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Function and Interface document of the inner aLIGO PSL Power Stabilization

LIGO-T-0900630

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The goal is to design a feedback control system to stabilize the power of the Advanced LIGO laser behind the PMC. This loop is called the inner loop (in contrast to the outer loop that senses downstream of the suspended mode cleaner and feeds back into the inner loop's error point). There are two photodiodes to allow out-of-loop diagnostics. A first electronic signal conditioning is on the board of the photdiodes, therefore the servo can be placed in the rack. (The cicuit board documentaion of the servo can be found in DCC T-0900631.) The analog servo has several gain settings and switches, which can be controlled by EPICS. (A user manual of all PSL EPICS screens can be found in DCC T-0900634.) The actuator, an AOM, is placed in the high power beam. In order to allow a stable operation of the loop over long periods, the reference signal of the loop can be automatically updated by EPICS. The performance of this control loop can be found in DCC T-0900617.

Contents

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1 Requirements

Relevant Document

"Pre-Stabilized Laser Design Requirements" T-050036-v2

Long Term Stability

- less than 5% peak-to-peak power fluctuations over a period of 24 hours

Control Band Fluctuations (0.1 to 10 Hz)

frequency [Hz]			RIN $[Hz^{-1/2}]$		
0.1 -	0.2			10^{-2}	
	0.2 -	0.5	$1.5\times$	10^{-7}	f^{-7}
		0.5 - 10	$2\times$	10^{-6}	f^{-3}

GW Band Noise (10 to 10 kHz)

frequency [Hz]			RIN $[Hz^{-1/2}]$		
10			$2\times$	10^{-9}	
10 -	100		$2\times$	10^{-10}	f
	100 -	1k	$2\times$	10^{-8}	
		1k - 10k	$2\times$	10^{-11}	f

above the GW band

- between 10 kHz and 9 MHz the laser amplitude noise must be below $2\times10^{-7}\,Hz^{1/2}$
- in RF band (> 9 MHz) the amplitude noise must be less than 1 dB above shot-noise in an average photo current of 100 mA (corresponds to $RIN_{tech} < 9\times10^{-10}\,Hz^{-1/2}$)

Power line frequencies (50 Hz and its harmonics)

- maximal 30 dB above the broadband requirement for the surrounding frequency range

2 Aspects to consider

- the in-loop and the out-of-loop photodiode should be interchangeable by an electronic switch
- a first whitening filter and a gain stage for the photodiodes should be placed on the photo detectors in order to reduce the effect of disturbances on the cable to the servo board
- the offset of the AOM power actuator should be digital adjustable
- allow an automatic update of the reference signal by EPICS to keep the loop stable, if the laser looses power
- provide an input for the outer loop stabilization
- for the measurement of the transfer function provide analog and digital channels for the inner loop as well as for the outer loop
- digital switch to turn the control loop on and off

3 Block Diagram

A schematic layout of the controller can be seen in Fig. 1.

The two photodiodes of the inner loop will be placed behind the bow-tie PMC using the same low power PMC output as the frequency stabilization. The photodiodes will have a first signal conditioning step, consisting of a whitening filter and a first gain step, on their boards. So a negative effect of the cable to the servo is reduced. There will be the possibility to exchange the functions of the two photodiodes, so you can decide, if PD A is the internal loop diode or PD B. The other diode is used for the out of loop measurement.

The reference signal for the DC power level is generated digital. The lowpass, which filters a possible AC noise of the reference signal, will have it's corner frequency at 100 mHz, in order to allow for PSL external power control (from Interferometer Sensing and Control) over time scales longer than 10 seconds.

To measure the transfer function of the control loop there are both analog and digital channels provided. There will be another digital channel (cal in) to generate a signal in the control loop. This signal could be used to identify possible couplings to the interferometer and to monitor the loop gain at this frequency.

The signal of the outer loop photodiode will pass a filter for a possible dewhitening and this path will have it's own channels to measure the transfer function of the outer loop. The outer loop signal is added to the control loop previous to the error point of the loop.

The DC gain of the two integrators can be limited and the loop can be turned off by EPICS. A last gain step and the offset of the AOM can be adjusted by EPICS, too. There is also the possibility for an automatic update of the AOM offset controlled by EPICS.

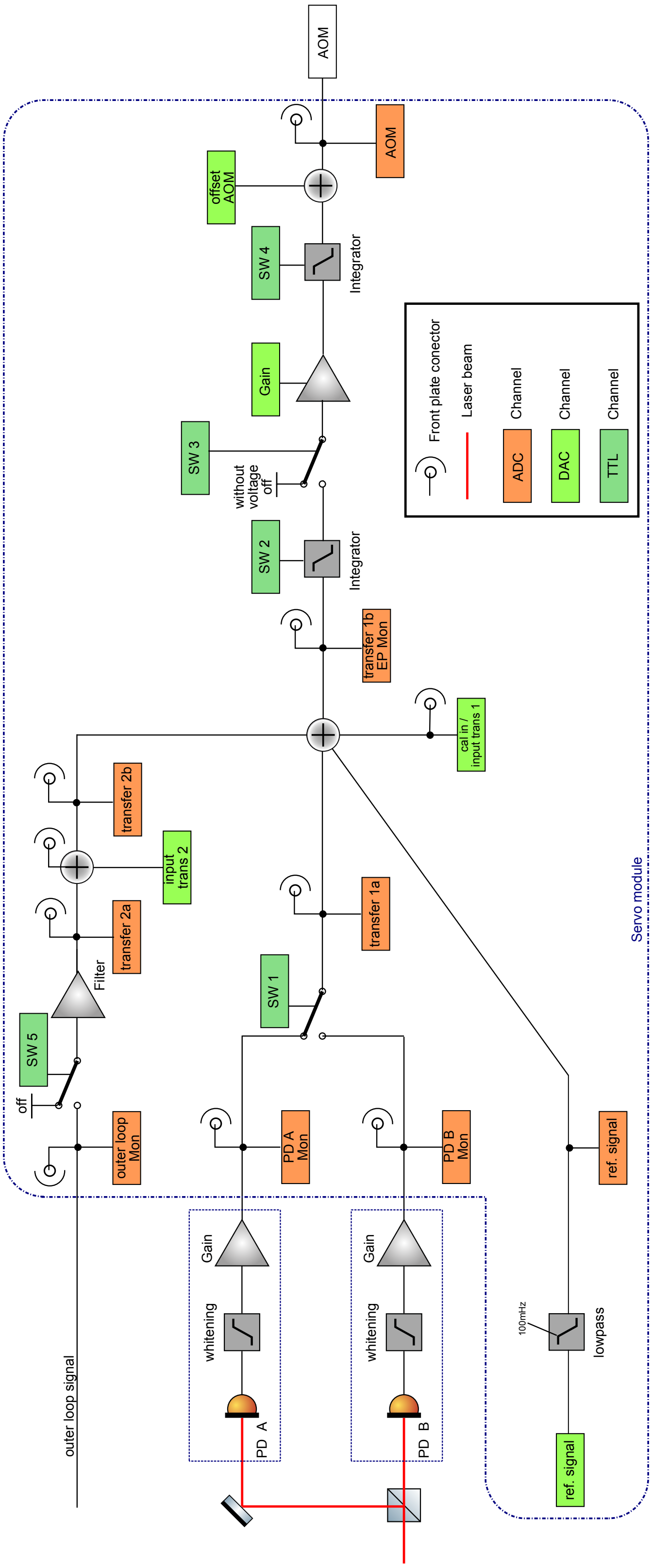

Figure 1: Block diagram of the Power Stabilization

4 Required Channels

	name/description	type
13 inputs	PD A	analog
	PD B	analog
	outer loop PD	analog
	cal in / input transfer 1	analog
	input transfer 2	analog
	ref. signal	DAC
	cal in / input transfer 1	DAC
	input transfer 2	DAC
	adjustable gain	DAC
	offset AOM	DAC
	switch to interchange PD A and PD B	TTL
	switch to turn the outer loop on and off	TTL
	switch to limit the DC gain of both intgrators including switch to turn the loop on and off	TTL
18 outputs	PD A Mon	analog
	PD B Mon	analog
	outer loop PD Mon	analog
	transfer 1a	analog
	transfer 1b/ EP Mon	analog
	transfer 2a	analog
	transfer 2b	analog
	AOM output	analog
	AOM output Mon	analog
	PD A Mon	ADC
	PD B Mon	ADC
	outer loop PD Mon	ADC
	transfer 1a	ADC
	transfer 1b/ EP Mon	ADC
	transfer 2a	ADC
	transfer 2b	ADC
	ref. signal	ADC
	AOM output	ADC