T1000429-v1
Test Plan for T1000430-v1 (aLIGO PSL PMC)

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Test plan for: T1000430-v1 (aLIGO PSL PMC)

Serial number: 08

Test date (DD.MM.YY): 10.11.10

Tested by: Jan H. Pöld

Data file location: aLIGO-PSL GIT

Overall test result: Pass/Fail: X (1 fail)

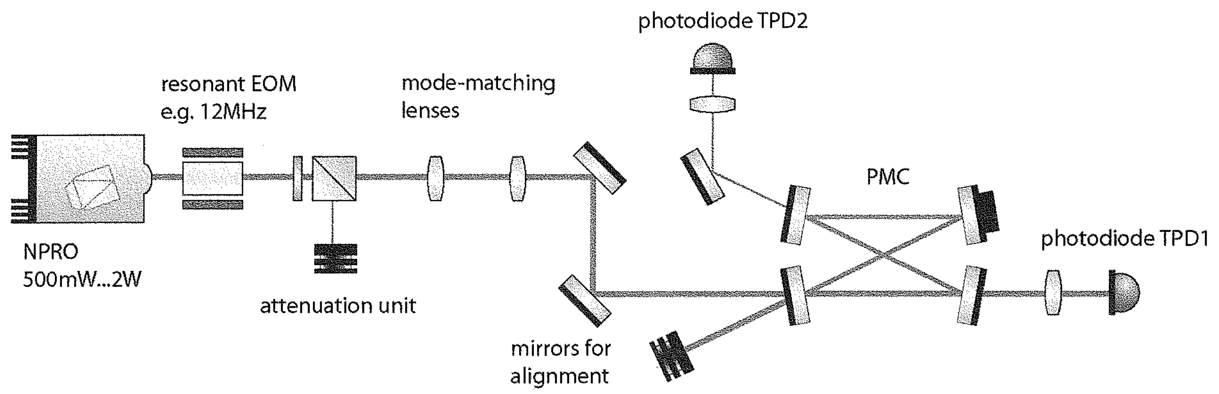

Figure 1: Setup used for testing the PMC.

1 Components

a) **Serial numbers:**
PMC spacer serial number: 08
PZT serial number: 2100215151
mirror IN/OUT coating run: V1-1732
mirror HR/PZT coating run: V3-1210

2 Pre-assembly tests

a) **PZT thickness:** Measure the absolute thickness of the PZT at one position.
Design value: 5 mm ±0.1 mm. Measured value: 4.98 mm — Pass/Fail: ✓

b) **PZT flatness:** Measure the relative thickness deviation of the PZT at four different positions with an accuracy of about 0.01 mm.
Design value: 0 mm ±0.01 mm. Measured value: ± 0.0 — Pass/Fail: ✓
Design value: 0 mm ±0.01 mm. Measured value: 0 — Pass/Fail: ✓
Design value: 0 mm ±0.01 mm. Measured value: 0 — Pass/Fail: ✓

c) **PZT resistance:** Measure the electrical resistance of the PZT.
Design value: >1 MΩ. Measured value: >1MΩ — Pass/Fail: ✓

It is assumed that the PMC is now fabricated according to T1000430-v1 but not placed into the PMC tank yet. Use the test setup shown in Fig. 1 to perform the following optical tests.

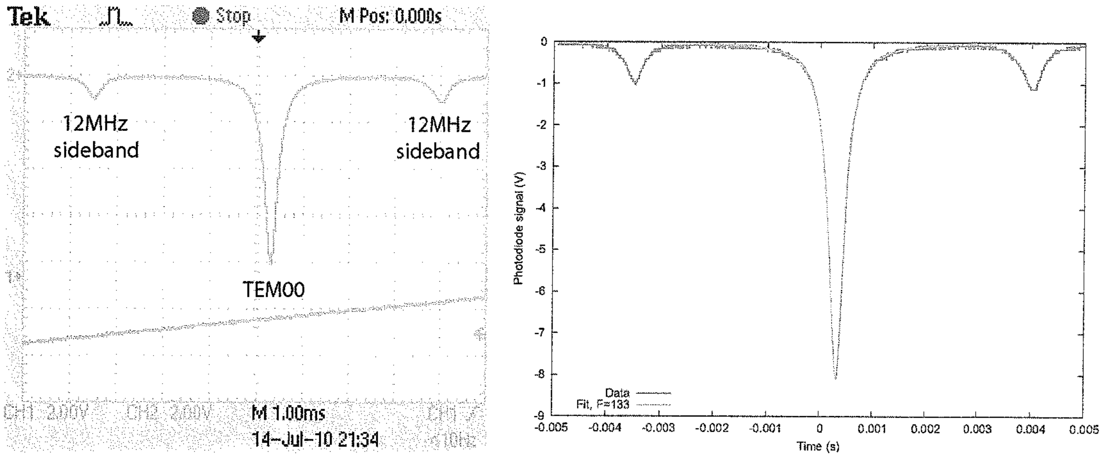

Figure 2: Example measurement of the PMC finesse and gnuplot fit used to determine the PMC finesse.

3 Optical tests

Scan the PMC: Connect a high voltage ramp signal (about 20 Hz, 300 V peak to peak) to the PZT. Align the NPRO laser beam to the fundamental mode of the PMC using, at first, a detector card in transmission and afterwards the photodiode TPD1.

a) **Finesse:**
Connect an RF source to the EOM in the setup to create phase modulation sidebands which show up as peaks near the a fundamental mode resonance. Set the high voltage ramp frequency to 5 Hz. Use a scope to measure the transmitted power using photodiode TPD1 near a fundamental mode resonance. Save this measurement and make sure the sidebands are visible in this measurement. Fit an Airy function to the fundamental mode resonance and use the sidebands to calibrate the frequency axis (assume an FSR of 150 MHz). Determine from this fit the finesse of the resonator (see Fig. 2). Attach the plot and the fit to this test report as documentation. For example, the following gnuplot script was used to fit the data shown in Fig. 2.

```
# Adjust this file in lines marked with (!!1)...(!!5)
reset

# Given parameters:
FSR = 150e6            # FSR of the PMC in Hz
sfreq = 12e6           # Frequency of Sideband in Hz
xs = -0.00348          # (!!1) Position of Sideband (read from plot)
filename = "ch2.dat"   # (!!2) Data file (time, pd voltage)


# Estimated parameters, will be fitted
F = 120             # Finesse
x0 = 0.0003         # (!!3) Position of peak
v = -8              # (!!4) Value of peak
```

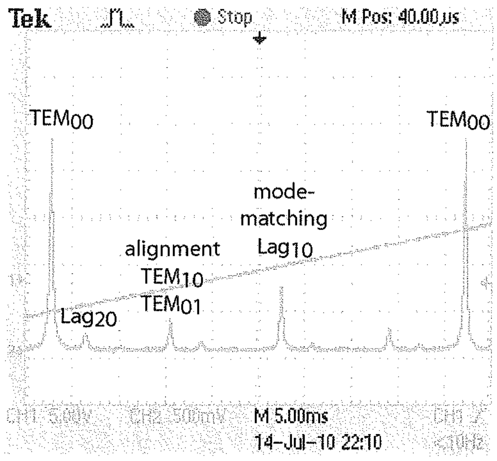

Figure 3: Typical positions of the higher order TEM/Lag modes.

```
# Airy function
peak(x) = v/(1+(2*F/pi)**2*sin((x-x0)/(xs-x0)*sfreq/FSR*pi)**2)

# (!!5) Adjust range to only include the fundamental peak
fit [-0.001:0.001] peak(x) filename via x0, F, v

set samples 1000
set key left bottom
set xlabel "Time (s)"
set ylabel "Photodiode signal (V)"

plot \
  filename title 'Data' w l lw 3, \
  peak(x) title gprintf('Fit, F=%.0f',F) w l lw 3
```

Design value: 126 ±10. Measured value: 125 Pass/Fail: ✓
File: GIT: msc. pdf

b) **PZT coefficient:**
Determine the PZT coefficient by measuring the voltage required to scan one FSR.
Design value: 150 V/FSR ±30 V/FSR. Measured value: 148 V/FSR Pass/Fail: ✓

40,4
~~39.6~~ ms = FSR
3.6 ms = Lag20

c) **Gouy Phase:**
Measure the distance in FSRs of the Lag20 mode (TEM40, TEM04) mode from its corresponding fundamental mode. The Lag20 mode should be near a fundamental mode of the next FSR (see Fig. 3). Divide the measured distance by 4 to calculate the round-trip gouy phase.
Design value: 0.285 FSR ±0.01 FSR. Measured value: 0,272 Pass/Fail: X

d) **Power transmission of the HR and PZT mirror:**
Use calibrated high-dynamic-range photodiodes to measure the power transmitted by the HR and PZT

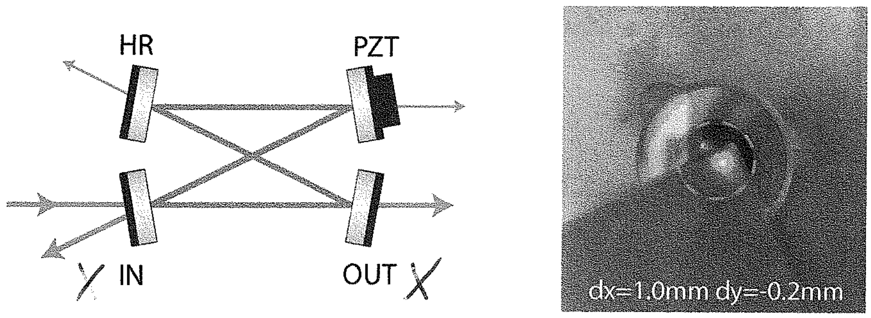

Figure 4: Naming convention for the PMC mirrors (left). Example photo used to determine the beam position relative to the drill hole center (right).

mirror relative to the power transmitted by the OUT mirror. Use a scope to simultaneously measure the photodiode signal at a fundamental mode resonance of photodiode TPD1 and TPD2.

2.46V @ 40dB 10.1 V @ 0dB

mirror HR: Design value: 2.5e-3 ±2e-4 . Measured value: 2.44 e-3 Pass/Fail: ✓
mirror PZT: Design value: 2.5e-3 ±2e-4 . Measured value: 2.5 e-3 Pass/Fail: ✓

2,56V @ 40 dB

e) **Fundamental mode position:**
Use a small detector card and a camera to measure the position of the fundamental mode at the four PMC mirrors relative to the drill hole center (see Fig. 4). The drill hole diameter is 12 mm and can be used to calibrate distances on the photo. Attach the camera photos to this test report as documentation.

Position at mirror IN.
X: Design value: 0 mm ±3 mm. Measured value: ~~0,02 mm~~ 0,44 mm Pass/Fail: ✓
Y: Design value: 0 mm ±3 mm. Measured value: ~~2,44 0,24 mm~~ 2,2 mm Pass/Fail: ✓
File: in.pdf

Position at mirror OUT.
X: Design value: 0 mm ±3 mm. Measured value: 0,85 mm Pass/Fail: ✓
Y: Design value: 0 mm ±3 mm. Measured value: 1,27 mm Pass/Fail: ✓
File: out.pdf

Position at mirror HR.
X: Design value: 0 mm ±3 mm. Measured value: 2,02 mm Pass/Fail: ✓
Y: Design value: 0 mm ±3 mm. Measured value: 4,15 mm Pass/Fail: ✓
File: HR.pdf

Position at mirror PZT.
X: Design value: 0 mm ±3 mm. Measured value: 1,97 mm Pass/Fail: ✓

Y: Design value: 0 mm ±3 mm. Measured value: 1,44 mm Pass/Fail: ✓
File: PZT.pdf

f) **Optical inspection:**
Check that all mirrors are clean.
mirror IN Pass/Fail: ✓
mirror OUT Pass/Fail: ✓
mirror HR Pass/Fail: ✓
mirror PZT Pass/Fail: ✓

The PMC should now be placed into the tank, see T1000430-v1.

4 Electrical tests

a) **Heater:**
Measure the resistance of the heater foils attached to the PMC by measuring the resistance between pin 3 and 4 of the 4-pin Lemo connector of the tank.
Design value: 26 Ω ±5 Ω. Measured value: 25,8 Ω Pass/Fail: ✓

b) **Temperature sensor:**
Measure the current between pin 1 and 2 of the 4-pin Lemo connector using at least a bias voltage of 5 V (pin 1 = +, pin 2 = −) to test the AD590 temperature sensor.
Design value: 293 μ A ±10 μ A. Measured value: 286 µ Pass/Fail: ✓

END