QubeDL System specifications sheet

1 Introduction to QubeDL System

1.1 Features

- Current noise spectral density $<$200 pA/$\sqrt{\text{Hz}}$
- Integrated current noise [10-1000 Hz] $<$200 nA_{RMS}
- Current temperature coefficient better than 5 $ppm_{FS}/°C$
- Current rating up to 250 mA
- Voltage compliance up to 7.5 V
- Capable of precision modulation from 10 nA
- Fast modulation up to 10 mA @ 3 MHz
- High modulation up to 200 mA @ 600 kHz
- Expansion modules: Temperature stabilization, Lock-in, PLL, Pound-Drever-Hall

1.2 Typical applications

- Precision gas spectroscopy
- Locking laser to molecular transition
- Locking laser to high-finesse cavity
- Metrological-grade laser frequency stabilization

1.3 General Description

The QubeDL System is a high-performance environment, uses the same patented technology as adopted for the QubeCL system but optimized for diode lasers that require low currents and low working voltages. The expansion modules allow you to customize the system, obtaining a high-performance instrument in a 10x10 cm^2 footprint. The system is designed to minimize external wiring and enclose susceptible connections inside its frame, thus reducing noise coupling and maximizing performance.

2 Specifications

Interface	Mode	Settings	Notes
USB	Virtual Serial Port	115200 8N1	
WiFi	Access Point/Client	software configurable	

Table 1: Communication Interfaces

Parameter	Values	Unit	Notes
Operating temperature	-20 to +40	°C	
Storage temperature	-20 to +70	°C	
Main power supply voltage (PS_{LAS})	15	V	No terminal must be connected to ground
TEC power supply voltage (PS_{TEC})	18	V	
Monitor power supply voltage (PS_{MON})	5.5	V	
Modulation inputs	±10	V	

Table 2: Absolute Maximum Ratings

3 Electrical Specifications

PS_{LAS} = 24 V_{dc}, PS_{TEC} = 12 V_{dc}, PS_{MON} = 5 V_{dc}, Warm-up time 120 min, room temperature 25 °C, unless otherwise noted.

Parameter	**Min**	**Typ**	**Max**	**Unit**	**Notes**
Noise spectral density		100	200	$pA/\sqrt{Hz}$	test current 200mA
Integrated noise		80	100	nA_{RMS}	10 Hz - 100 kHz
Integrated noise		140	200	nA_{RMS}	10 Hz - 1 MHz
Stability (1h)	4	5	6	ppm_{FS}	
Stability (12h)	5	6	7	ppm_{FS}	
Temperature coefficient	-2	-3	-5	$ppm_{FS}/°C$	
Voltage compliance		7.5		V	

Table 3: Current Generator Specs

Parameter	**Min**	**Typ**	**Max**	**Unit**	**Notes**
Analog input voltage	0		±10	V	
DC offset	20	30	50	μA	input shorted
Low current					
Noise spect. dens. floor	50		100	$pA/\sqrt{Hz}$	input shorted
Output current	0		±5	mA	
Gain		-0.5		mA/V	
Modulation BW (-3 dB)		3		MHz	
High current					
Noise spect. dens. floor	200		2000	$pA/\sqrt{Hz}$	input shorted
Output current	0		±100	mA	
Gain		-10		mA/V	
Modulation BW (-3 dB)		600		kHz	

Table 4: Analog Current Modulators Specs

Parameter	Min	Typ	Max	Unit	Notes
Waveforms	Sine or Triangle				
Freq. range	10^{-3}		10^{6}	Hz	
Min freq. step		250		mHz	
Amplitude control res.		12		bits	
DC offset	20	30	50	μA	input shorted
Low current					
Noise spect. dens. floor	50		100	$pA/\sqrt{Hz}$	input shorted
Output current	0		± 2.5	mA	
Modulation BW (-3 dB)		3		MHz	
High current					
Noise spect. dens. floor	200		2000	$pA/\sqrt{Hz}$	input shorted
Output current	0		± 75	mA	
Modulation BW (-3 dB)		600		kHz	

Table 5: Mixed Current Generator Specs - Digital

Parameter	Min	Typ	Max	Unit	Notes
Analog input voltage	0		± 2.5	V	
DC offset	20	30	50	μA	input shorted
Low current					
Noise spect. dens. floor	50		100	$pA/\sqrt{Hz}$	input shorted
Output current	0		± 2.5	mA	
Gain		-1		mA/V	
Modulation BW (-3 dB)		3		MHz	
High current					
Noise spect. dens. floor	200		2000	$pA/\sqrt{Hz}$	input shorted
Output current	0		± 75	mA	
Gain		-30		mA/V	
Modulation BW (-3 dB)		600		kHz	

Table 6: Mixed Current Generator Specs - Analog

Parameter	Min	Typ	Max	Unit	Notes
Thermistor	1		10	kΩ	NTC
TEC current			±3	A	
TEC compl. voltage		10		V	
Temp stability		40	400	μK	absolute stability in 12h
Temp. coefficient		-90	-100	μK/K	

Table 7: Temperature Controller Specs

Parameter	Min	Typ	Max	Unit	Notes
RF freq. input	10		250	MHz	
LO freq. input	10		100	MHz	
Input level	-30		0	dBm	
Input stage gain	0		30	dB	
Lock bandwidth			800	kHz	

Table 8: PLL Module Specs

Parameter	Min	Typ	Max	Unit	Notes
RF freq. input	1		100	MHz	
LO freq. input	1		100	MHz	
RF Input level	-30		0	dBm	
LO Input level		5		dBm	
Lock bandwidth			800	kHz	

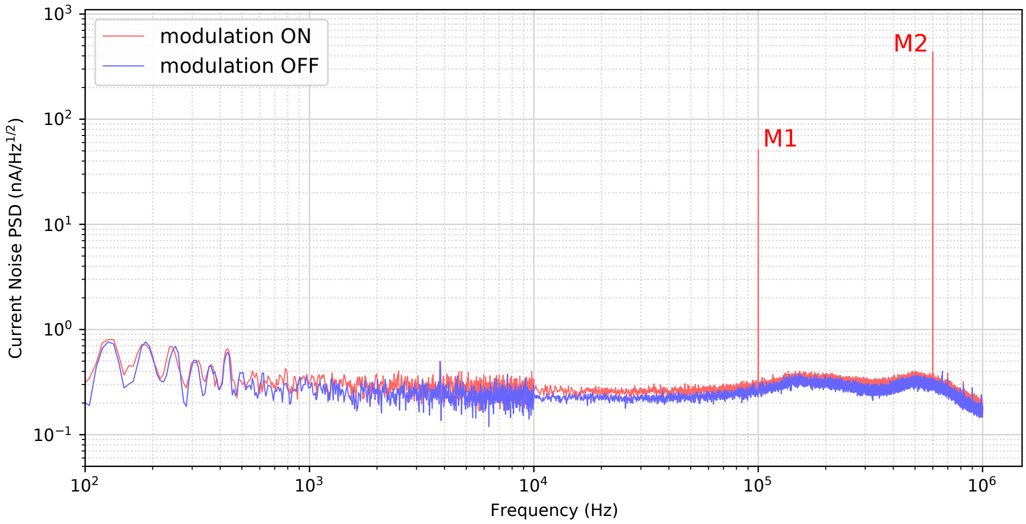
Table 9: Pound-Drever-Hall module Specs

3.1 Lock-In module

Parameter	Min	Typ	Max	Unit	Notes
Modulation frequency		32768		Hz	fixed
Ramp frequency	1		1000	Hz	
Input voltage noise		30		μV_{RMS}	
Input stage gain	0		60	dB	
Integration time	1		10000	ms	
Lock bandwidth			1	kHz	

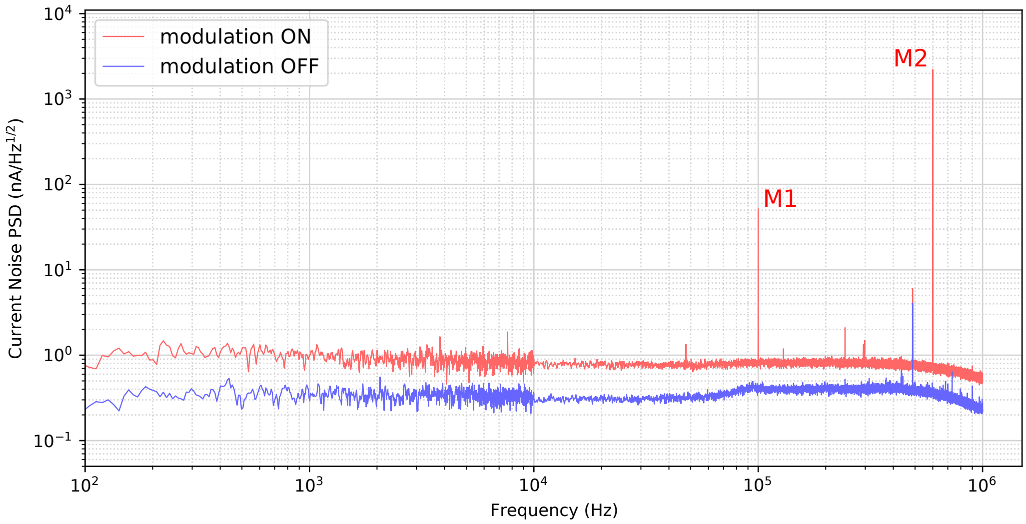
Table 10: Lock-In module Specs

4 Typical performance characteristics



M1 = $50nA_{rms}$	M2 = $440nA_{rms}$

Figure 1: Current noise spectral density comparison with low current modulator



M1 = $50nA_{rms}$	M2 = $2\mu A_{rms}$

Figure 2: Current noise spectral density comparison with high current modulator

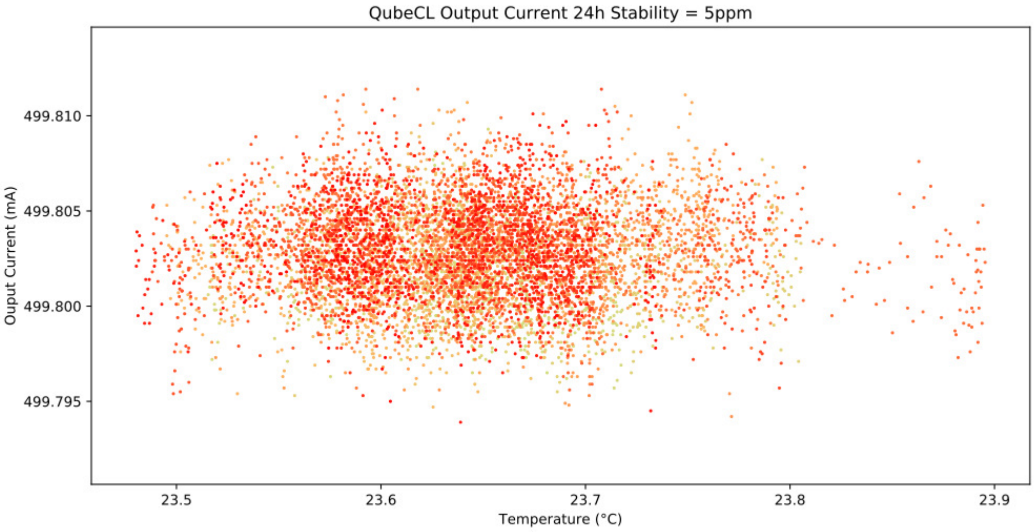


Figure 3: 24h Current stability over ambient temperature

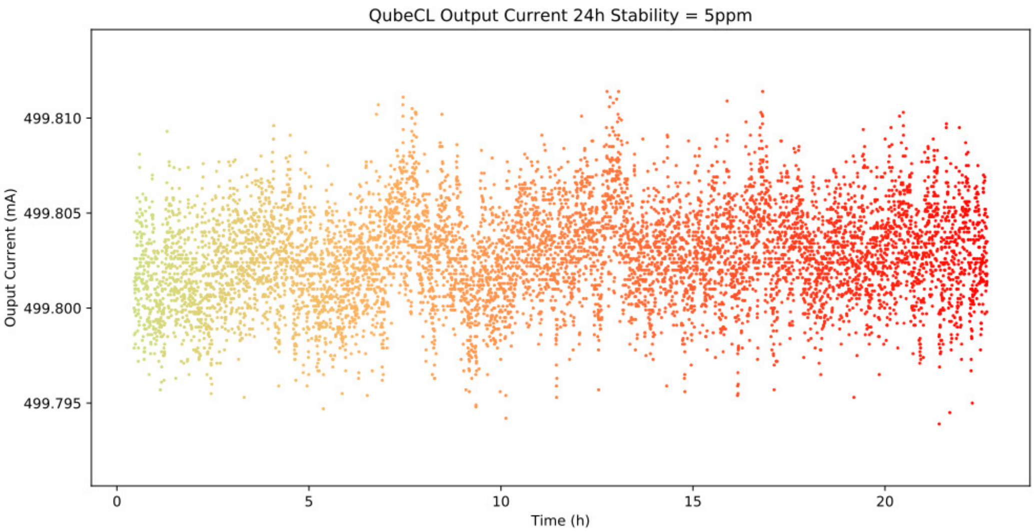


Figure 4: 24h Current stability over time

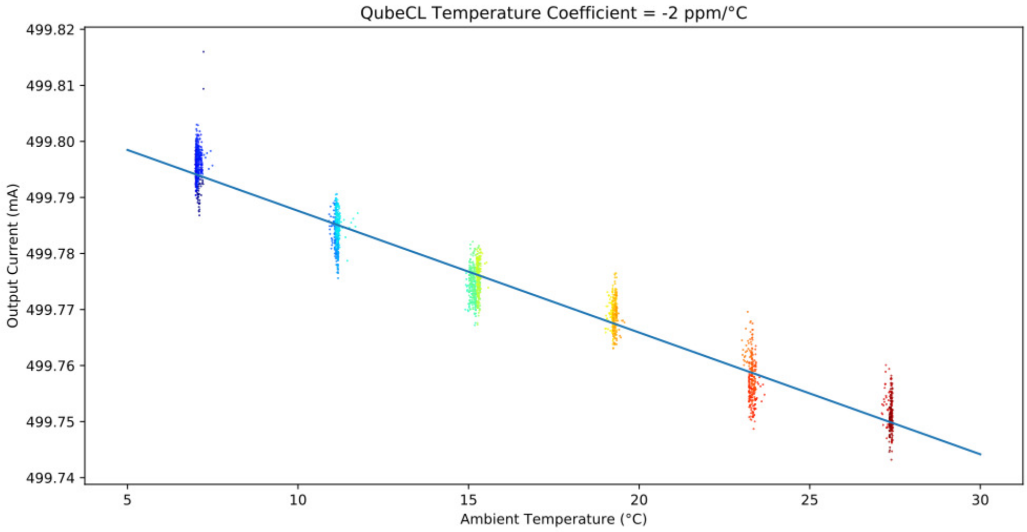


Figure 5: Current temperature coefficient

5 Current Modulators

Tsystem has two current modulators designed to meet the most common needs in terms of modulation. There are two modulation ranges:

- **The low current range** allows to add to the laser even small currents, down to tens of nA, with a high level of precision and very low added noise.
- **The High Current range** allows to add currents up to hundreds of mA to perform large laser frequency scans.

The modulators have a negative gain. If we denote the modulation current with I_{mod}, the input control voltage V_{in} and the absolute value of the gain in mA/V with G, the modulation current is equal to:

$$I_{mod} = -G \cdot V_{in}.$$

This means that a positive control voltage will subtract current to the laser bias current, and a negative control voltage will add it.

CAUTION

The high current modulator can provide currents up to 100 mA which can be added or subtracted to the bias current of the laser.
Using negative control voltages the modulation current is added to the bias current, in this case the total current may exceeding the maximum current allowed by the laser. Therefore it is necessary to be very careful to avoid the risk of damaging the laser itself.
Conversely, using positive control voltages it is possible to use the high current modulator safely, because the modulation current is subtracted from the laser bias current.

6 Power instructions

6.1 Power supply requirements

The system needs three power supplies:

- The power line called PS_{LAS} has a typical value of 12V and it's used to power the laser driving electronics.
- The power line called PS_{TEC} has a typical value of 12V and it's used to supply the power circuitry for temperature stabilization.
- The power line called PS_{MON} has a typical value of 5V and it's used to power the monitor outputs of some boards.

All the voltages used to power the QubeCL **must be floating**, i.e., they **must not be referred to ground**. QubeCL can be powered using common stabilized linear power supplies, the use of switching power supplies can degrade the noise characteristics of the system.

DC input	Min [V]	Typ [V]	Max [V]	Curr. [A]
PS_{LAS}	8	12	15	3
PS_{TEC}	8	12	18	3
PS_{MON}	-	5	5.5	0.5

Table 11: Power Supply Reference

CAUTION

Be sure to use a FLOATING DC power supply to electrically drive QubeCL system. The power supply terminals must not be connected to ground. Connecting any terminal to ground will damage the instrument!