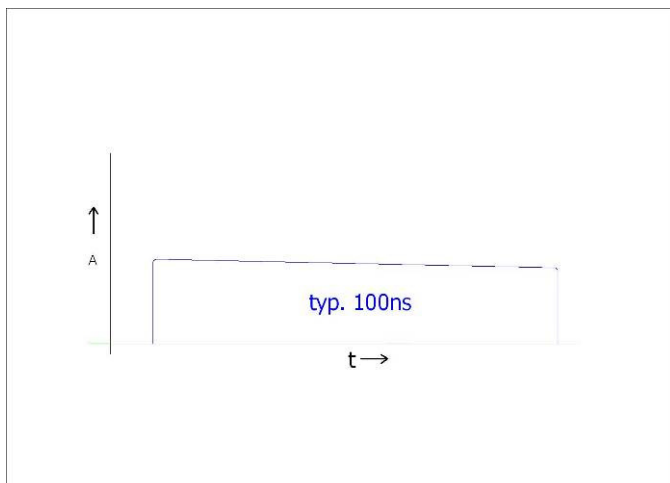
Figure 12: Principle of the intra pulse mode

Figure **13** shows the simplest intra pulse mode setup. Here the trigger signal comes from the internal generator of the Q-MACS power supply and no temperature set point is given. In this way the set point is 0V which means 0°C. The pulse width is prefixed with a default value of 16ns. This initial value can be changed via a serial connection. For more details please refer to chapter 4.5.3, page 26 .

Figure 13: Setup for intra pulse mode operation

For a more elaborate setup a pulse generator, a programmable power supply, a voltmeter and a PC for setting the pulse width can be used (see Figure 14).

Figure 14: Intra pulse mode setup with pulse generator and PC

4.5 External control

4.5.1 Introduction

As described above one of the main parameters is the pulse width. The Q-MACS head contains a circuit to provide a variable 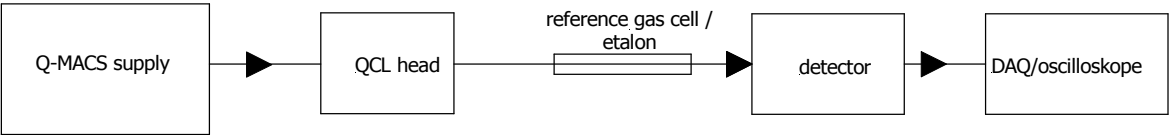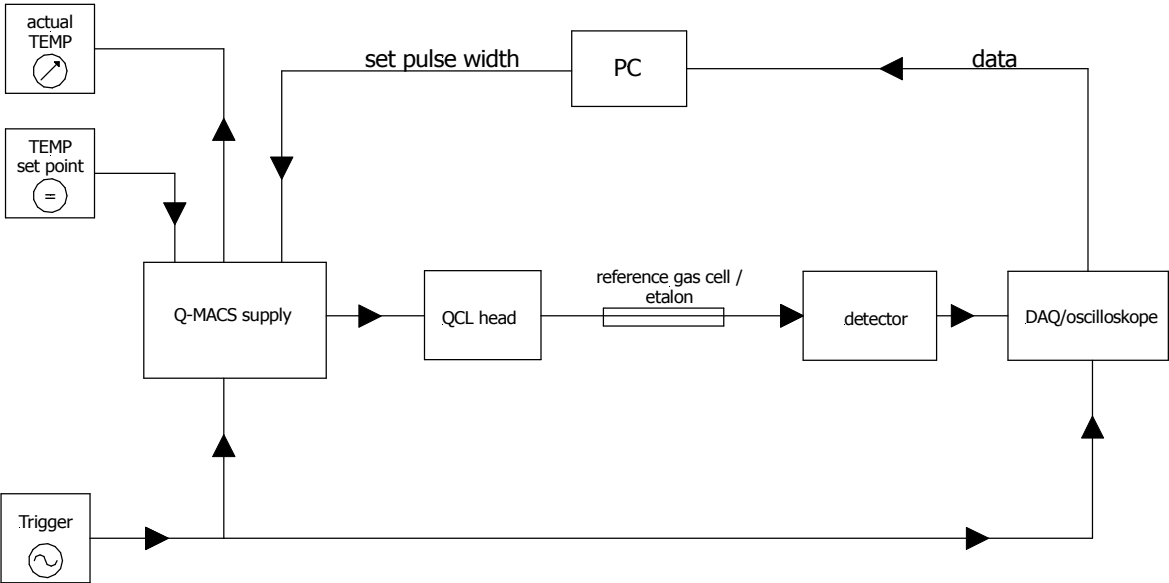pulse width. This circuit permits the active pulse width to be set and to store an initial value of the pulse width. These parameters can be programmed via a serial port on the Q-MACS supply using a device like a PC or laptop. The next chapter describes the complete serial interface used for setting the pulse width.
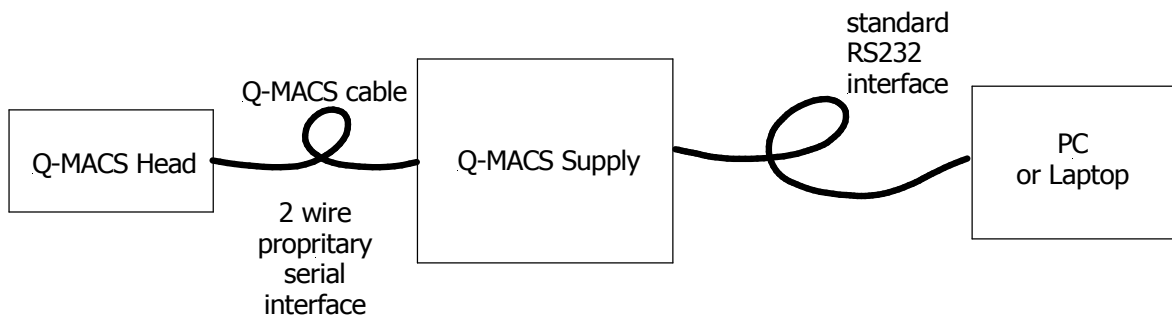
Figure 15: Serial connection head – supply – PC

4.5.2 The RS-232C connector

Besides the analog signal connectors the Q-MACS supply has a RS-232C connector on the back. This connector is a 9 pole D-Sub header strip. It provides the possibility to control some features of a Q-MACS device, such as the pulse width and the polarity of the gate signal. These parameters should have appropriate values, depending on the application of the particular device. Nevertheless, in some cases it is necessary to change these parameter settings. This can be done by a terminal device like a PC. Therefore the port is configured as DCE, *data communication equipment*, and can be connected to a DTE, *data terminal equipment*, using a straight-through cable.

The pin and cable assignments as well as the commands used to communicate with Q-MACS devices are described in the following section.

4.5.2.1 Pin and cable assignment

The pinout of the 9 pole D-Sub is shown in the appendix on page 51. Only the RX, TX and GND lines of this connector are used.

With this 3-wire connection it could be possible that the terminal program hangs if this software checks the modem signal lines in a way compliant to EIA-232C. To overcome this problem the connector provides loop back handshaking. The RTS and CTS as well as the DTR and DSR lines are bridged, so the handshake techniques are emulated. The following Table (Table 1) shows the pinout of the RS-232C cable.

Pin	Signal	Function
1	Data Carrier Detect	Not used
2	Received Data (RX)	Data Transmitted to the PC
3	Transmitted Data (TX)	Data Transmitted to the Q-MACS device
4	Data Terminal Ready	Not used, loop back with DSR line
5	Signal Ground (GND)	Signal Ground
6	Data Set Ready (DSR)	Not used, loop back with DTR line
7	Request To Send (RTS)	Not used, loop back with CTS line
8	Clear To Send (CTS)	Not used, loop back with RTS line
9	Ring Indicator	Not used

Table 1: Pinout of the RS-232C cable

4.5.2.2 Settings of the serial port

The communication between a PC and a Q-MACS device is realized via the serial interface (RS-232C). The transfer parameters are hard-coded in the Q-MACS device. To set up the serial port, these parameters must be set on the PC side as follows:

Speed   :   9600 bits per second

Parity   :   none

Data bits   :   8

Stop bits   :   1

Handshake   :   none (RTS / CTS emulated)

4.5.2.3 Command description

The Q-MACS device can be controlled from a PC via the RS-232C interface. This is a point-to-point-connection with exactly one master (PC) and one slave (Q-MACS device). Each communication is started from the PC. This is done by sending one ASCII command. The Q-MACS device answers by echoing the command and returning the requested information. The commands used to control Q-MACS devices are in ASCII format. Each command is given by a single character, followed by none or one numeric parameter and enclosed by a carriage return character. The following table (Table 2) shows the supported commands and their functions.

Command name	ASCII	Hex	Parameter	Action
reset	R	52	-	Restart head
get_name	?	3F	-	Return name
get_head_snr	h	68	-	Return serial number of the head
get_supply_snr	s	73	-	Return serial number of the supply
set_pulse_width	W	57	0.. 255	Set active pulse width value
get_pulse_width	w	77	-	Return active pulse width value
set_gate_polarity	G	47	0 / 1	Set active polarity of gate signal
get_gate_polarity	g	67	-	Return active polarity of gate signal
set_clock_active	T	54	0 / 1	Switch clock input on/off
get_clock_active	t	74	-	Return clock state
set_initial_pulse_width	I	49	0.. 255	Set pulse-width value stored in E²PROM
get_initial_pulse_width	i	69	-	Return pulse-width value stored in E²PROM
set_initial_gate_polarity	J	4A	0 / 1	Set value of gate signal polarity stored in E²PROM
get_initial_gate_polarity	j	6A	-	Return value of gate signal polarity stored in E²PROM
set_initial_clock_active	K	4B	0 / 1	Set clock state on startup, value stored in E²PROM
get_initial_clock_active	k	6B	-	Return value of initial clock state stored in E²PROM

Table 2: Commands of the RS-232C interface

Commands other than those described are ignored by the Q-MACS device. Nevertheless the device will answer with an error message on receipt of an unknown command. When a valid command is executed by the Q-MACS device it will answer with an ASCII message enclosed by a carriage return. This answer message can be the word `ok`, when the command was completed successfully. If an error occurred during the execution of a command, the answer message will start with the character `e` followed by an ASCII representation of the error code. The possible error codes are listed in Table 3.

Error number	Location	Description
0	Head	No Error
1	Head	Not Clear To Send (Line Busy)
2	Head	Communication Error (CRC16)
3	Head	Timeout During Receipt Of Stop Bit
4	Head	Pinout Mismatch
5	Head	EEPROM Data Mismatch
6	Head	Communication Error (CRC16)
7	Head	Unknown Command
8	Supply	Not Clear To Send (Line Busy)
9	Supply	Timeout During Receipt Of Start Bit
10	Supply	Timeout During Receipt Of Stop Bit
11	Supply	Trigger Control Pinout Mismatch
12	Supply	Communication Error (CRC16)
13	Supply	RS232 Line Busy During Receipt (NN)
14	Supply	RS232 Character Overrun
15	Supply	RS232 Unknown Command
16	Supply	RS232 Wrong Parameter
17	Supply	RS232 No Termination Character

Table 3: Error numbers returned by the Q-MAC System

4.5.3 Software

The pulse settings can be changed in several ways. One opportunity is to use the application called "Q-MACS setup tool", which is delivered with the Q-MAC System. This program can also be used to check functionality of the Q-MAC System. In addition, the package includes a software library for creating applications to control Q-MACS devices. This "Q-MACS library" supports common programming languages, like C / C++, Delphi® and Visual Basic®. The setting of additional laser parameter like the pulse voltage and the temperature setpoint is also provided by the "Q-MACS library". Therefore, data acquisition equipment needs to be installed on the underlying computer system. The setup of the "Q-MACS library" and the tuning of all supported laser parameter will be done with an application named "Q-MACS Configurator", which is also part of the software package and described later in this section.

To use the software tools described in this documentation, it is necessary to connect the Q-MACS supply to the computer using a serial straight-through cable. This connection is necessary for detecting a particular device. It is possible to control multiple Q-MACS devices with one instance of the mentioned applications.

4.5.3.1 Q-MACS setup tool

With the "Q-MACS setup tool" it is possible to edit the pulse settings. This application is written using the software library which is described later in this chapter.
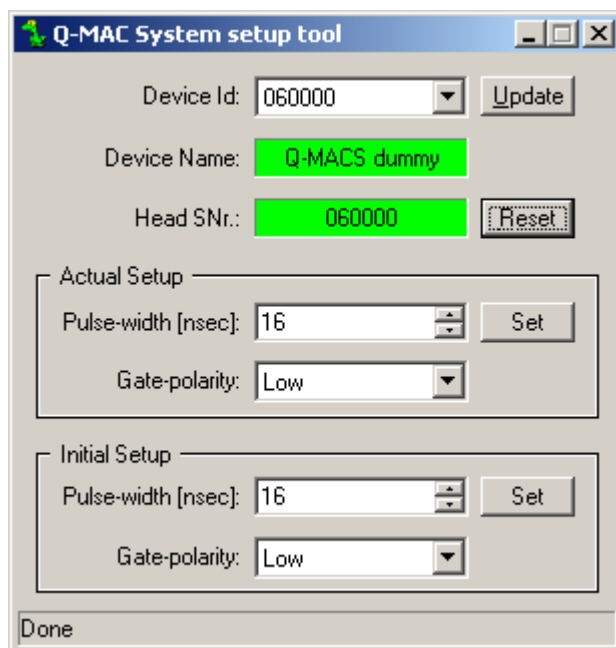

Figure 16: The setup application window

When using the setup tool a Q-MACS device is identified by its serial number. That makes the program independent of the serial port where the device is connected to the PC. If no device configuration entry is defined, the application searches all serial ports for attached Q-MACS devices automatically. The user can choose then one of the recognized devices from the device list and can change its settings to the desired ones.

4.5.3.2 Q-MACS Configurator

With the "Q-MACS Configurator" it is possible to edit all important settings of the Q-MACS devices. Moreover this software, because of its configuration features, is the central point of the "Q-MACS library", which will be introduced later on.
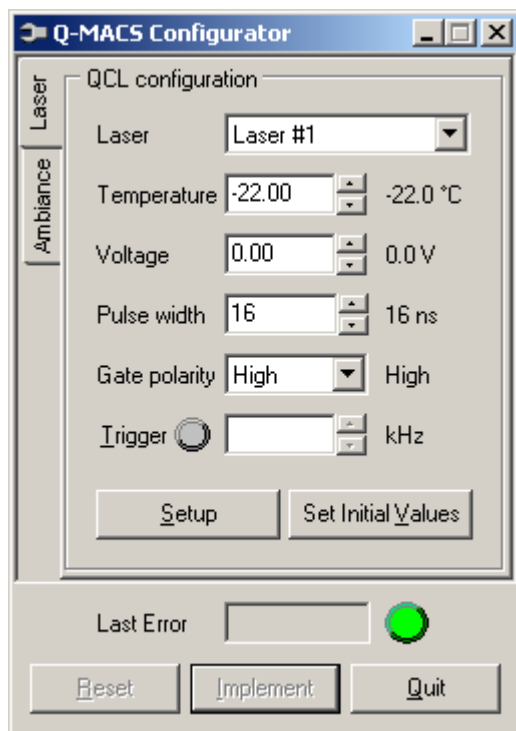

Figure 17: Q-MACS Configurator main window

The main window of the "Q-MACS Configurator" has three sections. It is divided into the application bar, an upper section allowing definition of settings for the components of a Q-MAC System and a lower section with button controls for the application. With its features the "Q-MACS Configurator" allows setting up intra pulse mode operation for Q-MACS devices.

The application bar provides system menu commands. The System menu offers the following commands, which provide you assistance with this application.
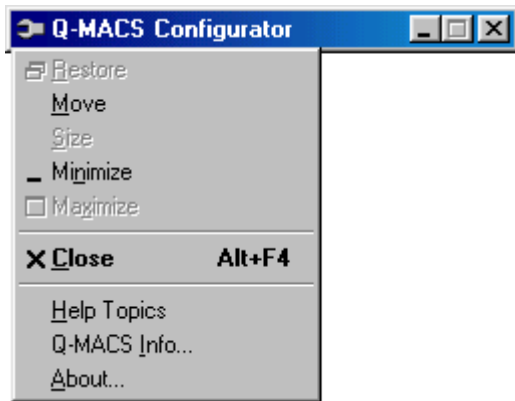
Figure 18: Application bar and system menu

The command `Move` is a standard system command for window positioning. Use this command to display a four-headed arrow so you can move the application window with the arrow keys. When the window is the preferred position pressing the Enter key finishes moving. The next available command called `Minimize` is also a standard system command to hide a window. Use this command to hide the application window. The icon in the task bar will be still visible. The command `Close` is used to exits the application. Double-clicking the control menu box is the same as choosing the `Close` command.

The subsequent commands in the system menu are application specific. The command called `Help Topics` offers an index to topics on which help information is available. Use this command to display the opening screen of the help database. From the opening screen, you can jump to step-by-step instructions for using the "Q-MACS Configurator" and various types of reference information. Once the help system is opened, a click on the `Contents` button returns to the opening screen. The `Q-MACS Information` command can be used to display information about the installed "Q-MACS library" and the connected device. This command is used to display the version number of the "Q-MACS library" used by the running copy of the "Q-MACS Configurator". In addition some information, like the serial number and firmware version, concerning the connected device are displayed. The last menu command named `About` displays the copyright notice and version number of the application.

On the application main window follows the upper section with a tabulator on the left, which allows toggle between the setup parameters of the QCLaser and the ThermoCube, used for ambiance temperature controlling. Here the actual values for the QClaser, displayed under the `Laser` tab and for supply parameters like the temperature, displayed under the `Ambiance` tab, are monitored and set. The properties of the particular setup unities are described below.

The different controls located in the lower section are described here in detail. The field called `Last Error` displays the last error message reported by the Q-MAC System. The field shows an error number code. To get more detailed information about an error the status notification can be clicked, which is colored red when fault.

The next control button is labeled Reset. This control allows reset the content of the fields in the upper section to the values last preset to the controlled device. When the button called Implement is pressed, the values of the fields in the upper section are assigned to the controlled device. The most right button, called Quit, can be used to close the "Q-MACS Configurator" program.

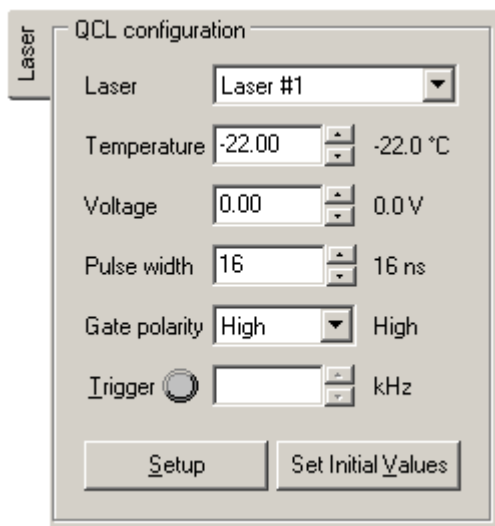In the upper section of the main application window, different laser parameters can be set.

Figure 19: Laser setup unity

The Laser tab provides all supported settings for Q-MAC Systems connected via the serial cable(s). The supported parameters are applied to the selected Q-MACS device, when the Implement button of the lower section of the main window is pressed. The first selection control called Laser switches between the laser definitions. The selectable definitions are a combination of user defined and automatically defined settings.

If a data acquisition board is part of the system and if it was found by the automatic laser configuration, it is possible to set up the target laser temperature for the temperature controller with the control Temperature too. The same requirements are necessary for the edit control named Voltage. With a correctly configured data acquisition board this control allows to set up the pulse amplitude voltage of the pulse generator.

The control labeled Pulse width allows setting the pulse width for the pulse generator. Together with the selection control labeled Gate polarity, which allows setting the gate polarity of the pulse generator to High or Low, this setting defines the pulse generation cycle. The gate polarity defines the behavior of the Q-MACS device on the gate signal. When the value is set to High, the pulse signal is suppressed on the low state of the gate signal. Using the Q-MACS device together with an on-line measurement software like "TDLWintel" it is necessary to set the gate polarity value to High, since it uses an high active gate signal. To use a Q-MACS device without a gate signal connected to the Q-MACS supply it is

recommended to set this value to Low. Otherwise a 5 volt DC signal has to be plugged onto the gate signal input on the rear panel of the supply, to get the device working.

The `Trigger` control allows applying a trigger signal on a National Instruments® data acquisition card. This card must be set up with the Q-MACS library setup window, which is described later in this section. The `Trigger` control consists of two parts. The edit window is used to set the frequency value. The trigger is activated or deactivated by clicking the leading button, labeled with `Trigger`. When the trigger signal is active the button is colored green, otherwise it is colored gray.

On the bottom of the `QCL configuration` frame two button controls are located. The first one labeled `Setup` opens the Q-MACS library setup window, where the properties of the "Q-MACS library" can be defined. A later paragraph will deal with the details of this window. The second button is called `Set Initial Values`. It is used to apply the actual values as initial values to the connected Q-MACS device. Initial values are stored on an EEPROM in the Q-MACS laser head and applied every time, when the device is powered on. Therefore it is important to implement save operational parameters only.
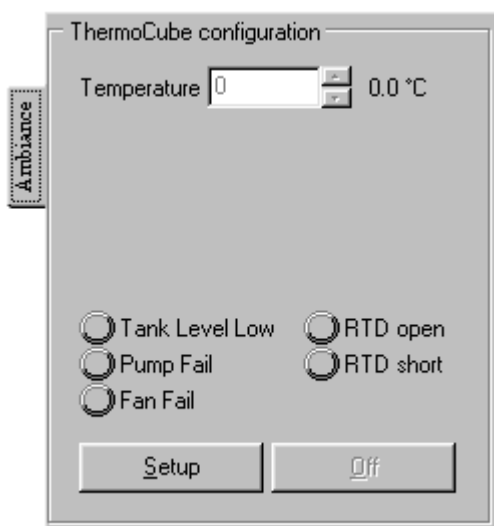

Figure 20: Ambient setup unity

The second setup page can be accessed by the tab called Ambiance. The controls on this frame provide some additional settings concerning Q-MAC Systems connected to the computer. Several settings of 3rd party hardware are supported. The main function in the actual version of the "Q-MACS Configurator" software is to control a ThermoCube connected via the serial interface, which is used as a water tempering and flow control device, for holding constant the surrounding temperature of the measurement system. The different controls on this dialog are described here in detail.

The only editable control labeled `Temperature` allows setting up the target temperature of the ThermoCube chiller connected to the controlling computer. To finally apply the entered

value to the ThermoCube device, the `Implement` button of the main windows lower section has to be pressed. The following control set shows the hardware status and errors of the ThermoCube device. The meaning of the particular status information can be found in the ThermoCube manual.

The bottom of the `ThermoCube configuration` frame provides two control buttons. The first button labeled `Setup` supports the user with a dialog for setting up a connected ThermoCube chiller. The second button is named `On/Off`. Pressing this button toggles the state of the ThermoCube chiller between the idle and the cooling mode state.

The following paragraphs describe the Q-MACS library setup window. This window allows setting up the "Q-MACS library". The settings made on the Q-MACS library setup window affect all software applications using this "Q-MACS library". The different controls on this dialog are described here in detail.
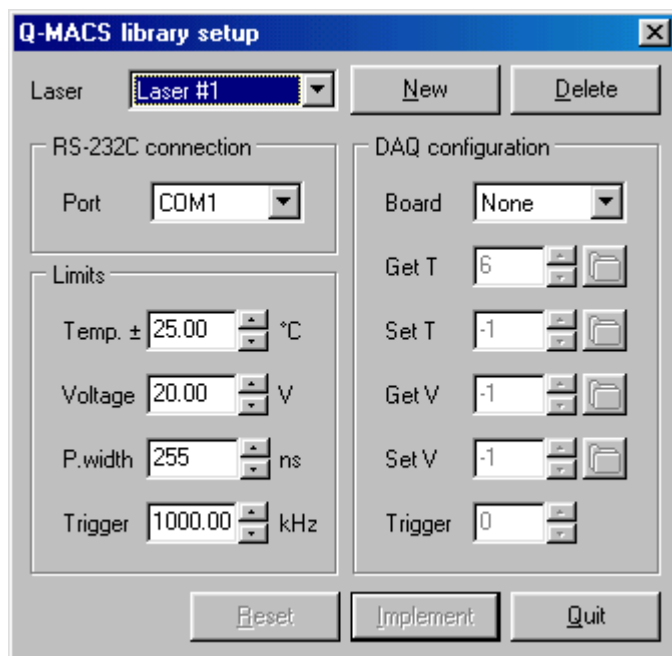

Figure 21: Q-MACS library setup window

The first selection control called `Laser` allows choosing the actual Q-MACS device definition entry, which should be edited. On the side of this selection control you will find two button controls. The first button control labeled `New` is used to insert a new definition entry to hold Q-MACS device settings. The second button labeled `Delete` is used to delete the setup stored in the actually selected laser definition entry.

The first frame on the Q-MACS library setup window called `RS-232C connection` allows the denotation of the serial port, where the Q-MACS device is connected to.

The controls on the right frame called `DAQ configuration` makes it possible to associate a DAQ device with the actual selected laser. First the DAQ-board is selected. National

Instruments® devices, named "NIDAQ#X" in the selection control list, as well as Measurement Computing® devices, named "UL#X", are supported by the "Q-MACS library". The X in the name stands for the corresponding device number in the appropriate 3rd party library. The following controls allow setting the particular channel for the different options, like measuring and tuning the temperature or the pulse voltage. The last control affects the counter output on National Instruments® data acquisition boards, which is used to generate the trigger signal. In the current version of the "Q-MACS Configurator" software, this control is not available for Measurement Computing® devices.

The edit controls in the frame named `Limits` allow defining limits for the Q-MACS values. These limits are used inside the "Q-MACS library" to protect the device against dangerous settings. When settings are requested, which exceeds these limits, the called library function returns an error.

The three button controls on the bottom of the Q-MACS library setup window are used to control its behavior. The first control named `Reset` allows reset the content of all editable controls to the values last stored in the actually selected definition. When the button called `Implement` is pressed, the values entered in the already mentioned editable controls are stored as the selected device definition entry. The most right button called `Quit` is used to leave the Q-MACS library setup window.

4.5.4 Programming

4.5.4.1 Setup using software library

Two methods exist to access the pulse settings for the user's applications. Both will be described in the next sections. The software library can be used to set up the Q-MACS device. The communication protocol is part of the "Q-MACS library". This library is needed to write own programs, which handle the Q-MAC System. It contains high level functions for all common operations of the Q-MAC System and it provides the identical set of functions and arguments for each supported programming language. If you switch languages, you will not have to learn a new library, with new syntax, and different features. The functions supported by this library at the time this manual was published are listed in Table 4.

Function	Parameter	Comments
QMACS_GetLibraryVersion	num	Request the version of the library
QMACS_GetDeviceCount	num	Return number of connected devices
QMACS_GetDeviceList	list	Return a string list of connected devices
QMACS_GetLaserVoltage	dev, num	Return the actual laser voltage setting
QMACS_SetLaserVoltage	dev, num	Set the actual laser voltage setting
QMACS_GetLaserTemperature	dev, num	Calculate laser temperature from head temperature
QMACS_GetHeadTemperature	dev, num	Return the current temperature setting
QMACS_SetHeadTemperature	dev, num	Set the current temperature setting
QMACS_GetPulseWidth	dev, num	Return the current pulse-width setting
QMACS_SetPulseWidth	dev, num	Set the current pulse-width setting
QMACS_GetGatePolarity	dev, num	Return the current setting of gate polarity
QMACS_SetGatePolarity	dev, num	Set the current setting of gate polarity
QMACS_GetTriggerFrequency	dev, num	Return the current setting of trigger frequency
QMACS_SetTriggerFrequency	dev, num	Set the current setting of trigger frequency
QMACS_GetDeviceInfo	dev, cmd, param	Request device information
QMACS_SetDeviceInfo	dev, cmd, param	Change device settings

Table 4: Q-MACS software library functions

For each programming language mentioned above more example programs can be found in the installation sub-directory. The names of the installation sub-directories are:

- C
- VBWIN
- DELPHI

The following example code shows how to edit the Q-MACS settings using the "Q-MACS library" commands. This code fragment illustrates how to handle the Q-MACS library function calls.

```cpp
#include <iostream>
#include <stdlib.h>
#include <conio.h>
#include <qmacs.h>

#include <windows.h>

int main(int argc, char** argv)
{
        const  int id = 1;
        int error;
        char errtext[256];
        laserinfo_t info = {0};

        info.nSize = sizeof(info);                      // fill size of setup structure
        info.dwType = QMACS_TYPE_LASER;         // fill type of setup structure
        info.dwMask = QMACS_INF_TEMP | QMACS_INF_VOLTS;
        info.dwMask |= QMACS_INF_WIDTH | QMACS_INF_POLARITY;
        info.fTemp = 10.0;                              // fill temperature setpoint
        info.fVolt = 5.0;                               // fill pulse voltage setpoint
        info.fWidth = 100;                              // fill pulse width setpoint
        info.nGate = 0;                                 // fill gate polarity
        error = QMACS_SetDeviceInfo(                    // apply setpoints to the q-macs device
                id,
                QMACS_CMD_LASER_SETPOINT,
                &info
        );
        if(error != QMACS_ERROR_NOERROR) {  // check for error
                QMACS_GetErrorTextEx(error, errtext, sizeof(errtext));
                std::cerr << "Error setting device parameter: " << errtext << std::endl;
                return EXIT_FAILURE;
        }

        error = QMACS_GetDeviceInfo(                    // query setpoints from the q-macs device
                id,
                QMACS_CMD_LASER_SETPOINT,
                &info
        );
        if(error != QMACS_ERROR_NOERROR) {  // check for error
                QMACS_GetErrorTextEx(error, errtext, sizeof(errtext));
                std::cerr << "Error recieving device parameter: " << errtext << std::endl;
                return EXIT_FAILURE;
        }
        std::cout << "Setpoints for laser " << id << std::endl;
        std::cout << "Temperature:\t" << info.fTemp << " °C" << std::endl;
        std::cout << "Pulse voltage:\t" << info.fVolt << " V" << std::endl;
        std::cout << "Pulse width:\t" << info.fWidth << " ns" << std::endl;
        std::cout << "Gate polarity:\t" << (info.nGate ? "high" : "low") << std::endl << std::endl;

        info.dwMask = QMACS_INF_TEMP;           // query only temperature parameter
        while(!_kbhit()) {
                error = QMACS_GetDeviceInfo(    // query parameter from q-macs device
                        id,
                        QMACS_CMD_LASER_PARAM,
                        &info
                );
                if(error != QMACS_ERROR_NOERROR) {   // check for error
                        QMACS_GetErrorTextEx(error, errtext, sizeof(errtext));
                        std::cerr << "Error recieving device parameter: " << errtext << std::endl;
                        return EXIT_FAILURE;
                }
                std::cout << "Actual temperature of laser " << id << " is " << info.fTemp << " °C" << std::endl;
        }
        return EXIT_SUCCESS;
}
```

4.5.4.2 Setup using low level commands

The following example code shows how to edit the Q-MACS settings through the low level ASCII commands. This code fragment illustrates how to communicate with a Q-MACS device using Win32-API function calls.

```cpp
#include <windows.h>
#include <iostream>

int main(int argc, char* argv[])
{
        HANDLE hPort;
        DWORD read;
        DWORD ccsize;
        DWORD written;
        char answer[16];
        COMMCONFIG ccfg;
        COMMTIMEOUTS cto;

        // Open serial port 1
        hPort = CreateFile(
                "COM1:",
                GENERIC_READ | GENERIC_WRITE,
                FILE_SHARE_READ | FILE_SHARE_WRITE,
                NULL,
                OPEN_EXISTING,
                FILE_ATTRIBUTE_NORMAL,
                NULL
        );
        // ... on error exit program
        if(hPort == INVALID_HANDLE_VALUE) return EXIT_FAILURE;
        // Determine current settings of serial port
        ccsize = sizeof(ccfg);
        GetCommConfig(hPort, &ccfg, &ccsize);
        // Set up new configuration and timeouts
        ccfg.dcb.BaudRate = CBR_9600;
        ccfg.dcb.ByteSize = 8;
        ccfg.dcb.Parity = NOPARITY;
        ccfg.dcb.StopBits = ONESTOPBIT;
        ccfg.dcb.fDtrControl = DTR_CONTROL_DISABLE;
        ccfg.dcb.fRtsControl = RTS_CONTROL_DISABLE;
        SetCommConfig(hPort, &ccfg, ccsize);
        cto.ReadIntervalTimeout = 10;
        cto.ReadTotalTimeoutConstant = 100;
        cto.ReadTotalTimeoutMultiplier = 2;
        cto.WriteTotalTimeoutConstant = 0;
        cto.WriteTotalTimeoutMultiplier = 0;
        SetCommTimeouts(hPort, &cto);
        // Write command to set the pulse width to 10 nsec through the serial port
        WriteFile(hPort, "W10\r", 4, &written, NULL);
        // Read the answer of the Q-MACS device from the serial port
        if(ReadFile(hPort, answer, sizeof(answer), &read, NULL) && !memcmp(answer, "ok", 2))
                std::cout << "Pulse width value of 10 nsec successfully set." << std::endl;
        else
                std::cerr << "Unable to set up pulse width value." << std::endl;
        // Close serial port
        CloseHandle(hPort);
        return EXIT_SUCCESS;
}
```

4.6 Setting the DC bias current

A second possibility for passing a current through the QCL is via the bias circuit as shown in Figure 35 on page 55. This circuit converts an input voltage in the range from 0V to 10V to an output current from 0 to 500mA. The DC bias current can be calculated as follows:

$$i_{DC} = \frac{v_{RAMP}}{20\Omega}$$

For spectroscopic purposes usually a ramp (with positive or negative slope) is used to tune the QCL temperature and thus the emission wavelength. Other bias curves can be supplied to accommodate the fact that a linear ramp does not necessarily correspond to linear temperature tuning.

⚠️ Note: This current must be added to the pulse current.

4.7 Quick Start Guide

4.7.1 General

(1) Check that the QCL voltage switch on the front side is switched off and that the QCL voltage potentiometer is at zero
(2) Make sure that the data sheet of the specified QCL is to hand
(3) Make sure that the threshold voltage of the specified QCL is known
(4) If anything is unclear about the operating conditions please contact the manufacturer of the QCL or preferably the supplier

4.7.2 Cabling

(1) Connect the Q-MACS head with the Q-MACS supply
(2) Connect the BNC ports (TRIGGER, GATE, RAMP, Set TEMP., Actual TEMP.) on the back of the Q-MACS power supply with the appropriate ports (e.g. at the NI board)
(3) Set the TRIGGER source to Ext.
(4) Set the QCL Voltage to Int.

Note: An internal trigger of 100 kHz in combination with too long pulse width will destroy the QCL.

(5) Check the appropriate setting of the supply voltage of the Q-MACS supply (115V/230V)
(6) Connect the Q-MACS supply to the power line

4.7.3 Beginning a QCL measurement

(1) Check the cable connections from the Q-MACS head to the Q-MACS power supply
(2) Check the BNC connections from the Q-MACS power supply to the NI BNC board
(3) Turn on the measurement computer
(4) Start TDLWintel
(5) Set the measurement temperature
(6) Check that the ramp is set to zero and that the number of shut off points is small in comparison to the length of the ramp (e.g. 800/20) and that the frequency has an appropriate value (e.g. 100 kHz)
(7) You can now switch on the Q-MACS power supply

Note: If TDLWintel is not started before the Q-MACS-power supply the "set temp" for the QCL is zero and is therefore set to 0 °C. This may cause e.g. higher currents (> 0.5 A) to flow through the thermo cooling element or other problems!

Note: High DC currents will destroy the QCL. Therefore, only use duty cycle values of less than 1 % and stay below the maximum effective current limit for the QCL.

(8) Check that the "<u>TC current</u>" has decreased after a short time (~ 60 sec)
(9) Switch on the QCL voltage at the Q-MACS Supply
(10) Increase the QCL voltage on the Q-MACS Supply until you see a signal on the scope or in TDLWintel

⚠️ Note: The QCL current must be monitored as frequently as possible.

(11) Program a small ramp and increase it gradually until you see a spectrum or an etalon fringe pattern.

4.8 Q-MACS and TDLWintel

4.8.1 General

Before reading this chapter it is strongly recommended to study the TDLWintel manual. Reading this manual is necessary to become familiar with the functionality and parameters of the laser control and spectroscopic analysis program, TDLWintel. As described earlier Q-MACS was designed to be controlled by TDLWintel. That means that almost all signals from TDLWintel's hardware interface, which generally consists of two NI PCI DAQ boards, can be used for driving Q-MACS. These signals and their description are specified in Table 5.

Signal	Description	Electrical specification
TRIGGER IN	Pulse to drive pulse amplifier	TTL Input
TRIGGER OUT	Pulse synchronous to the pulse provided to the head	TTL Output
GATE	Signal to gate the pulse on/off	TTL input
RAMP	For DC bias or other modulation	Input range 0V…10V; Imax@10V=500mA
Set TEMP.	Temperature set point	-4V…+4V <-> -40°C…+40°C; 0V = 0°C
Act. TEMP	Current temperature @ QCL	-0.4V…+0.4V <-> -40°C…+40°C; 0V = 0°C
Set QCL voltage	Input to program the QCL voltage	0V programming voltage = 0V QCL voltage 5V programming voltage = 15V QCL voltage[2]
Act. QCL voltage	Optional monitor output	Depends on the used voltage divider[3]

Table 5: I/O's on rear panel

The pulse amplifier can be switched off using a gate to turn off the laser emission. This functionality is used to determine the voltage delivered by the detector when no laser light is received. The trigger, gate and ramp signal are responsible for wavelength tuning of the QCL. These signals must be used very carefully to avoid damaging the QCL. Additional connections are necessary to set and to monitor the actual temperature of the QCL, to read the pressure from a pressure gauge and to get the detector signals. When using TDLWintel,

---

[2] QCL voltage depends on the maximum voltage of the QCL power supply, general formula

$V_{QCL} = \dfrac{V_{QCL\,max}}{5V} \bullet V_{externalprogam}$. The standard power supply provides 15V which can be increased to

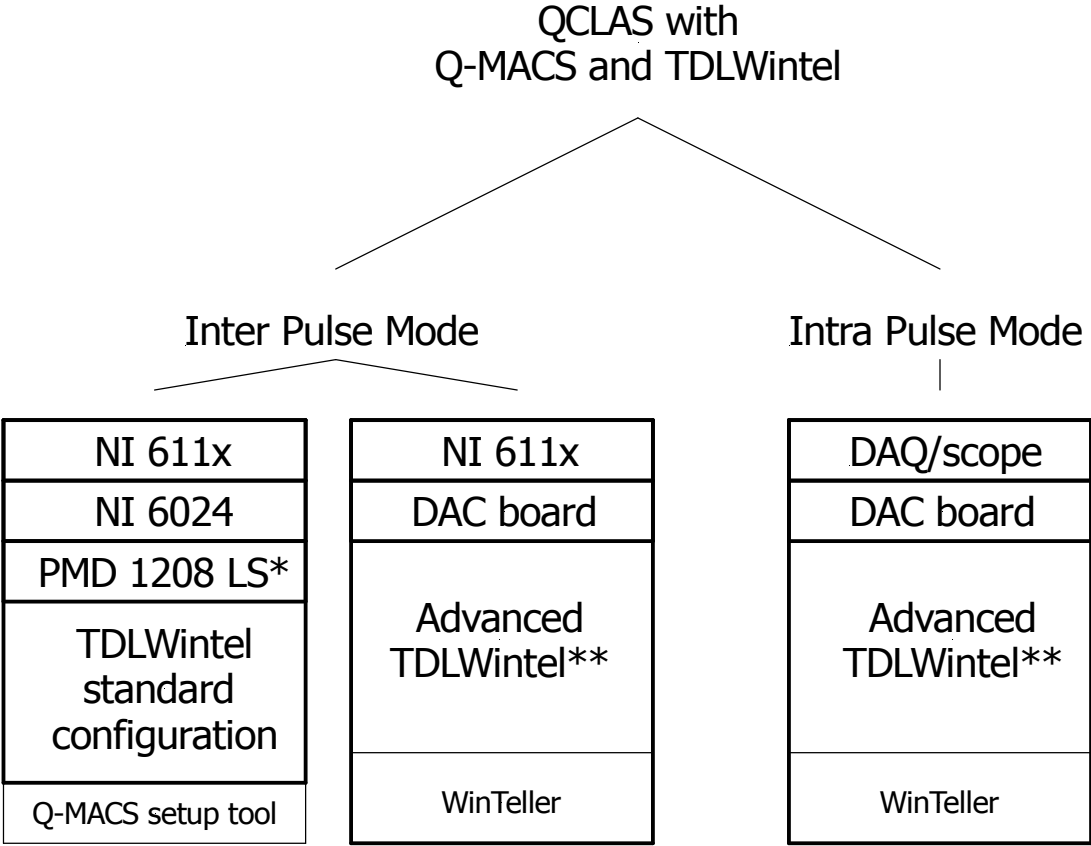17V. Alternative a power supplies can be provided with a range up to 24V (27V).

[3] For safety reasons the monitor output is unused. For more information contact the manufacturer.

the pull down menus are the most important set of interface controls. These menus provide the primary method for editing most of the important operational parameters which control the mechanics of the basic data acquisition process.

To simplify the cabling the BNC plugs are labeled with colored heat shrink tube. T shows the coding.

Mark	Signal	Color		Note
⚠	TRIGGER IN	White	◯	A too high trigger frequency may damage the laser
	TRIGGER OUT	Black	◯	
	GATE	Yellow	◯	
⚠	RAMP	Red	◯	A too high RAMP current may damage the laser
	Set TEMP.	Blue	◯	
	Act. TEMP	Orange	◯	
⚠	Set QCL voltage	Green	◯	A too high QCL voltage may damage the laser
⚠	Act. QCL voltage	Brown	◯	Don't use this output as an input! If this output is used as an input the voltage source could drive the QCL. In this case this applies: A too high QCL voltage may damage the laser

TDLWintel does not support all of the features included in the Q-MACS devices. There are two ways to operate Q-MAC System in combination with TDLWintel. Figure 22 shows these possibilities in detail.

QCLAS with
Q-MACS and TDLWintel

Inter Pulse Mode   Intra Pulse Mode

NI 611x	NI 611x	DAQ/scope
NI 6024	DAC board	DAC board
PMD 1208 LS*		
TDLWintel standard configuration	Advanced TDLWintel**	Advanced TDLWintel**
Q-MACS setup tool	WinTeller	WinTeller

*	optionally; to programm the QCL voltage with TDLWintel
**	from TDLWintel vers.10

DAQ	data aquisition
DAC	digital analog converter
NI	National Instruments

Figure 22: Overview about the interoperability of Q-MACS and TDLWintel

In principle it is safe to use any TDLWintel version with the Q-MACS setup tool which is only necessary to access some advanced Q-MACS feature like the pulse width and the above mentioned standard hardware environment. To use the Q-MACS setup tool please refer to 4.5.3.1 on page 26.

To provide a much more flexible hardware environment and to allow user friendly access to all Q-MACS functions, these features were added to the TDLWintel software working with TDLWintel version 10. This advanced TDLWintel software version supports both pulsed modes of operation too. An external program is developed to achieve this additional functionality which interacts with TDLWintel to extend its behavior. This executable file is

located in the installation folder of TDLWintel and is called `WinTeller.exe`. To use the additional features you have to run the `WinTeller.exe` instead of the TDLWintel executable. After the execution of the program, you will get the TDLWintel screen but with a new menu named `Tools`. This provides menu entries to access the configuration controls for the new features. Additionally some control elements are provided to access these features. These new components are described in the following chapter.
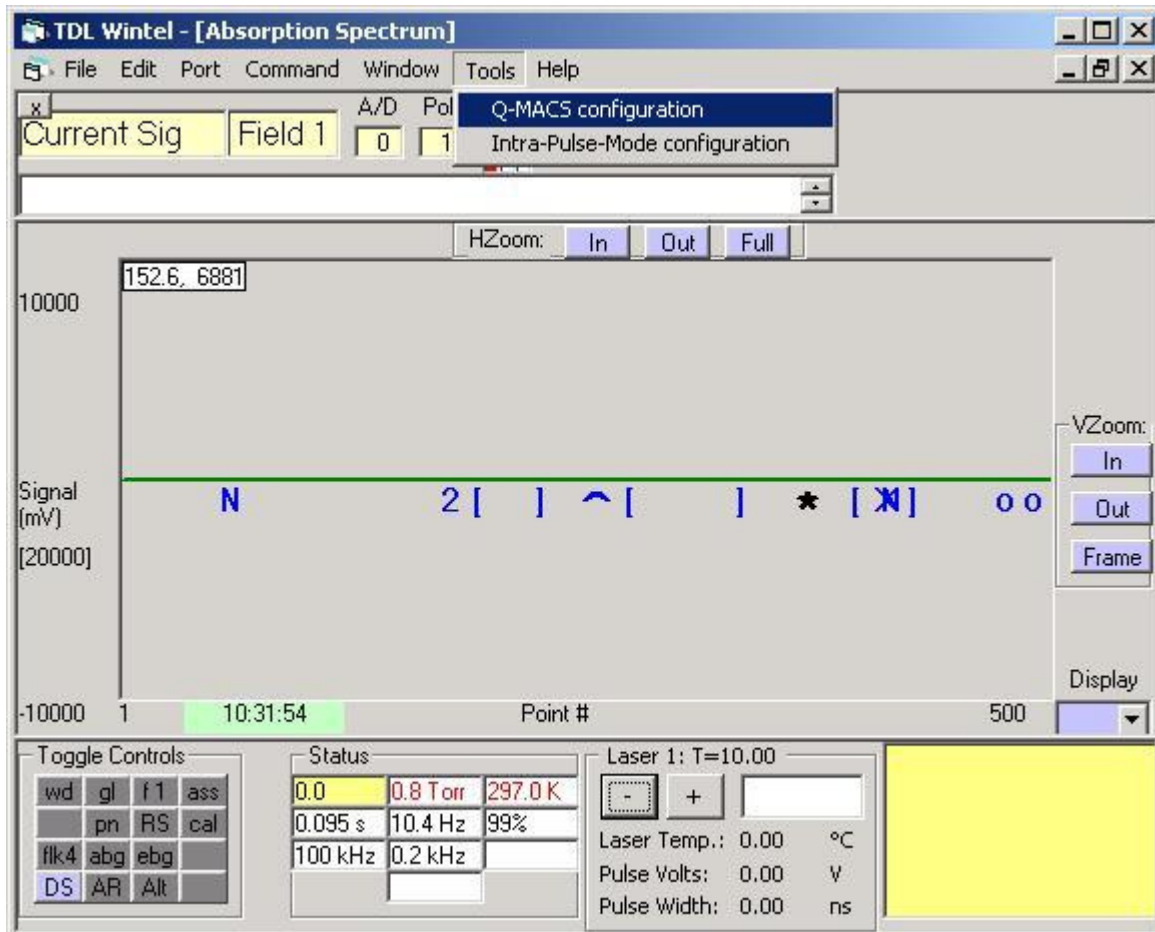
Figure 23: Extended TDLWintel window

Therefore a chapter is devoted to them because they are the primary method for configuring the Q-MACS devices. Changes which are made using the pull down menu `Tools` will be stored and will be remembered the next time the software started. As mentioned above the `Tools` menu controls the settings for the extended functions of the `WinTeller.exe` to support the continuative abilities of the Q-MACS devices in the TDLWintel software. The menus are described in the next chapter.

4.8.2 Q-MACS laser parameter

As described in the previous paragraph, some of the useful features supported by the Q-MACS devices are not part of the TDLWintel software. A modified `Laser control` (Figure 24) will be provided when running the extended TDLWintel application `WinTeller.exe`.
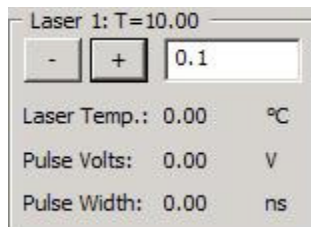
Figure 24: Q-MACS `Laser control`

The `Laser control` is located to the right of the `Status control` in the lower panel. This also contains the `Toggle control`s, the `Status control`, the `View Burst Spectra control` and a large numeric display. Each of these controls are discussed in the TDLWintel manual. It is necessary to enter the connection configuration in order to use the Q-MACS `Laser control`. The connection configuration consists of information about the serial port, where the Q-MACS supply is connected to, and the identification of the analog input and output channels, which can optionally be used to control the temperature and pulse-voltage parameter of the corresponding QCL. This configuration is executed in the Q-MAC System configuration dialog (Figure 24), which is achieved through the `Tools` menu as mentioned above.
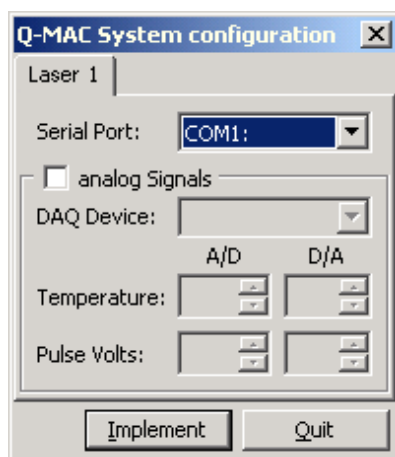
Figure 25: Q-MACS setup menu

With this dialog box each laser will be assigned to a serial port and to analog input and output signals of a DAQ board. If the software is configured to multiplex two or more lasers, then there will be a tabbed page for each laser. Be aware that the Q-MACS device is optimized for optical setups with only one QCL. If the analog signals are not defined, then the default `Laser control` of TDLWintel is used and the operator has to change parameters like the pulse-width externally. Changing the analog settings forces a restart of TDLWintel. This option uses a lot of new features added to TDLWintel. Using these features requires at least in version 10 of TDLWintel.

After defining the laser configuration the Q-MACS `Laser control` will operate in the selected way. The functionality of the adapted `Laser control` is similar to that performed by TDLWintel. So it is used to provide easy adjustment of the QCL's frequency by changing the temperature set point for the TE coolers, the voltage and the pulses width.

As the picture shows the `Laser control` contains two command buttons (Figure 24). These buttons increase or decrease the selected laser parameter. The selected parameter is displayed at the top of the control. Clicking on this label allows stepping through the list of available properties. For a single laser system three properties are available: temperature, pulse voltage and pulse width. For a dual laser system six properties are available: temperature, pulse voltage and pulse width for each laser. The properties can be adjusted in small steps or in large steps using the left mouse button or the right mouse button respectively. The Q-MACS `Laser control` also displays the current values of these laser parameters.

Set up cable connection

To connect a Q-MACS device to your system, you have to make sure that all necessary analog and digital signal lines are attached. For a more detailed description of the signal lines used to set up and control the Q-MACS device from inside TDLWintel please see chapter 4.7.2. The names of the signal lines, like those introduced in chapter 4.8, are used here to explain the necessary connections. It is recommended that Tyco connectors are used for National Instruments boards for connecting the laser control signals and the detector signals. In addition it is important to connect the RS-232C cable to a free serial port at the controlling computer. This facilitates the possibility to set and to monitor the value of the pulse width parameter for the Q-MACS device.

4.8.3 Q-MACS, TDLWintel and inter pulse mode

As mentioned in chapter 1 the Q-MAC System is designed to be fully compatible to the powerful spectroscopy software package TDLWintel with a less of hardware. All names of the signals (expect for the pulse width) which are used for Q-MACS can be found in the TDLWintel software. A PC with a fast National Instruments data acquisition board (NI 6110, NI 6111, and NI 6115) and a slower board like NI6024 are necessary in addition to a basic setup.
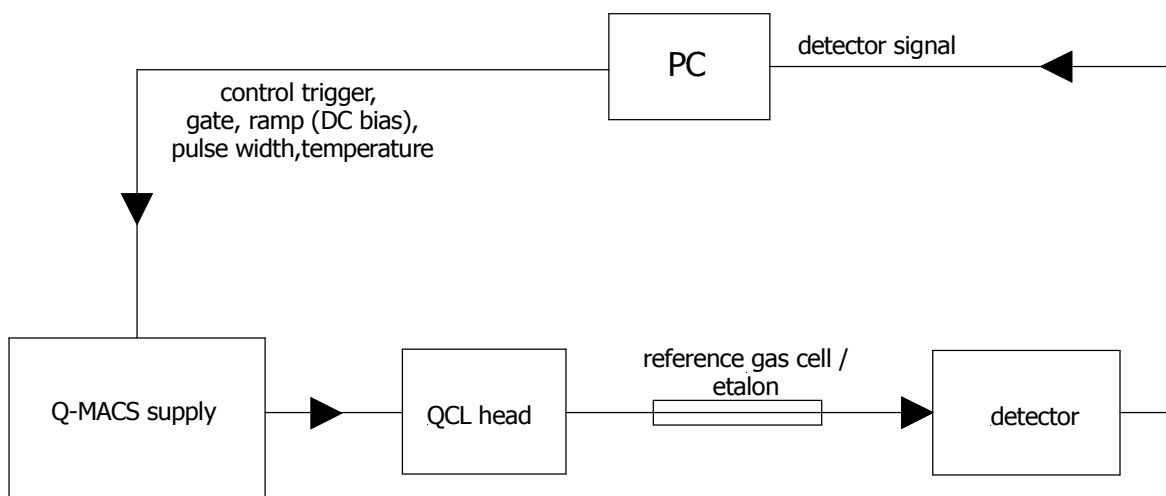
Figure 26: Q-MACS setup for TDLWintel and inter pulse mode

To set up a single quantum cascade laser spectroscopy system with Q-MACS and TDLWintel please refer to the TDLWintel manual.

4.8.4 Q-MACS, TDLWintel and intra pulse mode

The data acquisition mode of TDLWintel is designed for the inter pulse mode. In addition the program `WinTeller.exe` already mentioned offers the possibility to analyze data measured with different devices, like oscilloscopes. This extends the application range of TDLWintel to the possibility of analyzing data which is measured inside an optical pulse of the laser. The following devices are supported (Table 6).

Name	Connection	Comments
Tektronix Oscilloscope	RS-232C, GPIB	readout only, settings at the device
Acqiris PCI Digitizer Card	PCI	readout and setup

Table 6: Supported hardware for using the intra pulse mode

Since the Acqiris PCI Digitizer Card is not part of the Q-MAC System, a more reliable solution will be a Tektronix oscilloscope connected either through a RS-232C port or a GPIB port to the controlling computer. The necessary connection and the resulting dataflow for the intra pulse mode with TDLWintel are shown in the following schematic (Figure 27).
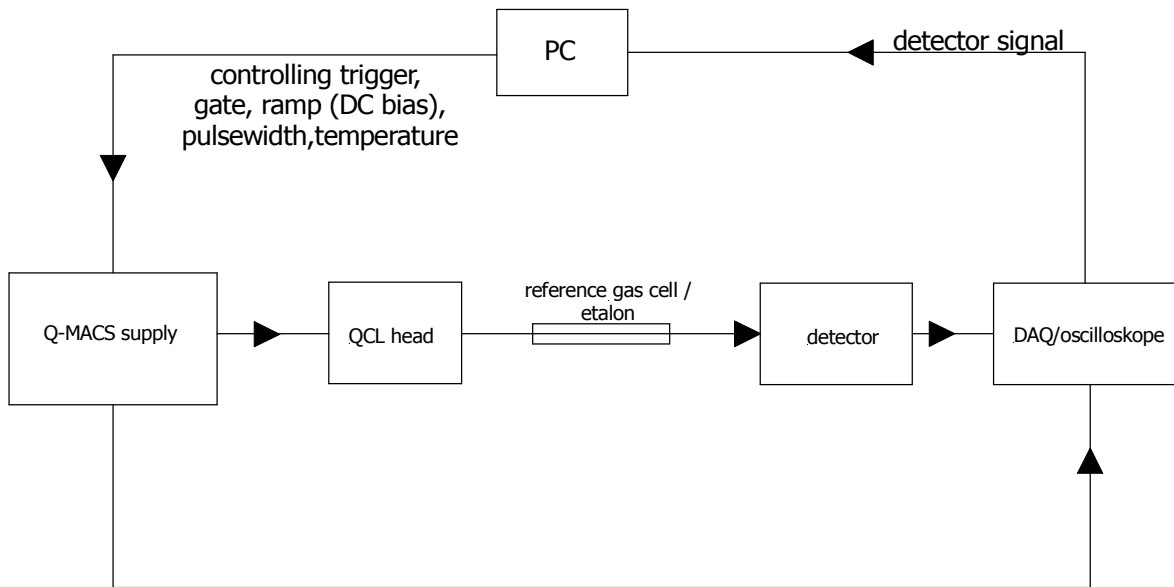
Figure 27: Data flow diagram for the intra pulse mode

When running `WinTeller.exe` the menu `Tools` already mentioned provides an entry for the configuration of the intra pulse mode. The configuration dialog enables the user to select the measurement device which will deliver the data for analysis (Figure 28). When the device is chosen, `WinTeller.exe` will permanently read it out and hand over the data to TDLWintel for analyzing. To disable this feature one can select no device. The button called `Details...` allows the user to change some hardware parameters of the selected device. When an oscilloscope is used, it is possible to declare the connection type and port. The Acqiris PCI Digitizer are supported with more complex configuration options like signal ranges and trigger settings.
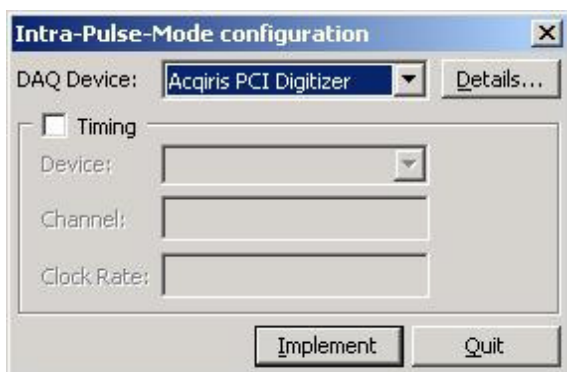
Figure 28: Dialog for configuring the intra pulse mode

The group of controls called `Timing` implements the function to create the trigger pulses at an alternative device. This option is useful if TDLWintel is used mainly in the intra pulse mode.

In this case the timing signals do not need to be as fast as possible. Often some 100 kHz for the repetition rate are appropriate to achieve the desired results. When enabling this feature TDLWintel needs to be restarted what happens automatically. The `Timing` controls let the user choose a DAQ device, the index number of a clock channel on this board and the desired A/D clock rate supported by the DAQ device. The A/D clock rate is the rate of individual A/D conversions. After configuring the intra pulse mode the data are read and analyzed by TDLWintel each time on starting the `Playback stream data` mode inside TDLWintel.

Set up cable connection

Make sure that the Q-MACS device is set up properly. The software requires a Tektronix oscilloscope to determine the voltage data from the fast detector. The connections have to be made similar to the description for the Q-MACS `Laser parameter mentioned` in the above paragraph. In addition the oscilloscope has to be connected with the controlling computer.

5 Troubleshooting

Problem	Symptom	Solution
Everything is connected but the system shows no functionality	On the supply no lights and no LCD are on	1. Check the main switch 2. Check the fuses on the power inlet module
Changing the QCL voltage no QCL current is displayed	**QCL voltage is adjustable,** everything is connected, supply seems to be ready	1. Check the ON/OFF switch for the QCL voltage at the front panel 2. Check the GATE polarity, if the polarity is set to *high active* a HIGH TTL level on the GATE is necessary 3. Check the switch *MODE BNC/NI*; if the switch is set to BNC and the NI connectors are plugged nothing will happen 4. If 1. , 2 and 3. are OK check the proper contact in the head 5. If the temperature of the head is too high the pulse electronics shuts down the amplifier
While changing the QCL voltage no QCL current is displayed	**QCL voltage is NOT adjustable**, everything is connected, supply seems to be ready	1. Check on the back panel that the switch *Set QCL* is set to *external* and a voltage of $0\leftrightarrow5V$ programs the QCL power supply 2. If no mode is working contact the manufacturer
Dark or no bright green LED on QCL supply	ON/OFF switch is on, QCL voltage is displayed, QCL current is running	The brightness of the LED on the QCL power supply follows the output voltage; if the output voltage is small the LED will be dark; if the output voltage is at the maximum the LED is bright
QCL current higher than expected	Everything seems to be connected correctly	1. Check the pulse width 2. Check the TRIGGER frequency 3. Check the switch *TRIGGER internal/external*. If the switch is set to internal then 100 kHz pulses will pulse the QCL! 4. Check the RAMP 5. If no signal then check the contact to see if there is a short circuit in the head

Table 7: Troubleshooting

6   Appendix

6.1   Specification

Q-MACS technical specifications

Q-MACS Head

Dimensions :	64mm x 64mm x 170mm
Weight:	1450 g
Pulse width:	8ns* $\leftrightarrow$ 256ns**

*	(Depending on the QCL device and the QCL voltage)
**	(longer pulses can be provided on request (e.g. 500 ns, 1µs))

Pulse frequency:	up to 1 MHz
QCL temperature range:	-35°C $\leftrightarrow$ +40°C
Supported QCL:	Alpes Lasers
	Laser Components (on request)
	Nanoplus (on request)

Q-MACS Cable

Length:	2m (other length on request)
Connector:	straight or rectangular
Weight:	480g

Q-MACS Supply

Dimensions:	42TE (235mm)/ 3HE (140mm) * 235mm
Weight:	5400 g
Power:	230V/1A
	115V/2A
Working range:	+5°C <-> 40°C
BNC connections:	Input
	TRIGGER (external/internal) (TTL)
	GATE (TTL)
	Set TEMP (-4V (-40°C) to +4V (+40°C))
	Set QCL Voltage (0 $\leftrightarrow$ 5V programming voltage

$\rightarrow$ 0 $\leftrightarrow$ 15V QCL voltage;
3*programming voltage=QCL voltage)
Pressure

Output
Actual TEMP
(-400mV (-40°C) to +400mV (+40°C))

Actual QCL voltage ($\frac{V_{QCL}}{11}$;0... $\frac{V_{QCL_{MAX}}}{11}$)

6.2 Connectors

6.2.1 9-pole Serial Port
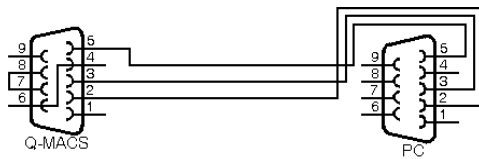
Figure 29: Scheme of the RS232 connector

25 pole D-Sub Connector

Pin 1: +QCL voltage with bi-metal switch (@50°C)

Pin 2: -Peltier voltage; negative sense feedback to power supply

Pin 3: -driver voltage

Pin 4: +driver voltage 8...9V

Pin 5: -QCL voltage

Pin 6: +QCL voltage with bi-metal switch (@50°C); in combination with Pin 1

Pin 7: +Peltier voltage; positive sense feedback to power supply

Pin 8: -Peltier voltage

Pin 9: -Peltier voltage

Pin 10: digital ground

Pin 11: trigger pulse input

Pin 12: gate pulse input

Pin 13: serial connection for setting pulse width

Pin 14: bias voltage 10V -> 0,5A

Pin 15: +/- 4V input for set temperature

Pin 16: +/- 4V output for current temperature

Pin 17: analog ground

Pin 18: +Peltier voltage 15V/6A

Pin 19: +Peltier voltage

Table 8: Pin assignment 25 pole D-Sub
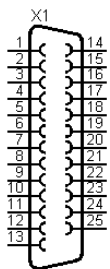
Figure 30: 25 pole D-Sub connector

6.3 Technical diagrams

The following sketches of the Q-MACS head might be helpful for integrating the head into an experimental setup. If more information is necessary, like the dimensions or special components like an adapted ground cover for a Newport xyz- stage, please contact the Q-MACS distributor to obtain this.
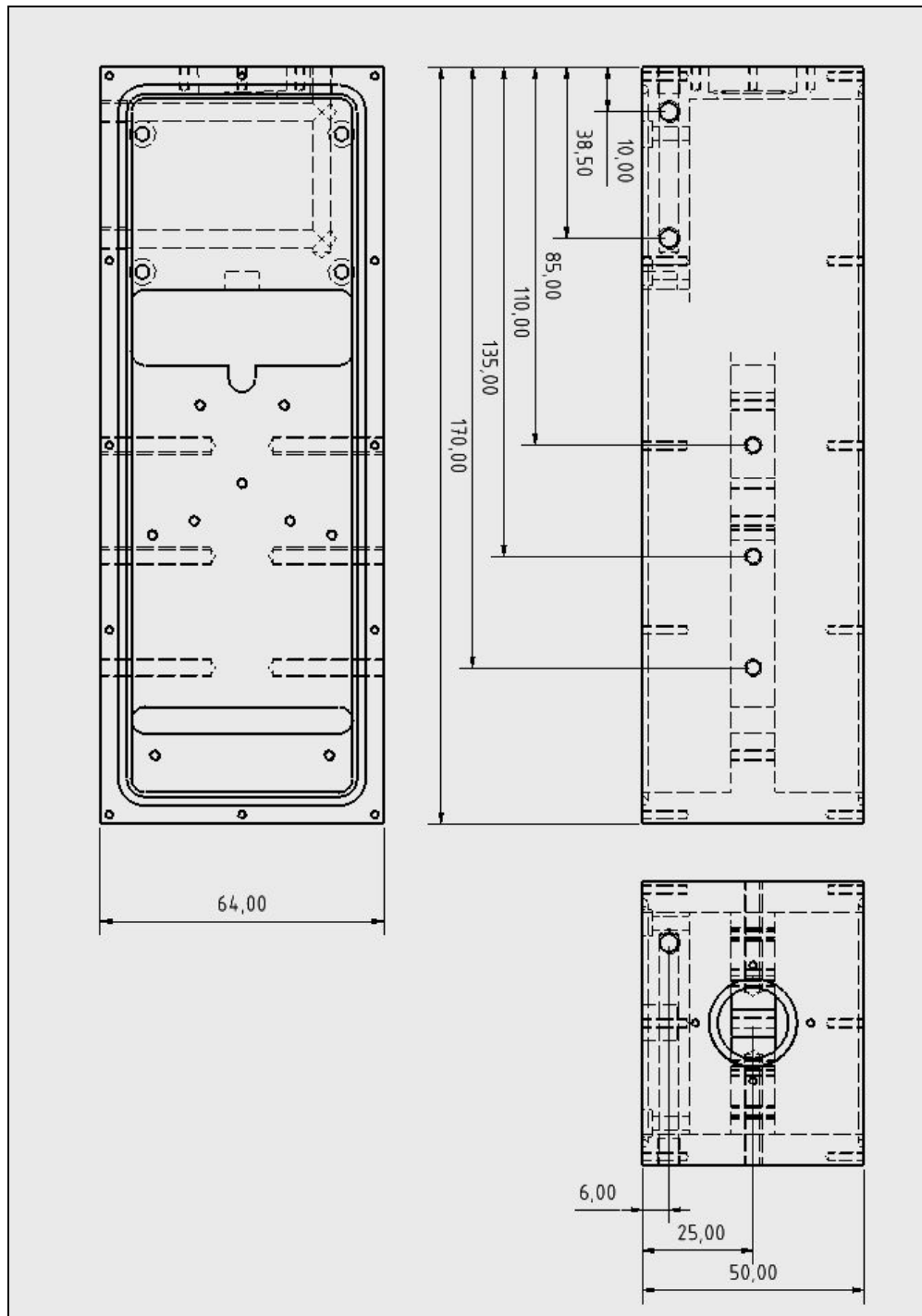
Figure 31: Q-MACS Head
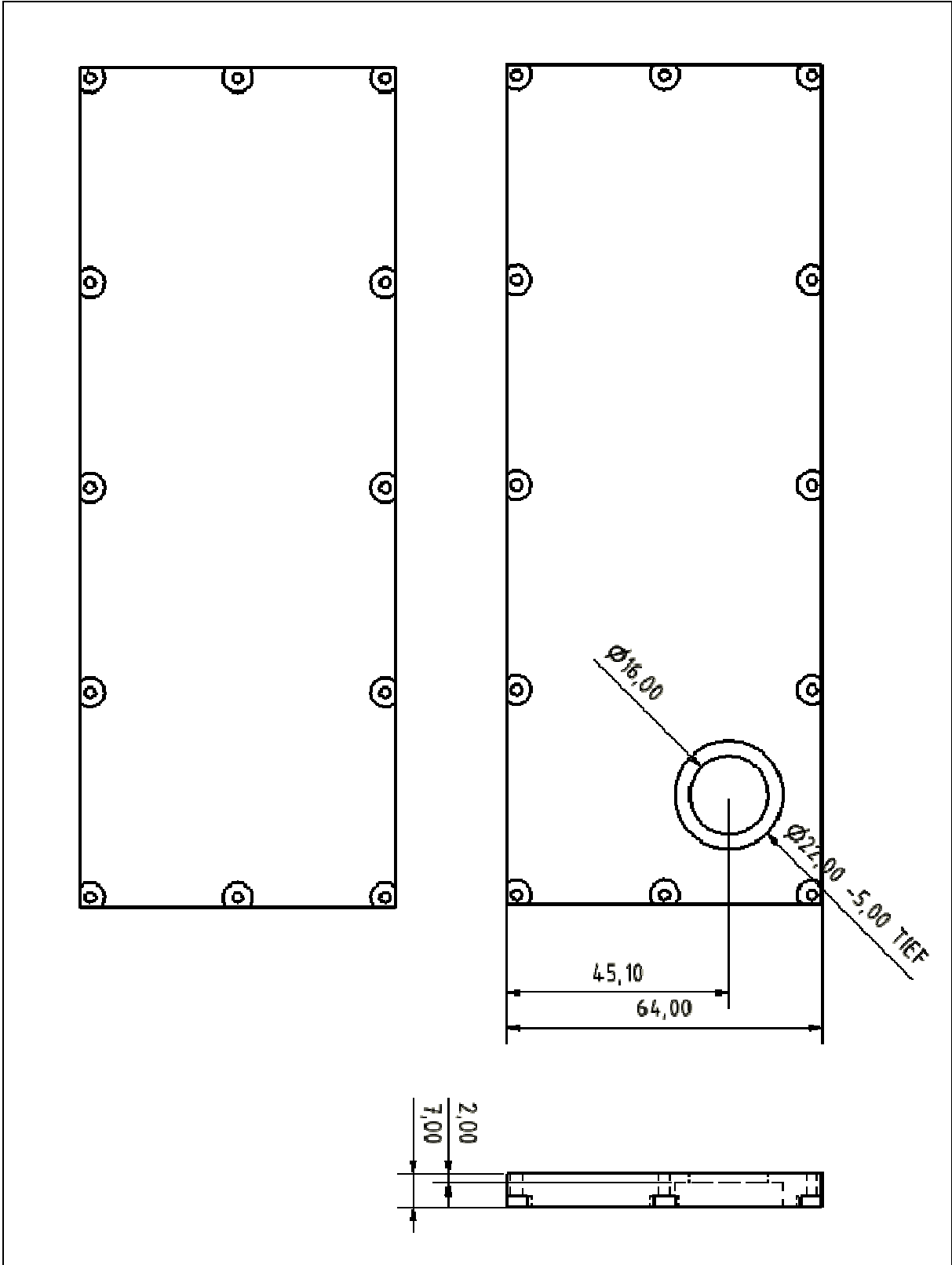
Figure 32: Upper and lower cover plates
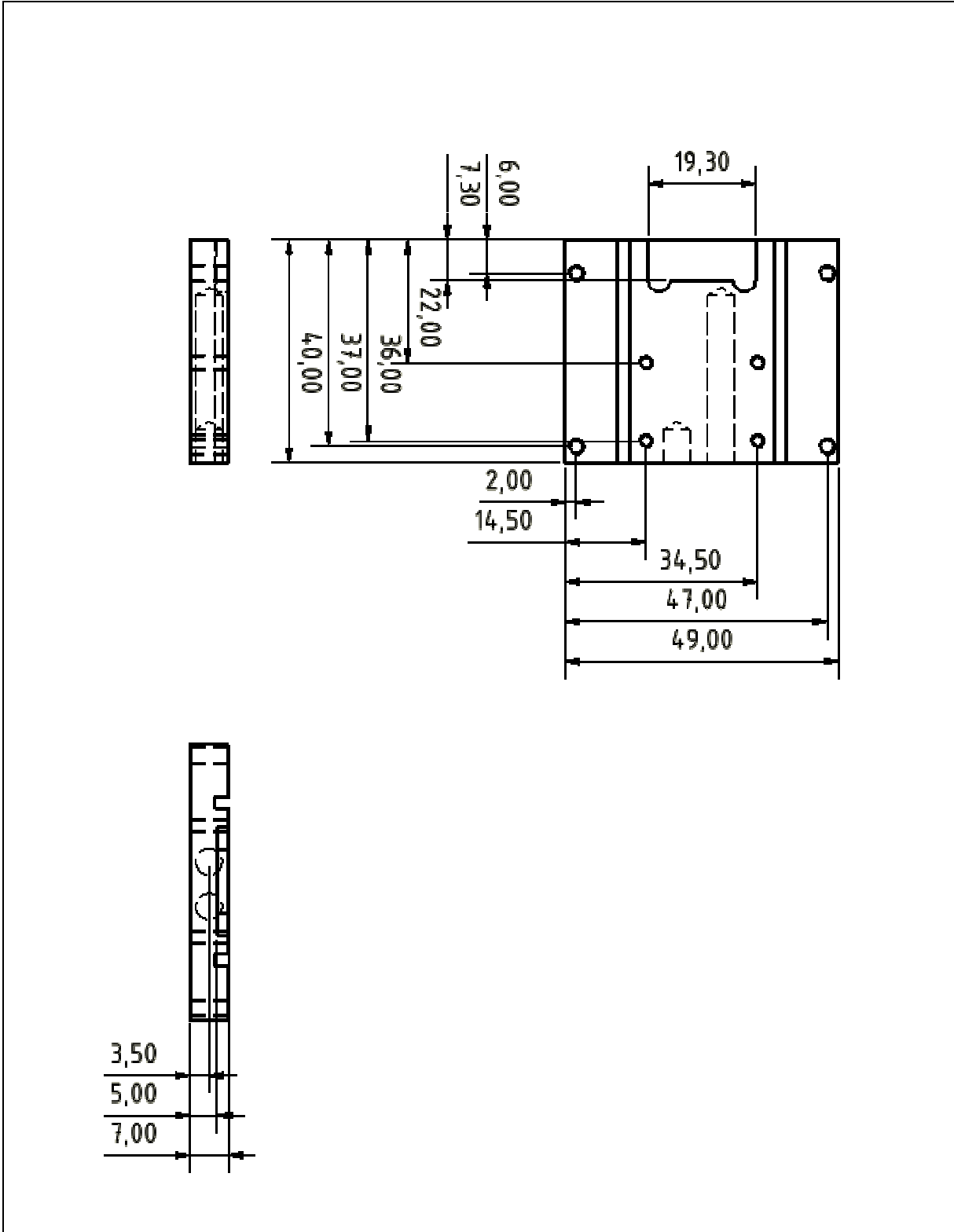
Figure 33: Q-MACS holder

6.4   Block diagrams
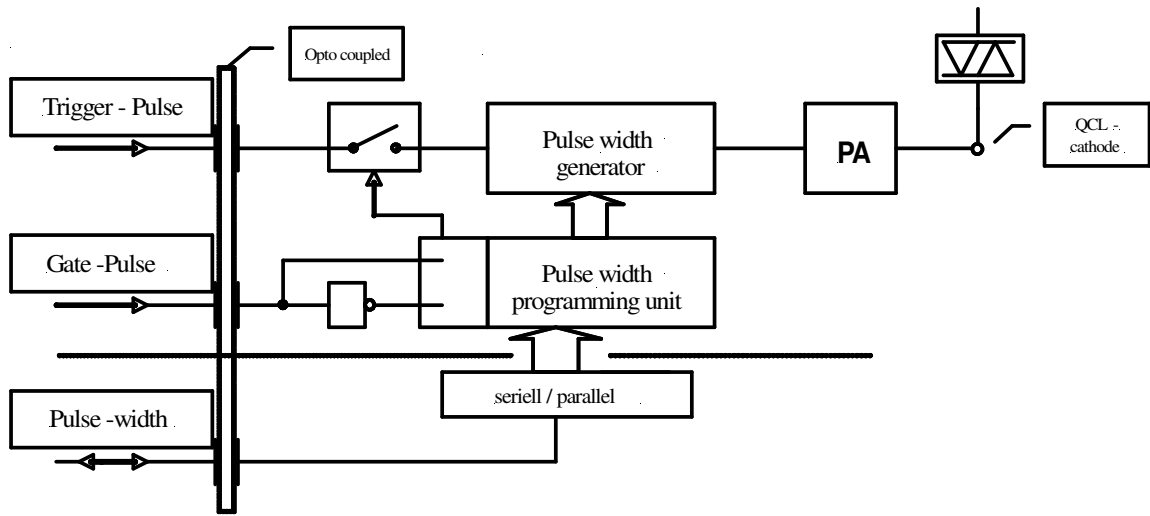
Figure 34: Pulse amplifier
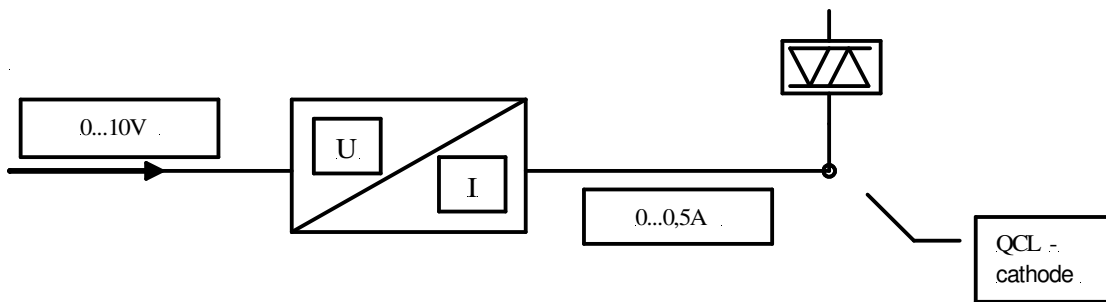
Figure 35: Bias- unit

6.5 Structure charts
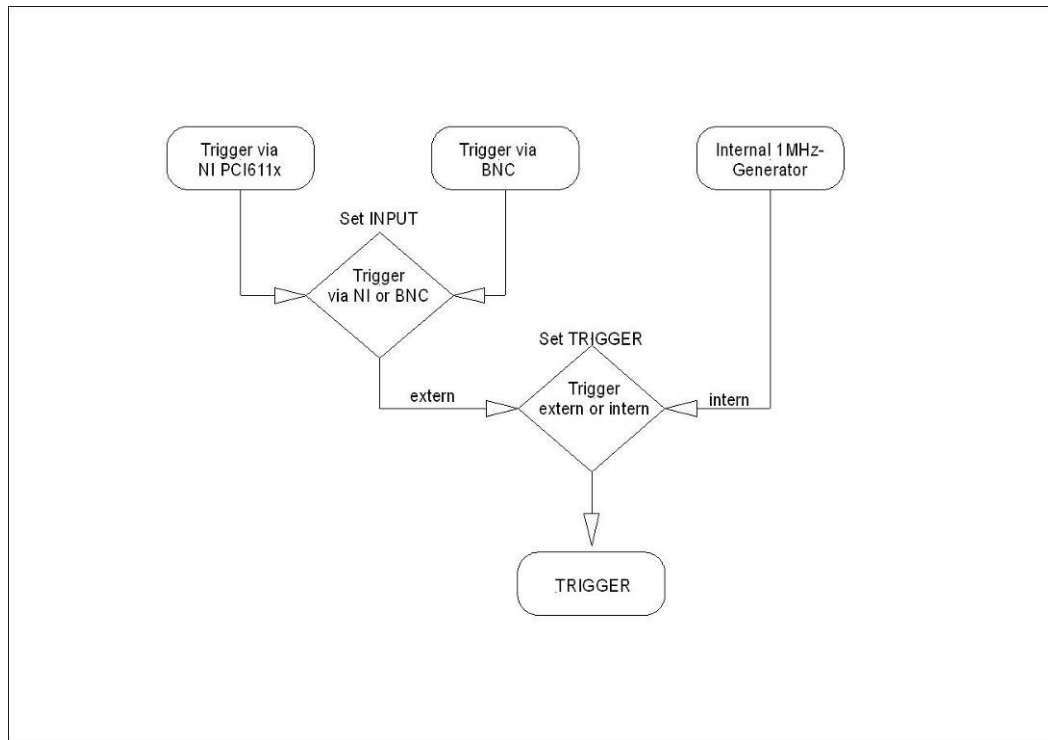
Figure 36: Source selection for the TRIGGER signal
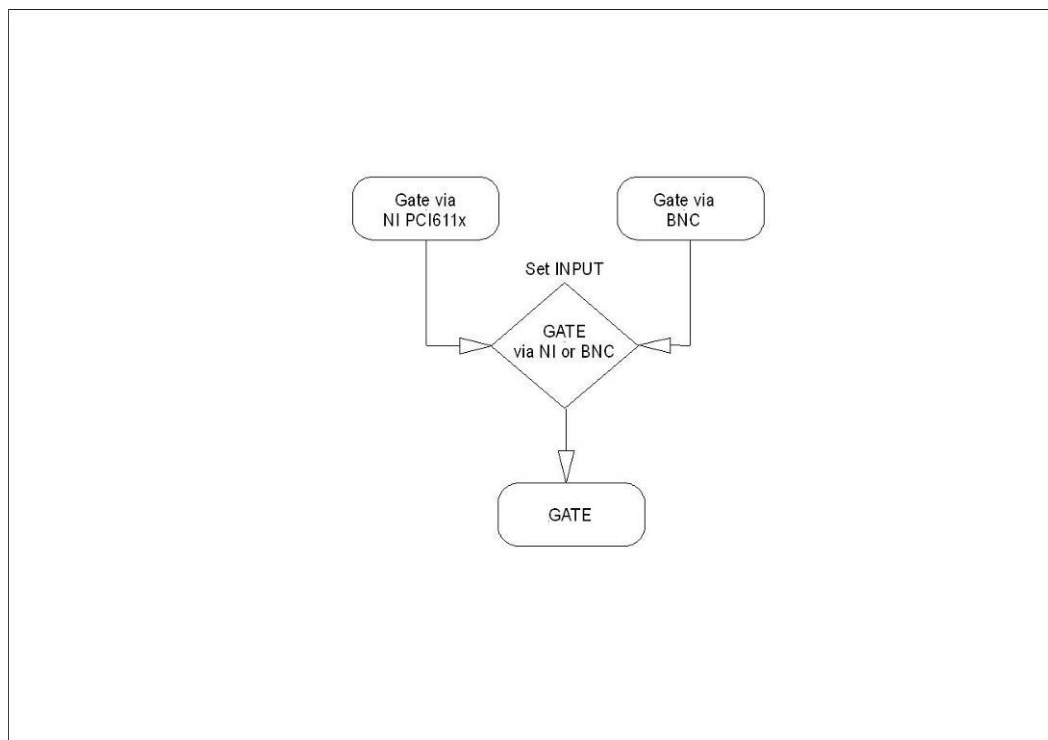
Figure 37: Source selection for the GATE signal
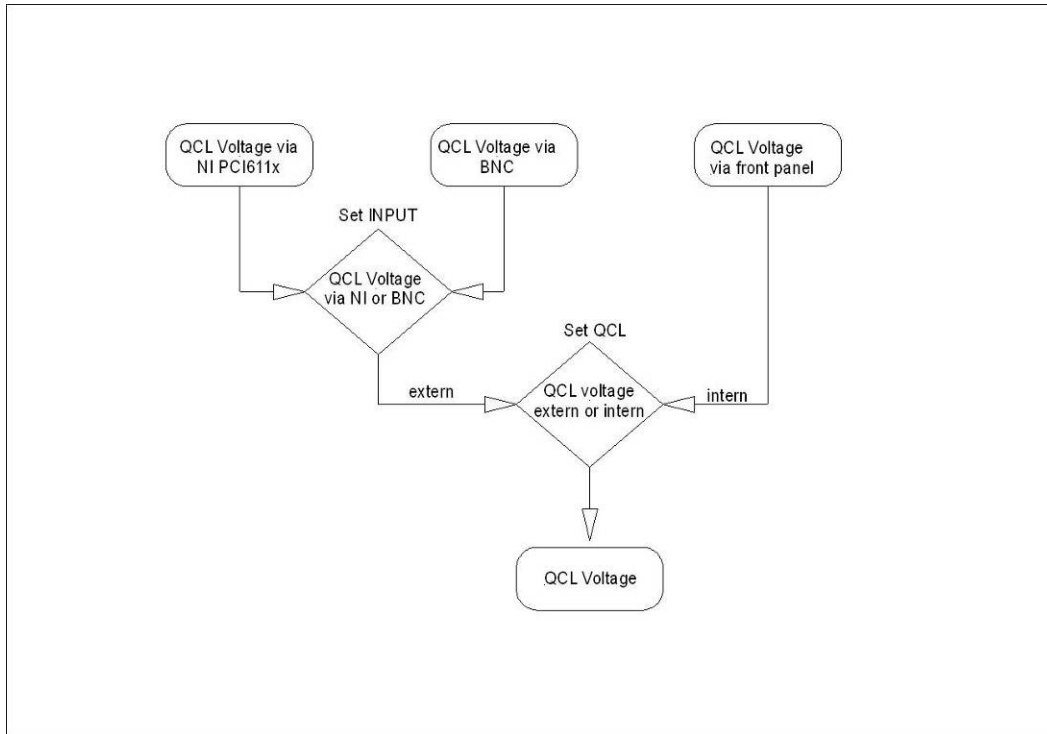
Figure 38: Source selection of the programming voltage for the Q-MACS supply
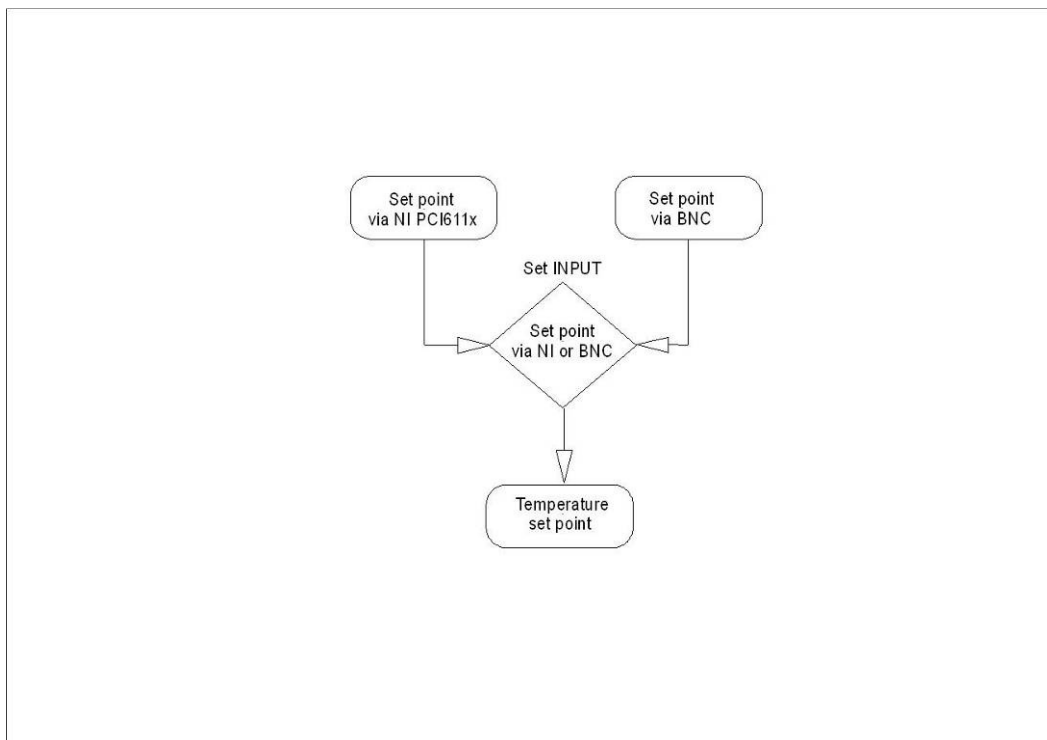
Figure 39: Source selection of the temperature set point
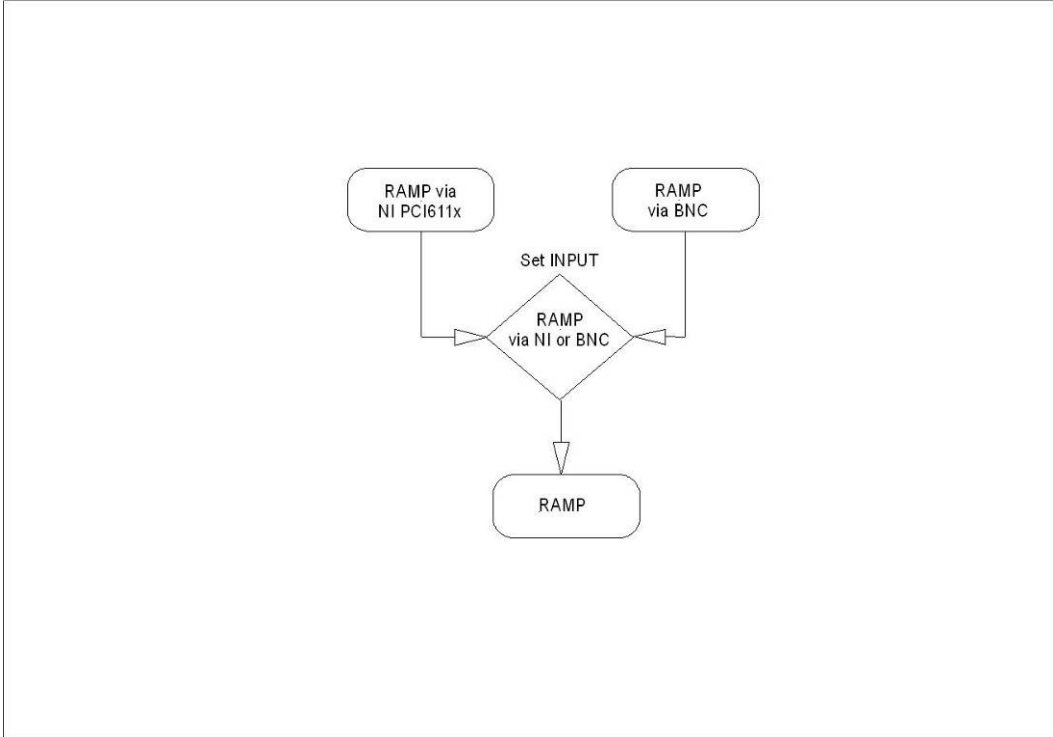
Figure 40: Source selection of the ramp signal (DC bias)

7 Tables

8 Table of figures