

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
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aLIGO DRMI Sensing Matrices		
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This is an internal working
note of the LIGO project

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1 Intro

The purpose of this document is to calculate the length sensing matrices for a few different configurations for the DRMI test at LLO (which should also match the DRMI sensing matrix at LHO). We look at four in particular, DRMI and PRMI, sideband locked and carrier locked. For the purpose of full interferometer locking, the DRMI sideband lock is the necessary configuration.

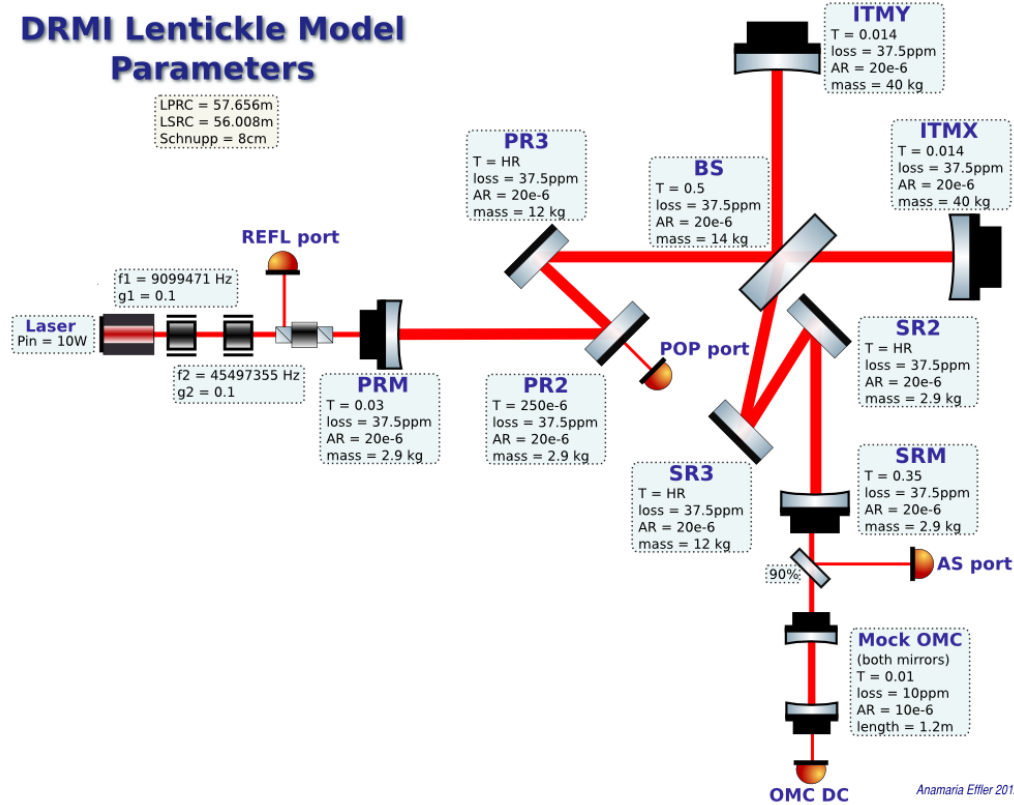


Figure 1: Diagram of DRMI Model Parameters (not to scale)

Fig. 1 shows the optical parameters used in this calculation. Table 1 shows the common parameters used for all the calculations. We use 5W input power as a reasonable starting point for DRMI commissioning. At each port, there may be RFPDs both in air and in vacuum looking at the same signal, comparable in size.

The modeling doesn't take into account mode matching or contrast defect, so there will be inaccuracies associated with that, especially an underestimate of the DC powers and signal strength at the AS port.

Input Power	REFL PO	POP PO	AS PO	OMC / AS Split	$\gamma_1 = \gamma_2$
5W	1.25%	12.5%	1.25%	90/10	0.1

Table 1: Common parameters for all calculations

2 Sensing Matrices

For each configuration we calculate the DC powers reaching our PDs (attenuated), then the RF DC powers at various points in the optical configuration (not attenuated). These tables can be used to initially gauge if we want to change the attenuation level at some port to optimize our sensing. Then we show the sensing matrix for each RFPD I and Q signals, in table form and radar-plot form. In green we point out the elements to be used in the readout scheme.

Script to produce these can be found in the cvs mit iscm modeling repository at [iscmodeling/LentickleAligo/DRMI/](https://github.com/iscmodeling/LentickleAligo/DRMI/).

2.1 DRMI Carrier Locked

DC Powers at Ports	
REFL DC	7.8mW
POP DC	9.1mW
AS DC	26nW
OMC DC	230 nW

Table 2: Table of the attenuated powers at our ports (carrier lock).

RF Powers in important places in DRMI						
Freq	INPUT	REFL	PRC	SRC	OMC IN	OMC
+f2	12.4mW	12.4mW	91.3uW	13.7uW	4.3uW	13.2nW
+f1	12.4mW	12.4mW	93.8uW	7.44nW	2.3nW	0.12nW
carrier	4.95 W	0.575W	290W	0.73uW	0.23 uW	23uW
-f1	12.4mW	12.4mW	93.8uW	7.44nW	2.3nW	0.12nW
-f2	12.4mW	12.4mW	91.3uW	13.7uW	4.3uW	13.2nW

Table 3: Table of RF DC powers in various places of DRMI.

DRMI Carrier Lock

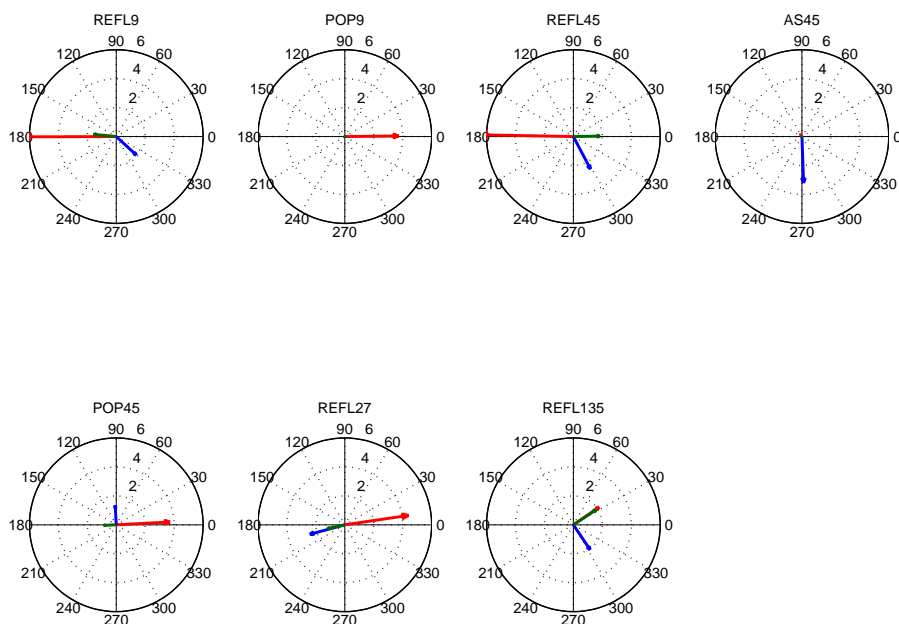


Figure 2: Radar representation of the sensing matrix: MICH blue, PRCL red, SRCL green.

Sensing Matrix in W/m			
Probe	MICH	PRCL	SRCL
REFL 9I	115	4.3×10^6	38
REFL 9Q	106	2	4
REFL 45I	330	4.3×10^6	68
REFL 45Q	599	51	2
POP 9I	0.5	5330	0.08
POP 9Q	0.2	56	0.005
POP 45I	2	5250	7
POP 45Q	43	272	0.3
AS 45I	0.01	0.9	0.4
AS 45Q	3270	1	0.01
REFL 27I	627	2.84×10^4	17
REFL 27Q	75	1	1
REFL 135I	3	144	80
REFL 135Q	236	0.02	1

Table 4: Sensing matrix for carrier lock.

2.2 DRMI sideband locked

DC Powers at Ports	
REFL DC	62mW
POP DC	56uW
AS DC	20uW
OMC DC	456nW

Table 5: Table of the attenuated powers at our ports (sideband lock).

RF Powers in important places in DRMI						
Freq	INPUT	REFL	PRC	SRC	OMC IN	OMC
+f2	12.4mW	1.8mW	152mW	23mW	7.2mW	22uW
+f1	12.4mW	1.4mW	726mW	58uW	18uW	890nW
carrier	4.95 W	4.95W	37mW	94pW	30pW	3nW
-f1	12.4mW	1.4mW	726mW	58uW	18uW	890nW
-f2	12.4mW	1.8mW	152mW	23mW	7.2mW	22uW

Table 6: Table of RF DC powers in various places of DRMI (sideband lock).

DRMI Sideband Lock

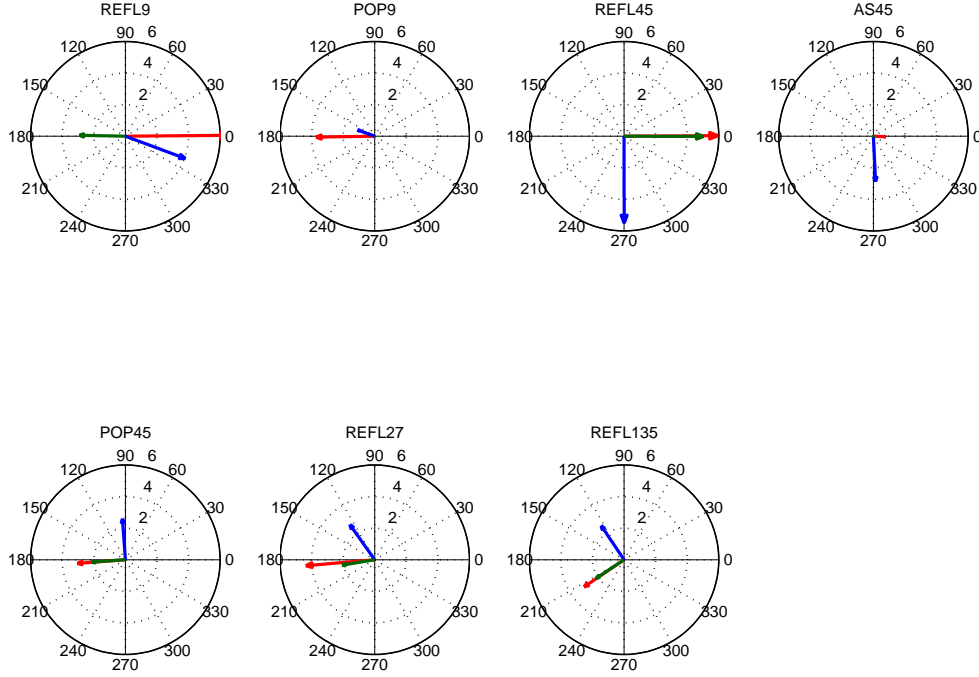


Figure 3: Radar representation of the sensing matrix: MICH blue, PRCL red, SRCL green.

Sensing Matrix in W/m			
Probe	MICH	PRCL	SRCL
REFL 9I	2.1×10^4	4.3×10^6	817
REFL 9Q	8080	58	23
REFL 45I	2970	9.1×10^5	1.1×10^5
REFL 45Q	6.4×10^5	17	910
POP 9I	27	5340	1
POP 9Q	10	83	0.01
POP 45I	57	1110	136
POP 45Q	803	84	9
AS 45I	0.02	6	0.7
AS 45Q	1520	0.5	0.07
REFL 27I	537	2.4×10^4	125
REFL 27Q	918	1	10
REFL 135I	3	1140	136
REFL 135Q	801	0.02	1

Table 7: Sensing matrix for sideband lock.

2.3 PRMI Carrier Locked (with SRM misaligned)

DC Powers at Ports	
REFL DC	7.8mW
POP DC	9mW
AS DC	20nW
OMC DC	9nW

Table 8: Table of the attenuated powers at our ports.

RF Powers in important places in DRMI						
Freq	INPUT	REFL	PRC	SRC	OMC IN	OMC
+f2	12.4mW	12.4mW	93.5uW	546nW	172nW	0.5nW
+f1	12.4mW	12.4mW	93.8uW	22nW	7nW	0.3nW
carrier	4.95 W	575mW	290W	29nW	9nW	912nW
-f1	12.4mW	12.4mW	93.8uW	22nW	7nW	0.3nW
-f2	12.4mW	12.4mW	93.5uW	546nW	172nW	0.5nW

Table 9: Table of RF DC powers in various places of PRMI.

PRMI Carrier Locked

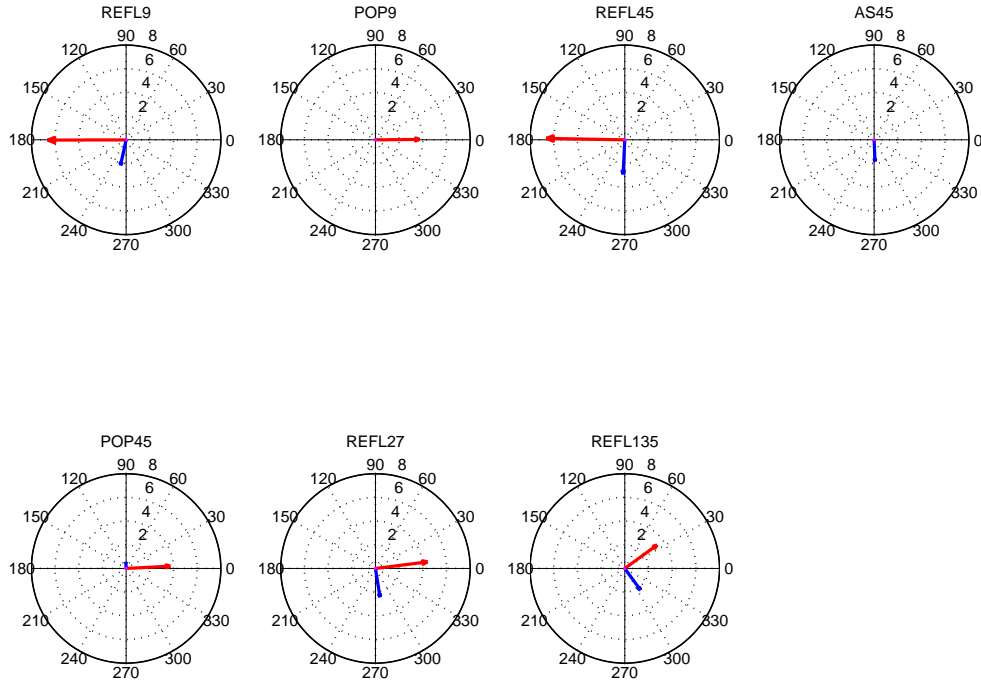


Figure 4: Radar representation of the sensing matrix: MICH blue, PRCL red.

Sensing Matrix in W/m		
Probe	MICH	PRCL
REFL 9I	33	4.3×10^6
REFL 9Q	152	1.4×10^4
REFL 45I	41	4.3×10^6
REFL 45Q	824	8.1×10^4
POP 9I	0.04	5330
POP 9Q	0.7	55
POP 45I	0.1	5320
POP 45Q	3	274
AS 45I	2.6	0.5
AS 45Q	65.4	0.007
REFL 27I	43.8	2.66×10^4
REFL 27Q	279	3340
REFL 135I	106	1890
REFL 135Q	146	1370

Table 10: Sensing matrix (PRMI carrier lock).

2.4 PRMI Sideband Locked (with SRM misaligned)

DC Powers at Ports	
REFL DC	62mW
POP DC	82uW
AS DC	3uW
OMC DC	0.1uW

Table 11: Table of the attenuated powers at our ports.

RF Powers in important places in DRMI						
Freq	INPUT	REFL	PRC	SRC	OMC IN	OMC
+f2	12.4mW	445uW	569mW	3.3mW	1mW	3uW
+f1	12.4mW	1.4mW	719mW	168uW	53uW	2.6uW
carrier	4.95 W	575mW	37.4mW	3.7pW	1pW	118pW
-f1	12.4mW	1.4mW	719mW	168uW	53uW	2.6uW
-f2	12.4mW	445uW	569mW	3.3mW	1mW	3uW

Table 12: Table of RF DC powers in various places of PRMI.

PRMI Sideband Locked

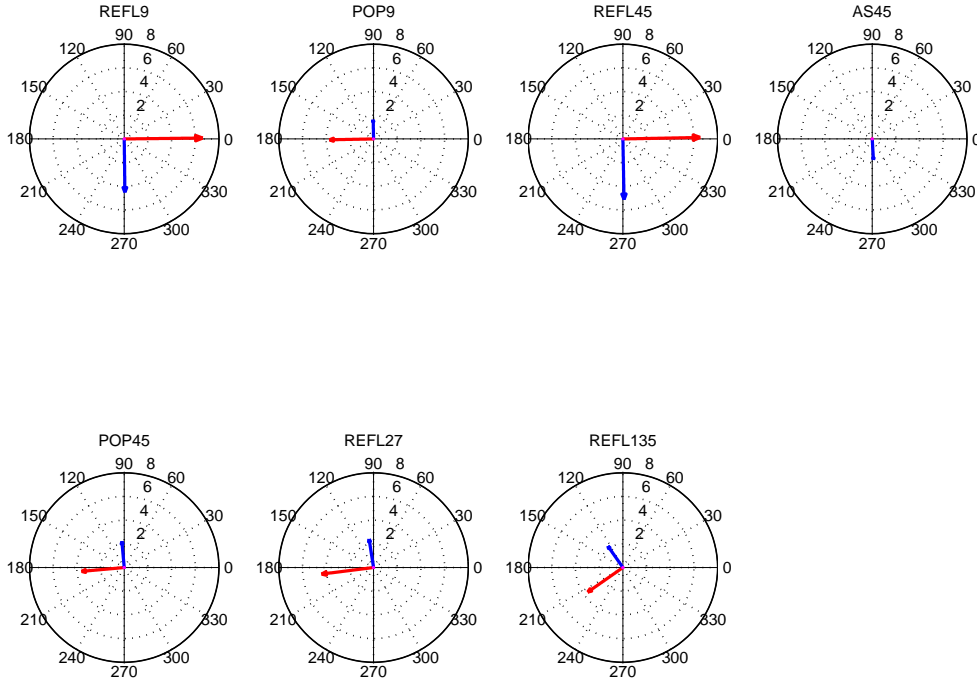


Figure 5: Radar representation of the sensing matrix: MICH blue, PRCL red.

Sensing Matrix in W/m		
Probe	MICH	PRCL
REFL 9I	414	4.3×10^6
REFL 9Q	3.27×10^4	5×10^4
REFL 45I	2460	3.4×10^6
REFL 45Q	1.30×10^5	6.4×10^4
POP 9I	0.8	5280
POP 9Q	41	99
POP 45I	14.5	4150
POP 45Q	162	372
AS 45I	3.4	0.9
AS 45Q	58	0.04
REFL 27I	42	2.66×10^4
REFL 27Q	269	3340
REFL 135I	92	3470
REFL 135Q	132	2420

Table 13: Sensing matrix (PRMI sideband lock).