Current Controller and Offset Phase Lock Servo Board

Model No. ICE-CP1

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Please read Limited Warranty and General Warnings and Cautions prior to operating the ICE-CP1.

The guide to programming the ICE-CP1 through serial commands can be found here. The ICE-CP1 web page can be found here.

Description

The Current Controller & Offset Phase Lock Servo Board has either a 200 mA (ICE-CP1-200) or 500 mA (ICE-CP1-500) precision current source based on the Libbrecht-Hall[1] circuit and an integrated offset phase-lock laser servo. The ICE-CP1 contains a tunable PID loop filter for a robust phase-lock.

Absolute Maximum Ratings

Note: All modules designed to be operated in laboratory environment

Parameter	Rating
Environmental Temperature	>15°C and <30°C
Environmental Humidity	<60%
Environmental Dew Points	<15°C

Specifications

	ICE-CP1-200	ICE-CP1-500	Units
Current Source			
<html> </html>Current range	0-200	0-500	mA
<html> </html>Current setpoint resolution	200	500	µA
<html> </html>Current noise density[2]	<100	<200	pA / <HTML> √Hz </HTML>
<html> </html>RMS Noise (10Hz - 100kHz)[3]	<50	<100	nA
<html> </html>RMS Noise (10Hz - 1MHz)[4]	<100	<150	nA
<html> </html>RMS Noise (10Hz - 10MHz)[5]	<300	<500	nA
<html> </html>Absolute accuracy	2		%

	ICE-CP1-200	ICE-CP1-500	Units
Current Source			
Offset Phase Lock Servo Input Signal			
<html> </html>Min Offset Frequency	250		MHz
<html> </html>Max Offset Frequency	Min: 9, Typical: 10[6]		GHz
<html> </html> Max Electronic Beat-Note Input <html> </html><html> </html>(ICE-CP1-SMA)	10		dBm
<html> </html> Min Electronic Beat-Note Input <html> </html><html> </html>(ICE-CP1-SMA)	-10		dBm
<html> </html> Min Electronic Beat-Note S/N <html> </html><html> </html>(ICE-CP1-SMA)	>50		dB
<html> </html> Max Optical Beat-Note Input <html> </html><html> </html>(ICE-CP1-FC)	1		mW
<html> </html> Min Optical Beat-Note Input <html> </html><html> </html>(ICE-CP1-FC)[7]	50		µW
<html> </html> Front-panel Input Connection <html> </html><html> </html>(ICE-CP1-FC)[8]	SC		
<html> </html> Front-panel Input Connection <html> </html><html> </html>(ICE-CP1-SMA)	SMA		
Offset Phase Lock Servo Performance			
<html> </html>Bandwidth[9]	1.5		MHz
<html> </html> Interval reference frequency drift	+/-20		ppm
<html> </html> PFD Noise[10]	-213		dBc/Hz
Loop Filter Parameters			
<html> </html>Proportional Gain	-72 – 0		dB
<html> </html>Proportional Gain Resolution	2		dB
<html> </html>Integrator	3, 10, 30, 100, 300		kHz
<html> </html>Differential	Off, 10, 30, 100, 300		kHz
<html> </html>Differential Gain	18		dB

Electrical Specifications				
	Min	**Typical**	**Max**	**Units**
5V_A Current Draw		N/A		A
5V_D Current Draw		600		mA
+15V Current Draw (ICE-CP1-200)[11]	80		280	mA
+15V Current Draw (ICE-CP1-500)[12]	80		580	mA

Electrical Specifications				
	Min	**Typical**	**Max**	**Units**
-15V Current Draw		40		mA

Setting the Offset Frequency

Two numbers control the offset frequency of the ICE-CP1: The divider setting N and the reference frequency. The divider setting N can be set to N=8,16,32 or 64. The reference frequency can be generated internally with a range from 50 - 240 MHz. Or an external frequency reference can be provided (external frequency must be from 32 MHz - 240 MHz). The offset frequency of the laser is given by the following formula:

<html><center></html> **Offset = N * Reference Frequency** <html></center></html>

The table below shows the offset range for different values of N and using the internal or external frequency reference.

		Divide-by-N settings			
		N=8	**N=16**	**N=32**	**N=64**
Reference Frequency Setting	**External**	250 - 1,920	480 - 3,840	960 - 7,680	1,920 - 10,000
	Internal	320 - 1,920	640 - 3,840	1,280 - 7,680	2,560 - 10,000

Tab. 1: Offset frequency ranges for ICE-CP1. All frequencies are in MHz.

Understanding Gain in the OPLS

The charge pump (CP) output is proportional to phase-error when phase-locked, but the slope is proportional to the value of N. This means that when N is increased, the same voltage on the CP monitor reflects twice as much phase-error. The result is that the input to the loop filter has half as much gain with N=16 than with N=8. To compensate, the OPLS internally increases the gain of the Loop Filter by a factor of N so the user does not see a change in the closed-loop gain when changing the value of N.

Understanding the Transfer Function

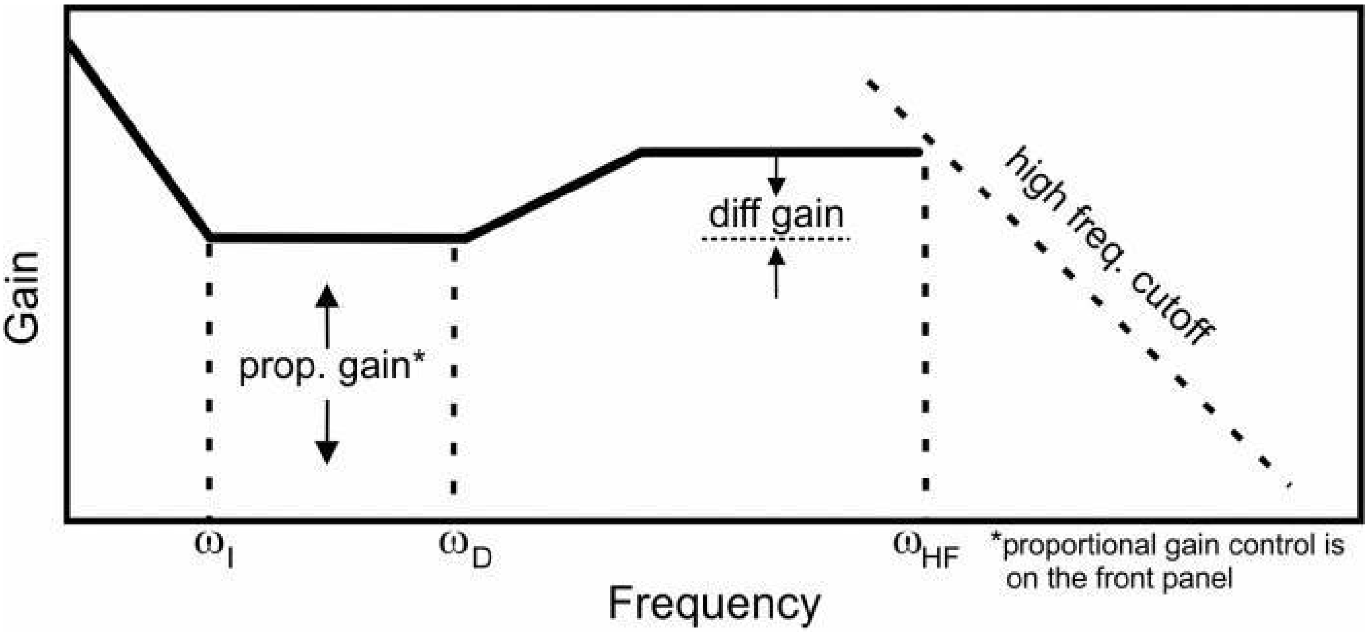

Fig. 1: Schematic of the OPLS right-side panel, showing the configurable transfer function and its user-controls.

The charge pump in the OPLS outputs a signal proportional to the phase-error and the transfer function is as shown in figure 1. However, the OPLS will typically be used to control a *frequency*-tunable device (such as a laser). In this configuration, the effective loop filter is not the one shown in figure ##, but includes a extra integration corresponding to converting the phase-error input to a frequency error. Thus, ω_I sets the frequency transition from single-integration to double-integration and ω_I from single-integration to proportional feedback. It is important to understand this 'hidden' integrator when configuring the loop filter parameters.

Calculating Phase Noise

The phase-noise specified in Section 1.3 is referenced to the phase frequency detector (PFD) at 1 Hz. To convert that to the noise measured on the actual beat-note, it must be rescaled with the following formula:

<html><center></html> **D2-135 Phase-Noise Floor = -213 + 20Log(N) + 10Log(F_{REF})**<html></center></html>

where N is the value of the divider and F_{REF} is the reference frequency as measured in Hz. For more details, please see http://www.vescent.com/2012/calculating-phase-noise-from-the-d2-135/ .

I/O (ICE-BOX)

Only when purchased with the ICE-Box.

Beat Note Monitor

The Front Panel for the ICE-CP1 has four SMA or FC connectors. The second bottom-most connector is an SMA which is the digitized (i.e. square-wave) version of the input beat-note after a divide-by-2. For example, if the input beat note is 6 GHz, the monitor will have a 3 GHz output. The signal is ~0 dBm in power regardless of the strength of the input beat-note signal.

External Reference Frequency Input

The Front Panel for the ICE-CP1 has four SMA or FC connectors. The second top-most connector is an SMA input for the external frequency reference. The input is AC coupled and 50 Ω terminated. Max power is 10 dBm.

Beat Note Input

The Front Panel for the ICE-CP1 has four SMA or FC connectors. The top connector (SMA for ICE-CP1-SMA, FC for ICE-CP1-FC) is the beat note signal input. When FC, this input should be a <1 mW signal containing overlapped light from both lasers. When an SMA, this input should be an electrical signal, typically the output of the D2-160.

Laser Current

The Front Panel for the ICE-CP1 has four SMA or FC connectors. The bottom SMA goes to the laser and drives positive current to the laser. The center conductor of the SMA goes to the laser anode.

I/O (OEM Only)

Only for OEM versions of the ICE-CP1 purchased without the ICE-Box.

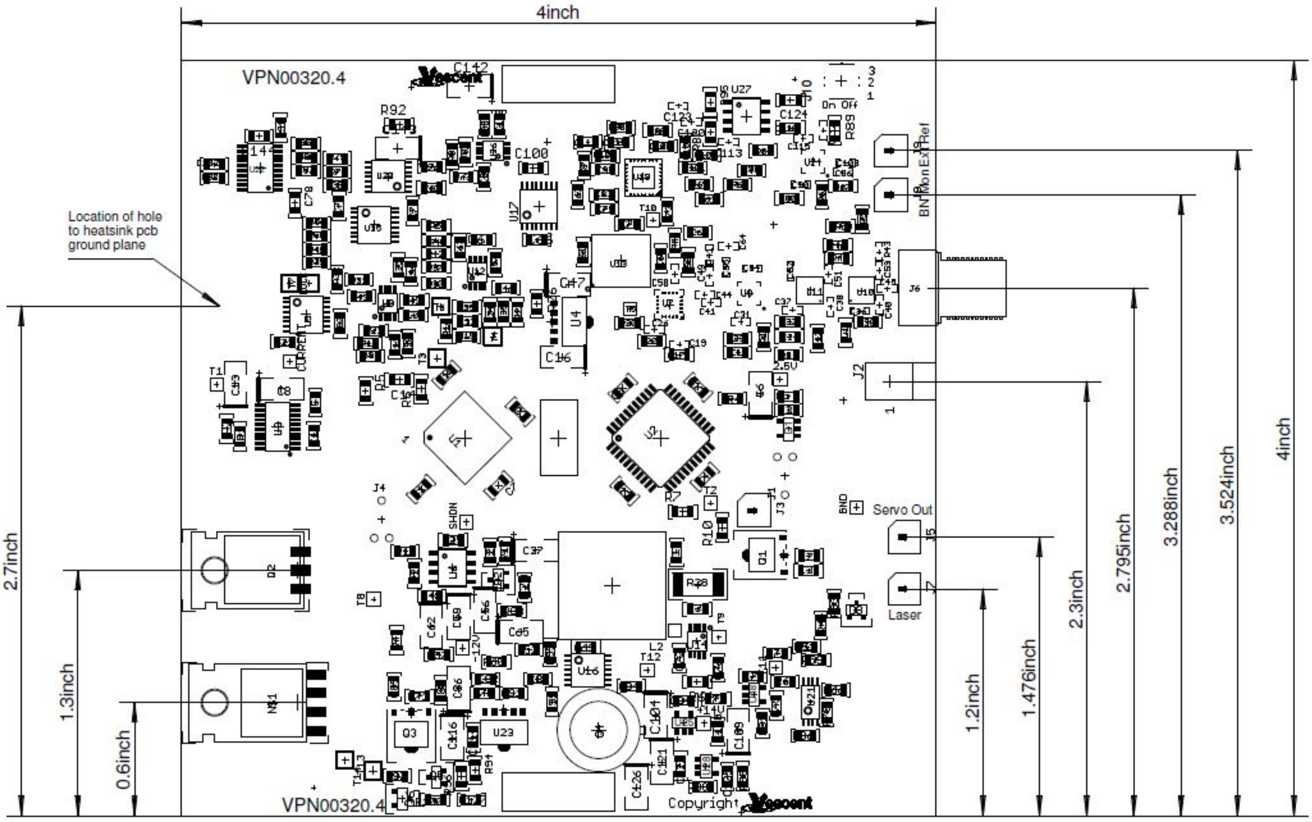

Fig. 2: Connector and component positions on PCB.

Beat Note Input

The ICE-CP1 has one SMA connector which is the beat note signal input. This signal should be an electrical beat -note between -10dBm and 10dBm of electrical power. Input is 50 Ω terminiated.

External Reference Frequency Input

The ICE-CP1 has three UMCC (Molex PN: 0734120110) connectors. The one labelled “Ext Ref” is an UMCC input for the external frequency reference. The input is AC coupled and 50 Ω terminated. Max power is 10 dBm.

Beat Note Monitor

The ICE-CP1 has three UMCC connectors. The one labelled “BN Mon” is an UMCC containing is the digitized (i.e. square-wave) version of the input beat-note after a divide-by-2. For example, if the input beat note is 6 GHz, the monitor will have a 3 GHz output. The signal is ~0 dBm in power regardless of the strength of the input beat-note signal.

Laser Current

The ICE-CP1 has three UMCC connectors. The one labelled “Laser” goes the laser and drives positive current to the laser. The center conductor of the UMCC goes to the laser anode.

Quick Start Commands Guide (Laser Current)

Please see the Quick Start Commands Guide (Laser Current) in the ICE-CS1 manual.

Quick Start Commands Guide (Offset Phase Lock Servo)

Please see Overview of Commands and Basic Usage, Common Commands to all Slave Boards and Current Controller & Offset Phase Lock Servo Commands for a complete command list. Set the ICE-MC1 to communicate with the slot that this ICE-CS1 is in (see Master and Control Board Overview for details).

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[1]
Libbrecht and Hall, A Low-Noise, High-Speed Current Controller, Rev. Sci. Inst. 64, pp. 2133-2135 (1993).

[2], [3], [4], [5]
All measurements guaranteed on design and verified experimentally on D2-105 which uses same circuit.

[6]
Maximum Offset Frequency depends on power of input beat-note signal.

[7]
Approximate value as exact value depends on wavelength of the light and spatial overlap between the lasers.

[8]
ICE-CP1-FC is shipped with an FC to SC multimode patch cord

[9]
May be limited by the bandwidth of the laser being servoed

[10]
See Calculating Phase Noise section for a full description

[11], [12]
Current draw depends on output current to laser diode.