1. **<u>Comparison cases in the frequency calibration methodology in presence of jitter (From Chapter 3 pg. 82)</u>**

Hence,if f1 =min(f,1−f), and $\left|\frac{\Delta T_j}{T_{del}}\right|$<f1

probability of fp (fp1) = 0.5 * (1−f−$\frac{\Delta T_j}{T_{del}}$) + 0.5* (1−f+$\frac{\Delta T_j}{T_{del}}$)

probability of fp+1 (fp11)= 0.5 * (f+ $\frac{\Delta T_j}{T_{del}}$) + 0.5 *(f−$\frac{\Delta T_j}{T_{del}}$)

Now, in this case

l_1== fp -> probability is fp1 (decision no change in frequency)

->probability is fp11 (decision to decrease frequency) if l_1 ~ p1 otherwise decision to increase frequency with probability of fp11

l_1>fp

If l_1−fp>1 -> probability is 1 (decision to increase frequency)

otherwise

-> probability is fp1 (decision to increase frequency)

-> probability is fp11 (decision of no change in frequency)

l_1<fp

If fp<p1 -> probability is 1 (decision to decrease frequency)

otherwise

-> probability is fp1 (decision to decrease frequency)

-> probability is fp11(decision to increase frequency)

If $\left|\frac{\Delta T_j}{T_{del}}\right| > f \ \wedge \ \left|\frac{\Delta T_j}{T_{del}}\right| < (1-f)$ (^ stands for logical AND)

then probability of fp (fp1) = $0.5*(1-f-\frac{\Delta T_j}{T_{del}}) + 0.5*(1-\frac{\Delta T_j}{T_{del}}+f)$

probability of fp−1 (fp21)= $0.5*(\frac{\Delta T_j}{T_{del}}-f)$

and probability of fp+1 (fp11) = $0.5*(f+\frac{\Delta T_j}{T_{del}})$

Now, in this case

l_1== fp -> probability is fp1 (decision no change in frequency)

->If l_1 ~ p1 ^ l_1 ~ 0

->probability is fp11 (decision to decrease frequency)

->probability is fp21 (decision to increase frequency)

->If l_1==p1

->probability is 0 (decision to decrease frequency)

->probability is fp11+fp21 (decision to increase frequency)

->If l_1==0

->probability is fp11+fp21 (decision to decrease frequency)

->probability is 0 (decision to increase frequency)

l_1>fp

If l_1−fp>1 ^ fp>0

->probability is 1 (decision to increase frequency)

If l_1−fp>1 ^ fp==0

->probability is fp21 (decision to decrease frequency; it is assumed l_1−fp<p1)

->probability is fp1+fp11 (decision to increase frequency)

If $l_1 - fp == 1 \wedge fp > 0$

-> probability is fp1+fp21 (decision to increase frequency)

->probability is fp11 (decision of no change in frequency)

Else

-> probability is fp1 (decision to increase frequency)

->probability is fp11 (decision of no change in frequency)

->probability is fp21 (decision to decrease frequency)

$l_1 < fp$

If $fp - l_1 == 1 \wedge fp < p1$

-> probability is fp1+fp11 (decision to decrease frequency)

->probability is fp21 (decision for no change)

If $fp - l_1 == 1 \wedge fp == p1$

->probability is fp1 (decision to decrease frequency)

->probability is fp11 (decision to increase frequency)

->probability is fp21 (no change)

If $fp - l_1 > 1 \wedge fp < p1$

-> probability is 1(decision to decrease frequency)

If $fp - l_1 > 1 \wedge fp == p1$

->probability is fp1+fp21 (decision to decrease frequency)

->probability is fp11 (decision to increase frequency; assumed $fp - l_1 < p1$)

If $\left|\frac{\Delta T_j}{T_{del}}\right| > (1-f) \quad \wedge \quad \left|\frac{\Delta T_j}{T_{del}}\right| < f$

then probability of fp (fp1) = $0.5(1-f+\frac{\Delta T_j}{T_{del}})$

probability of fp+1 (fp11)= $0.5*(2-\frac{\Delta T_j}{T_{del}}-f)+0.5*(f-\frac{\Delta T_j}{T_{del}})$

and probability of fp+2 (fp12) = $0.5*(\frac{\Delta T_j}{T_{del}}+f-1)$

Now,

l_1== fp -> probability is fp1 (decision no change in frequency)

->If l_1 <p1−1

->probability is fp11+fp12 (decision to decrease frequency)

->probability is 0 (decision to increase frequency)

->If l_1==p1−1

->probability is fp11 (decision to decrease frequency)

->probability is fp12 (decision to increase frequency)

->If l_1==p1

->probability is 0 (decision to decrease frequency)

->probability is fp11+fp21 (decision to increase frequency)

l_1>fp

If l_1−fp>2

->probability is 1 (decision to increase frequency)

If l_1−fp>1 ^ l_1−fp<=2

->probability is fp12 (decision for no change in frequency)

->probability is fp1+fp11 (decision to increase frequency)

If $l_1 - fp == 1 \wedge l_1 == p1$

-> probability is fp1+fp12 (decision to increase frequency)

->probability is fp11 (decision of no change in frequency)

Else

-> probability is fp1 (decision to increase frequency)

->probability is fp11 (decision of no change in frequency)

-> probability is fp12 (decision to decrease frequency)

$l_1 < fp$

If $fp < p1 - 1$

-> probability is 1 (decision to decrease frequency)

If $fp == p1 - 1$

->probability is fp1 +fp11(decision to decrease frequency)

->probability is fp12 (decision to increase frequency)

If $fp == p1$

->probability is fp1 (decision to decrease frequency)

->probability is fp11+fp12 (decision to increase frequency)

If $\left|\frac{\Delta T_j}{T_{del}}\right| > (1-f) \quad \wedge \left|\frac{\Delta T_j}{T_{del}}\right| > f \wedge \left|\frac{\Delta T_j}{T_{del}}\right| < 1$

then probability of fp (fp1) = $0.5*(1-\frac{\Delta T_j}{T_{del}}+f)$

probability of fp+1 (fp11)= $0.5*(2-\frac{\Delta T_j}{T_{del}}-f)$

probability of fp−1 (fp21) = $0.5*(\frac{\Delta T_j}{T_{del}}-f)$

probability of fp+2 (fp12) = $0.5*(\frac{\Delta T_j}{T_{del}}+f-1)$

Now,

l_1== fp -> probability is fp1 (decision no change in frequency)

->If $l_1 < p1-1 \wedge l_1 \sim 0$

->probability is fp11+fp12 (decision to decrease frequency)

->probability is fp21 (decision to increase frequency)

->If l_1==p1−1

->probability is fp11 (decision to decrease frequency)

->probability is fp12+fp21 (decision to increase frequency)

->If l_1==p1

->probability is 0 (decision to decrease frequency)

->probability is fp11+fp12+fp21 (decision to increase frequency)

->If l_1==0

->probability is fp11+fp12+fp21 (decision to decrease frequency)

->probability is 0 (decision to increase frequency)

$l_1 > fp$

If $l_1 - fp > 2 \wedge fp > 0$

->probability is 1 (decision to increase frequency)

If $l_1 - fp > 2 \wedge fp == 0$

->probability is fp21 (decision to decrease frequency; it is assumed $l_1 - fp < p1$)

->probability is fp1+fp11+fp12 (decision to increase frequency)

If $l_1 - fp > 1 \wedge l_1 - fp <= 2 \wedge fp > 0$

-> probability is fp1+fp11+fp21 (decision to increase frequency)

->probability is fp12 (decision of no change in frequency)

If $l_1 - fp > 1 \wedge l_1 - fp <= 2 \wedge fp == 0$

-> probability is fp1+fp11 (decision to increase frequency)

->probability is fp12 (decision of no change in frequency)

->probability is fp21 (decision to decrease frequency)

If $l_1 - fp == 1$

If $l_1 == p1$

-> probability is fp1+ fp21+fp12 (decision to increase frequency)

->probability is fp11 (decision of no change in frequency)

If $l_1 == 1$

-> probability is fp1 (decision to increase frequency)

->probability is fp11 (decision of no change in frequency)

->probability is fp21+fp12 (decision to decrease frequency)

Else

-> probability is fp1+fp21 (decision to increase frequency)

->probability is fp11 (decision of no change in frequency)

->probability is fp12 (decision to decrease frequency)

If $l_1 < fp$

If $fp - l_1 == 1 \wedge fp < p1 - 1$

-> probability is fp1+fp11+fp12 (decision to decrease frequency)

->probability is fp21 (decision for no change)

If $fp - l_1 == 1 \wedge fp == p1 - 1$

->probability is fp1+fp11 (decision to decrease frequency)

->probability is fp12 (decision to increase frequency)

->probability is fp21 (no change)

If $fp - l_1 == 1 \wedge fp == p1$

->probability is fp1 (decision to decrease frequency)

->probability is fp11+fp12 (decision to increase frequency)

->probability is fp21 (no change)

If $fp - l_1 > 1 \wedge fp < p1 - 1$

-> probability is 1(decision to decrease frequency)

If $fp - l_1 > 1 \wedge fp == p1 - 1$

->probability is fp1+fp21+fp11 (decision to decrease frequency)

->probability is fp12 (decision to increase frequency; assumed $fp - l_1 < p1$)

If $fp - l_1 > 1 \wedge fp == p1$

->probability is fp1+fp21 (decision to decrease frequency)

->probability is fp11+fp1 (decision to increase frequency; assumed $fp - l_1 < p1$)

2. <u>Probability of convergence plot (theoretical and simulated) for other frequencies when sampler delay variation is present (From Chapter 3 pp. 90)</u>

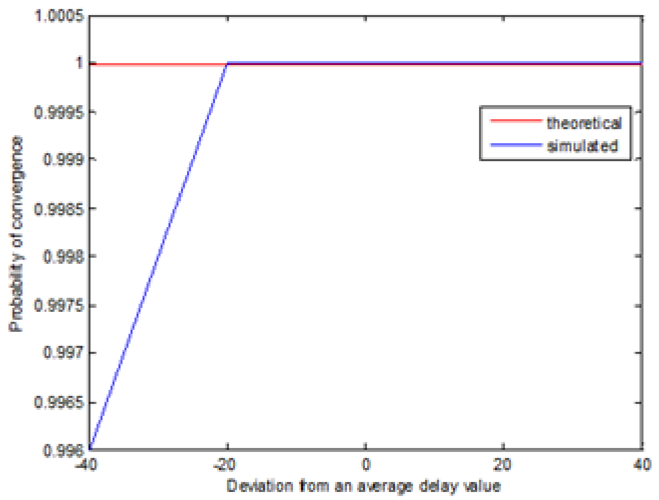

Fig. 1 Probability of frequency convergence plot (theoretical and simulated) for different sampling delay deviations from the nominal value(in ps) for frequency of 402.1 MHz (accuracy 400 ppm)

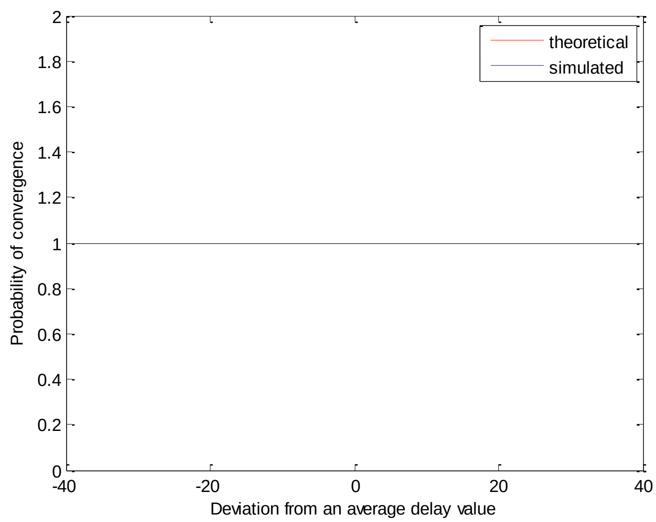

Fig. 2 Probability of frequency convergence plot (theoretical and simulated) for different sampling delay deviations from the nominal value(in ps) for frequency of 403.5 MHz (accuracy 400 ppm)

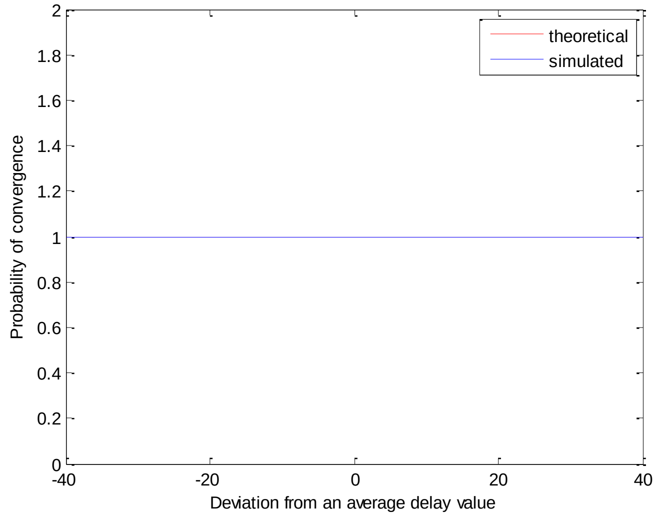

Fig. 3 Probability of frequency convergence plot (theoretical and simulated) for different sampling delay deviations from the nominal value(in ps) for frequency of 403.9 MHz (accuracy 400 ppm)

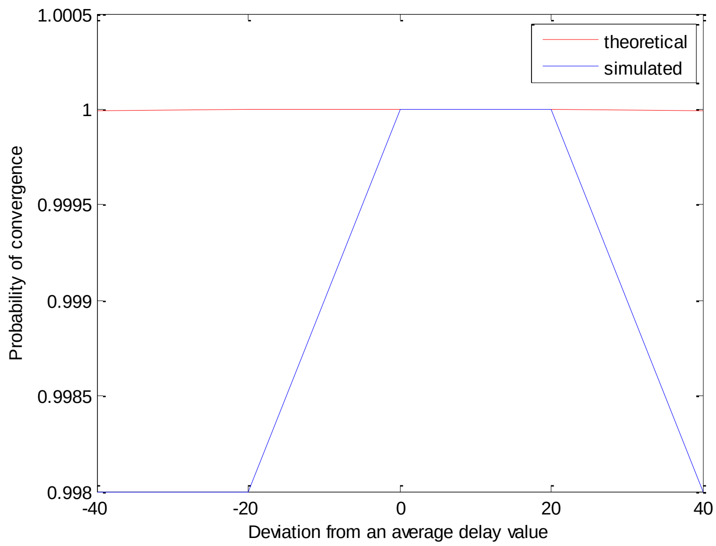

Fig. 4 Probability of frequency convergence plot (theoretical and simulated) for different sampling delay deviations from the nominal value(in ps) for frequency of 404.3 MHz (accuracy 400 ppm)

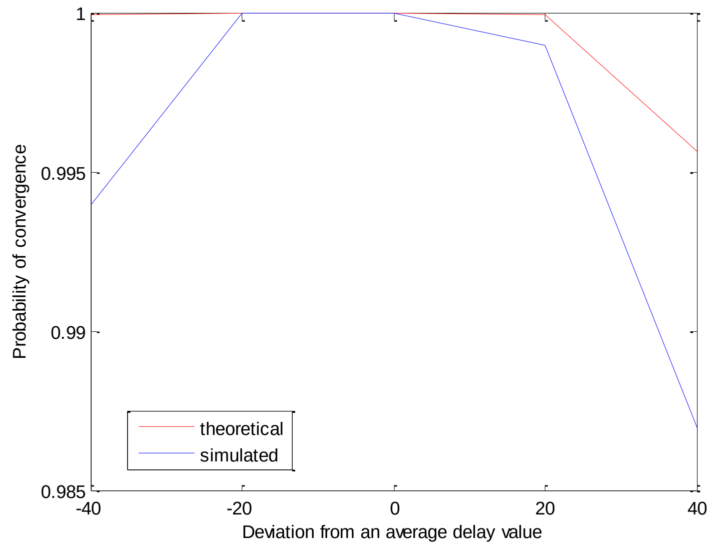

Fig. 5 Probability of frequency convergence plot (theoretical and simulated) for different sampling delay deviations from the nominal value(in ps) for frequency of 404.7 MHz (accuracy 400 ppm)

From Fig. 1-5, it is seen that close match is obtained between theory and simulation in accordance with Fig. 28 in thesis.

3. Phase noise plot of the oscillator at 400 MHz at different process corners

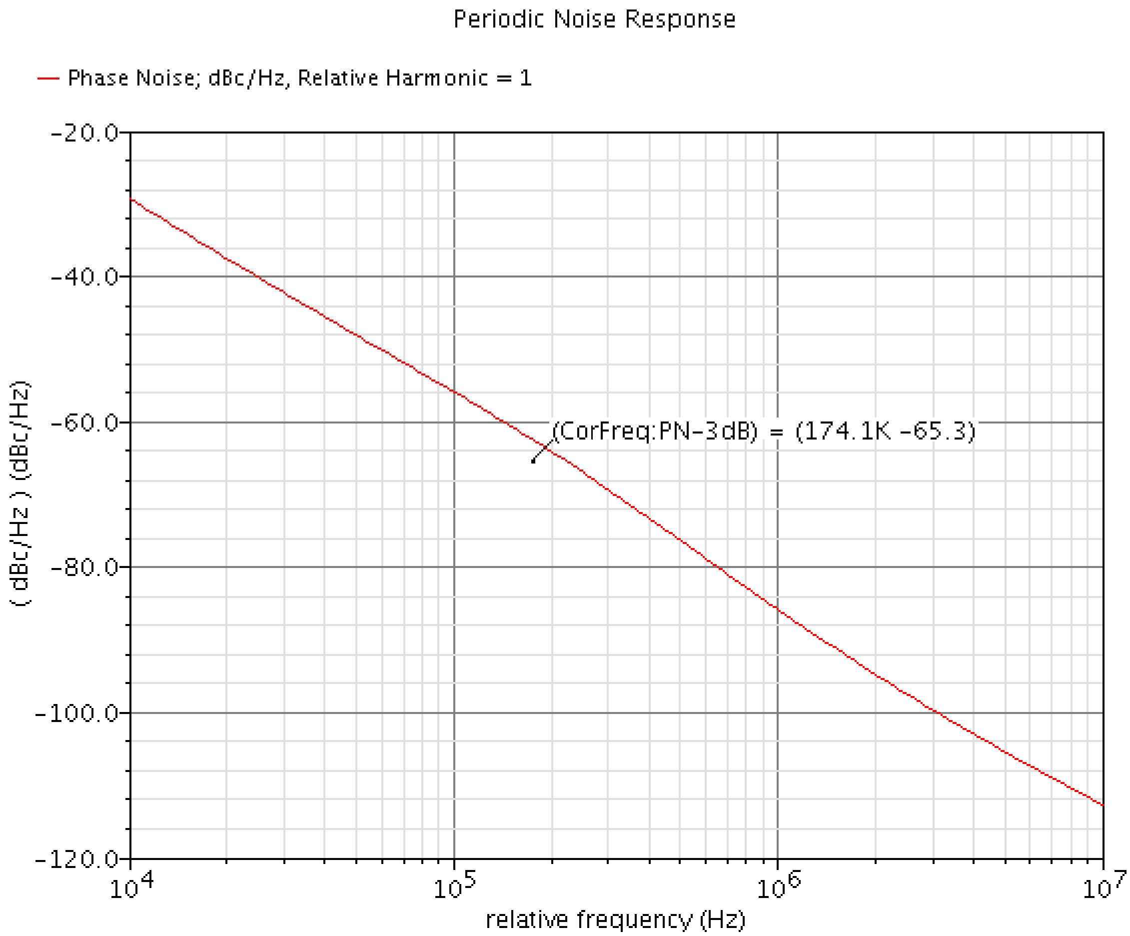

Fig. 6 Phase noise of 400 MHz oscillator at fast corner

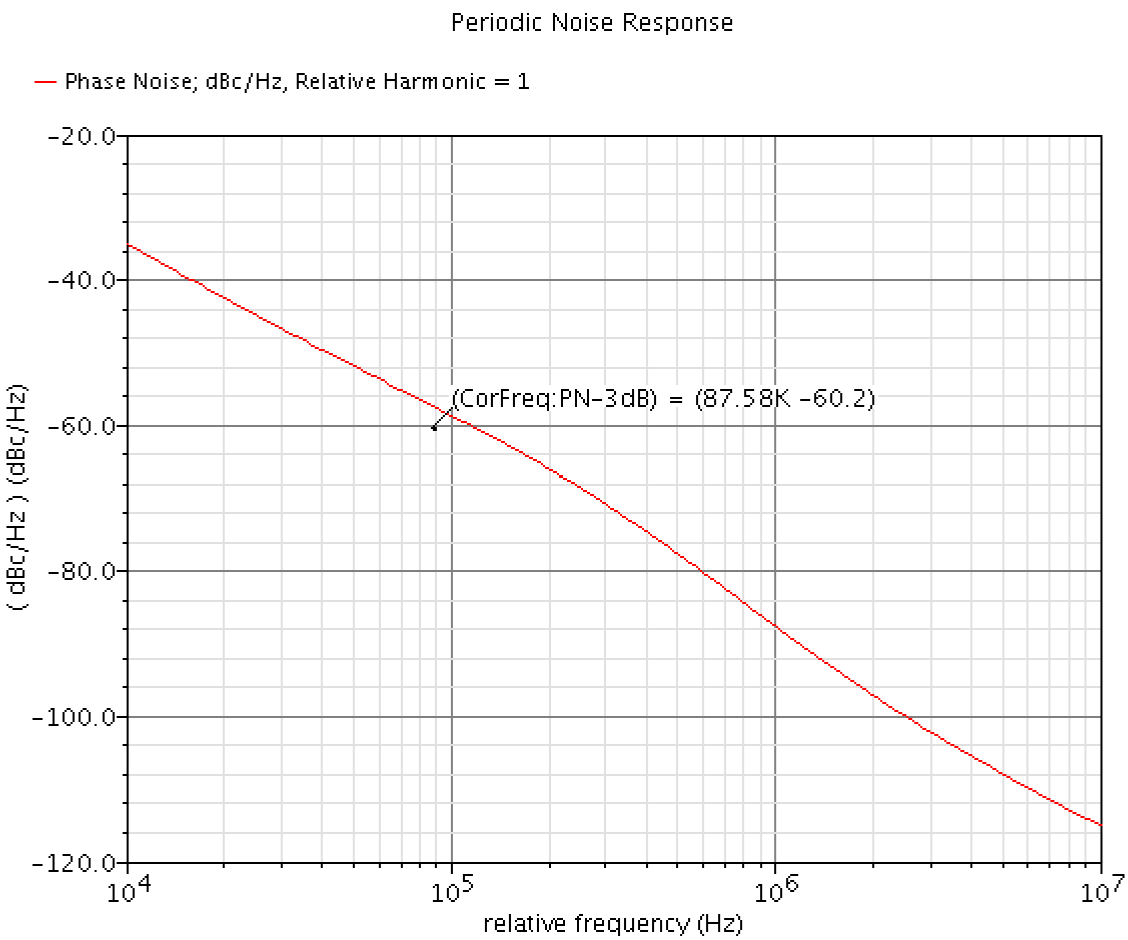

Fig. 7 Phase noise of 400 MHz oscillator at slow corner

From Fig. 6 and Fig. 7, it is seen that the phase noise at 1 MHz offset is almost unchanged. The $1/f^3$ corner frequency at fast corner is almost doubled which can be reduced by increasing the slew rate. In any ways, its effect will be minimal.