

**LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY**

**-LIGO-**

CALIFORNIA INSTITUTE OF TECHNOLOGY

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<b>Length Sensing and Control Photodiode Assembly Instructions</b>		
Joe Suina		

This is an internal working note  
of the LIGO Project.

**California Institute of Technology**  
**LIGO Laboratory MS 18-34**  
**Pasadena CA 91125**  
Phone (626) 395-2129  
Fax (626) 304-9834  
E-mail: info@ligo.caltech.edu

**Massachusetts Institute of Technology**  
**LIGO Laboratory MS 20B-145**  
**Cambridge, MA 01239**  
Phone (617) 253-4824  
Fax (617) 253-7014  
E-mail: info@ligo.mit.edu

WWW: <http://www.ligo.caltech.edu/>

## ASSEMBLY INSTRUCTIONS

### Required Items:

<u>Part Description</u>	<u>Quantity</u>
RF box, Compac #S84050-250-0, pre-machined with connector holes drilled, includes #2-56 machine screws (24)	1
LSC Photodiode PCB, Rev.0	1
Thermal block, aluminum	1
Photodiode securing plate, aluminum	1
Heatsink, Wakefield Engineering #623K, Pre-machined with holes drilled	1
DB-9 male –to- ten-conductor dual row female header connector cable assembly	1
RF cage cover, 3" X 3.5", tin-plated steel, 15 mil thickness	1
RF cage material, Pre-punched for TNC connectors, 15 mil thickness	1
Thermal conducting grease	
Plastic tubing, 90 mil O.D., 20 mil O.D., 0.150" long	3
Electronic parts, SMT & through-hole	See BOM
Screws, pan head, #2-56, 0.25"	10
Flat washers, #2	4
Screws, pan head, #4-40, 0.375"	4
Screws, Allen head anodized, #4-40, 0.500"	4
Flat washers, #4	8
Lock washers, #4	8
Jackscrew sets, #4-40, 0.625", set includes flat washers (4), lock washers (4)	2 sets
Heatsink, TO-39 press-on type, Aavid #325705B00000	1

1. Bottom side – Wick away excess solder from large rectangular bare copper area. DO NOT add solder to fix problems!
2. Top side – Cut trace between C23 / C12.
3. Top side – Install a Kynar wire jumper between the C12 + pad to the C3 + pad.
4. Ask Joe to provide the proper values of L1,L2,L8,C39,C40.
5. Top side – Solder all SMT parts EXCEPT L3, C1, C14, C6, C13, L4, R3, R5. Leave pads empty.
6. Top side – Solder a 0 Ohm SMT resistor in place of L3.
7. Press the TO-39 heatsink onto U3; position it so that the vertical slit shall point towards U4.
8. Top side – Solder J4, U3, U4, & U9. The heatsink on U3 must not touch U4!
9. Visually inspect the PCB for correct placement, polarity, etc. of soldered components.
10. Punch 3 holes into the RF cage material, using the sheet metal 17/32” hole punch, to correspond to the size and location of the TNC connectors.
11. Top side – Carefully shape the RF cage, and PUSH THE MATERIAL TOWARDS THE CONNECTOR SIDE BOARD EDGE, all the way around. Solder RF cage.
12. Top side – Install TNC connectors J1-J3 with #2-56 0.25” screws (6). Push connectors against RF cage, MAKING SURE CONNECTOR IS ORTHOGONALLY STRAIGHT, THEN TIGHTEN SCREWS and solder.
13. Bottom side – Solder U2.
14. Give the PCB assembly to Joe to perform the “smoke test”. Visually inspect the PCB assembly and check for short circuits to +/-15V & ground nets on various places of the PCB with a Fluke multimeter. If all is well, connect the PCB +/-15 VDC & ground J4 pins to a dual power supply to check for component overheating.

15. Place U7 onto the bottom side of board BUT DO NOT SOLDER.
16. Spread a thin even coat of thermal grease onto the bottom side of D1. Remove any excess thermal grease with an isopropanol soaked Q-tip.
17. Place D1 onto the topside well of the thermal block. Secure D1 with the machined securing plate/flat washers (4)/#2-56 0.25" screws (4). Make sure screw threads do not extend beyond the bottom thermal block surface.
18. Slip the pieces of tubing onto the leads of D1. Center the photodiode leads. Slide tubing all the way up to the casing.
19. Spread a thin even coat of thermal grease onto the bottom side of the thermal block. Coat the double well for U7. Avoid getting thermal grease into the holes of the thermal block.
20. With the thermal grease side up, place the thermal block and PCB together. Make sure U7 seats properly within its double well. The thermal block should make contact with the PCB all the way around with no gaps. Make sure pieces of tubing touch the casing on the bottom of D1. The tubing must isolate the D1 leads from touching the thermal block. Center the thermal block within the white silkscreen rectangle and secure thermal block with lock washers (4)/ flat washers (4)/ #4-40 0.375" screws (4), silver-colored. Make sure screw threads do not extend beyond the top thermal block surface.
21. Solder U7 & D1.
22. Loosely fasten PCB/ chassis box lid/ heatsink together using lock washer (4)/ flat washers (4)/ anodized Allen head #4-40 0.500" screws (4). The PCB, box lid, and heatsink will be repositioned later.
23. The PCB must be calibrated at this point. Give to Joe. Tweak L1/C40/R4/R5.
24. Write in the frequency within the rectangle box inside the RF cage with a Sharpie pen. Write the serial number on the top of the RF cage cover.
25. Place the cover onto the RF cage. The bottom of the RF cage cover should touch the top flat notch of the TNC connector thread.

26. Install the DB-9 male connector cable assembly through the front panel of the chassis box using #4-40 0.625" jackscrews (2)/ flat washers (4)/ lock washers (4).
27. Install the PCB assembly into the chassis box; guide the TNC connectors of the PCB assembly through the holes of the chassis box body. Straighten out the position of the PCB and make sure the chassis box lid screw holes line up with holes in the chassis box body. Tighten Allen head screws.
28. Secure the chassis box lid with PCB onto the chassis box body using the #2-56 short machine screws (12). Check the tightness of the Allen head screws.
29. Plug the ten-conductor ribbon cable into J4 of the PCB so that the black triangle mates with the pin nearest the corner of the inside of the box. (pin 1 = conductor 1)
30. Secure the remaining chassis box lid onto the chassis box body using the #2-56 short machine screws (12).

---END OF DOCUMENT---

Part Description	Qty/ Bd	Vendor	Pg.	Vendor's Part #	Unit Price [\$]	Comment	Components	Pattern	Subtotal
<b>PHOTODIODE</b>									0.000
C30642, with glass window, TO-5 case	1	EG&G Canada	WS	C30642G	111.000	(450)424-3418, EG&G Canada, Brenda Cocciardi. Lead time 8-10 weeks Price is for qty 40	D1	C30642	111.000
<b>CAPACITORS</b>									0.000
1nF 5%, 50V 1206 footprint, ceramic NPO	2	garrett	R13	MCH315A102JK	0.130	Manufactured by Rohm Electronics. Price is for 200 qty. Garrett Electronics Corp., 3070 Skyway Drive #104, Santa Maria CA 93455, www.garrettelec.com (1800)767-0081	C2, C3	1206	0.260
0.01uF 10%, 50V, 1206 footprint, ceramic X7R	8	garrett	M9	CE103K3NR	0.060	Manufactured by MMC Electronics. Price is for 500 qty.	C15, C16, C17, C18, C19, C20, C21, C22	1206	0.480
0.1uF 10%, 50V, 1206 footprint, ceramic X7R	6	garrett	R14	MCH315C104KP	0.060	Manufactured by Rohm Electronics. Price is for 500 qty.	C7, C8, C9, C10, C11, C12	1206	0.360
1uF 10%, 35V, 3528 footprint, tantalum	10	garrett	K14	TMC1VB105KLRH	0.180	Manufactured by Rohm Electronics. Price is for 500 qty.	C23, C24, C25, C26, C27, C28, C34, C35, C36, C37	3528	1.800
2.2uF 10%, 20V, 3528 footprint, tantalum	4	garrett	K14	TMC1DB225KLRH	0.190	Manufactured by Rohm Electronics. Price is for 200 qty.	C30, C31, C32, C33	3528	0.760
0.0056uF 5%, 50V, 1206 footprint, PPS film	2	digikey	323	PCF1021CT-ND	0.462	Panasonic #ECH-U1H562JB5 Unit price represents a total price of \$46.23 for qty 100	C4, C5	1206	0.925
10uF, 16V, 6032 footprint, tantalum	1	newark	109	89F5043	0.260	Kemet #T491C106K016AS. Tolerance is unknown.	C38	6032	0.260
6.8pF +/-0.5pF, 50V, 1206 footprint, ceramic NPO	1	digikey	316	PCC6R8CCT-ND	0.102	Unit price represents a total price of \$10.15 for qty 100. Originally selected from Panasonic PNO dielectric multilayer ceramic chip kit, Digikey #PCC5-KIT-ND (\$34.95) on P.466	C39	1206	0.102
1.5-10pF variable, surface mount, 7227 footprint	1	newark	135	95F9920	0.920	Johanson #9343-4. N400 dielectric. Temp.Coeff. +/-500ppm/deg C	C40	7227	0.920
100pF 5%, 50V, 1206 footprint, ceramic NPO	1	newark	108	93F2375	0.080	25 min.buy qty. Kemet #C1206C101J5GACTR.	C29	1206	0.080
Note: Leave C1 pad empty...							C1	1206	0.000
Note: Leave C6 pad empty...							C6	1206	0.000
Note: Leave C13 pad empty...							C13	7227	0.000
Note: Leave C14 pad empty...							C14	7227	0.000
<b>INDUCTORS</b>									0.000
0.142uH +/-3% molded coil, MC120 footprint surface mount, ferrite core	1	digikey	252	TKS2705CT-ND	1.73	Toko #E558CN-100025. 6 1/2 turns, test freq. 100MHz, Q=120.	L1	MC152	1.730
10uH, 1.1A rms, surface mount power inductors	2	Stewart Marketing	117	Coilcraft DO1608C-103	0.000	Manufactured by Coilcraft. Steve Stewart will provide qty 20 of 5 different values as free samples. Stewart Marketing, Inc., 23120 Alicia Parkway, Suite 209, Mission Viejo CA 92692, 714/454-0933 Fax 714/454-0932	L5, L6	SMT-PWR-IND	0.000
1.45uH 5%, 1210 footprint surface mount, 330 mA max	1	Coilcraft	18	1008CS-152	0.000	Manufactured by Coilcraft. To order refills, xerox and fill in information on the order form found in the inductor kit box, and FAX it to Coilcraft directly. Originally selected from Coilcraft Designer's Kit C100.	L7	1210	0.000
5%, 1210 footprint surface mount, inductance value is dependent on 2-omega frequency	1	Coilcraft	18	1008CS-xxx	0.000	Same comment as 1.45uH inductor. See SCHEMATIC page 2 for the component values used for the various frequencies. See Coilcraft catalog p.18 for specific part number.	L8	1210	0.000
5%, 1210 footprint surface mount, inductance value is dependent on 1-omega frequency	1	Coilcraft	18	1008CS-xxx	0.000	Same comment as 1.45uH inductor. See SCHEMATIC page 2 for the component values used for the various frequencies. See Coilcraft catalog p.18 for specific part number.	L2	1210	0.000
Note: Leave L4 pad empty...	1						L4	1210	0.000
<b>RESISTORS (Use Resistor chip kit on Phoenix's workbench, 1206, 1 % for all resistors)</b>		garrett	K36	RK23MCR18F25-20		Resister chip kit, 1206 footprint, 1%, 200V, 0.1Watt, Rohm Electronics, 25 each of 482 values, steel frame cabinet w/ 20 drawers. \$670			0.000
0 Ohm jumper	1	garrett	R4	MCR18J000	0.110	Use part#MCR18J000 to order qty 25 of this resistor from Garrett.	L3	1210	0.110
20 Ohm	2	garrett	R4	MCR18FX20R0	0.110	Use part#MCR18FX20R0 to order qty 25 of this resistor from Garrett.	R6, R7	1206	0.220
30.9 Ohm	1	garrett	R4	MCR18FX30R9	0.110	Use part#MCR18FX30R9 to order qty 25 of this resistor from Garrett.	R4	1206	0.110
49.9 Ohm	1	garrett	R4	MCR18FX49R9	0.110	Use part#MCR18FX49R9 to order qty 25 of this resistor from Garrett. Use this value instead of 50 Ohm resistor seen on the schematic.	R14	1206	0.110
75 Ohm	1	garrett	R4	MCR18FX75R0	0.110	Use part#MCR18FX75R0 to order qty 25 of this resistor from Garrett.	R2	1206	0.110
200 Ohm 1%	2	garrett	R4	MCR18FX2000	0.110	Use part#MCR18FX2000 to order qty 25 of this resistor from Garrett.	R18, R19	1206	0.220
681 Ohm	1	garrett	R4	MCR18FX6810	0.110	Use part#MCR18FX6810 to order qty 25 of this resistor from Garrett.	R1	1206	0.110

## LSC Photodiode Bill of Materials

## LIGO E980316-00-C

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Part Description	Qty/ Bd	Vendor	Pg.	Vendor's Part #	Unit Price [\$]	Comment	Components	Pattern	Subtotal
909 Ohm 1%	2	garrett	R4	MCR18FX9090	0.110	Use part#MCR18FX9090 to order qty 25 of this resistor from Garrett.	R17	1206	0.220
1K Ohm 1%	3	garrett	R4	MCR18FX1001	0.110	Use part#MCR18FX1001 to order qty 25 of this resistor from Garrett.	R3, R10, R11	1206	0.330
1.15K Ohm 1%	1	garrett	R4	MCR18FX1151	0.110	The value of R16 was originally 909 Ohms.	R16	1206	0.110
2K Ohm 1%	1	garrett	R4	MCR18FX2001	0.110	Use part#MCR18FX2001 to order qty 25 of this resistor from Garrett.	R9	1206	0.110
68K Ohm	1	garrett	R4	MCR18FX6812	0.110	Use part#MCR18FX6812 to order qty 25 of this resistor from Garrett. Use this value instead of 68.1K resistor seen on the schematic.	R8	1206	0.110
100K Ohm 1%	2	garrett	R4	MCR18FX1003	0.110	Use part#MCR18FX1003 to order qty 25 of this resistor from Garrett.	R12, R15	1206	0.220
200K Ohm 1%	1	garrett	R4	MCR18FX2003	0.110	Use part#MCR18FX2003 to order qty 25 of this resistor from Garrett.	R13	1206	0.110
Note: Leave R5 pad empty...	1						R5	1206	0.000
<b>ICs</b>									0.000
MAX4107ESA Ultra low noise op-amp	1	allied	610	MAX4107ESA	7.39	Maxim. SO-8 package. 300MHz BW. 500V/uS slew rate. 0.75nV/rt-Hz voltage noise. Stable in closed loop gains of 10V/V or greater.	U1	SO-8	7.390
OPA547F High Voltage High Current op-amp	1	digikey	165	OPA547F-ND	6.27	Burr-Brown. 7LEAD-DDPAK surface mount package. Found in Digikey's new catalog.	U2	7LEAD-DDPAK	6.270
LM309H +5V Reg, 1Watt	1	digikey	150	LM309H-ND	5.43	National Semiconductor Three terminal. TO-39 case. Higher Wattages attainable with proper heatsink.	U3	TO-39	5.430
LM120H-5.0 Negative V Reg, 0.5A, 2Watt	1	digikey	150	LM120H-5.0-ND	15.40	National Semiconductor Three terminal. TO-39 case.	U4	TO-39	15.400
OP27GS Low noise, precision op-amp	2	allied	619	OP27GS	2.87	Analog Devices. 3.5nV/rt-Hz @ 10Hz, SO-8 pkg. This IC replaces the AD797BR originally used for U5 & U6; it oscillated @ 50.5MHz due to its capacitive sensitivity when configured in the unity-gain mode.	U5, U6	SO-8	5.740
LM35AH Prec. Celcius Temp. Sensor	1	digikey	149	LM35AH-ND	23.58	National Semiconductor. Range -55 to +150C (wider than the LM35CAH). TO-46 case. Price @ qty 40.	U7	TO-46	23.580
MM74HC04M High speed CMOS Hex Inverter	1	digikey	142	MM74HC04M-ND	0.4636	Min buy qty 25. Fairchild. SO-14 pkg. Unit price represents a total price of \$11.59 for qty 25.	U8	SO-14	0.464
LM117H, Pos. adjustable V Reg 500mA	1	digikey	150	9244B-ND	16.10	National Semiconductor. TO-39 case. Price is for qty 1-24.	U9	TO-39	16.100
EMI filter, surface mount, 10000pF, 50 VDC	8	digikey	260	P9832CT-ND	0.5762	Panasonic #EXC-CET103U. Unit price represents a total price of \$57.62 for qty 100.	FLT1, FLT2, FLT3, FLT4, FLT5, FLT6, FLT7, FLT8	SMT-EMIFILTR	4.610
<b>CONNECTORS</b>									0.000
TNC, right angle, PCB mount, 50 Ohm, metal body	3	amp	WS	227838-1	0.000	Elaine Rivest, CA rep.(1800) 522-6752	J1, J2, J3	TNC-PCB-RT	0.000
Adapters, TNC male -to BNC female	3	pasternack	76	PE9088	12.95	Screw onto TNC connectors. Reason for using this item: Most cables in the LVEA have BNC cable connectors.	J1, J2, J3		38.850
Dual row connector, female	1	digikey	19	MSC10A-ND	0.428	Mates with 3M male dual row header. Unit price represents a total price of \$4.28 for qty 10.	J4	IDC10	0.428
Dual row header, male, 0.1"x0.1"	1	digikey	28	929715-10-36-ND	4.49	3M, dual row 0.1X0.1" male pins 0.025" square, 72 cond., gold plated	J4	HEADER10	4.490
DB-9 Male To IDC bulkhead adapter connector	1	newark	323	44F6355	5.73	Cinch #FC-9P, zinc plated stell shell with yellow chromate coating. Use Keystone jackscrew sets to secure connector.	J5	DB9 MALE	5.730
									0.000
<b>FASTENING HARDWARE</b>									0.000
Jackscrew sets, #4-40, 0.625", set includes flat washers(4),lock washers(4)	2	newark	428	16F1081	0.540	Keystone #7233-5. Zinc chromate. Price for 1-50 qty.			1.080
Screws, pan head, #2-56, 0.25"	10	caltech electronic storeroom				Whatever hardware items Stores doesn't have, we can purchase at Berg Hardware, Pasadena.			0.000
Flat washers, #2	4	caltech electronic storeroom							0.000
Screws, pan head, #4-40, 0.375"	4	caltech electronic storeroom							0.000

## LSC Photodiode Bill of Materials

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Part Description	Qty/ Bd	Vendor	Pg.	Vendor's Part #	Unit Price [\$]	Comment	Components	Pattern	Subtotal
Screws, Allen head anodized, #4-40, 0.500"	4	caltech electronic storeroom							0.000
Flat washers, #4	8	caltech electronic storeroom							0.000
Lock washers, #4	8	caltech electronic storeroom							0.000
<b>OTHER ITEMS</b>									0.000
Ribbon cable, 0.050", 28 AWG, 4"	1	?	?	?		Need it cut to 10 conductors wide, 3.5" long.			0.000
DB9 Backshells, EMI/RFI shielded diecast	1	newark	325	50F5667	3.480	Cinch #DMH-E-001. Price break is at QTY 10.			3.480
TO-39 Heatsink	1	allied	890	619-0060	0.46	Aavid #325705B00000, 57.0 C/W thermal resistance @ 1 Watt load, press-on, 0.32" inner dia., 0.37"high, 0.50" outer dia., for TO-5 and TO-39 cases.			0.460
RF cage fence, 15 mil thk, 3.5"x3"	1	leader tech	10	84-CBS-3.0 X 3.5 X .75		(813)855-6921 Bill Lange. 15 mil thick pre-tin coated steel			0.000
RF cage cover, 3.5"x3"x.28"	1	leader tech	---	?		(813)855-6921 Bill Lange. 15 mil thick pre-tin coated steel			0.000
Aluminum thermal base plate	1	mach.shop	---	acct #5J511		"plate.pcb" is the mechanical drawing for this part.			0.000
Placement-clamping washer for photodiode	1	mach.shop	---	acct #5J511		"clamp.pcb" is the mechanical drawing for this part.			0.000
Heatsink, anodized, 3.00X4.81X0.46"	1	newark	869	58F539	6.35	Wakefield Engineering #623K. Price of 1-24 qty. Must be machined to fasten onto enclosure (heatsink.pcb)			6.350
Plastic tubing, 90 mil OD, 20 mil OD, 0.150" long	3	?	?	?		A spool may be found in the lab.			0.000
Thermal joint compound		caltech electronic storeroom				Thermalcote thermal joint compound, 1 oz., Part #249			0.000
RF Enclosure, 5"X4"X2.5"	1	compac	?	S84050-250-0	150	(1-888)546-3313. 12 Week leadtime. Must be machined to accept connectors. "chassis.pcb" is the mechanical drawing for this part.			150.000
PCB, LSC Photodiode, Rev.0, w/electrical test	1	valley circuits,inc.	---	351822AB PLX	157	(818)897-2006 Drew Janes. \$132 each for a qty of six PCBs, 2 week delivery. Electrical test charge of \$150 for each batch of PCBs. "Pd2sc.pcb" is the layout drawing for this PCB.			157.000
<b>TOTAL COST OF PARTS SHOWN IN THE UNIT PRICE COLUMN</b>					<b>573.73</b>				<b>573.727</b>