LIGO Laboratory / LIGO Scientific Collaboration

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Dual PD Amp Circuit Board Data Summary and Information

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LIGO Scientific Collaboration

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1 Introduction

This document contains information about the Dual PD Amp circuit board proto-type that was put together by Alexa. Ultimately, five of these boards will be made and placed inside the ALS Fiber Distribution box (wiki).

**IMPORTANT:

1. I switched the 33pF capacitors to 27pF capacitors so that the cut-off points at the transfer functions were all around 6KHz.
2. Eight 10K resistors need to be switched from 1206 to 0805 size resistors (green color).
3. C4 was left out it since it did not improve the noise significantly.
4. Switched U5A to OP284 (ADA4075 kept over heating).
5. I would recommend collecting shot noise data with a better source.

2 Data

1) Transfer Function:

Board Side B:

DO	D1	kHz (knee)	~ Max dB	.78D file
0	0	6.71	6	SRS001
1	0	5.98	16	SRS002
1	1	5.98	26	SRS012
0	1	5.98	36	SRS011

Board Side A:

DO	D1	kHz (knee)	~ Max dB	.78D file
0	0	6.71	6	SRS005
1	0	5.98	16	SRS006
1	1	5.98	26	SRS010
0	1	5.98	36	SRS009

Note: All files are saved under Transfer Function folder (there are more than those listed due to retake of some measurements). The matlab file is called TF.m. The following command line was used to convert floppy disk files into .mat files: /Omat /Cx,mag,p /UdB,deg /"File location"*.78D.

2) Electronic Noise Signal:

Board Side B:

DO	D1	Freq Span	.78D file
0	0	102.4kHz	SRS047
0	0	12.8kHz	SRS048
0	0	1.6kHz	SRS049
0	0	200Hz	SRS050
1	0	102.4kHz	SRS051
1	0	200Hz	SRS052
1	1	102.4kHz	SRS053
1	1	200Hz	SRS054
0	1	102.4kHz	SRS055
0	1	12.8kHz	SRS056
0	1	1.6kHz	SRS057
0	1	200Hz	SRS058

Electric shot noise for all gains settings is approximately 60nVrms/√Hz (noise is dominated by U3).

Board Side A (with ADA4075 op amp--faulty):

DO	D1	Freq Span	.78D file
0	0	102.4kHz	SRS035
0	0	12.8kHz	SRS036
0	0	1.6kHz	SRS037
0	0	200Hz	SRS038
1	0	102.4kHz	SRS039
1	0	200Hz	SRS040
1	1	102.4kHz	SRS041
1	1	200Hz	SRS042
0	1	102.4kHz	SRS043
0	1	12.8kHz	SRS044
0	1	1.6kHz	SRS045
0	1	200Hz	SRS046

Electric shot noise for all gains settings is approximately 100nVrms/√Hz.

Board Side A (with OP284 op amp):

DO	D1	Freq Span	.78D file
0	0	102.4kHz	SRS084
0	0	12.8kHz	SRS085
0	0	1.6kHz	SRS086
0	0	200Hz	SRS087
1	0	102.4kHz	SRS088
1	0	200Hz	SRS089
1	1	102.4kHz	SRS090
1	1	200Hz	SRS091
0	1	102.4kHz	SRS092
0	1	12.8kHz	SRS093
0	1	1.6kHz	SRS094
0	1	200Hz	SRS095

Electric shot noise for all gains settings is approximately 60nVrms/√Hz (noise is dominated by U3).

Note: All files are saved under Noise Signal folder (there are more than those listed due to retake of some measurements). The matlab file is called NS.m. The following command line was used to convert floppy disk files into .mat files: /Omat /Cx,mag /Urms /"File location"*.78D.

3) Shot Noise:

Board Side B:

DO	D1	Freq Span	.78D file
0	0	102.4kHz	SRS062
0	0	12.8kHz	SRS063
0	0	1.6kHz	SRS065
0	0	200Hz	SRS066
1	0	102.4kHz	SRS077
1	0	12.8kHz	SRS078
1	0	200Hz	SRS068 *not at 10V see SN.m
1	1	102.4kHz	SRS070

1	1	12.8kHz	SRS071
1	1	200Hz	SRS072
0	1	102.4kHz	SRS073
0	1	12.8kHz	SRS074
0	1	1.6kHz	SRS075
0	1	200Hz	SRS076

With LED OFF: SRS061 (equivalents to electronic noise)

Board Side A:

DO	**D1**	**Freq Span**	**.78D file**
0	0	102.4kHz	SRS096
0	0	12.8kHz	SRS097
0	0	1.6kHz	SRS098
0	0	200Hz	SRS099
1	0	102.4kHz	SRS100
1	0	12.8kHz	SRS101
1	0	200Hz	SRS102
1	1	102.4kHz	SRS103
1	1	12.8kHz	SRS104
1	1	200Hz	SRS105
0	1	102.4kHz	SRS106
0	1	12.8kHz	SRS107
0	1	1.6kHz	SRS108
0	1	200Hz	SRS109

Note: All files are saved under Shot Noise folder (there are more than those listed due to retake of some measurements). The matlab file is called SN.m. The following command line was used to convert floppy disk files into .mat files: /Omat /Cx,mag /Urms /"File location"*.78D.

One can calculate the expected shot noise through the circuit board for each gain setting. Let V be the output voltage. For my calculations, I set V =10Volts. Let R be the resistance for each specific gain. There will be a gain of 2 from op-amp U5. Then one can calculate the voltage density $\hat{v}$

(Vrms/√Hz) via equations: $\hat{v} = \hat{i}R$ and $\hat{i} = \sqrt{2qI}$, where I is the current and q is the charge of an electron. Here are my results:

DO	D1	R(kΩ)	V	$\hat{v}$ (nVrms√Hz)
0	0	1x2	10	80
1	0	3.16x2	10	142
1	1	10x2	10	253
0	1	31.6x2	10	449

4) Optical Transfer Function.

Using the Oz Optics laser (6), I first had to examine the modulated signal and see if it was really flat up to 100kHz. Taking, the transfer function, one can see there is a pole at 2kHz approximately.

Modulated Laser:

Freq. Span	.78D
102.4kHz	SRS110

Board Side B:

DO	D1	kHz (knee)	~ Max dB	.78D file
0	0	2	2	SRS111
1	0	2	12	SRS112
1	1	2	22	SRS113
0	1	2	32	SRS114

Board Side A:

DO	D1	kHz (knee)	~ Max dB	.78D file
0	0	2	6	SRS115
1	0	2	16	SRS116
1	1	2	26	SRS117
0	1	2	36	SRS118

Note: All files are saved under Optical Transfer Function folder. The matlab file is called OTF.m. The following command line was used to convert floppy disk files into .mat files: /Omat /Cx,mag,p /UdB,deg /"File location"*.78D.

Matlab script normalizes the TF from the laser and subtracts it out from the optical TF.

5) Optical Transfer Function with 100ft cable.

Board Side B:

DO	D1	kHz (knee)	~ Max dB	.78D file
0	0	2	2	SRS119
1	0	2	12	SRS120
1	1	2	22	SRS121
0	1	2	32	SRS122

Board Side A:

DO	D1	kHz (knee)	~ Max dB	.78D file
0	0	2	6	SRS123
1	0	2	16	SRS124
1	1	2	26	SRS125
0	1	2	36	SRS126

Note: All files are saved under Long Cable → Optical Transfer Function folder. The matlab file is called LCOTF.m. The following command line was used to convert floppy disk files into .mat files: /Omat /Cx,mag,p /UdB,deg /"File location"*.78D.

The results were very similar to those of the short cable.

6) Shot Noise with 100ft cable (and LED as before).

Board Side B:

DO	D1	Freq Span	.78D file
0	0	102.4kHz	SRS127
0	0	12.8kHz	SRS128
0	0	1.6kHz	SRS129
0	0	200Hz	SRS130
1	0	102.4kHz	SRS131
1	0	12.8kHz	SRS132
1	0	200Hz	SRS133
1	1	102.4kHz	SRS134

1	1	12.8kHz	SRS135
1	1	200Hz	SRS136
0	1	102.4kHz	SRS137
0	1	12.8kHz	SRS138
0	1	1.6kHz	SRS139
0	1	200Hz	SRS140

Board Side A:

DO	**D1**	**Freq Span**	**.78D file**
0	0	102.4kHz	SRS141
0	0	12.8kHz	SRS142
0	0	1.6kHz	SRS143
0	0	200Hz	SRS144
1	0	102.4kHz	SRS145
1	0	12.8kHz	SRS146
1	0	200Hz	SRS148
1	1	102.4kHz	SRS149
1	1	12.8kHz	SRS150
1	1	200Hz	123
0	1	102.4kHz	SRS003
0	1	12.8kHz	SRS004
0	1	1.6kHz	SRS007
0	1	200Hz	SRS008

Note: All files are saved under Long Cable → Shot Noise folder (there are more than those listed due to retake of some measurements). The matlab file is called LCSN.m. The following command line was used to convert floppy disk files into .mat files: /Omat /Cx,mag /Urms /"File location"*.78D.