Appendix I. Calculations for phase noise for 100 MHz crystal oscillator.

Phase noise Plot based on analytical formulae see [1]
After defining all the values the phase noise can be correctly predicted

$C1 := 15.6\ pF$ $qcharge := 1.602 \cdot 10^{-19} \cdot coul$ $y11 := (0.00084 - 0.000158j) \cdot mho$

$C2 := 12.5\ pF$ $R := 0.2 \cdot \Omega$ $y21 := (-0.0105 - 0.00084j) \cdot mho$

$Vcc := 10$ $L := 1600 \cdot 10^{-9} \cdot henry$ $Ic := 28 \cdot mA$

$i := 0 .. 7$ $p := 1.45$ $q := 1.05$ $Ib := 220 \cdot \mu A$ $Qmac := 377$ $af := 2$ $Q := 200000$

$fc := 100 \cdot MHz$ $wc := 2 \cdot \pi \cdot fc$ $nfdB := 7.7$ $kf := 1 \cdot 10^{-10}$

$fo_i := 10^i \cdot Hz$ $wo_i := 2 \cdot \pi \cdot fo_i$ $PoutdB := 14$ $KT := 4.143 \cdot 10^{-21} \cdot J$

$$y := \frac{C1}{C2} \qquad Bl_i := (wo_i)^2 \cdot L^2 \cdot Vcc^2$$

$$kconstant := \frac{KT \cdot R}{wc^2 \cdot C2^2} \qquad b := \frac{|y21| \cdot y^p}{|y11|} \qquad gm := |y21| \cdot y^q \qquad k0_i := \frac{kconstant}{Bl_i}$$

$$klconstant_i := qcharge \cdot Ic \cdot gm^2 + \frac{kf \cdot Ib^{af} \cdot gm^2}{wo_i} \qquad t2_i := k0_i \cdot \frac{(1+y)^2}{y^2}$$

$$kl_i = \frac{klconstant_i}{wc^2 \cdot Bl_i} \qquad k3_i = wc^2 \cdot gm^2 \qquad k2_i = wc^4 \cdot b^2$$

$$k_i := \frac{k3_i}{k2_i \cdot C2^2} \qquad t1_i := \left[\left(\frac{b^2}{gm^3}\right)^2 \cdot \frac{(k_i)^3 \cdot kl_i \cdot (wc)^2}{(y^2 + k_i)}\right] \cdot \frac{(1+y)^2}{y^2}$$

$$t_i = t1_i + t2_i$$

$$m_i := 10 \cdot \log\left[t_i \cdot (kg^{-2} \cdot m^{-4} \cdot s^5 \cdot A^2) \cdot \frac{Qmac^2}{Q^2}\right]$$

$$L_i := if\left[m_i < (-(177 + PoutdB - nfdB)), (-(177 + PoutdB - nfdB)), m_i\right]$$

m_i

-88.035
-117.814
-146.064
-169.714
-190.327
-210.394
-230.4
-250.401

fo_i

$1 \cdot s^{-1}$
$10 \cdot s^{-1}$
$100 \cdot s^{-1}$
$1 \cdot 10^3 \cdot s^{-1}$
$1 \cdot 10^4 \cdot s^{-1}$
$1 \cdot 10^5 \cdot s^{-1}$
$1 \cdot 10^6 \cdot s^{-1}$
$1 \cdot 10^7 \cdot s^{-1}$

L_i

-88.035
-117.814
-146.064
-169.714
-183.3
-183.3
-183.3
-183.3