



Measuring LISA Phase

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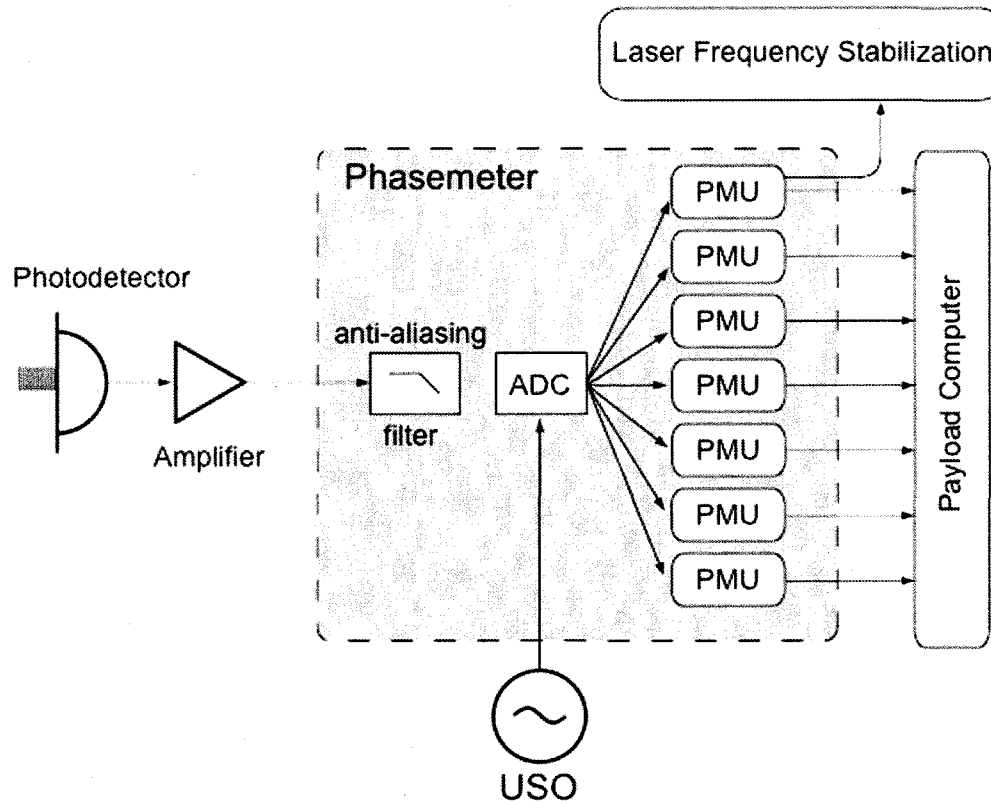
Requirements



- Frequency range ± 20 MHz (Doppler from ± 20 m/s)
- 10^{-6} cycles/ $\sqrt{\text{Hz}}$ phase noise
- Dynamic range of phase 10^{11} @ 1 mHz
 - Laser freq noise 10^5 cycles/ $\sqrt{\text{Hz}}$ @ 1 mHz
- 7 sidebands to be extracted
- 10 kHz tracking: 10^{-3} cycles/ $\sqrt{\text{Hz}}$
- 10 Hz science: 10^{-6} cycles/ $\sqrt{\text{Hz}}$
- Operates with fast changes expected from stabilised laser

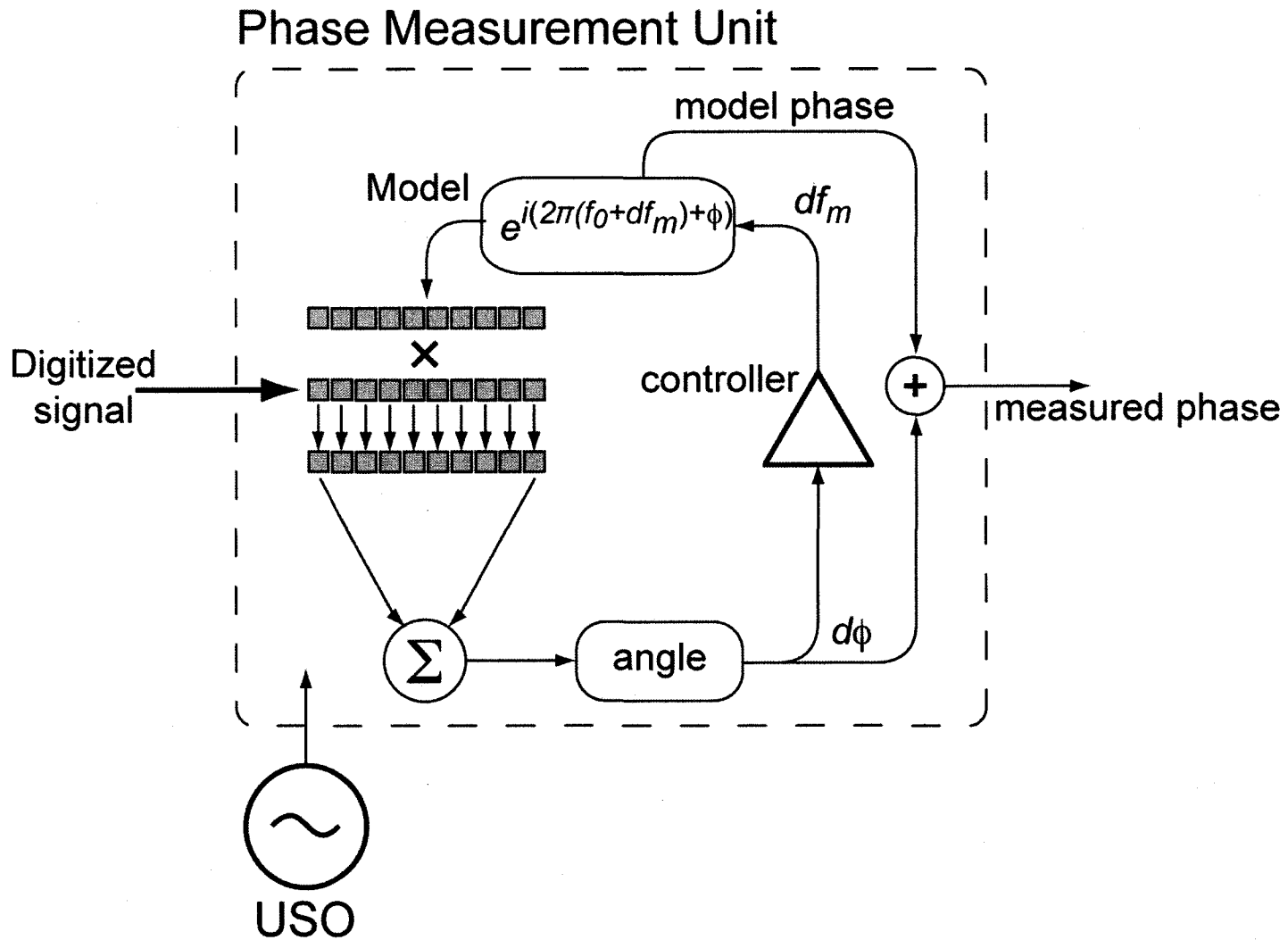


Phasemeter block diagram





PMU block diagram





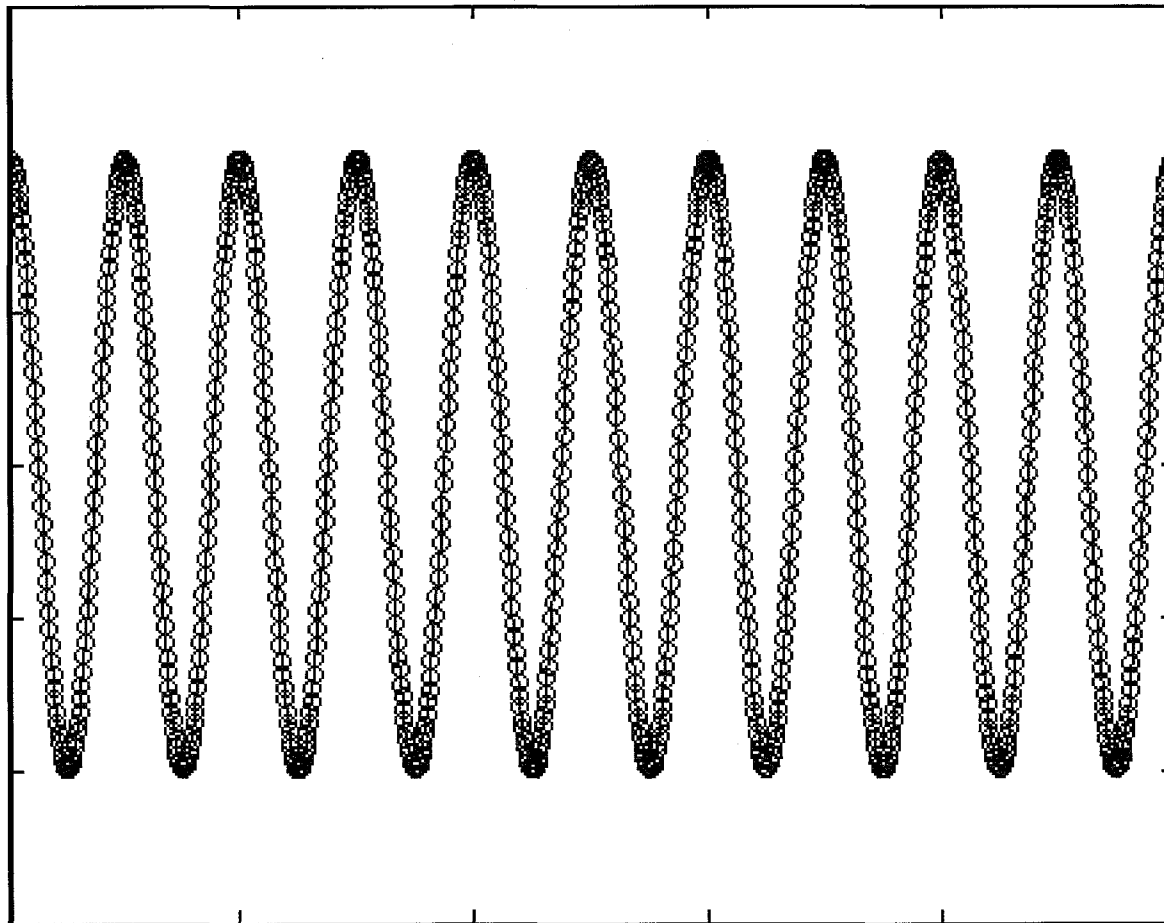
PLL Controller



- Feedback to frequency of model only
 - No feedback to phase of model
 - No feedback to frequency rate
- Controller contains proportional, integral, double integral feedback
- Unity gain several kHz
- PLL update rate 10 kHz



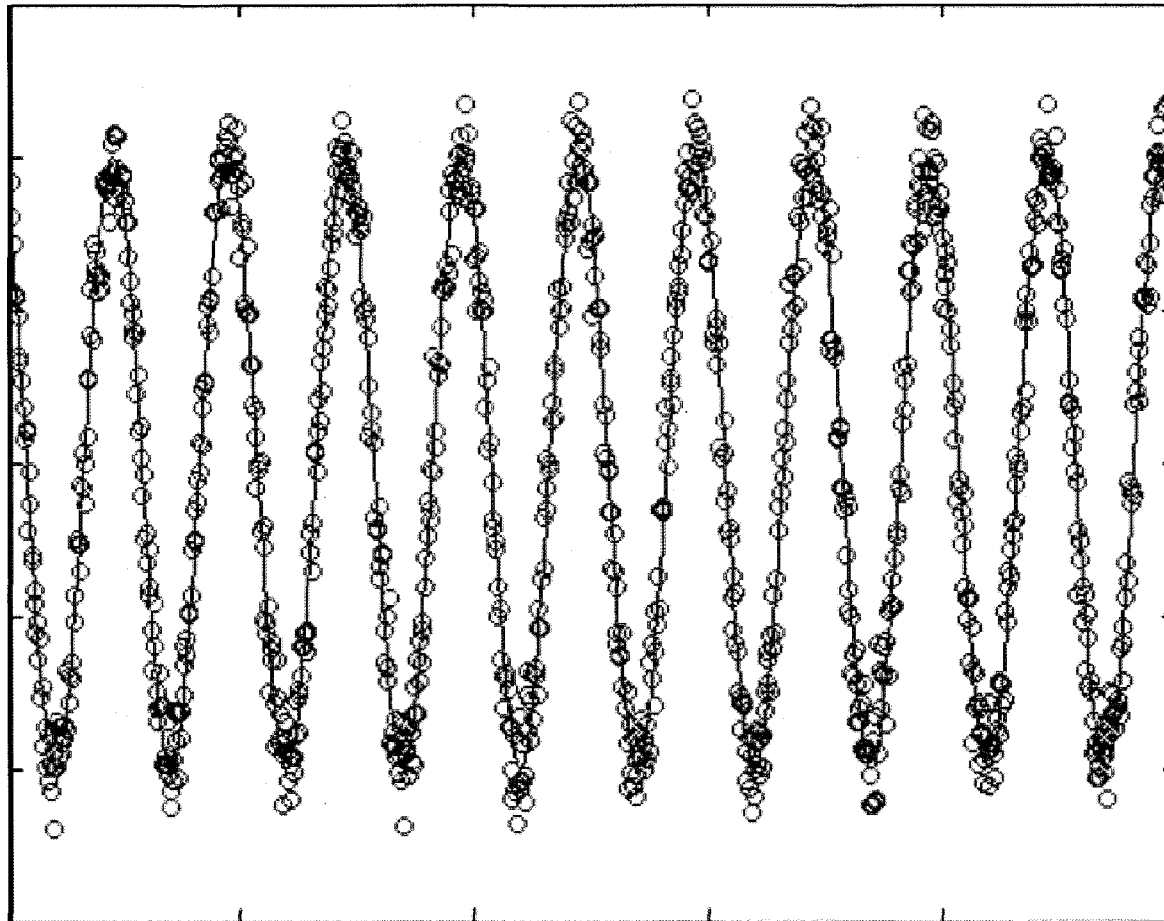
Frequency tracking (white)



White laser frequency
noise only (no shot noise)



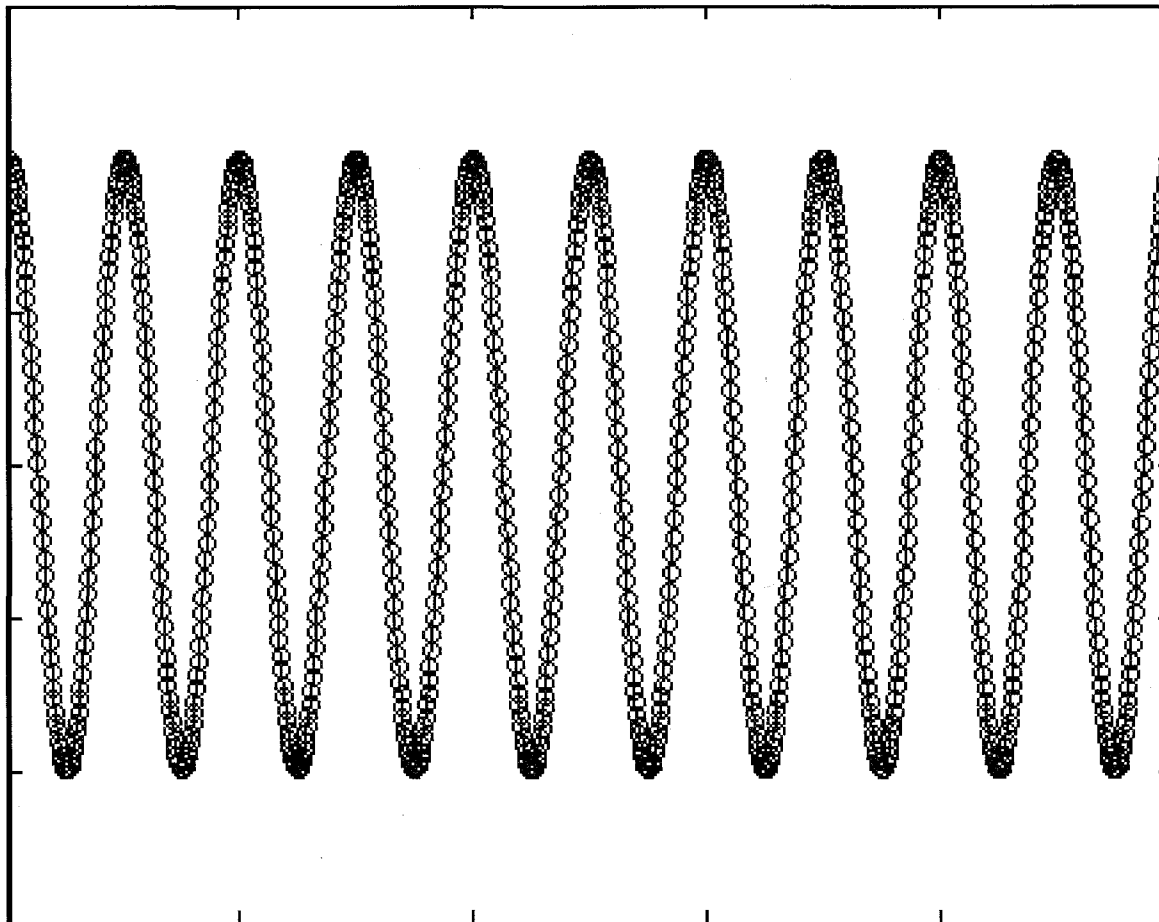
Frequency tracking (white)



White laser frequency
noise with shot noise



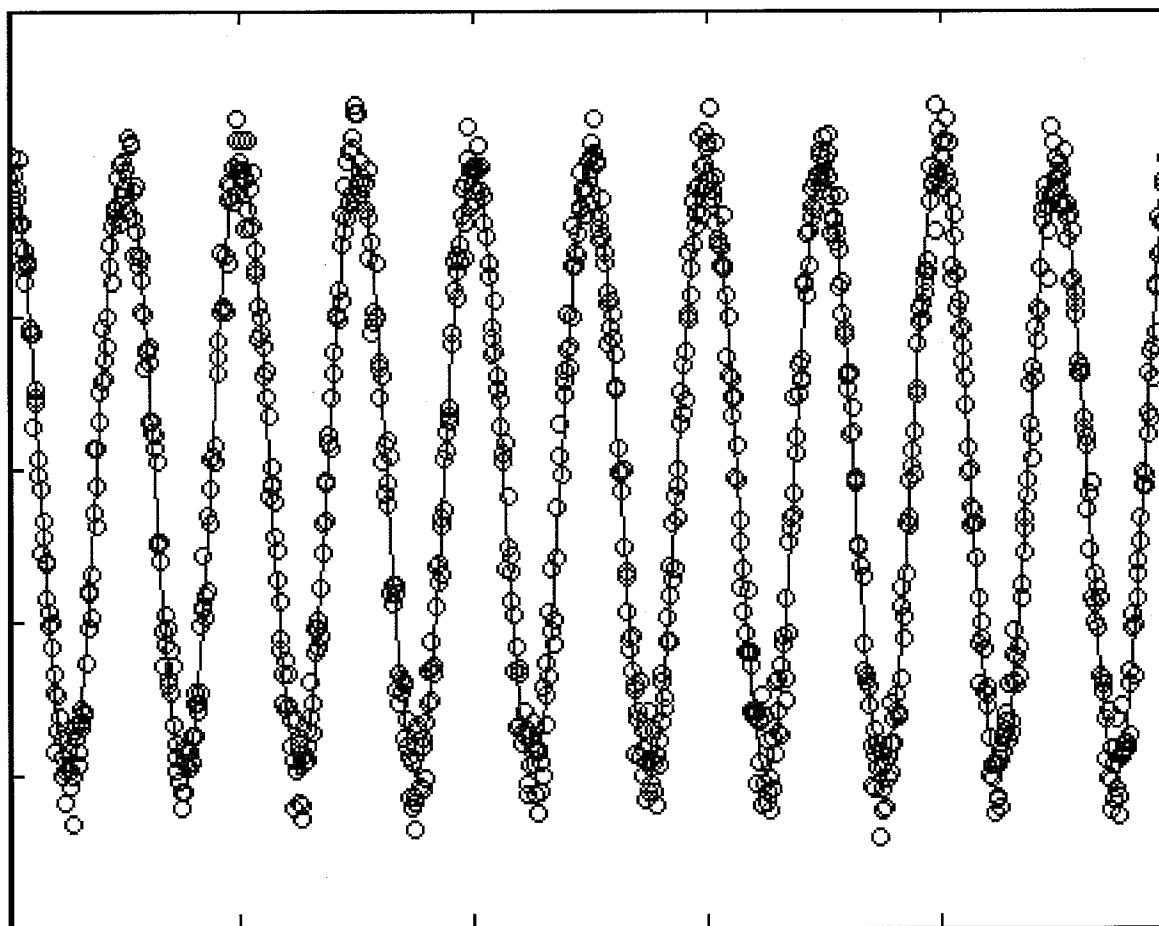
Frequency tracking (1/f)



1/f laser frequency noise
only (no shot noise)



Frequency tracking (1/f)



1/f laser frequency noise
with shot noise



Comments



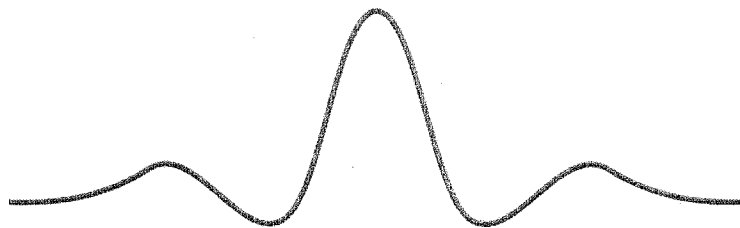
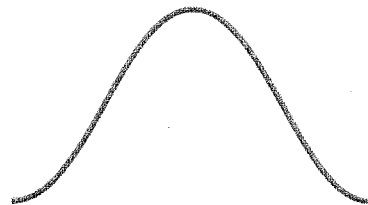
- Multiple bits (8-12)
- Identical hardware PMUs for each tone
- Windowing to prevent aliasing of noise and second harmonic
- Fast (10 kHz) and slow (10 Hz) outputs
 - Fast used for laser locking - accuracy not critical
 - Slow is science output



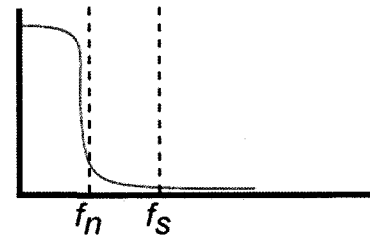
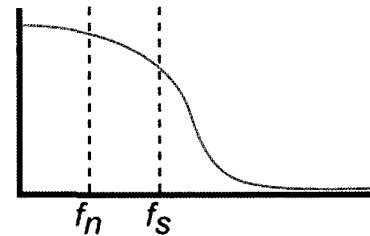
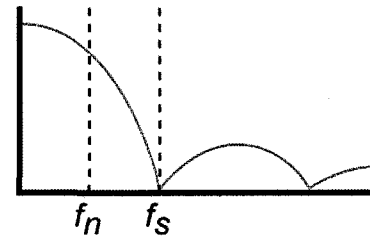
Aliasing and windows



window (time domain)

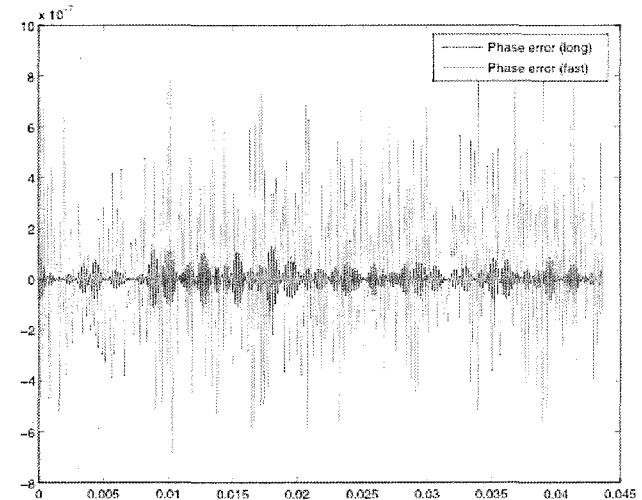
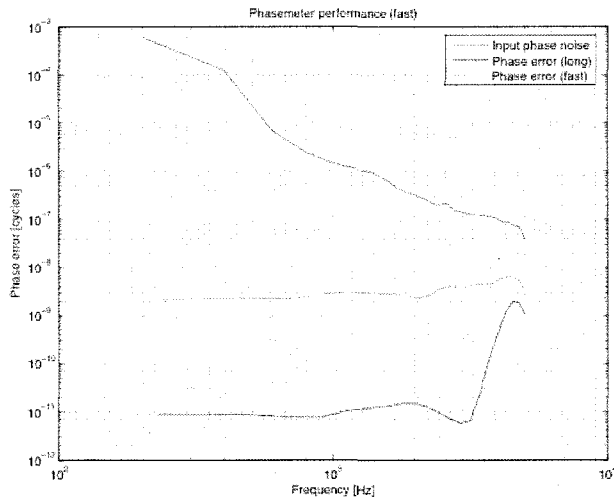
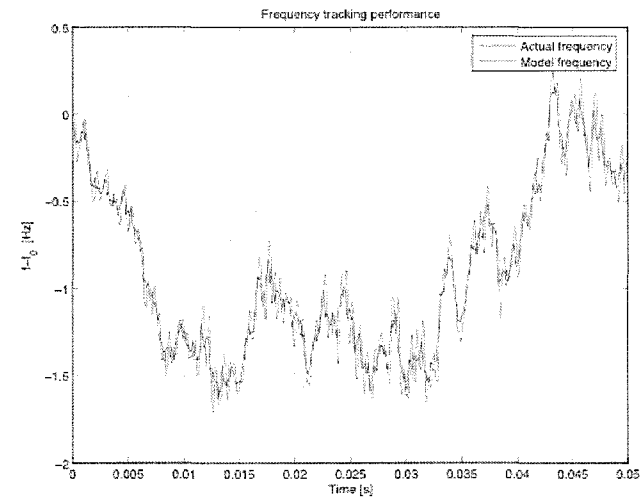
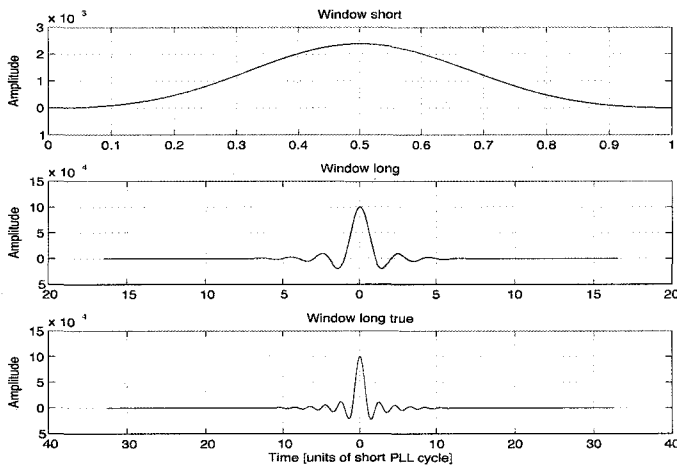


Frequency response



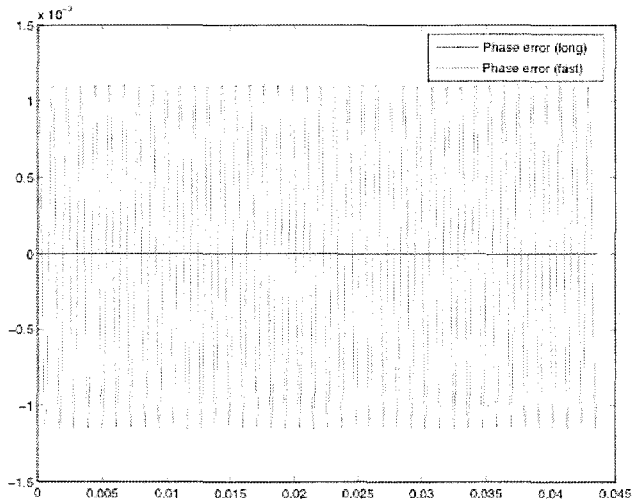
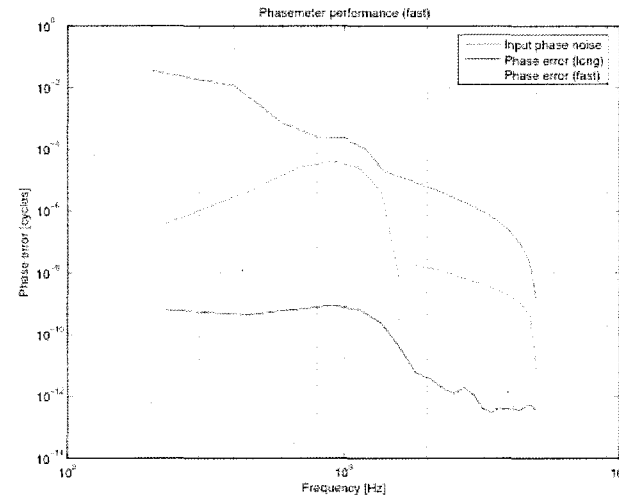
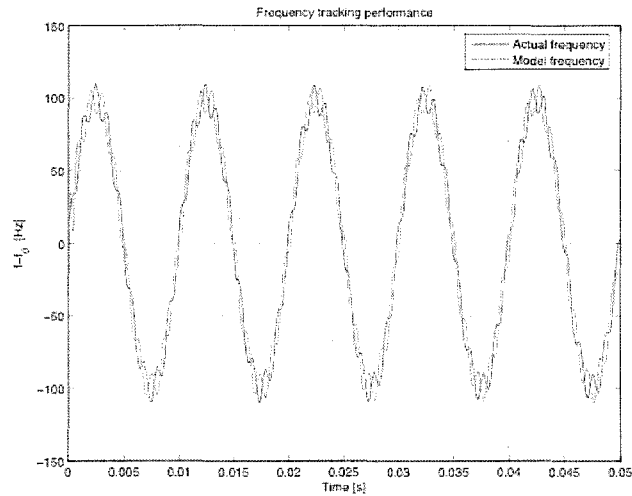


Performance results (random noise)





Performance results (aliasing)





Future Plans



- Measurement of laser frequency noise
- Accurately model phase meter input
 - Shot noise
 - Photodiode electronic noise
 - Real laser frequency noise [non-gaussian]
- Multiple tones (crosstalk)
- Incorporate into LISA TDI simulation
- Implement in FPGA hardware (in progress)
- Detailed design
 - Number of bits
 - feedback loops