

FIGURES

2.1 Definition of phase noise	16
2.2 Plot of the function $F(x)$	21
2.3 Leeson's model of phase noise for an ideal linear LC oscillator	24
2.4 Summary of the relation between different quantities	27
3.1 Vibrational mode shape of the beam with doubly clamped boundary condition imposed and its Gaussian approximation	54
3.2 Plot of the function $\xi(x)$	55
3.3 Plot of $X(x)$ and its asymptotic form	56
4.1 Self-oscillation scheme for the phase noise measurement of NEMS	70
4.2 Configuration of a phase-locked loop based on NEMS	71
4.3 Pictures of two-port NEMS devices	79
4.4 Implementation of the homodyne phase-locked loop based on a two-port NEMS device	80
4.5 Mechanical resonant response after nulling	81
4.6 Phase noise density of the 125 MHz homodyne phase-locked loop based on a two-port NEMS device	82
4.7 Allan deviation of the 125 MHz homodyne phase-locked loop based on a two-port NEMS device	83
4.8 Conceptual diagram of frequency modulation phase-locked loop (FM PLL) scheme	85
4.9 Implementation of frequency modulation phase-locked loop (FM PLL) scheme	88
4.10 Phase noise density of the 190 MHz frequency modulation phase-locked loop (FM PLL)	92
4.11 Allan deviation of the 133 MHz frequency modulation phase-locked loop (FM PLL)	93
4.12 Phase noise density of the 419 MHz frequency modulation phase-locked loop (FM PLL)	94
4.13 Allan deviation of the 419 MHz frequency modulation phase-locked loop (FM PLL)	95

4.14 Phase noise spectrum of NEMS-based phase-locked loops versus the local oscillator (LO) requirement of chip scale atomic clock (CSAC).....	98
4.15 Allan deviations of NEMS-based phase-locked loops versus the local oscillator (LO) requirement of chip scale atomic clock (CSAC).....	99
4.16 Experimental configuration for diffusion noise measurement.....	102
4.17 Adsorption spectrum of xenon atoms on NEMS surface.....	104
4.18 Representative fractional frequency noise spectra.....	106
4.19 Spectral density of fractional frequency noise contributed from gas.....	107
4.20 Spectral density of fractional frequency noise with fitting.....	110
4.21 Allan deviation data with gas and without gas.....	112
4.22 Comparison with prediction from diffusion noise theory and Yong and Vig's model....	113
5.1 Experimental configuration.	123
5.2 Real time zeptogram-scale mass-sensing experiment.....	126
5.3 Mass responsivities of nanomechanical devices.....	127
6.1 SEM picture of doubly clamped SiC beams.	136
6.2 Representative data of mechanical resonance.....	138
6.3 Frequency versus effective geometric factor for three families of doubly clamped beams made from single-crystal SiC, Si, and GaAs	141
7.1 Schematic diagrams for the magnetomotive reflection measurement and bridge measurement	147
7.2 Data from a doubly clamped n^+ Si beam	151
7.3 Narrowband and broadband transfer function from metalized SiC beam in bridge configuration	153

TABLES

3.1 Allan deviation and mass sensitivity limited by thermomechanical noise for representative realizable NEMS device configurations	36
3.2 Summary of Yong and Vig's and ideal gas models.....	48
3.3 Maximum Allan deviation and mass fluctuation of representative NEMS devices.....	49
3.4 Summary of expressions for spectral density and Allan deviation for fundamental noise processes considered in this work.....	64
4.1 Summary of parameters of all phase-locked loops based on NEMS presented in this work	76
4.2 Summary of experimental parameters used in the frequency modulation phase-locked loops (FM PLL) at very high frequency (VHF) and ultra high frequency (UHF) bands.....	91
4.3 Summary of diffusion times and coefficients versus temperature.....	111