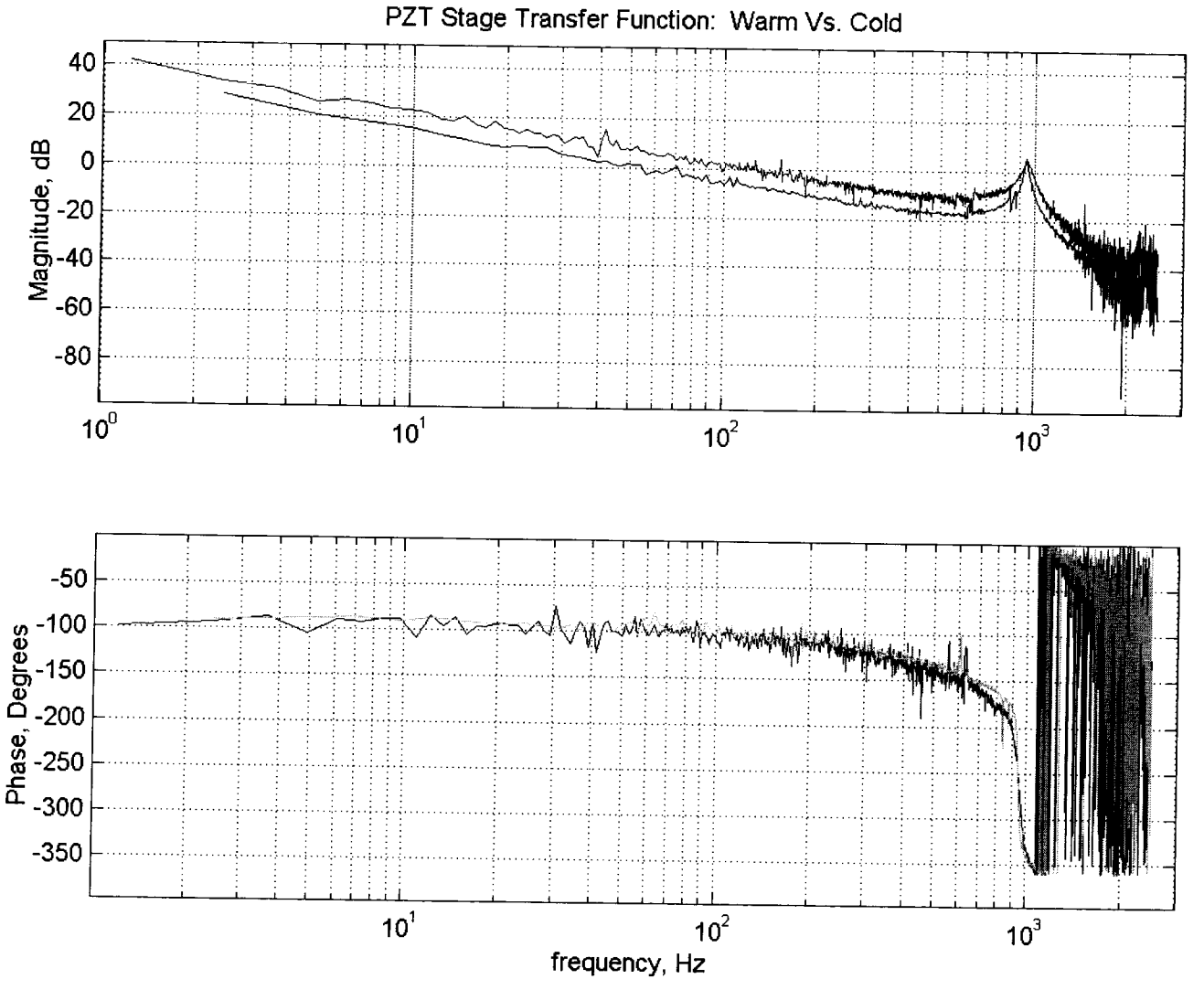
TPF Cryogenic Delay Line
FY 03 Development
10/15/03

Robert Smythe

PZT stage Measured Transmissibility: Warm vs. Cold



PZT stage Modeled Transfer Function: Cold & Warm

Modeled Cold Transfer function:

$$H_{cold}(z) = \frac{0.01548\, z^5 + 0.006353\, z^4 + 0.0004211\, z^3 + 0.003859\, z^2 + 0.007086\, z + 0.01277}{z^6 - 3.176\, z^5 + 5.211\, z^4 - 5.172\, z^3 + 3.105\, z^2 - 0.9679\, z}$$

Sampling time interval = 0.0002 seconds

Modeled Warm Transfer function:

$$H_{warm}(z) = \frac{0.03498\, z^5 + 0.01582\, z^4 + 0.00337\, z^3 + 0.0109\, z^2 + 0.01724\, z + 0.02886}{z^6 - 3.087\, z^5 + 4.979\, z^4 - 4.87\, z^3 + 2.893\, z^2 - 0.915\, z}$$

Sampling time interval = 0.0002 seconds

Kalman Signal Generation Model for Cold Motor Error in Open Loop : difference equation

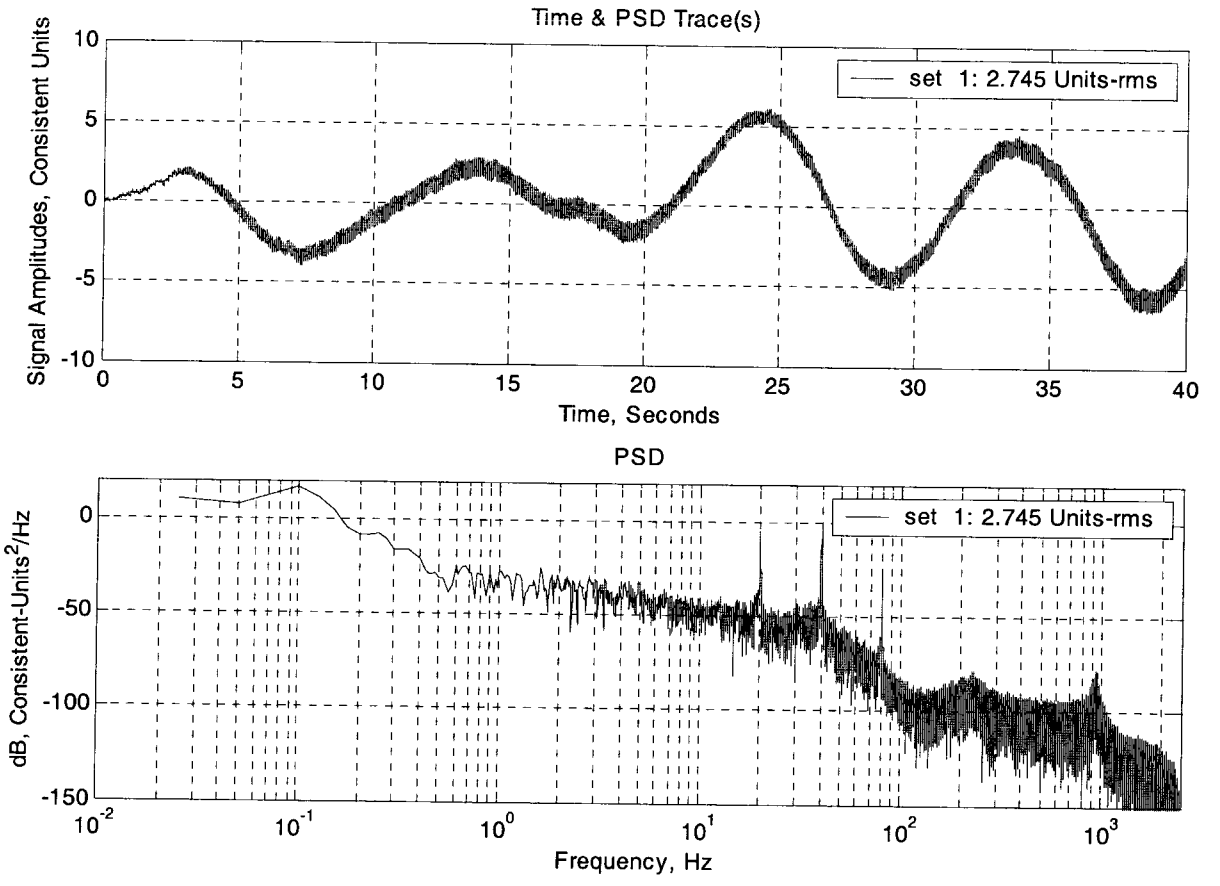
(use Gaussian sequence, $\sigma = 1$, as input to this linear model)

$$H(z) = \frac{0.0001874\, z^{15} - 0.002013\, z^{14} + 0.009784\, z^{13} - 0.02822\, z^{12} + 0.05299\, z^{11} - 0.06552\, z^{10} + 0.04757\, z^{9} - 0.003393\, z^{8} - 0.04071\, z^{7} + 0.0608\, z^{6} - 0.05388\, z^{5} + 0.03362\, z^{4} - 0.01506\, z^{3} + 0.004641\, z^{2} - 0.0008814\, z + 7.764e\text{-}005}{z^{15} - 13.57\, z^{14} + 86.51\, z^{13} - 344.5\, z^{12} + 960.3\, z^{11} - 1990\, z^{10} + 3173\, z^{9} - 3972\, z^{8} + 3938\, z^{7} - 3093\, z^{6} + 1908\, z^{5} - 906.2\, z^{4} + 320.1\, z^{3} - 79.23\, z^{2} + 12.26\, z - 0.8916}$$

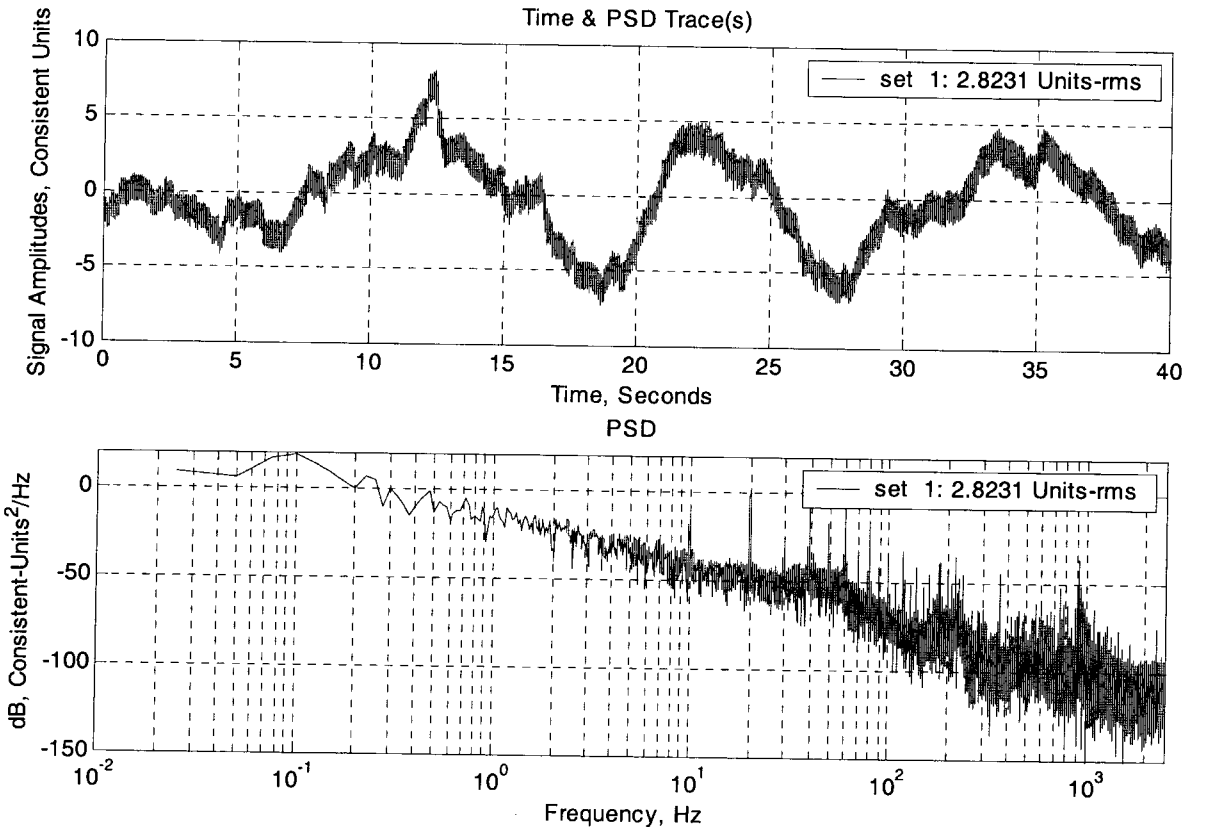
Sampling time: 0.0002 seconds

So, a realization of the estimate of the open loop OPD would be (n is the discrete time variable):
Opd(n) ~= (0.1mm/sec)*n + $J(n)$, where $J(n)$ is the output of the Kalman signal generation filter specified above. Positive ramp only.

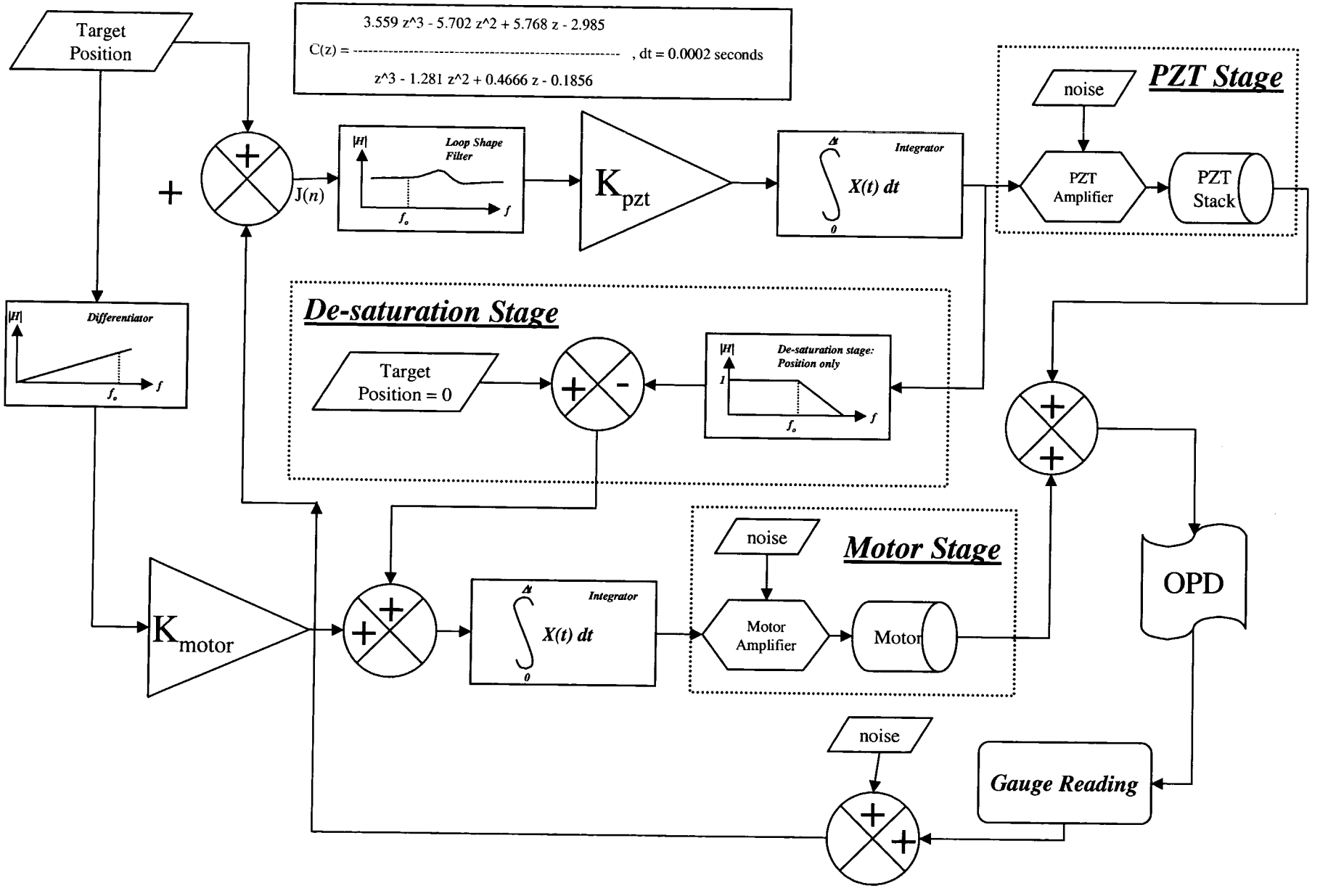
OPD Estimate Realization using specified signal generation model
Units = μm



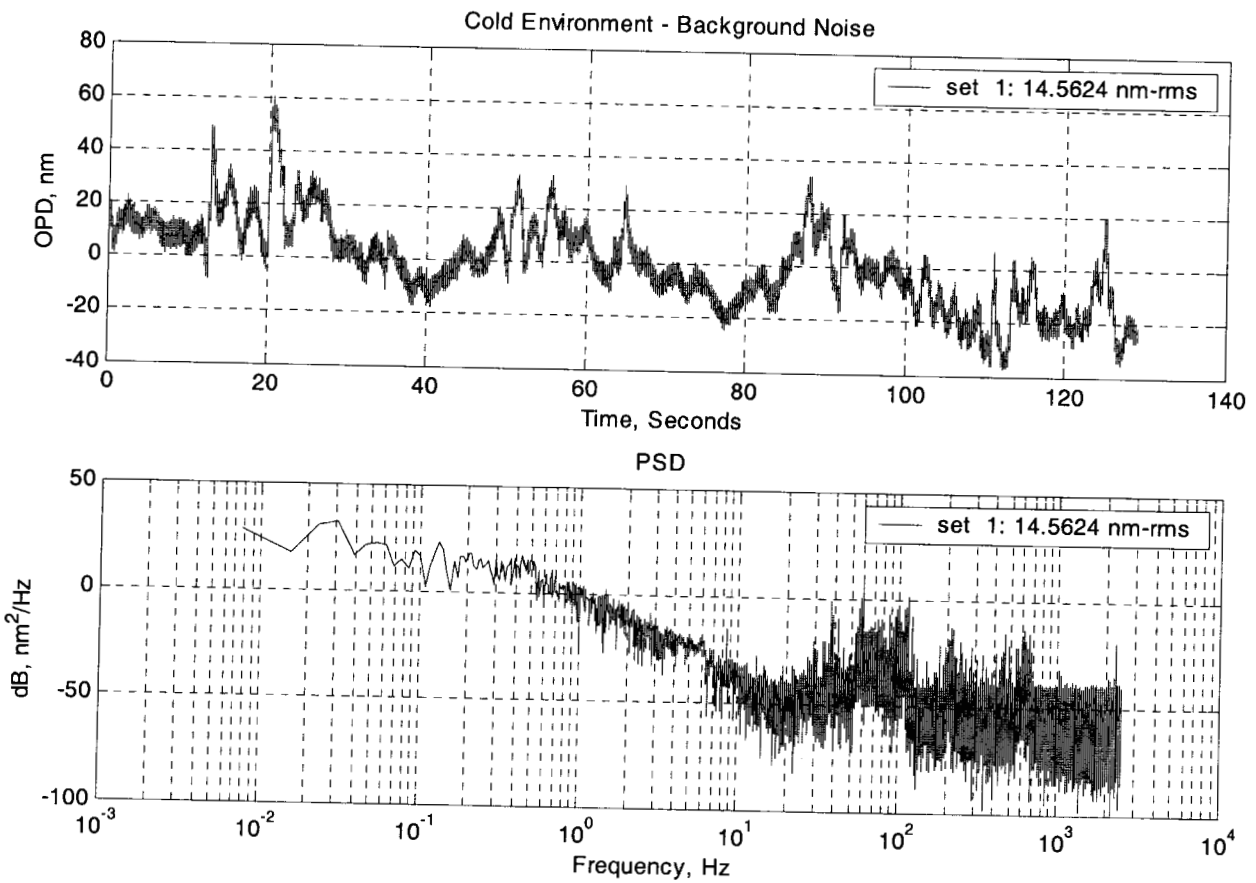
OPD Measured Realization with Cold Model
Units = μm



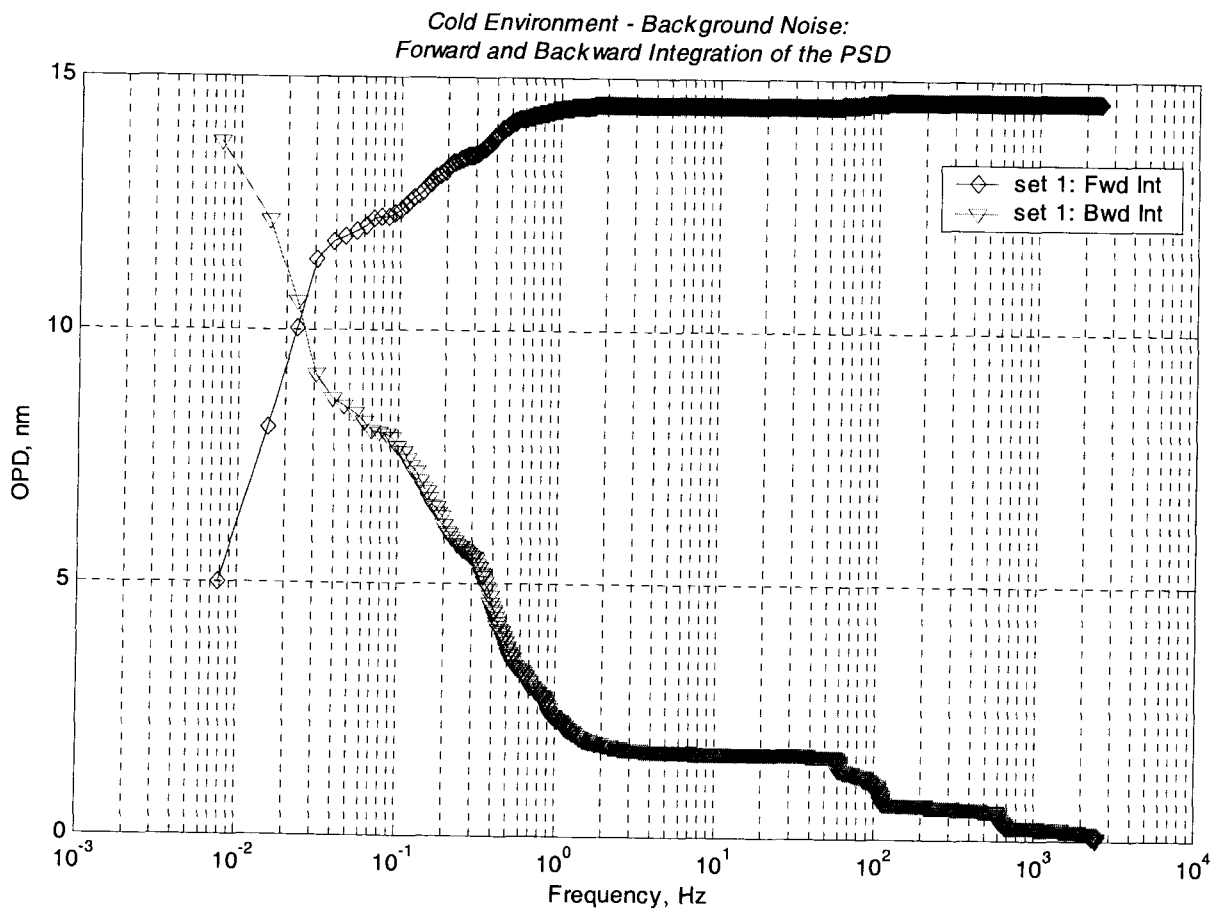
Cryogenic Delay Line's Control Flow-Diagram



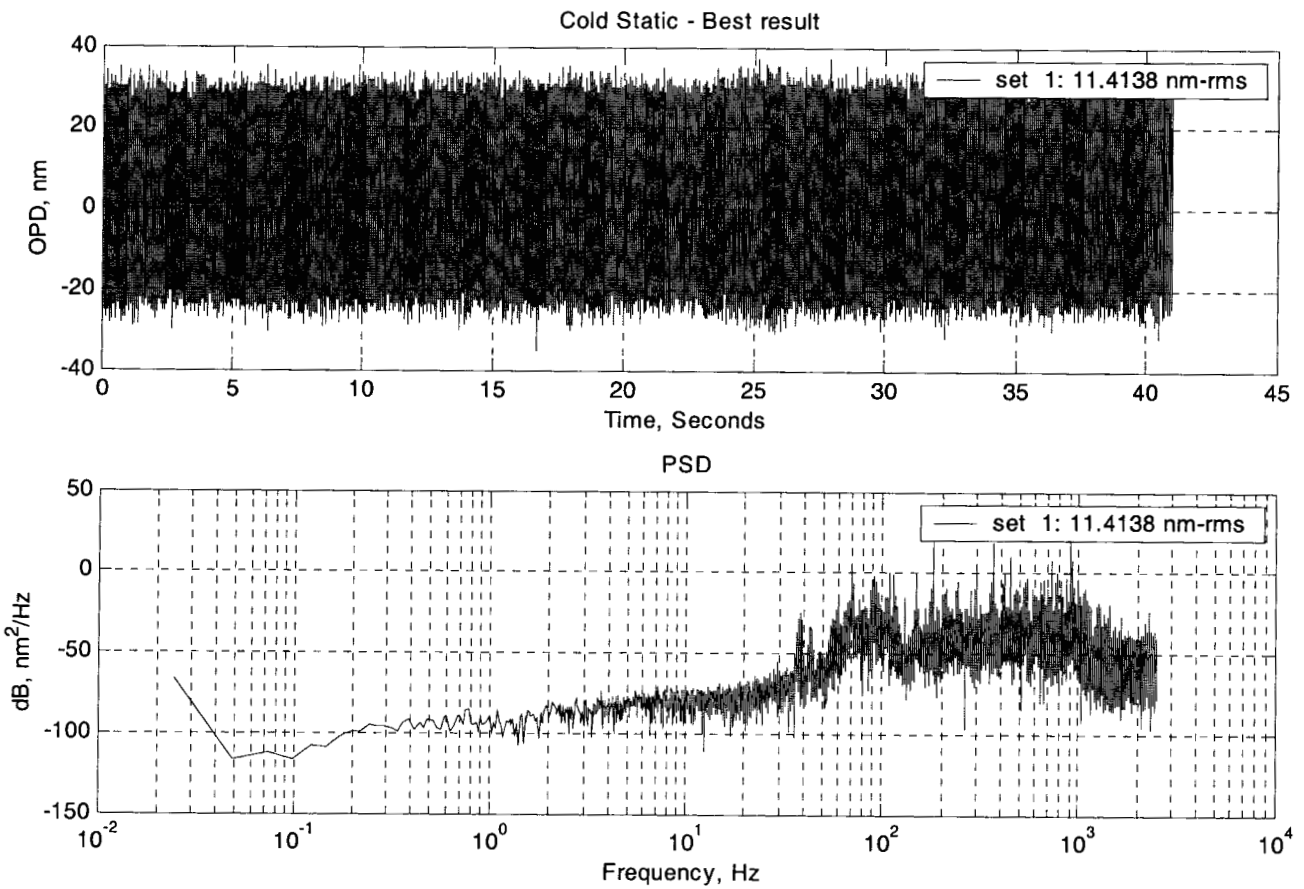
Background Noise



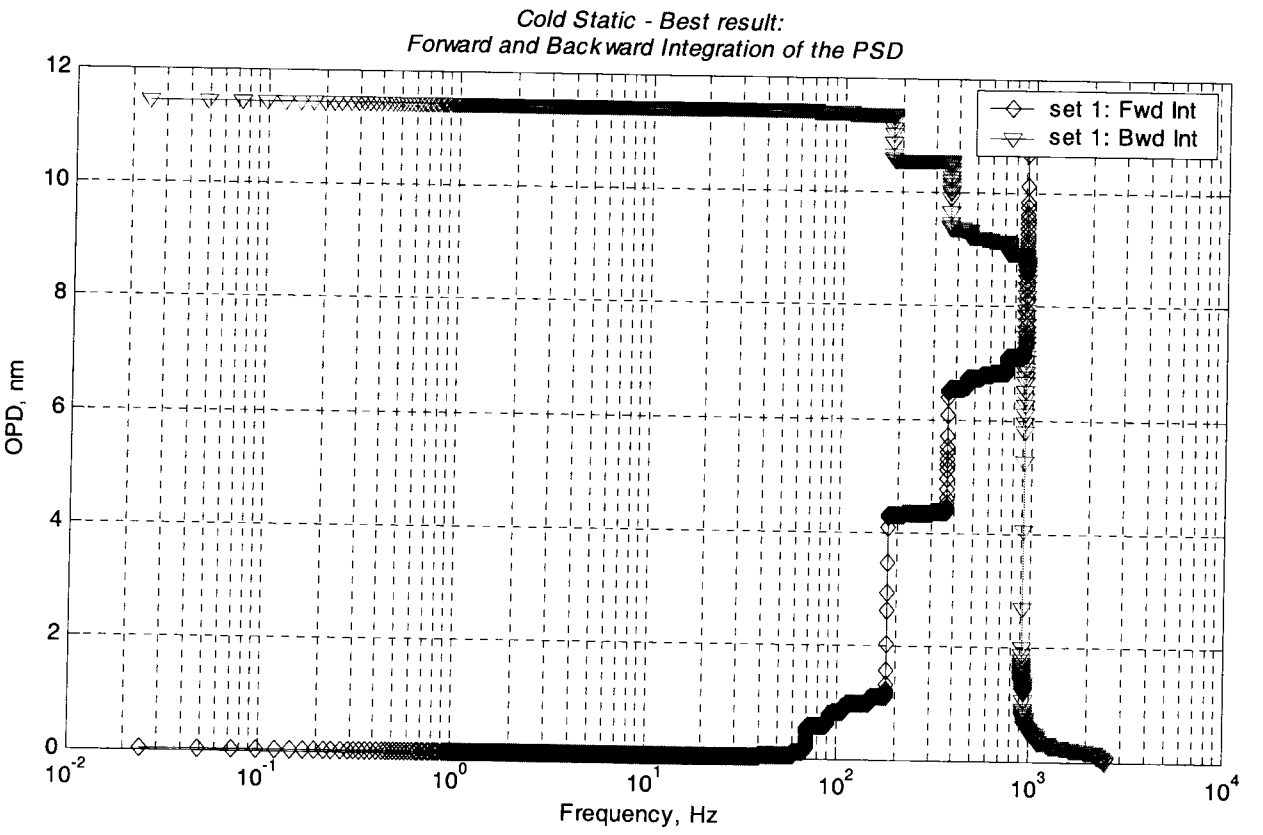
Background Noise



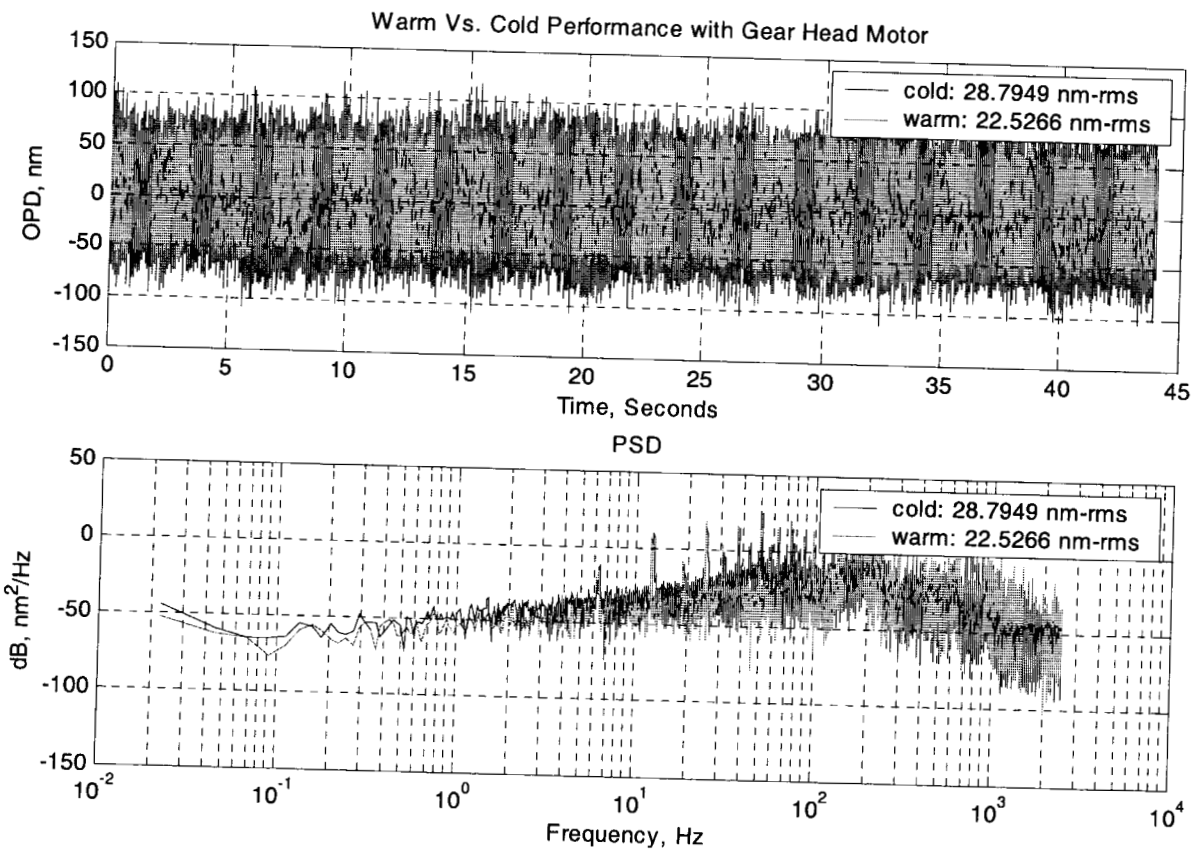
Cold Static – Best Result



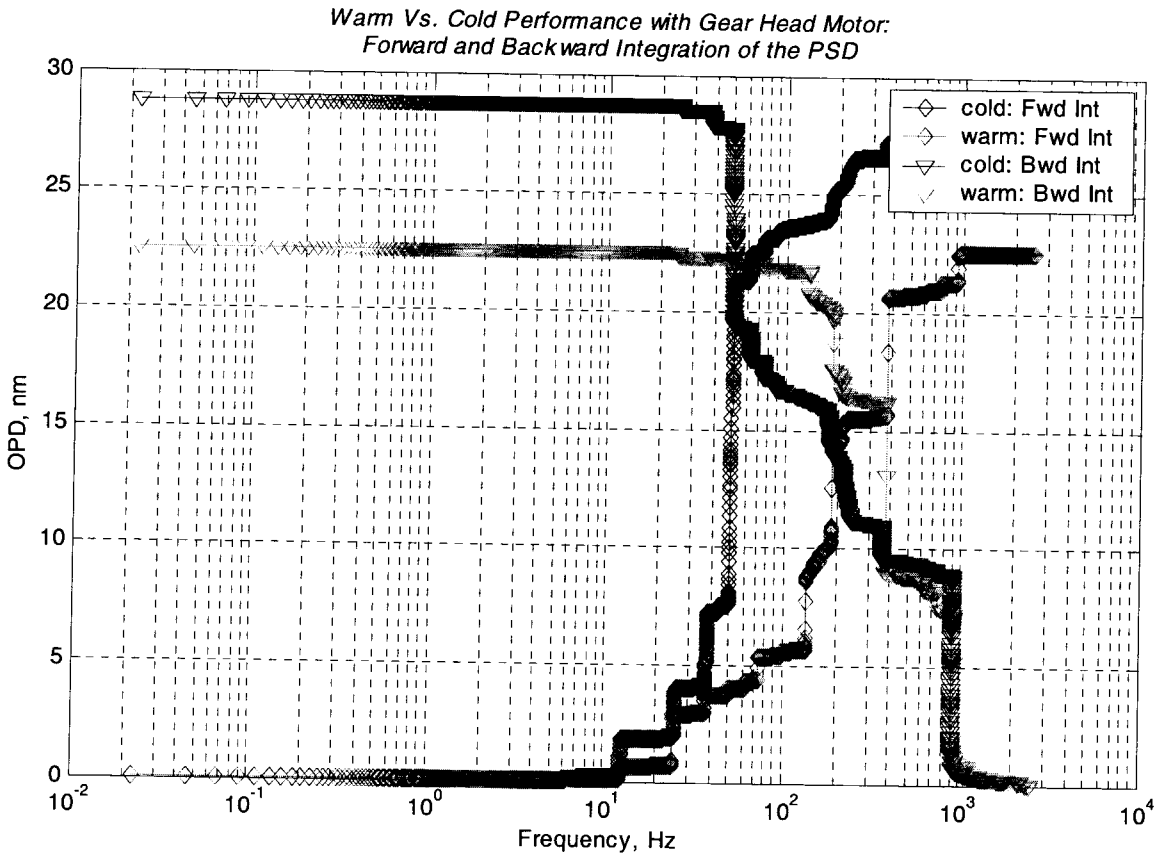
Cold Static – Best Result



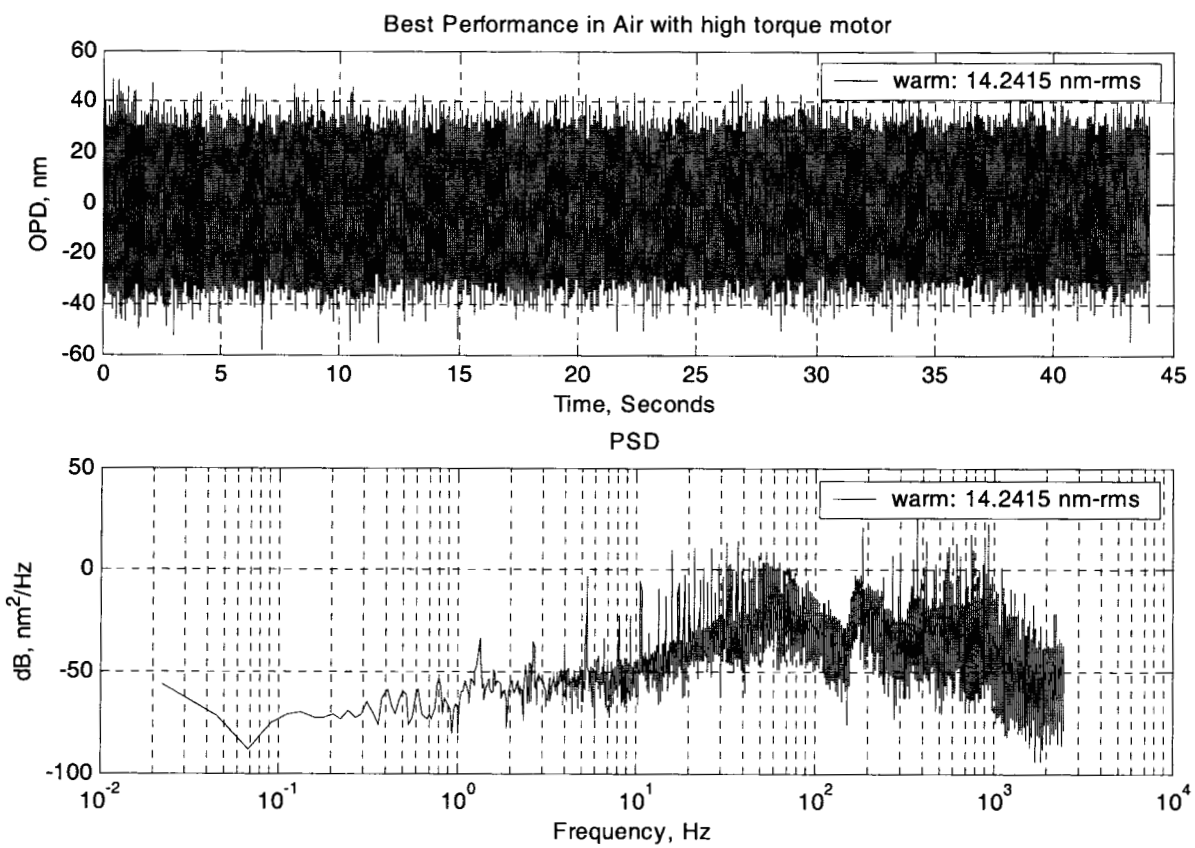
Cold Vs. Warm @ 0.1 mm/sec



Cold Vs. Warm @ 0.1 mm/sec



Best Warm Performance using high torque motor @ 0.1mm/sec



Best Warm Performance using high torque motor @ 0.1mm/sec

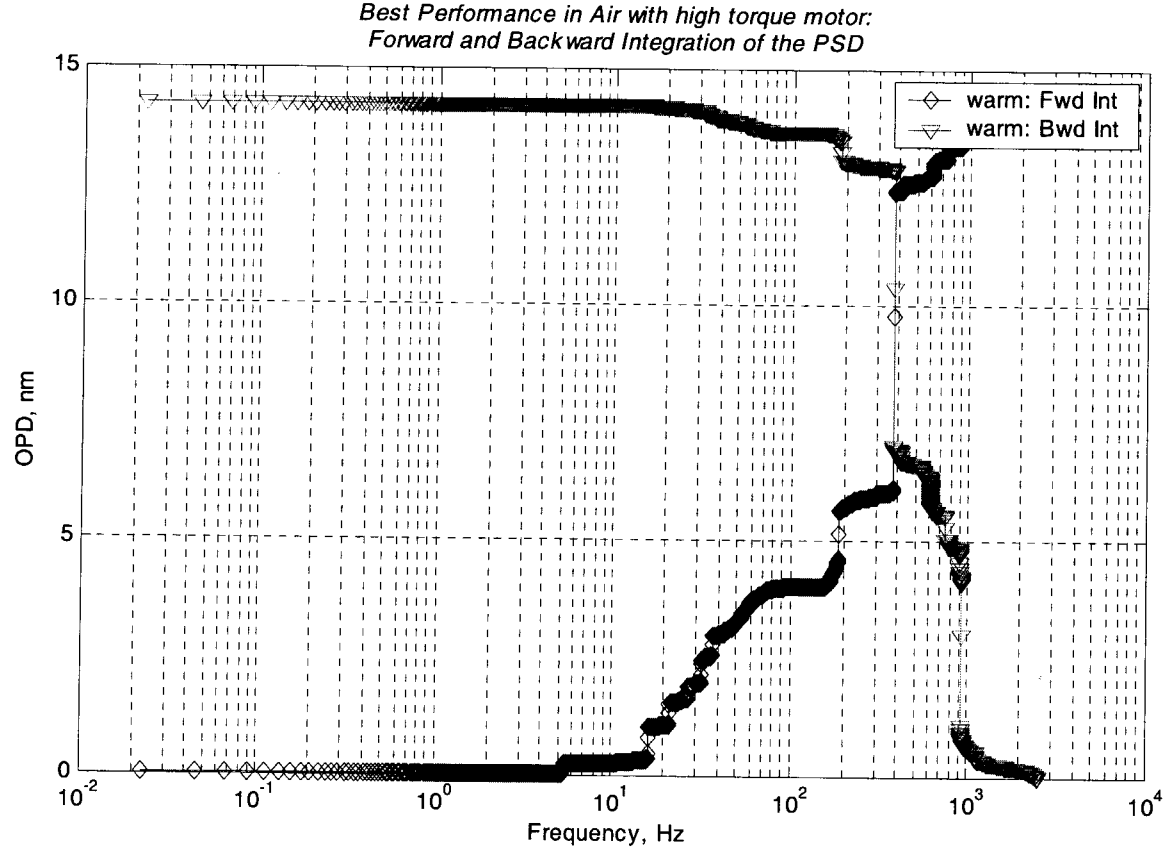
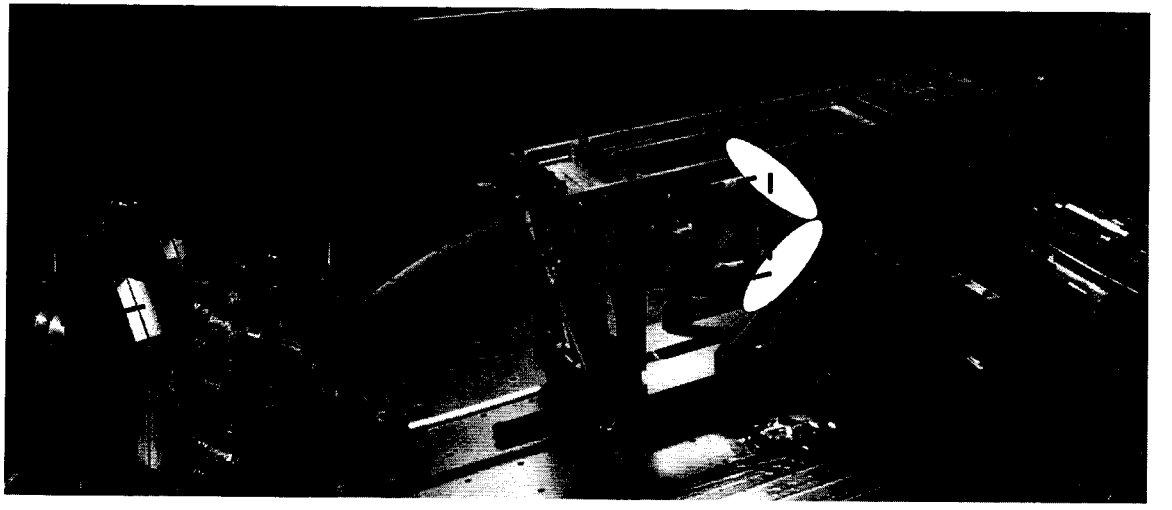


Photo of the cryo delay line.



Proposed delay line concept.