Department of Electronic & Telecommunication Engineering
University of Moratuwa

EN4431 - ANALOG IC DESIGN

FULLY DIFFERENTIAL 3GHZ LC-VCO SIMULATION TO ACHIEVE SPECIFICATIONS

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ABSTRACT

This report presents the design, simulation, and analysis of a fully differential 3GHz LC voltage-controlled oscillator (VCO) using a 45nm CMOS technology. The project aims to achieve low power consumption, a wide tuning range, and low phase noise, which are essential for high-frequency clock generation and distribution in modern processing systems. The design begins with the creation of a basic cross-coupled NMOS LC oscillator and progresses to incorporate MOS varactors for continuous tuning and switched capacitors for discrete tuning. A significant improvement is made by adding a cross-coupled PMOS device stage, resulting in a fully differential VCO with increased output swing and better performance. Transient and parametric simulations are conducted to validate the design, showing a 3GHz oscillation frequency with a tuning range of over 20% (2.7 GHz to 3.3 GHz). The frequency of oscillation as a function of the control voltage is also analyzed. Additionally, the report discusses potential improvements for achieving a more stable and wider tuning range. Results from the simulation, including frequency spectrum analysis and phase noise, are provided, along with a discussion on how the design can be optimized further for better performance. The circuit netlist is included in the appendix for reference.This is bassed on the module EN4431 - Analog IC Design, Which is conducted by Dr. Thayaparan Subramaniam.

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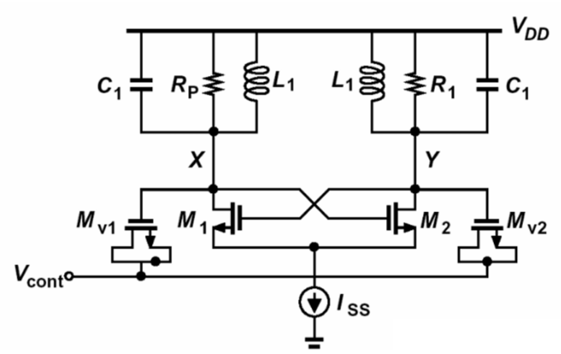
1 INTRODUCTION

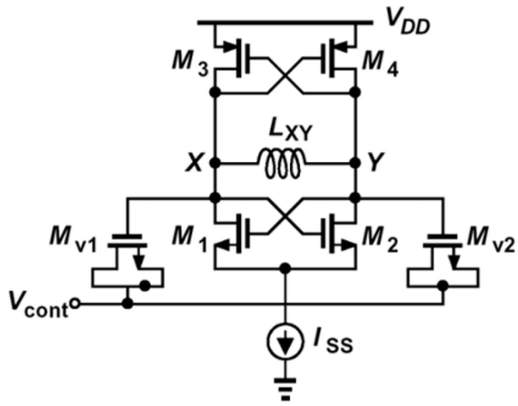
Voltage-Controlled Oscillators (VCOs) are essential components in modern communication systems, phase-locked loops (PLLs), and frequency synthesizers. They generate a periodic output signal whose frequency can be tuned by varying an external control voltage. Among the various VCO topologies, LC-based oscillators offer superior phase noise performance, making them ideal for high-frequency applications.
This report focuses on the analysis and design of two different LC-based VCO architectures:

* **Type I Cross-Coupled LC VCO** – A single-ended VCO with MOS varactors, which provides a compact and efficient design suitable for low-power applications.
* **Type IV Cross-Coupled Differential LC VCO** – A differential architecture incorporating a symmetric inductor and MOS varactors to achieve improved phase noise and higher tuning linearity.

The VCOs are designed in a 45nm CMOS process, operating with a 1V supply voltage and targeting an oscillation frequency of 3GHz. The design must achieve a tuning range of at least 20 (2.7GHz – 3.3GHz) while ensuring optimal performance metrics such as gain (K_{VCO}), quality factor (Q), and output swing.
This report provides a detailed step-by-step analysis of the key design parameters, including inductance, capacitance, and bias current selection. Furthermore, it presents calculations for both architectures to verify their compliance with the given specifications.



(a) A type I CC LC voltage-controlled oscillator (VCO) with MOS varactors



(b) A type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

Figure 1 — LC-VCO

2 DESIGN METHODOLOGY AND DETAILS OF THE CALCULATION AND DEVICE SIZES OF A TYPE I CC LC VOLTAGE-CONTROLLED OSCILLATOR (VCO) WITH MOS VARACTORS

2.1 VCO Design Specifications

VCO Design Specifications

Parameter	**Specification**
Technology Node	45 nm CMOS
Supply Voltage V_{DD}	1 V
Nominal Input Common-Mode Voltage $V_{DD}/2$	0.5 V
Bias Current I_{bias}	10 μA (adjustable)
Oscillation Frequency f_0	3 GHz
Tuning Range	$>$ 20% (2.7 GHz – 3.3 GHz)
VCO Gain K_{VCO}	To be determined (? GHz/V)
Varactor Type	MOS Varactor
Inductor Configuration	Symmetric Inductor (for Type IV VCO)

2.2 A type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

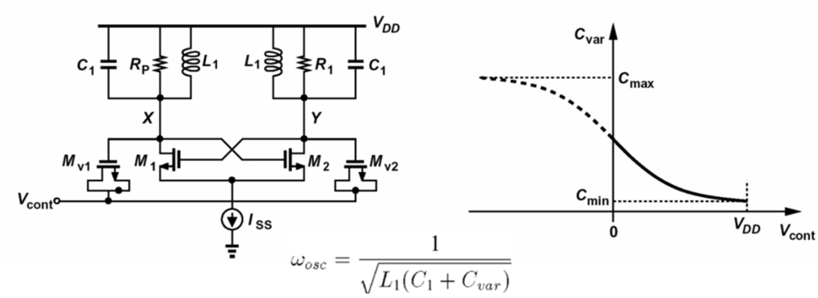


Figure 2 — A type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

This voltage-controlled oscillator (VCO) works by generating a continuous oscillating signal with a frequency that can be adjusted using a control voltage (V_{cont}). The **LC tank circuit**, made up of an inductor (L_1) and capacitors ($C_1 + C_{\text{var}}$), determines the oscillation frequency. The **cross-coupled transistors** (M_1 and M_2) provide **positive feedback**, which compensates for losses and keeps the oscillations going.
The **MOS varactors** (M_{v1} and M_{v2}) act as voltage-controlled capacitors, where their capacitance (C_{var}) changes based on V_{cont}. When V_{cont} increases, C_{var} decreases, making the frequency higher. When V_{cont} decreases, C_{var} increases, lowering the frequency.
The **current source** (I_{SS}) provides a steady current to bias the transistors and control the oscillation amplitude. **Resistors** (R_1 and R_p) represent circuit losses, which can affect efficiency and phase noise. This VCO is commonly used in **wireless communication, radio systems, and phase-locked loops (PLLs)** because it provides a stable and tunable frequency signal.

2.3 Pre-Calculations

2.3.1 Transistor Parameters from Cadence Simulation

The following parameters are obtained from Cadence simulation for NMOS and PMOS design with channel length $L = 1\mu$m (to minimize the channel length modulation) and width $W = 10\mu$m for both NMOS and PMOS transistors. The supply voltage is $V_{DD} = 1$V, and the bias current is $I_o = 10\mu$A.
Referefnce : - How to find process parameter of any technology node

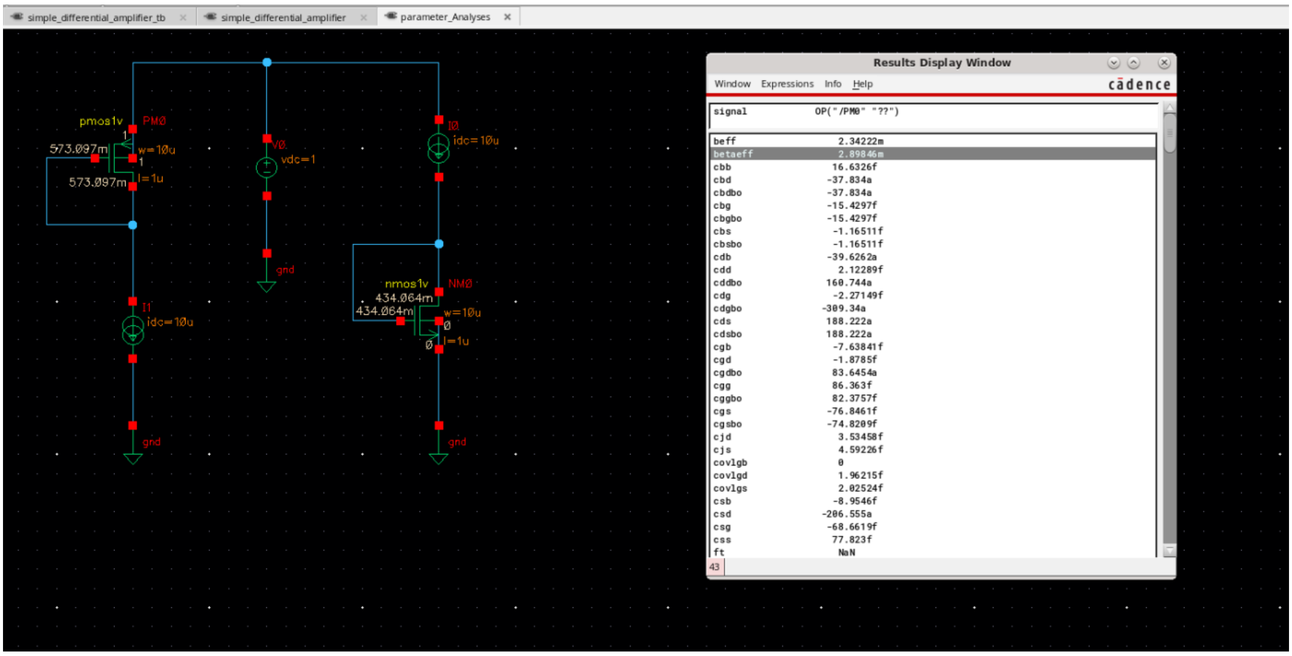


Figure 3 — Transistor Parameters from Cadence Simulation

NMOS Parameters

* Effective Beta ($\beta_{\text{eff, NMOS}}$): 2.89846 mA/V^2 (rounded to 3 mA/V^2)
* Threshold Voltage ($V_{\text{th, NMOS}}$): 397.975 mV (rounded to 0.4 V)

PMOS Parameters

* Effective Beta ($\beta_{\text{eff, PMOS}}$): 2.89846 mA/V^2 (rounded to 3 mA/V^2)
* Threshold Voltage ($V_{\text{th, PMOS}}$): -334.497 mV (rounded to -0.3 V)

2.3.2 Calculation of μC_{ox} for NMOS and PMOS

The effective beta (β_{eff}) is connected to the process transconductance parameter μC_{ox} through the equation:

$$\beta_{\text{eff}} = \mu C_{ox} \frac{W}{L}$$

where $W = 10$ μm, $L = 1$ μm, and the aspect ratio $\frac{W}{L} = 10$. This relationship is based on the effective beta values obtained from the Cadence simulation results.

NMOS $\mu_n C_{ox}$ Calculation

$$\beta_{\text{eff, NMOS}} \approx 3 \text{ mA/V}^2$$
$$\mu_n C_{ox} = \frac{\beta_{\text{eff, NMOS}}}{\frac{W}{L}}$$
$$\mu_n C_{ox} = \frac{3 \text{ mA/V}^2}{10}$$
$$\mu_n C_{ox} = 0.3 \text{ mA/V}^2$$

PMOS $\mu_p C_{ox}$ Calculation

$$\beta_{\text{eff, PMOS}} \approx 3 \text{ mA/V}^2$$
$$\mu_p C_{ox} = \frac{\beta_{\text{eff, PMOS}}}{\frac{W}{L}}$$
$$\mu_p C_{ox} = \frac{3 \text{ mA/V}^2}{10}$$
$$\mu_p C_{ox} = 0.3 \text{ mA/V}^2$$

2.4 Details of the Calculation and Device Sizes

2.4.1 LC Tank Design

The oscillation frequency is determined by the LC tank:

$$\omega_0 = \frac{1}{\sqrt{L_{\text{tank}} C_{\text{tank}}}} \tag{1}$$

where L_{tank} is a non-ideal inductor with a quality factor (Q) of 10, and C_{tank} includes the varactor capacitance (C_{var}) and parasitic capacitances (C_{par}) from transistors and the inductor. Rearranging for C_{tank}:

$$C_{\text{tank}} = \frac{1}{\omega_0^2 L_{\text{tank}}} \tag{2}$$

For $f_0 = 3GHz$:

$$\omega_0 = 2\pi \times 3 \times 10^9 \approx 1.885 \times 10^{10} \text{ rad/s} \tag{3}$$

Initially, I chose the L = 1nH, but in the later steps it will produce negative capacitance that's why I chose L = nH. Given $L_{\text{tank}} = 2nH$:

$$C_{\text{tank}} = \frac{1}{(1.885 \times 10^{10})^2 \times 2 \times 10^{-9}} \approx 1.407pF \tag{4}$$

2.4.2 Tuning Range 20%(2.7 GHz to 3.3 GHz)

$$C_{\text{tank,max}} = \frac{1}{(2\pi \times 2.7 \times 10^9)^2 \times 2 \times 10^{-9}} \approx 1.74pF \tag{5}$$
$$C_{\text{tank,min}} = \frac{1}{(2\pi \times 3.3 \times 10^9)^2 \times 2 \times 10^{-9}} \approx 1.16pF \tag{6}$$

Assuming parasitic capacitance $C_{\text{par}} \approx 10fF$: we are not using external capacitance to replace $C_{1,2}$. So we can use $C_{1,2} = 500fF$

$$C_{\text{var}} = C_{\text{tank}} - C_{\text{par}} - 2 \times C_{1,2} \tag{7}$$

$$C_{\text{var,min}} = 1.74 - 0.01 - 2 \times 0.5 = 0.73\text{fF}, \qquad \text{at } f_{\max} = 3.3 \text{ GHz}, \tag{8}$$
$$C_{\text{var,max}} = 1.16 - 0.01 - 2 \times 0.5 = 0.15\text{fF}, \qquad \text{at } f_{\min} = 2.7 \text{ GHz}. \tag{9}$$

2.4.3 Varactor Size calculation(M_{V1}, M_{V2})

Each varactor contributes $C_{\text{var}}/2$ since they are in parallel:

$$C_{\text{var,per}} = \frac{C_{\text{var}}}{2} \tag{10}$$

$$C_{\text{var,per,max}} = \frac{0.73}{2} \approx 365fF \tag{11}$$
$$C_{\text{var,per,min}} = \frac{0.15}{2} \approx 75fF \tag{12}$$

Capacitance formula:

$$C_{\text{var}} = \varepsilon_{\text{ox}} \frac{W \cdot L}{t_{\text{ox}}} \tag{13}$$

Where :

* $\varepsilon_{\text{ox}} \approx 3.9 \times 8.85 \times 10^{-12}$ F/m (for SiO_2)
* $t_{\text{ox}} \approx 1nm$ (typical for 45nm process)
* $W \cdot L$ is the gate area

$$C_{\text{var}} = \frac{3.45 \times 10^{-11} \cdot W \cdot L}{1 \times 10^{-9}} = 3.45 \times 10^{-2} \cdot W \cdot L \tag{14}$$

Solving for $W \cdot L$:

$$C_{\text{var,per,min}} = 365fF \tag{15}$$

$$W \cdot L = \frac{365 \times 10^{-15}}{3.45 \times 10^{-2}} = 105.79 \times 10^{-13} \approx 10.6{\times}10^{-12} m^2 \tag{16}$$

Setting $L = 1\mu m$:

$$W = \frac{10.6 \times 10^{-12} m^2}{1\mu m^2} = 10\mu m \tag{17}$$

Thus, Varactor Dimensions: $W = 10\mu\text{m}$, $L = 1\mu\text{m}$.

2.4.4 Calculation of Tank Loss R_p

The tank loss resistance is modelled by R_p with a quality factor of inductor Q=10:

$$R_p = Q \cdot \omega_0 \cdot L_{\text{tank}} \tag{18}$$

$$R_p = 10 \times (1.885 \times 10^{10}) \times (2 \times 10^{-9}) \approx 377\Omega \tag{19}$$

2.4.5 Calculation of Transistor Size (M_1, M_2)

The cross-coupled NMOS pair provides a negative resistance, which is essential for sustaining oscillation in a circuit such as an oscillator. This negative resistance is approximated as:

$$R_{\text{neg}} \approx \frac{-2}{g_m} \tag{20}$$

Ensuring oscillation:

$$g_m R_p \geq 1 \Rightarrow g_m \geq \frac{1}{R_p} = \frac{1}{377} \approx 2.65mS \tag{21}$$

For design purposes and to include a safety margin, we set the requirement as:

$$g_m \geq 2.65mS \tag{22}$$

$$g_m > 2mS \tag{23}$$

The drain current I_D for a MOSFET in saturation is given by:

$$I_D = \frac{1}{2}\mu C_{\text{ox}} \frac{W}{L}(V_{GS} - V_t)^2 \tag{24}$$

Transconductance relation:

$$g_m = \mu C_{\text{ox}} \frac{W}{L}(V_{GS} - V_t) \tag{25}$$

Solving for I_D:

$$g_m^2 = 2\mu C_{\text{ox}} \frac{W}{L} I_D \tag{26}$$

$$I_D = \frac{g_m^2}{2\mu C_{\text{ox}} \frac{W}{L}} \tag{27}$$

Given $\mu C_{\text{ox}} \approx 0.3 \times 10^{-3}$ A/V^2 and $g_m \approx 2mS$:

$$I_D = \frac{(2 \times 10^{-3})^2}{2 \times 0.3 \times 10^{-3} \times 5} \approx 66.667\mu A \tag{28}$$

$$I_{SS} = 2I_D \approx 133.33\mu A \tag{29}$$

Setting $W/L = 100$:

$$M_1, M_2 : W = 5\mu m, L = 50\text{n}m \tag{30}$$

$$\tag{31}$$

2.5 Summary of Calculated Values

Summary of Calculated Values

Parameter	Approximated	Chosen	Unit
Length of $M_{1,2}$	50	50	nm
Width of $M_{1,2}$	5	5	μm
Length of varators $M_{v1,v2}$	1	2	μm
Width of varators $M_{v1,v2}$	10	5	μm
Inductance L_1	1	3	nH
Capacitance C_1	500	720	fF
Resistance R_p	500	470	ω
Bias current I_{bias}	133.33	800	μA
Control voltage V_{cont}	-	500	mV

Summary of Calculated Values of Transistors

Transistor	Length	Width	Unit
M_1	0.05	5	μm
M_2	0.05	5	μm
M_{V1}	1	10	μm
M_{V2}	1	10	μm

3 SIMULATION RESULTS FOR A TYPE I CC LC VOLTAGE-CONTROLLED OSCILLATOR (VCO) WITH MOS VARACTORS

3.1 A type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

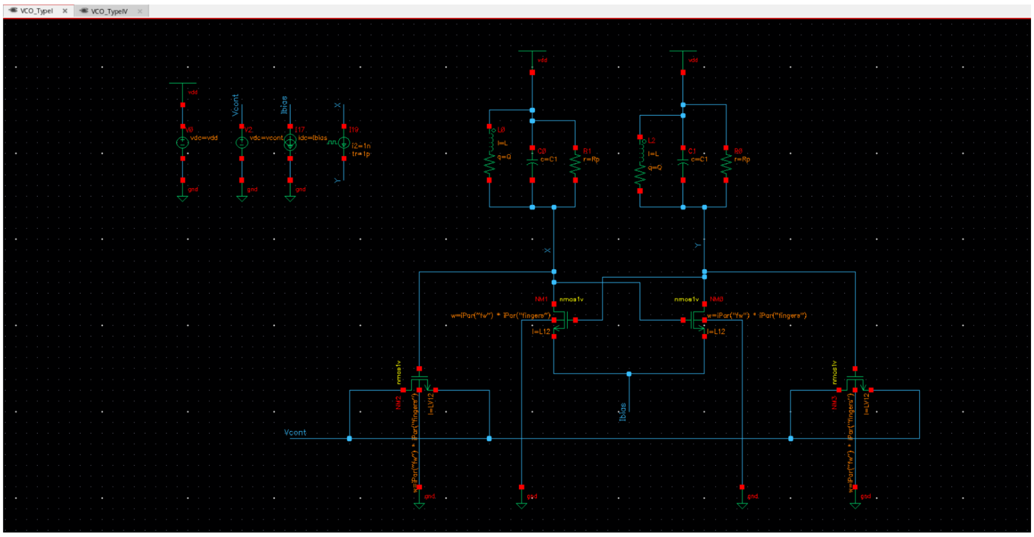


Figure 4 — Circuit diagram of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

To start the oscillation, a brief signal pulse was introduced with the following characteristics: Current 1 was set to 0 A, Current 2 to 1 mA, a rise time of 1 ps, a fall time of 1 ps, and a pulse width of 3 ps. All other parameters were configured based on the values specified in the table in the end of previous chapter.

3.1.1 Transient simulation results (up to 10 ns after steady state)

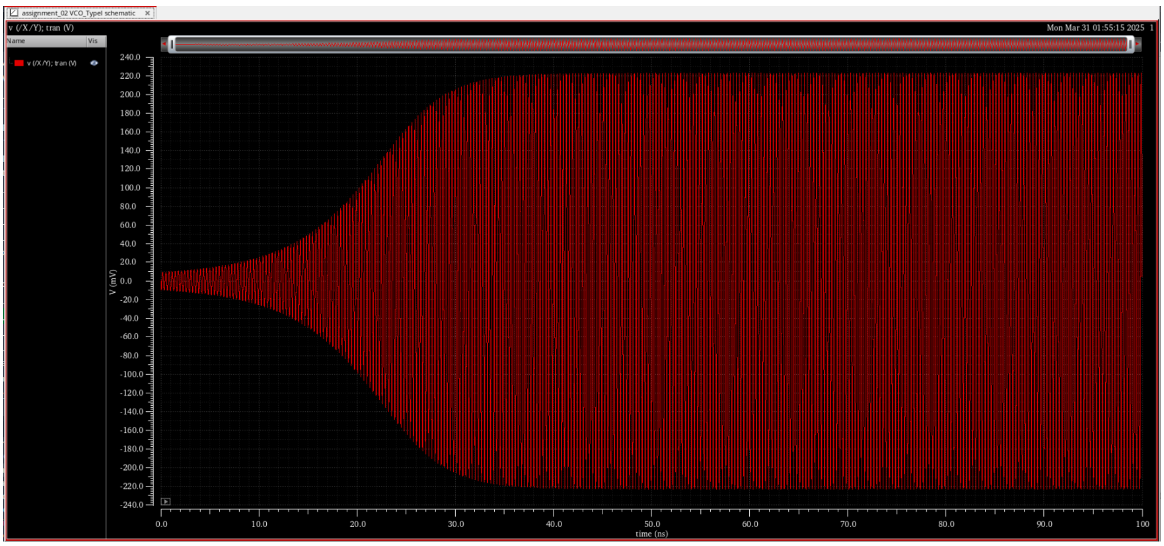


Figure 5 — A transient simulation of VX − VY was performed with Vcont set to 250mV, resulting in a peak-to-peak value of 446.1mV.a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

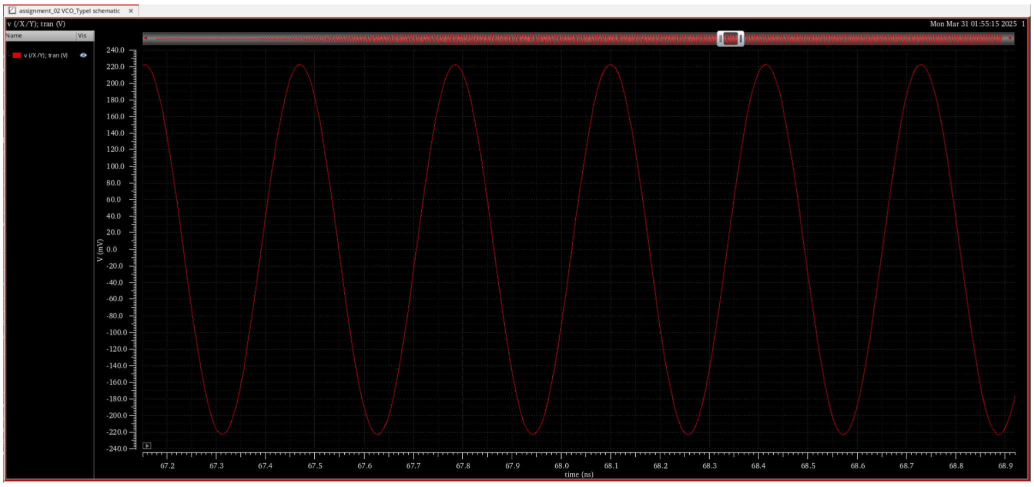


Figure 6 — Transient simulation of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

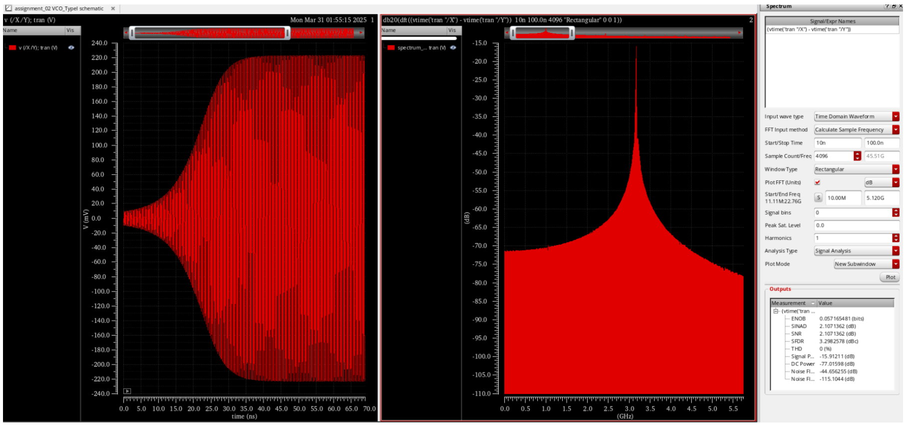


Figure 7 — A transient simulation of $V_X - V_Y$ was conducted with Vcont set to 500mV, and FFT analysis indicated an oscillation frequency of 3.048 GHz.

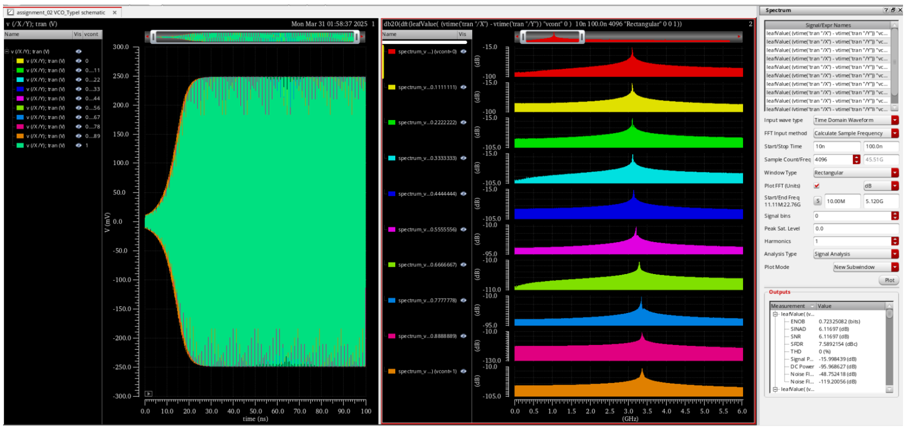


Figure 8 — Transient simulation of $V_X - V_Y$ and FFT analysis for $V_{cont} = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1V$ of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

3.1.2 Parametric simulation results of frequency of oscillation (f_0) vs. control voltage (V_{cont})

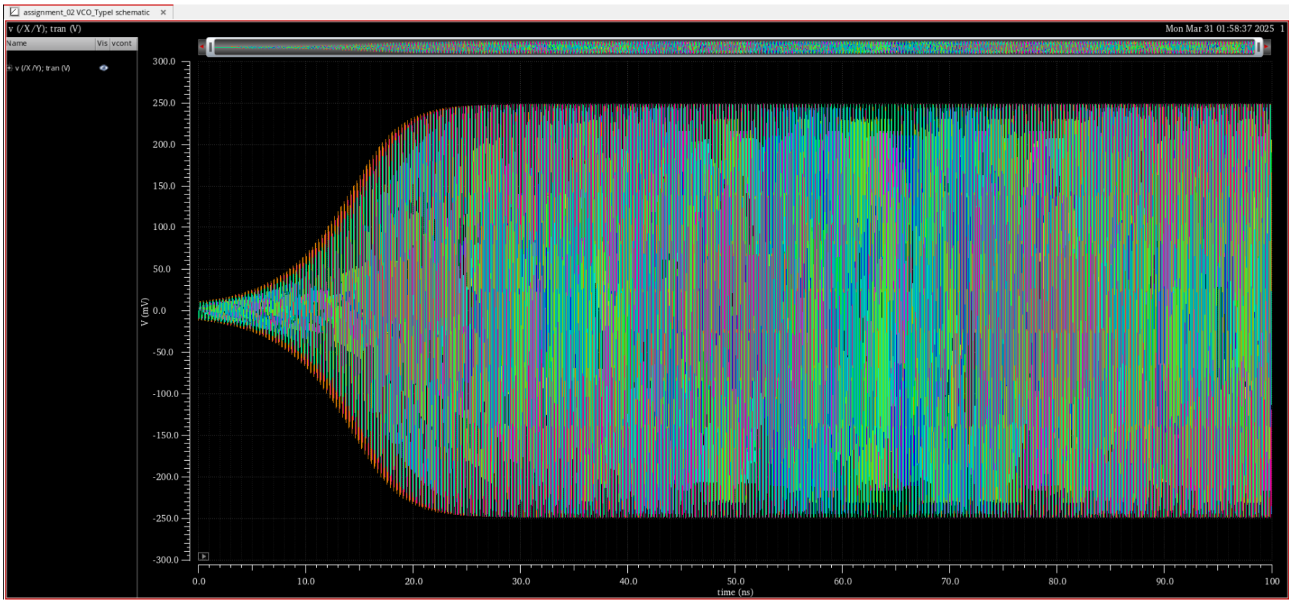


Figure 9 — Transient simulation of $V_X - V_Y$ and FFT analysis for $V_{cont} = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1V$ of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

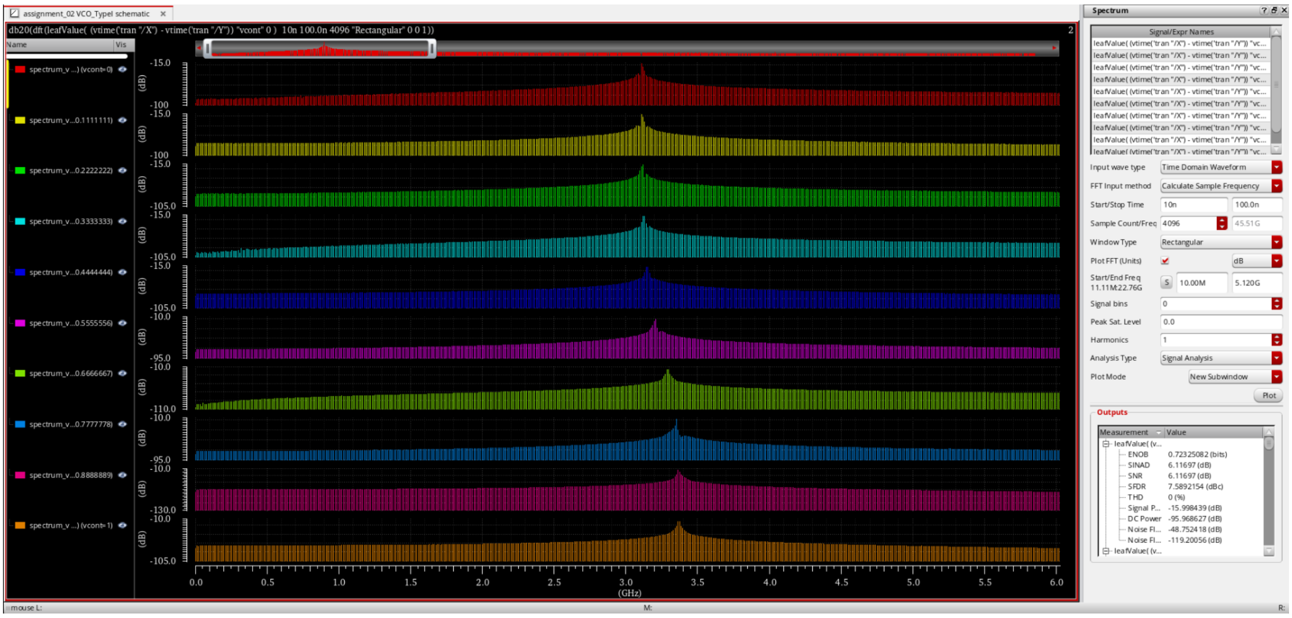


Figure 10 — Transient simulation of $V_X - V_Y$ and FFT analysis for $V_{cont} = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1V$ of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

The oscillation frequency f_{osc} increases with V_{cont} as a result of the VCO's positive gain.

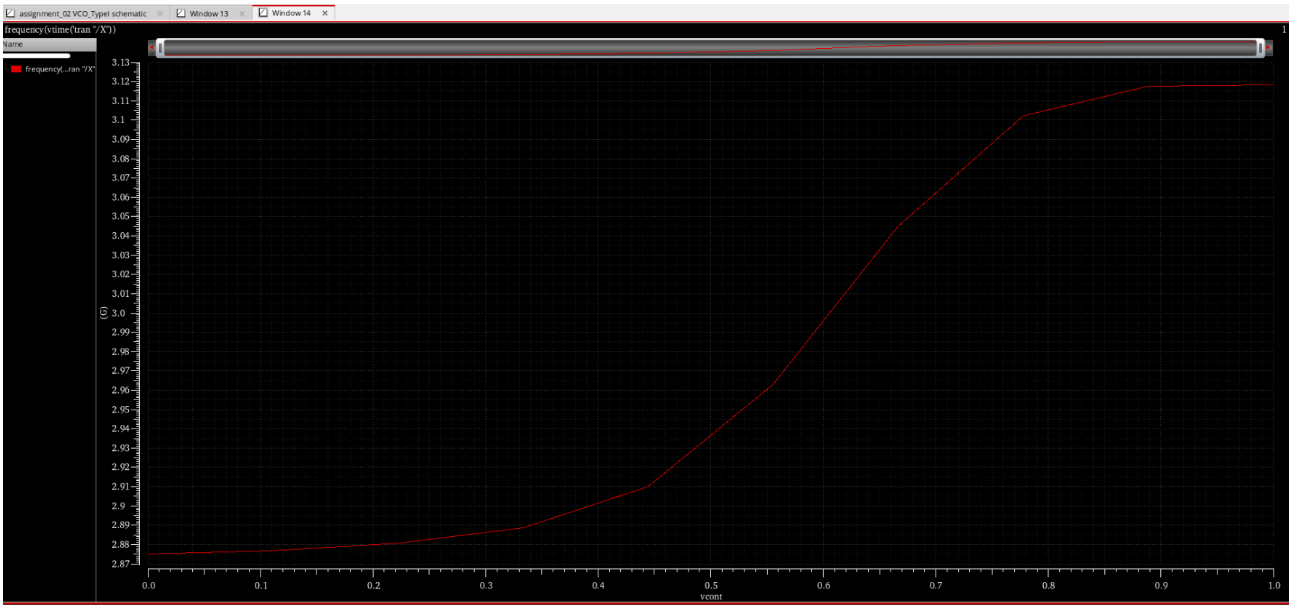


Figure 11 — The relationship between the oscillation frequency (f_0) and the control voltage (Vcont) of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

3.1.3 Periodic steady-state (PSS) simulation

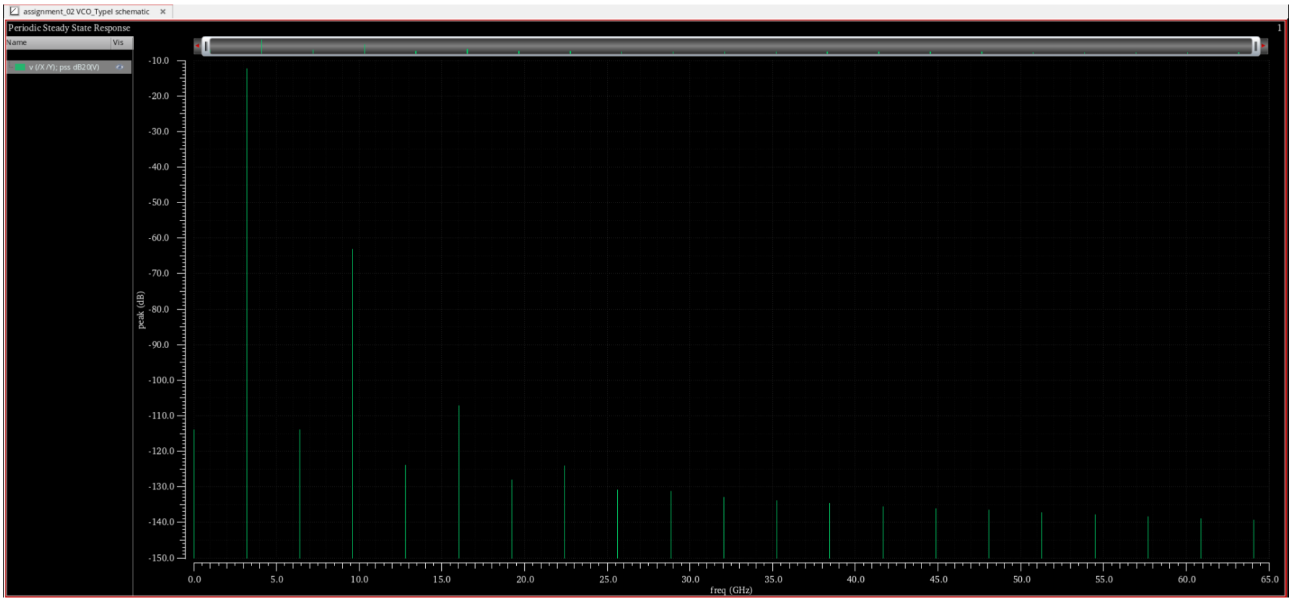


Figure 12 — A PSS simulation of VX − VY was performed at Vcont = 500mV, revealing a first harmonic frequency of 3.06 GHz of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

3.1.4 Phase noise (PS) simulation results.

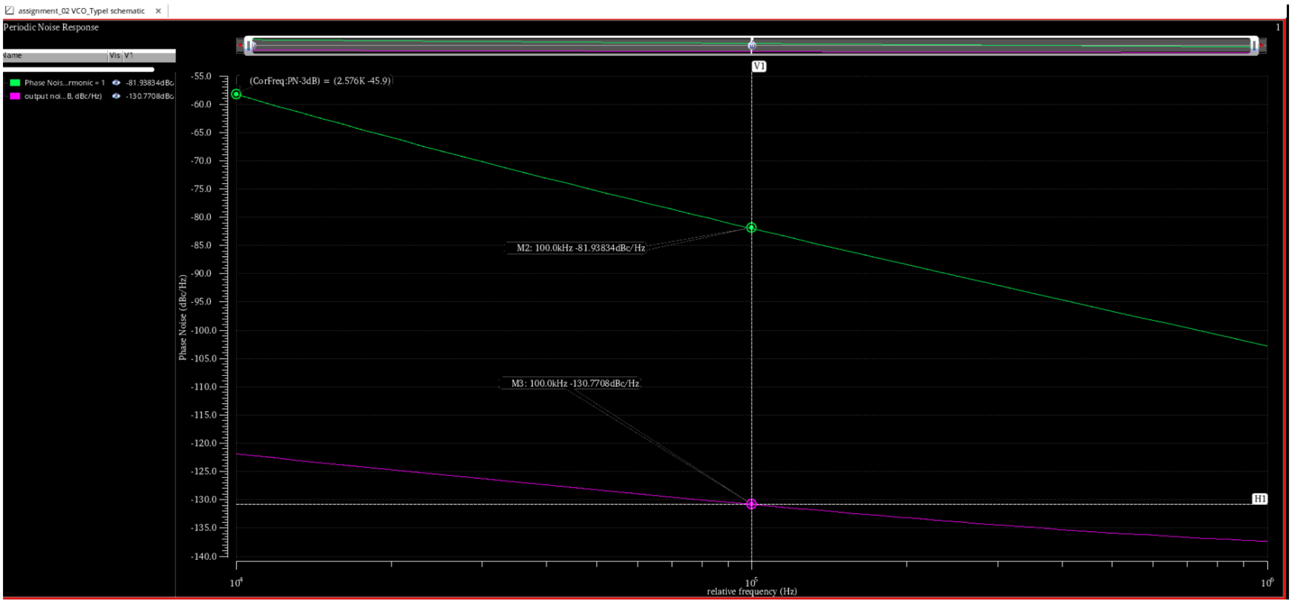


Figure 13 — PSS simulation results: The green curve represents Phase Modulation (PM), while the purple curve corresponds to Amplitude Modulation (AM) of a type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

3.2 Discussion on Type IV Fully Differential CC LC-VCO

3.2.1 Tuning Range

* **Center Frequency:**

$$f_{\text{center}} = \frac{f_{\max} + f_{\min}}{2} = \frac{3.117 + 2.875}{2} = 2.996 \text{ GHz} \tag{32}$$

* **Total Tuning Range:**

$$\frac{f_{\max} - f_{\min}}{f_{\text{center}}} \times 100\% = \frac{3.117 - 2.875}{2.996} \times 100\% = 8.077\% \tag{33}$$

* **Frequency Deviation:**

$$\pm 4.03\%, \text{ so the frequency spans } 2.996 \pm (0.0403 \times 2.996) = 2.9775 \pm 0.121 \text{ GHz} \tag{34}$$

* The wide tuning range is achieved through MOS varactors' capacitance swing and a symmetric inductor, ensuring balanced operation.

3.2.2 VCO Gain (K_{VCO})

* Defined as:

$$K_{VCO} = \frac{\Delta f}{\Delta V_{\text{cont}}}, \quad \text{where} \quad \Delta f \propto \frac{1}{L(C_{\text{var}}(V_{\text{cont}}))} \tag{35}$$

* Using two selected points from the f_0 vs. V_{cont} curve:

– At $V_{\text{cont}} = 542.82$ mV, $f = 3.1938$ GHz.
– At $V_{\text{cont}} = 720.91$ mV, $f = 3.3198$ GHz.

* The gradient calculation:

$$K_{VCO} = \frac{f_2 - f_1}{V_{\text{cont}_2} - V_{\text{cont}_1}} = \frac{3.3198 - 3.1938}{0.72091 - 0.54282} = 0.7075 \text{ GHz/V} \tag{36}$$

* Since $K_{VCO} > 0$, the VCO exhibits positive gain.

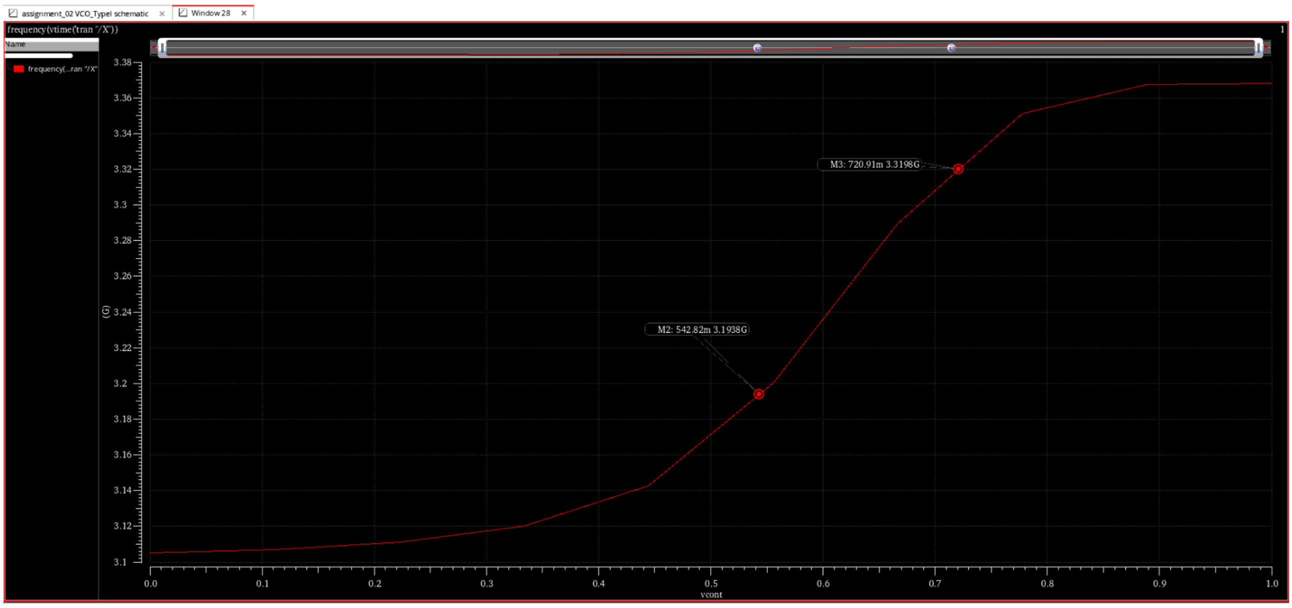


Figure 14 — Calculation of K_{VCO} from the V_{cont} vs. f_0 curve.

3.2.3 Output Voltage Swing

* The maximum swing reaches approximately 446.1 mV, which is nearly half of VDD.

3.2.4 Noise Performance (Phase & Amplitude)

* At a **100 kHz** offset from the carrier:

– **Phase Modulation (PM) Noise:** −81.9383 dBc/Hz
– **Amplitude Modulation (AM) Noise:** −130.7708 dBc/Hz

* The phase noise analysis indicates that **amplitude modulation (AM) noise is significantly lower compared to phase modulation (PM) noise**.

4 DESIGN METHODOLOGY AND DETAILS OF THE CALCULATION AND DEVICE SIZES OF A TYPE IV CC DIFFERENTIAL LC-VCO WITH MOS VARACTORS AND A SYMMETRIC INDUCTOR

4.1 VCO Design Specifications

VCO Design Specifications

Parameter	**Specification**
Technology Node	45 nm CMOS
Supply Voltage V_{DD}	1 V
Nominal Input Common-Mode Voltage $V_{DD}/2$	0.5 V
Bias Current I_{bias}	10 μA (adjustable)
Oscillation Frequency f_0	3 GHz
Tuning Range	> 20% (2.7 GHz – 3.3 GHz)
VCO Gain K_{VCO}	To be determined (? GHz/V)
Varactor Type	MOS Varactor
Inductor Configuration	Symmetric Inductor (for Type IV VCO)

4.2 A type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

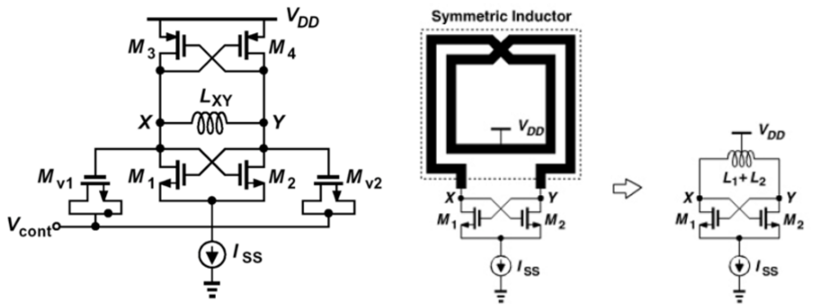


Figure 15 — A type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

The Type IV Cross-Coupled Differential LC Voltage-Controlled Oscillator (VCO) is a widely used design in RF applications, incorporating MOS varactors and a symmetric inductor to achieve stable oscillations with low phase noise. It consists of a cross-coupled NMOS transistor pair (M_1, M_2) that generates negative resistance, compensating for losses in the LC tank circuit formed by the inductor (L_{XY}) and the MOS varactors (M_{v1}, M_{v2}). A symmetric inductor is employed to ensure balanced operation, minimizing phase noise and improving oscillator performance. The circuit also includes a PMOS cross-coupled pair (M_3, M_4) to enhance negative resistance, facilitating reliable startup. The oscillation frequency is determined by the LC tank and can be tuned by adjusting the control voltage (V_{cont}), which modulates the capacitance of the varactors. The bias current source (I_{SS}) sets the oscillation amplitude, ensuring stable operation. The equivalent circuit representation simplifies the design, showing how the symmetric inductor can be viewed as two coupled inductors $(L_1 + L_2)$, preserving differential operation. This VCO architecture is commonly used in RF transceivers, phase-locked loops (PLLs), and high-frequency communication systems due to its efficient frequency tuning and low phase noise characteristics.

4.3 Pre-Calculations

4.3.1 Transistor Parameters from Cadence Simulation

The following parameters are obtained from Cadence simulation for NMOS and PMOS design with channel length $L = 1\mu$m (to minimize the channel length modulation) and width $W = 10\mu$m for both NMOS and PMOS transistors. The supply voltage is $V_{DD} = 1$V, and the bias current is $I_o = 10\mu$A.
Referefnce : - How to find process parameter of any technology node

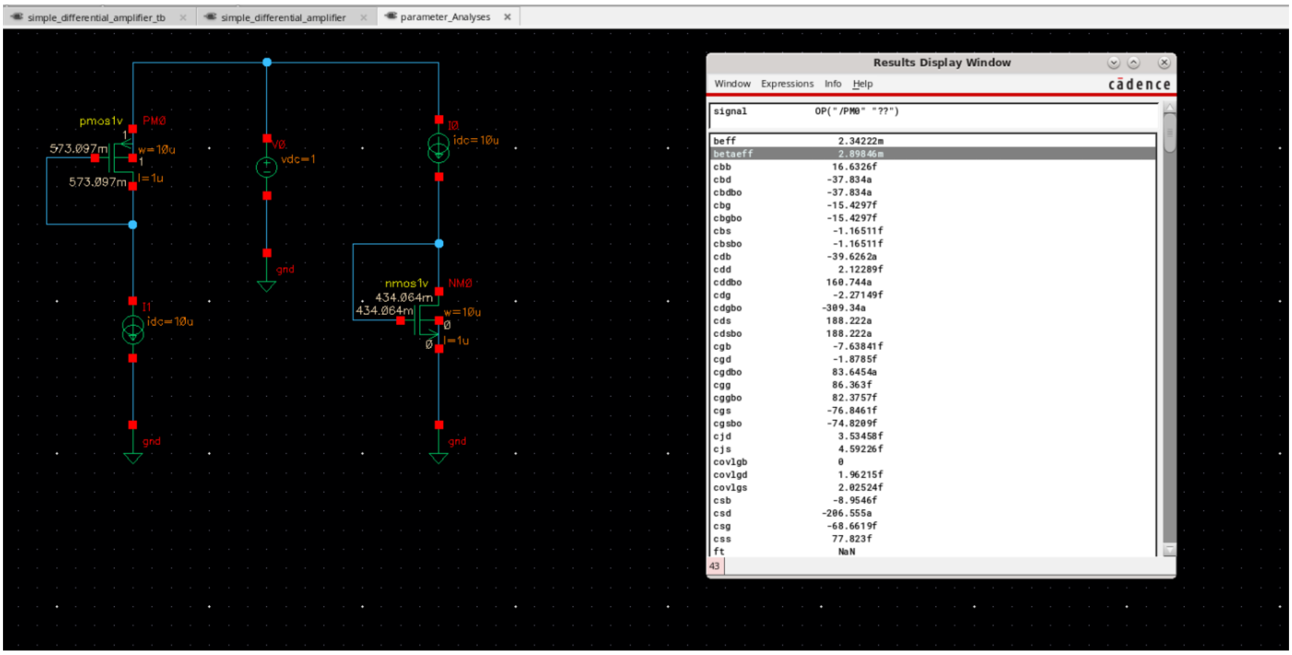


Figure 16 — Transistor Parameters from Cadence Simulation

NMOS Parameters

* Effective Beta ($\beta_{\text{eff, NMOS}}$): 2.89846 mA/V^2 (rounded to 3 mA/V^2)
* Threshold Voltage ($V_{\text{th, NMOS}}$): 397.975 mV (rounded to 0.4 V)

PMOS Parameters

* Effective Beta ($\beta_{\text{eff, PMOS}}$): 2.89846 mA/V^2 (rounded to 3 mA/V^2)
* Threshold Voltage ($V_{\text{th, PMOS}}$): -334.497 mV (rounded to -0.3 V)

4.3.2 Calculation of μC_{ox} for NMOS and PMOS

The effective beta (β_{eff}) is related to the process transconductance parameter μC_{ox} by the following equation:

$$\beta_{\text{eff}} = \mu C_{ox} \frac{W}{L} \tag{37}$$

where $W = 10\ \mu$m, $L = 1\ \mu$m, and $\frac{W}{L} = 10$.
Using the approximated effective beta values from the Cadence simulation:

NMOS $\mu_n C_{ox}$ Calculation

$$\beta_{\text{eff, NMOS}} \approx 3 \text{ mA/V}^2$$
$$\mu_n C_{ox} = \frac{\beta_{\text{eff, NMOS}}}{\frac{W}{L}}$$
$$\mu_n C_{ox} = \frac{3 \text{ mA/V}^2}{10}$$
$$\mu_n C_{ox} = 0.3 \text{ mA/V}^2$$

PMOS $\mu_p C_{ox}$ Calculation

$$\beta_{\text{eff, PMOS}} \approx 3 \text{ mA/V}^2$$
$$\mu_p C_{ox} = \frac{\beta_{\text{eff, PMOS}}}{\frac{W}{L}}$$
$$\mu_p C_{ox} = \frac{3 \text{ mA/V}^2}{10}$$
$$\mu_p C_{ox} = 0.3 \text{ mA/V}^2$$

4.4 Details of the Calculation and Device Sizes

4.4.1 LC Tank Design

The oscillation frequency is determined by the LC tank:

$$\omega_0 = \frac{1}{\sqrt{L_{\text{tank}} C_{\text{tank}}}} \tag{38}$$

where L_{tank} is a non-ideal inductor with a quality factor (Q) of 10, and C_{tank} includes the varactor capacitance (C_{var}) and parasitic capacitances (C_{par}) from transistors and the inductor. Rearranging for C_{tank}:

$$C_{\text{tank}} = \frac{1}{\omega_0^2 L_{\text{tank}}} \tag{39}$$

For $f_0 = 3GHz$:

$$\omega_0 = 2\pi \times 3 \times 10^9 \approx 1.885 \times 10^{10} \text{ rad/s} \tag{40}$$

Given $L_{\text{tank}} = 10nH$:

$$C_{\text{tank}} = \frac{1}{(1.885 \times 10^{10})^2 \times 10 \times 10^{-9}} \approx 281.45fF \tag{41}$$

4.4.2 Tuning Range 20%(2.7 GHz to 3.3 GHz)

$$C_{\text{tank,max}} = \frac{1}{(2\pi \times 2.7 \times 10^9)^2 \times 10 \times 10^{-9}} \approx 347.47fF \tag{42}$$
$$C_{\text{tank,min}} = \frac{1}{(2\pi \times 3.3 \times 10^9)^2 \times 10 \times 10^{-9}} \approx 232.60fF \tag{43}$$

Assuming parasitic capacitance $C_{\text{par}} \approx 10fF$:

$$C_{\text{var}} = C_{\text{tank}} - C_{\text{par}} \tag{44}$$
$$\tag{45}$$

$$C_{\text{var,min}} = 232.60 - 10 = 222.60\text{fF}, \qquad \text{at } f_{\max} = 3.3 \text{ GHz}, \tag{46}$$
$$C_{\text{var,max}} = 347.47 - 10 = 337.47\text{fF}, \qquad \text{at } f_{\min} = 2.7 \text{ GHz}. \tag{47}$$

4.4.3 Varactor Size calculation (M_{V1}, M_{V2})

Each varactor contributes $C_{\text{var}}/2$ since they are in parallel:

$$C_{\text{var,per}} = \frac{C_{\text{var}}}{2} \tag{48}$$

$$C_{\text{var,per,min}} = \frac{222.60}{2} \approx 111.30 fF \tag{49}$$

$$C_{\text{var,per,max}} = \frac{337.47}{2} \approx 168.735 fF \tag{50}$$

Capacitance formula:

$$C_{\text{var}} = \varepsilon_{\text{ox}} \frac{W \cdot L}{t_{\text{ox}}} \tag{51}$$

Where :

* $\varepsilon_{\text{ox}} \approx 3.9 \times 8.85 \times 10^{-12}$ F/m (for SiO_2)
* $t_{\text{ox}} \approx 1nm$ (typical for 45nm process)
* $W \cdot L$ is the gate area

$$C_{\text{var}} = \frac{3.45 \times 10^{-11} \cdot W \cdot L}{1 \times 10^{-9}} = 3.45 \times 10^{-2} \cdot W \cdot L \tag{52}$$

Solving for $W \cdot L$:

$$C_{\text{var,per,max}} = 168.735 fF \tag{53}$$

$$W \cdot L = \frac{168.735 \times 10^{-15}}{3.45 \times 10^{-2}} = 48.9 \times 10^{-13} \approx 5 \times 10^{-12} m^2 \tag{54}$$

Setting $L = 1\mu m$:

$$W = \frac{5 \times 10^{-12} m^2}{1\mu m} = 5\mu m \tag{55}$$

Thus, Varactor Dimensions: $W = 5\mu\text{m}$, $L = 1\mu\text{m}$.

4.4.4 Calculation of Tank Loss R_p

The tank loss resistance is modelled by R_p with a quality factor of inductor Q=10:

$$R_p = Q \cdot \omega_0 \cdot L_{\text{tank}} \tag{56}$$

$$R_p = 10 \times (1.885 \times 10^{10}) \times (10 \times 10^{-9}) \approx 1.885 k\Omega \tag{57}$$

4.4.5 Calculation of Transistor Size (M_1, M_2)

The cross-coupled NMOS pair provides a negative resistance, which is essential for sustaining oscillation in a circuit such as an oscillator. This negative resistance is approximated as:

$$R_{\text{neg}} \approx \frac{-2}{g_m} \tag{58}$$

Ensuring oscillation:

$$g_m R_p \geq 1 \Rightarrow g_m \geq \frac{1}{R_p} = \frac{1}{1885} \approx 0.53 mS \tag{59}$$

For design purposes and to include a safety margin, we set the requirement as:

$$g_m R_p \geq 0.53 mS \tag{60}$$

The drain current I_D for a MOSFET in saturation is given by:

$$I_D = \frac{1}{2} \mu C_{\text{ox}} \frac{W}{L} (V_{GS} - V_t)^2 \tag{61}$$

Transconductance relation:

$$g_m = \mu C_{\text{ox}} \frac{W}{L} (V_{GS} - V_t) \tag{62}$$

Solving for I_D:

$$g_m^2 = 2\mu C_{\text{ox}} \frac{W}{L} I_D \tag{63}$$

$$I_D = \frac{g_m^2}{2\mu C_{\text{ox}} \frac{W}{L}} \tag{64}$$

Given $\mu C_{\text{ox}} \approx 0.3 \times 10^{-3}$ A/V^2 and $g_m \approx 0.53mS$:

$$I_D = \frac{(0.53 \times 10^{-3})^2}{2 \times 0.3 \times 10^{-3} \times 5} \approx 100\mu A \tag{65}$$

$$I_{SS} = 2I_D \approx 200\mu A \tag{66}$$

Setting $W/L = 5$:

$$M_1, M_2 : W = 5\mu m, L = 1\mu m \tag{67}$$

$$M_3, M_4 : W = 10\mu m, L = 1\mu m \tag{68}$$

4.5 Summary of Calculated Values

Summary of Calculated Values

Parameter	Approximated	Chosen	Unit
Length of $M_{1,2}$	1	1	μm
Width of $M_{1,2}$	5	5	μm
Length of $M_{3,4}$	1	1	μm
Width of $M_{3,4}$	10	10	μm
Length of varators $M_{v1,v2}$	1	10	μm
Width of varators $M_{v1,v2}$	5	10	μm
Inductance L_1	10	5	nH
Bias current I_{bias}	200	800	μA
Control voltage V_{cont}	-	320	mV

Summary of Calculated Values of Transistors

Transistor	Length	Width	Unit
M_1	1	5	μm
M_2	1	5	μm
M_3	1	10	μm
M_4	1	10	μm
M_{V1}	1	5	μm
M_{V2}	1	5	μm

5 SIMULATION RESULTS FOR A TYPE IV CC DIFFERENTIAL LC-VCO WITH MOS VARACTORS AND A SYMMETRIC INDUCTOR

5.1 A type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

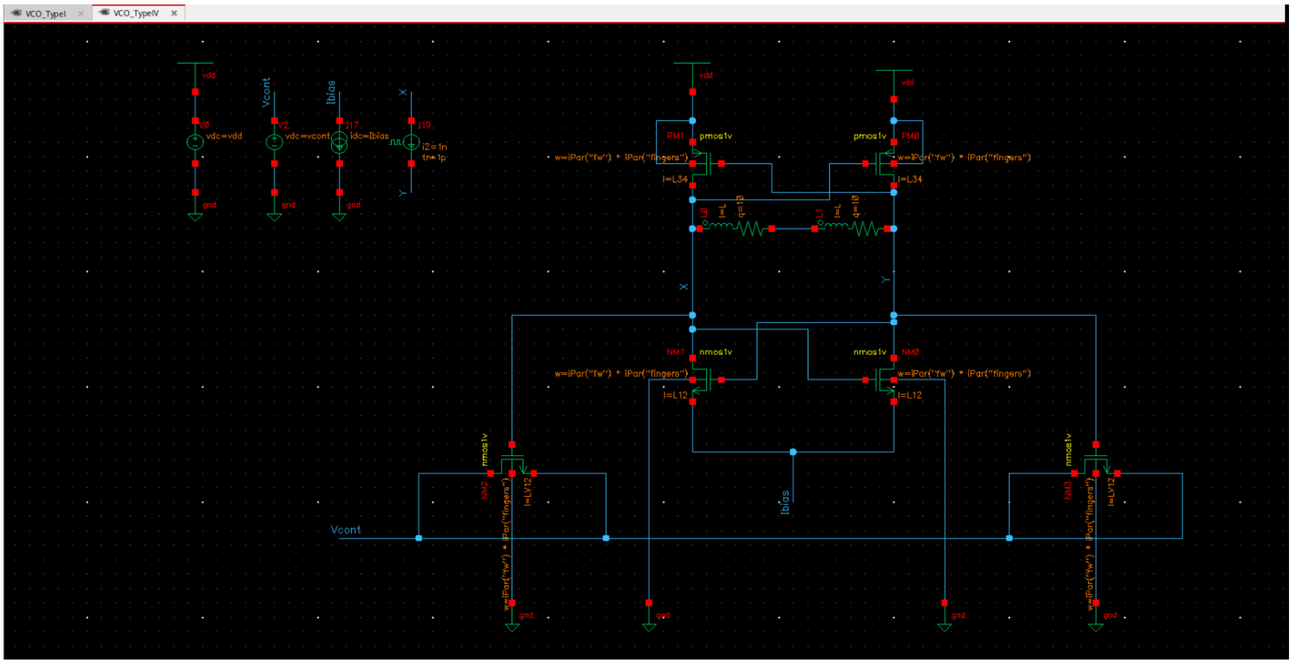


Figure 17 — A type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

To start the oscillation, a short signal pulse was applied with the following characteristics: Current 1 set to 0 A, Current 2 set to 1 nA, a rise time of 1 ps, a fall time of 1 ps, and a pulse width of 3 ps. A symmetric 10 nH inductor was created by connecting two non-ideal inductors of 5 nH each in series. All other parameters were configured in the previous chapter.

5.1.1 Transient simulation results (up to 10 ns after steady state)

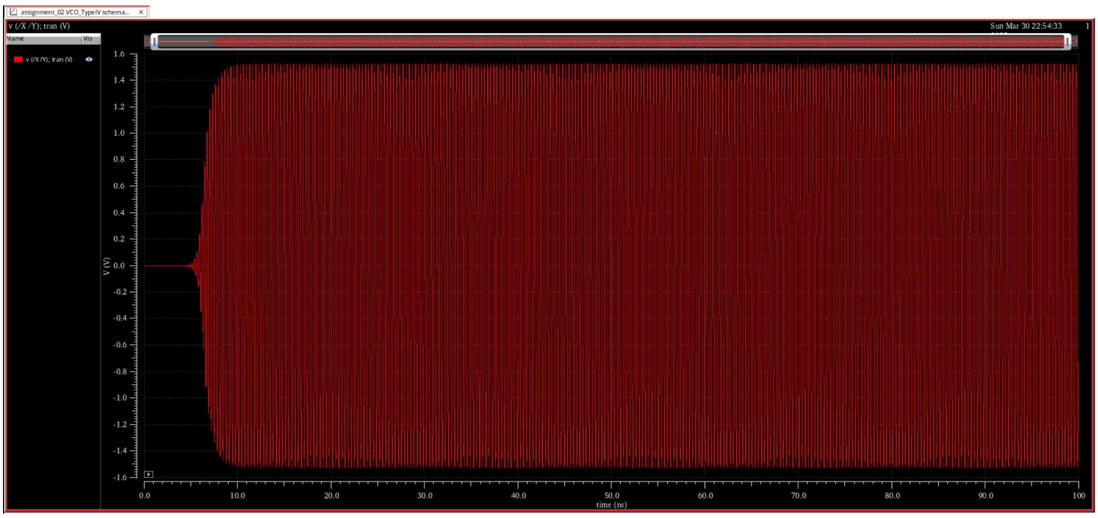


Figure 18 — Transient analysis of $V_X - V_Y$ with a control voltage (V_{cont}) of 320 mv with V_{pp} of 3.25V . of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

(Peak to peak is more than twice the value of VDD)

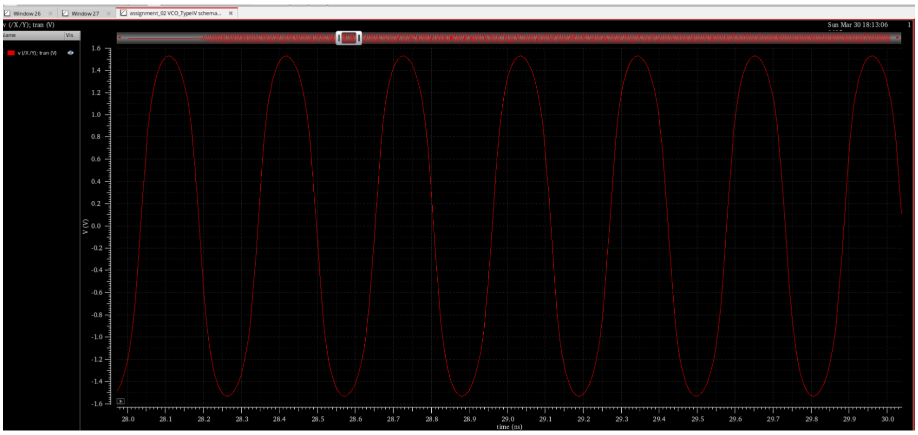


Figure 19 — Transient analysis of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

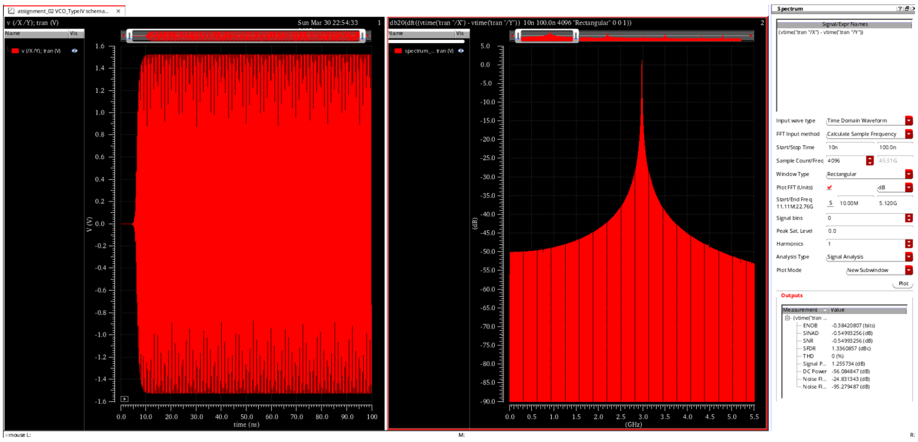


Figure 20 — Transient simulation of $V_X - V_Y$ with $V_{cont} = 320$ mV, and FFT analysis reveals an oscillation frequency of 3.023 GHz of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

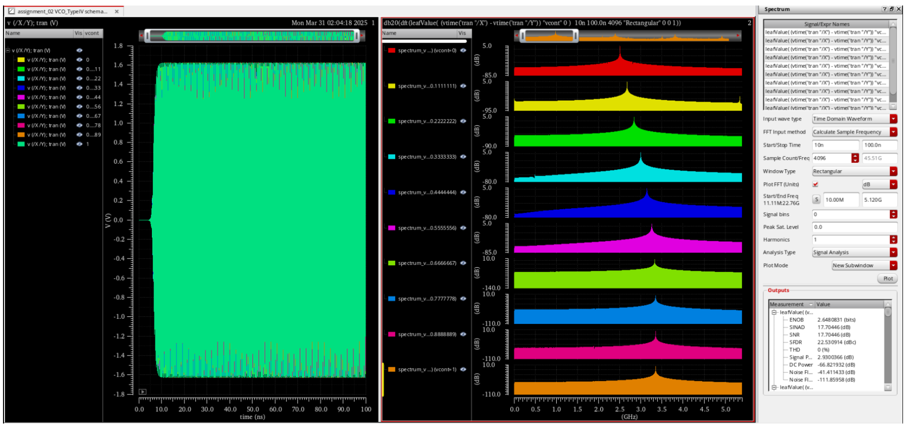


Figure 21 — Transient simulation of $V_X - V_Y$ and FFT analysis for $V_{cont} = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1V$ of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

5.1.2 Parametric simulation results of frequency of oscillation (f_0) vs. control voltage (V_{cont})

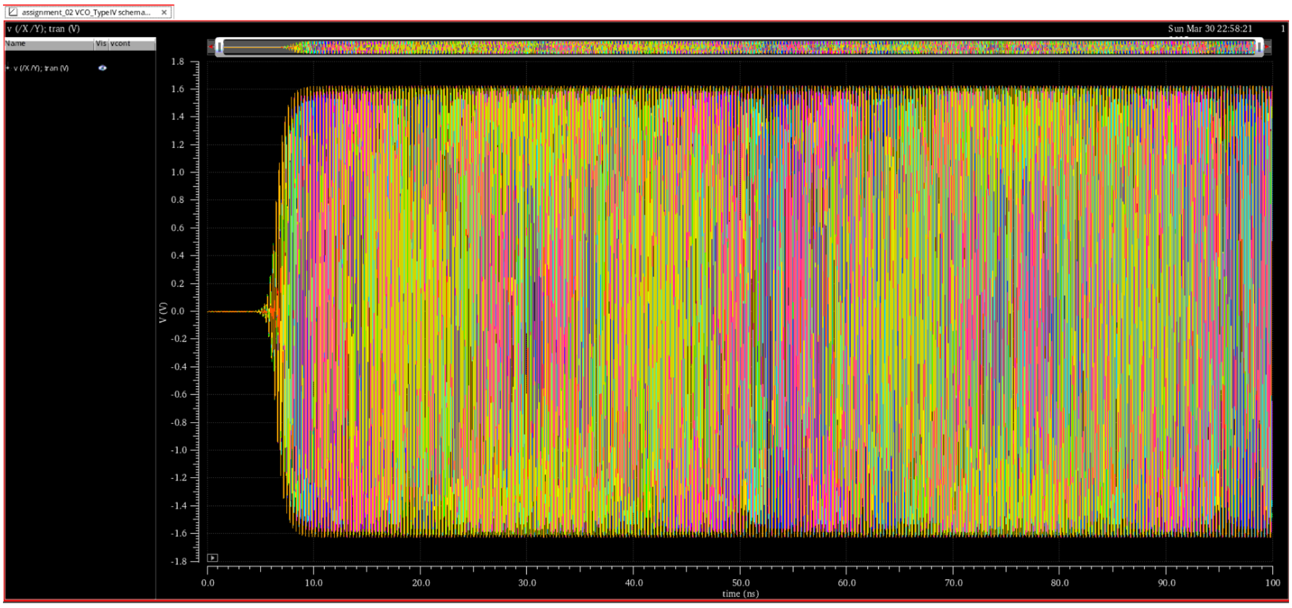


Figure 22 — Transient simulation of $V_X - V_Y$ and FFT analysis for $V_{cont} = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1V$ of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

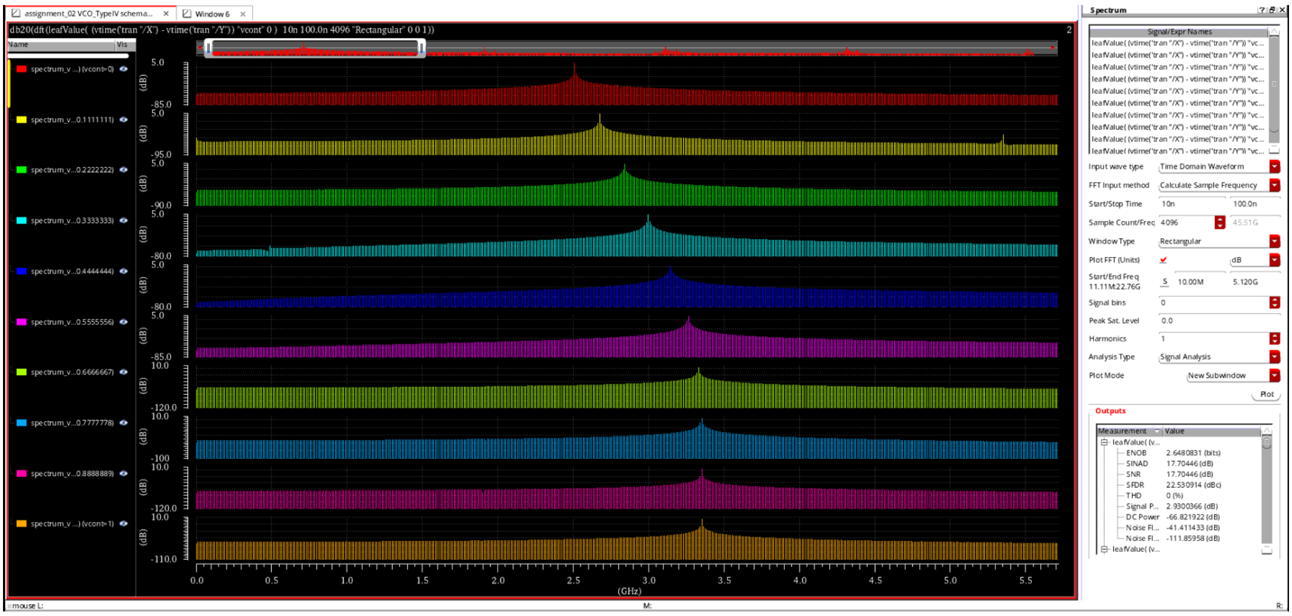


Figure 23 — Transient simulation of $V_X - V_Y$ and FFT analysis for $V_{cont} = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1V$ of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

The oscillation frequency f_{osc} increases with V_{cont} as a result of the positive gain of the VCO.

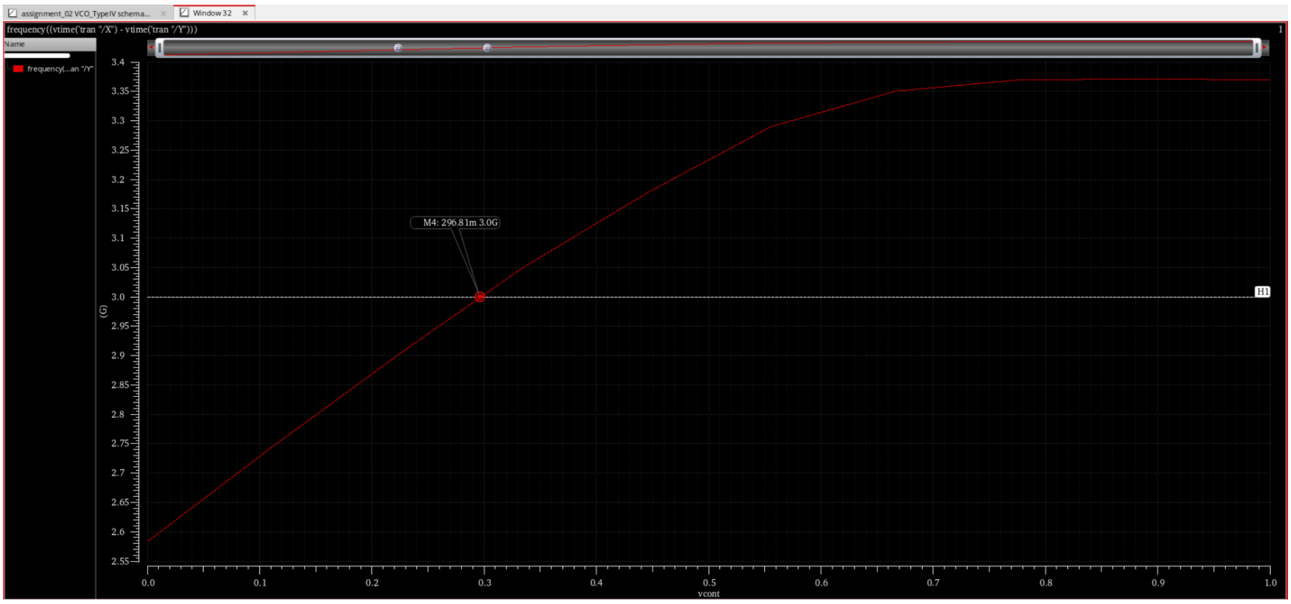


Figure 24 — Oscillation frequency (f_0) as a function of control voltage (V_{cont}) of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

5.1.3 Periodic steady-state (PSS) simulation

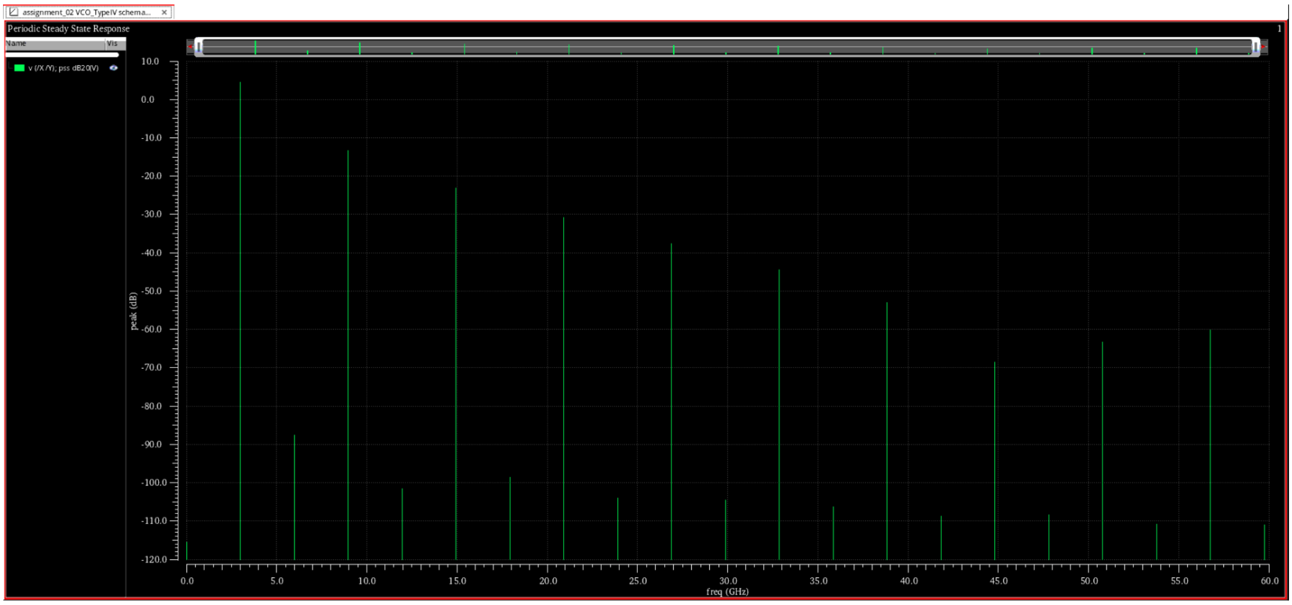


Figure 25 — PSS simulation of $V_X - V_Y$ at $V_{cont} = 500$ mV, indicating a first harmonic frequency of 2.989 GHz of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

5.1.4 Phase noise (PS) simulation results.

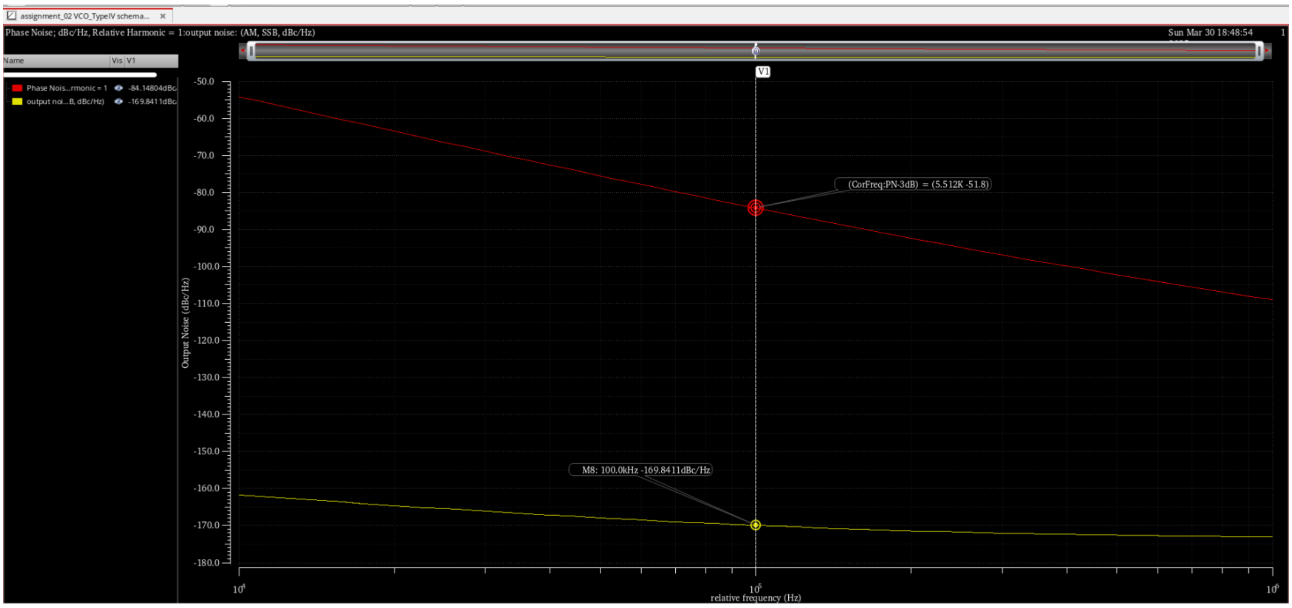


Figure 26 — PSS simulation results: The green curve represents Phase Modulation (PM), while the purple curve corresponds to Amplitude Modulation (AM) of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

5.2 Discussion on Type IV Fully Differential CC LC-VCO

5.2.1 Tuning Range

* **Center Frequency:**

$$f_{\text{center}} = \frac{f_{\max} + f_{\min}}{2} = \frac{3.371 + 2.584}{2} = 2.9775 \text{ GHz} \tag{69}$$

* **Total Tuning Range:**

$$\frac{f_{\max} - f_{\min}}{f_{\text{center}}} \times 100\% = \frac{3.371 - 2.584}{2.9775} \times 100\% = 26.43\% \tag{70}$$

* **Frequency Deviation:**

$$\pm 13.2\%, \text{ so the frequency spans } 2.9775 \pm (0.132 \times 2.9775) = 2.9775 \pm 0.394 \text{ GHz} \tag{71}$$

* The wide tuning range is achieved through MOS varactors' capacitance swing and a symmetric inductor, ensuring balanced operation.

5.2.2 VCO Gain (K_{VCO})

* Defined as:

$$K_{VCO} = \frac{\Delta f}{\Delta V_{\text{cont}}}, \quad \text{where} \quad \Delta f \propto \frac{1}{L(C_{\text{var}}(V_{\text{cont}}))} \tag{72}$$

* Using two selected points from the f_0 vs. V_{cont} curve:

- At $V_{\text{cont}} = 50.9$ mV, $f = 2.658$ GHz.
- At $V_{\text{cont}} = 555.56$ mV, $f = 3.2899$ GHz.

* The gradient calculation:

$$K_{VCO} = \frac{f_2 - f_1}{V_{\text{cont}_2} - V_{\text{cont}_1}} = \frac{3.2899 - 2.658}{0.55556 - 0.0509} = 1.252 \text{ GHz/V} \tag{73}$$

* Since $K_{VCO} > 0$, the VCO exhibits positive gain.

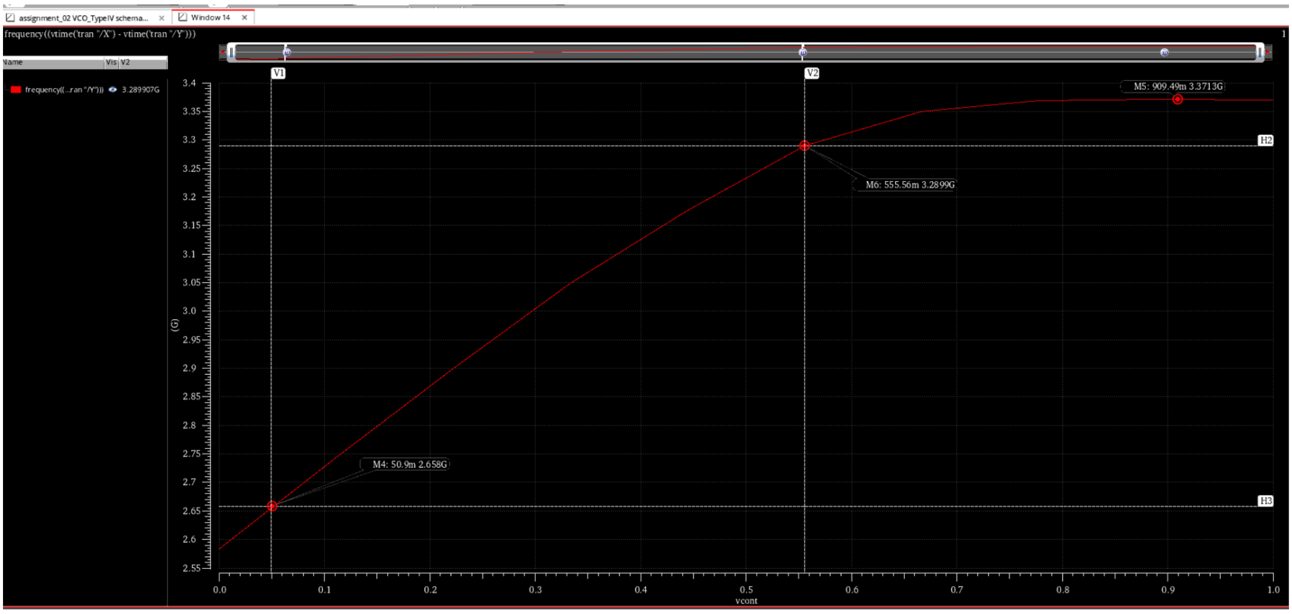


Figure 27 — Calculation of K_{VCO} from the V_{cont} vs. f_0 curve.

5.2.3 Output Voltage Swing

* The peak-to-peak output voltage swing exceeds twice the supply voltage ($V_{dd} = 1V$).
* Maximum peak-to-peak voltage:

$$3.25 \text{ V at } V_{\text{cont}} = 885.31 \text{ mV} \tag{74}$$

5.2.4 Noise Performance (Phase & Amplitude)

* At a **100 kHz** offset from the carrier:

– **Phase Modulation (PM) Noise:** -84.1480 dBc/Hz
– **Amplitude Modulation (AM) Noise:** -168.8411 dBc/Hz

* The phase noise analysis indicates that **amplitude modulation (AM) noise is significantly lower compared to phase modulation (PM) noise**.

6 COMPARISON BETWEEN SIMULATION RESULTS OF A TYPE I CC LC VOLTAGE-CONTROLLED OSCILLATOR (VCO) WITH MOS VARACTOR AND A TYPE IV CC DIFFERENTIAL LC-VCO WITH MOS VARACTORS AND A SYMMETRIC INDUCTOR

6.1 Comparison

Comparison between Type I CC LC-VCO and Type IV CC LC-VCO

Parameter	Type I CC LC-VCO	Type IV CC LC-VCO
Center Frequency	2.996 GHz	2.9775 GHz
Tuning Range	8.077% (±121 MHz)	26.43% (± 394 MHz)
K_{VCO}	0.7075 GHz/V	1.252 GHz/V
Output Voltage Swing	446.1 mV	3.25 V
PM Noise (at 100 kHz offset)	−81.9383 dBc/Hz	−84.1480 dBc/Hz
AM Noise (at 100 kHz offset)	−130.7708 dBc/Hz	−168.8411 dBc/Hz

6.2 Key points on the Tuning Range

* **Better Tuning Range:** Type IV achieves a much wider tuning range (26.43%) compared to Type I (8.077%), allowing it to support multiple frequency bands for modern wireless systems.
* **Higher Output Swing:** Type IV provides a stronger output signal (3.25V) than Type I (446.1mV), leading to better signal quality and overall system performance.

6.3 Enhancements and Improvements for a Wider and More Stable Tuning Range and Stability

6.3.1 Hybrid Capacitor Bank with Floating Switches

* Uses a mix of switchable capacitors and variable capacitors (varactors) for dual tuning.
* Allows both large frequency jumps (via the capacitor bank) and fine adjustments (via varactors).
* Improves stability by using floating switches, which reduce unwanted extra capacitance and maintain circuit efficiency.
* Separates coarse and fine tuning to keep the tuning sensitivity (K_{VCO}) stable.

Equation for frequency variation:

$$\Delta f \propto \frac{b_n C_u}{L(C_{\text{var}} + b_n C_u)}$$

Where:

* b_n are binary control bits
* C_u is unit capacitance
* C_{var} is the capacitance of the varactor

6.3.2 Optimized Symmetric Varactor Design

* Uses back-to-back varactors with adjustable bias for better tuning control.
* Expands the tuning range by adjusting bias levels to get the most capacitance variation.
* Enhances stability by keeping the capacitance change balanced, reducing noise and distortion.
* Maintains a steady K_{VCO}, minimizing phase noise fluctuations for better performance.

Equation for symmetric capacitance modulation:

$$C_{\mathrm{diff}} = \frac{C_{\mathrm{var1}}(V) \cdot C_{\mathrm{var2}}(V)}{C_{\mathrm{var1}}(V) + C_{\mathrm{var2}}(V)}$$

Where:

* $C_{\mathrm{var1}}(V)$ and $C_{\mathrm{var2}}(V)$ are the capacitances of the two varactors, which are symmetrically tuned.

7 APPENDIX: NETLISTS

7.1 Netlist of A type I CC LC voltage-controlled oscillator (VCO) with MOS varactors

```
// Generated for: spectre
// Generated on: Mar 30 03:52:57 2025
// Design library name: assignment_02
// Design cell name: VCO_TypeI
// Design view name: schematic
simulator lang=spectre
global 0 vdd!
parameters C1=700f Ibias=800u L=3n L12=50n LV12=2u Q=10 Rp=400 vcont=500m \
    vdd=1 W1=5u W2=5u W3=5u W4=5u F0=3G delF=10k
include "/home/aed/cadence/dicd_source/cadence_pdk/gpdk045_v_6_0/gpdk045/../
   models/spectre/gpdk045.scs" section=mc

// Library name: assignment_02
// Cell name: VCO_TypeI
// View name: schematic
NM3 (Vcont Y Vcont 0) g45n1svt w=((W4) * (1)) l=LV12 nf=1 as=((W4) < 119.5n) ?
   ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W4) *
   50n)) + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W4) * 100
   n))) + ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50
   n : (((60n) - 0) + 60n)) * 120n) + ((W4) * 50n)) : 0)) / 1 : (((100n > (((60n
   ) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W4)) + (floor(((1) - 1) / 2.0)
    * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W4))) + ((((1)
    / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n)
   - 0) + 80n)) * (W4)) : 0)) / 1 \
         ad=((W4) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
             + ((W4) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W4) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W4))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W4)) : 0)) / 1 \
         ps=((W4) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
             + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
            > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
            1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            ) + (2 * (W4))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W4)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W4))) : 0)) / 1 \
         pd=((W4) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
            ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
            + 50n))) + (2 * (W4)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
            W4))) : 0)) / 1 \
         nrd=((W4) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
            ) + ((W4) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W4) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W4))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W4)) : 0)) / 1 / ((W4) * (1) * (W4) * (1)) \
```

```
        nrs=((W4) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
            0) + 60n)) * 120n) + ((W4) * 50n)) + (floor(((1) - 1) / 2.0) *
            (((((60n) - 0) + 60n) * 120n) + ((W4) * 100n))) + ((((1) / 2) -
            floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n)) * 120n) + ((W4) * 50n)) : 0)) / 1 : (((100n > (((60n) -
             0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W4)) + (floor(((1) - 1)
            / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
            (W4))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
            + 80n) ? 100n : (((60n) - 0) + 80n)) * (W4)) : 0)) / 1 / ((W4) * (1)
             * (W4) * (1)) \
        sa=((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sb=((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sd=((W4) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
             0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
        sca=(( (W4) * ( (((1u) * (1u) / (((W4) < 119.5n) ? (50n > (((60n) - 0)
            + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
             80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W4) <
             119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
             5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            +60n)+(45n)))) + ((1u) * (1u) / (((W4) < 119.5n) ? (50n > (((60n) -
            0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
            0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W4
            ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
            ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
            )+60n)+(45n))))) + ( (45n) * ( (((1u) * (1u) / (60n)) - ((1u) * (1u)
             / ((60n)+(W4)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W4
            )))))) / ((W4) * (45n)) \
        scb=(((W4) * (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W4) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W4) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)) + ((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W4) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W4) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)))) + ((45n) * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u
            )) - (((60n)+(W4))/10 + (1u)/100)*exp(-10 * ((60n)+(W4)) / (1u)) +
            ((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W4))/10 +
            (1u)/100)*exp(-10 * ((60n)+(W4)) / (1u)))) / ((W4) * (45n)) \
        scc=(((W4) * (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W4) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W4) < 119.5n)
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                ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
                (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
               )) / (1u)) + ((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
               (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
               (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W4) < 119.5n)
               ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
               (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
               )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
                - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
                - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W4) < 119.5n)
                ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
                (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
               )) / (1u)))) + ((45n) * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u
               )) - (((60n)+(W4))/20 + (1u)/400)*exp(-20 * ((60n)+(W4)) / (1u)) +
               ((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W4))/20 +
               (1u)/400)*exp(-20 * ((60n)+(W4)) / (1u))))) / ((W4) * (45n)) \
           m=(1)
NM2 (Vcont X Vcont 0) g45n1svt w=((W3) * (1)) l=LV12 nf=1 as=((W3) < 119.5n) ?
    ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W3) *
    50n)) + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W3) * 100
    n))) + ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50
    n : (((60n) - 0) + 60n)) * 120n) + ((W3) * 50n)) : 0)) / 1 : (((100n > (((60n
    ) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W3)) + (floor(((1) - 1) / 2.0)
     * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W3))) + ((((1)
     / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n)
    - 0) + 80n)) * (W3)) : 0)) / 1 \
           ad=((W3) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
                + ((W3) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
               (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W3) *
               50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
                60n : (((60n) - 0) + 50n)) * (W3))) + ((((1) / 2) - floor((1) / 2)
               != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
                (W3)) : 0)) / 1 \
           ps=((W3) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
               - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
                + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
               > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
               1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
               ) + (2 * (W3))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
               0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W3)))) + ((((1) / 2)
                - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
                (((60n) - 0) + 80n))) + (2 * (W3))) : 0)) / 1 \
           pd=((W3) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
               440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
                0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
               ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
               + 50n))) + (2 * (W3)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
                (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
               W3))) : 0)) / 1 \
           nrd=((W3) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
               ) + ((W3) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
               (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W3) *
               50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
                60n : (((60n) - 0) + 50n)) * (W3))) + ((((1) / 2) - floor((1) / 2)
               != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
                (W3)) : 0)) / 1 / ((W3) * (1) * (W3) * (1)) \
           nrs=((W3) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
               0) + 60n)) * 120n) + ((W3) * 50n)) + (floor(((1) - 1) / 2.0) *
               (((((60n) - 0) + 60n) * 120n) + ((W3) * 100n))) + ((((1) / 2) -
               floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
               - 0) + 60n)) * 120n) + ((W3) * 50n)) : 0)) / 1 : (((100n > (((60n) -
                0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W3)) + (floor(((1) - 1)
               / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
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(W3))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
 + 80n) ? 100n : (((60n) - 0) + 80n)) * (W3)) : 0)) / 1 / ((W3) * (1)
  * (W3) * (1)) \
        sa=((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sb=((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sd=((W3) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
             0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
        sca=(( (W3) * ( (((1u) * (1u) / (((W3) < 119.5n) ? (50n > (((60n) - 0)
            + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
             80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W3) <
             119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
             5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            +60n)+(45n)))) + ((1u) * (1u) / (((W3) < 119.5n) ? (50n > (((60n) -
            0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
            0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W3
            ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
            ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
            )+60n)+(45n))))) + ( (45n) * ( (((1u) * (1u) / (60n)) - ((1u) * (1u)
             / ((60n)+(W3)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W3
            )))))) / ((W3) * (45n)) \
        scb=(((W3) * (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W3) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)) + ((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W3) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u))) + ((45n) * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u
            )) - (((60n)+(W3))/10 + (1u)/100)*exp(-10 * ((60n)+(W3)) / (1u)) +
            ((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W3))/10 +
            (1u)/100)*exp(-10 * ((60n)+(W3)) / (1u))))) / ((W3) * (45n)) \
        scc=(((W3) * (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W3) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)) + ((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
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            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W3) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)))) + ((45n) * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u
            )) - (((60n)+(W3))/20 + (1u)/400)*exp(-20 * ((60n)+(W3)) / (1u)) +
            ((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W3))/20 +
            (1u)/400)*exp(-20 * ((60n)+(W3)) / (1u))))) / ((W3) * (45n)) \
        m=(1)
NM1 (X Y Ibias 0) g45n1svt w=((W1) * (1)) l=L12 nf=1 as=((W1) < 119.5n) ? ((((50
    n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W1) * 50n))
    + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W1) * 100n))) +
     ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n :
    (((60n) - 0) + 60n)) * 120n) + ((W1) * 50n)) : 0)) / 1 : (((100n > (((60n) -
    0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W1)) + (floor(((1) - 1) / 2.0) *
    ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W1))) + ((((1) /
    2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) -
    0) + 80n)) * (W1)) : 0)) / 1 \
        ad=((W1) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
             + ((W1) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W1) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W1))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W1)) : 0)) / 1 \
        ps=((W1) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
             + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
            > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
            1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            ) + (2 * (W1))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W1)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W1))) : 0)) / 1 \
        pd=((W1) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
            ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
            + 50n))) + (2 * (W1)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
            W1))) : 0)) / 1 \
        nrd=((W1) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
            ) + ((W1) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W1) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W1))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W1)) : 0)) / 1 / ((W1) * (1) * (W1) * (1)) \
        nrs=((W1) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
            0) + 60n)) * 120n) + ((W1) * 50n)) + (floor(((1) - 1) / 2.0) *
            (((((60n) - 0) + 60n) * 120n) + ((W1) * 100n))) + ((((1) / 2) -
            floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n)) * 120n) + ((W1) * 50n)) : 0)) / 1 : (((100n > (((60n) -
             0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W1)) + (floor(((1) - 1)
            / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
            (W1))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
            + 80n) ? 100n : (((60n) - 0) + 80n)) * (W1)) : 0)) / 1 / ((W1) * (1)
             * (W1) * (1)) \
        sa=((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
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        sb=((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sd=((W1) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
             0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
        sca=(( (W1) * ( (((1u) * (1u) / (((W1) < 119.5n) ? (50n > (((60n) - 0)
            + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
             80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W1) <
             119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
             5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            +60n)+(45n)))) + ((1u) * (1u) / (((W1) < 119.5n) ? (50n > (((60n) -
            0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
            0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W1
            ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
            ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
            )+60n)+(45n))))) + ( (45n) * ( (((1u) * (1u) / (60n)) - ((1u) * (1u)
             / ((60n)+(W1)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W1
            )))))) / ((W1) * (45n)) \
        scb=(((W1) * (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W1) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W1) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)) + ((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W1) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W1) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u))) + ((45n) * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u
            )) - (((60n)+(W1))/10 + (1u)/100)*exp(-10 * ((60n)+(W1)) / (1u)) +
            ((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W1))/10 +
            (1u)/100)*exp(-10 * ((60n)+(W1)) / (1u)))) / ((W1) * (45n)) \
        scc=(((W1) * (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W1) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W1) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)) + ((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W1) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W1) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u))) + ((45n) * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u
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            )) - (((60n)+(W1))/20 + (1u)/400)*exp(-20 * ((60n)+(W1)) / (1u)) +
            ((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W1))/20 +
            (1u)/400)*exp(-20 * ((60n)+(W1)) / (1u))))) / ((W1) * (45n)) \
        m=(1)
NM0 (Y X Ibias 0) g45n1svt w=((W2) * (1)) l=L12 nf=1 as=((W2) < 119.5n) ? ((((50
   n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W2) * 50n))
   + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W2) * 100n))) +
    ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n :
   (((60n) - 0) + 60n)) * 120n) + ((W2) * 50n)) : 0)) / 1 : (((100n > (((60n) -
   0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W2)) + (floor(((1) - 1) / 2.0) *
   ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W2))) + ((((1) /
   2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) -
   0) + 80n)) * (W2)) : 0)) / 1 \
        ad=((W2) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
             + ((W2) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W2) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W2))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W2)) : 0)) / 1 \
        ps=((W2) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
             + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
            > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
            1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            ) + (2 * (W2))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W2)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W2))) : 0)) / 1 \
        pd=((W2) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
            ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
            + 50n))) + (2 * (W2)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
            W2))) : 0)) / 1 \
        nrd=((W2) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
            ) + ((W2) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W2) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W2))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W2)) : 0)) / 1 / ((W2) * (1) * (W2) * (1)) \
        nrs=((W2) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
            0) + 60n)) * 120n) + ((W2) * 50n)) + (floor(((1) - 1) / 2.0) *
            (((((60n) - 0) + 60n) * 120n) + ((W2) * 100n))) + ((((1) / 2) -
            floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n)) * 120n) + ((W2) * 50n)) : 0)) / 1 : (((100n > (((60n) -
             0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W2)) + (floor(((1) - 1)
            / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
            (W2))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
            + 80n) ? 100n : (((60n) - 0) + 80n)) * (W2)) : 0)) / 1 / ((W2) * (1)
             * (W2) * (1)) \
        sa=((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sb=((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sd=((W2) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
             0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
        sca=(( (W2) * ( (((1u) * (1u) / (((W2) < 119.5n) ? (50n > (((60n) - 0)
            + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
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                80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W2) <
                119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
                5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
               +60n)+(45n)))) + ((1u) * (1u) / (((W2) < 119.5n) ? (50n > (((60n) -
               0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
               0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W2
               ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
               ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
               )+60n)+(45n))))) + ( (45n) * ( (((1u) * (1u) / (60n)) - ((1u) * (1u)
                / ((60n)+(W2)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W2
               )))))) / ((W2) * (45n)) \
           scb=(((W2) * (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
               (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
               (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W2) < 119.5n)
               ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
               (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
               )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
                - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
                - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W2) < 119.5n)
                ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
                (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
               )) / (1u)) + ((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
               (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
               (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W2) < 119.5n)
               ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
               (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
               )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
                - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
                - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W2) < 119.5n)
                ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
                (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
               )) / (1u)))) + ((45n) * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u
               )) - (((60n)+(W2))/10 + (1u)/100)*exp(-10 * ((60n)+(W2)) / (1u)) +
               ((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W2))/10 +
               (1u)/100)*exp(-10 * ((60n)+(W2)) / (1u))))) / ((W2) * (45n)) \
           scc=(((W2) * (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
               (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
               (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W2) < 119.5n)
               ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
               (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
               )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
                - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
                - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W2) < 119.5n)
                ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
                (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
               )) / (1u)) + ((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
               (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
               (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W2) < 119.5n)
               ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
               (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
               )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
                - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
                - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W2) < 119.5n)
                ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
                (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
               )) / (1u)))) + ((45n) * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u
               )) - (((60n)+(W2))/20 + (1u)/400)*exp(-20 * ((60n)+(W2)) / (1u)) +
               ((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W2))/20 +
               (1u)/400)*exp(-20 * ((60n)+(W2)) / (1u))))) / ((W2) * (45n)) \
           m=(1)
C1 (vdd! Y) capacitor c=C1
C0 (vdd! X) capacitor c=C1
R1 (vdd! X) resistor r=Rp
```

```
R0 (vdd! Y) resistor r=Rp
V2 (Vcont 0) vsource dc=vcont type=dc
V0 (vdd! 0) vsource dc=vdd type=dc
I17 (Ibias 0) isource dc=Ibias type=dc
I19 (X Y) isource type=pulse val0=0 val1=1m rise=1p fall=1p width=3p
L2 (vdd! Y) inductor l=L q=Q fq=100M mode=1
L0 (vdd! X) inductor l=L q=Q fq=100M mode=1
simulatorOptions options reltol=1e-3 vabstol=1e-6 iabstol=1e-12 temp=27 \
    tnom=27 scalem=1.0 scale=1.0 gmin=1e-12 rforce=1 maxnotes=5 maxwarns=5 \
    digits=5 cols=80 pivrel=1e-3 sensfile="../psf/sens.output" \
    checklimitdest=psf
tran tran stop=100n errpreset=conservative write="spectre.ic" \
    writefinal="spectre.fc" annotate=status maxiters=5
finalTimeOP info what=oppoint where=rawfile
pss  (  X  Y  )  pss  fund=F0  harms=20  errpreset=conservative
+    autosteady=yes  oscic=lin  annotate=status
pnoise  (  X  Y  )  pnoise  sweeptype=relative  relharmnum=1
+       start=10k  stop=1M  noisetype=timeaverage  noiseout=[am  pm  usb
+       lsb]  annotate=status
modelParameter info what=models where=rawfile
element info what=inst where=rawfile
outputParameter info what=output where=rawfile
designParamVals info what=parameters where=rawfile
primitives info what=primitives where=rawfile
subckts info what=subckts where=rawfile
save NM1:d NM0:d
saveOptions options save=allpub
```

Listing 7.1 — Example Circuit Netlist

7.2 Netlist of a type IV CC Differential LC-VCO with MOS varactors and a symmetric inductor

```
// Generated for: spectre
// Generated on: Mar 30 18:07:33 2025
// Design library name: assignment_02
// Design cell name: VCO_TypeIV
// Design view name: schematic
simulator lang=spectre
global 0 vdd!
parameters Ibias=100u L=5n L12=1u L34=1u LV12=1u vcont=0.5 vdd=1 W1=5u \
    W2=5u W3=5u W4=5u W5=10u W6=10u F0=10k delF=10k
include "/home/aed/cadence/dicd_source/cadence_pdk/gpdk045_v_6_0/gpdk045/../
    models/spectre/gpdk045.scs" section=mc

// Library name: assignment_02
// Cell name: VCO_TypeIV
// View name: schematic
NM3 (Vcont Y Vcont 0) g45n1svt w=((W4) * (1)) l=LV12 nf=1 as=((W4) < 119.5n) ?
    ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W4) *
    50n)) + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W4) * 100
    n))) + ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50
    n : (((60n) - 0) + 60n)) * 120n) + ((W4) * 50n)) : 0)) / 1 : (((100n > (((60n
    ) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W4)) + (floor(((1) - 1) / 2.0)
     * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W4))) + ((((1)
     / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n)
    - 0) + 80n)) * (W4)) : 0)) / 1 \
         ad=((W4) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
             + ((W4) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
             (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W4) *
             50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
              60n : (((60n) - 0) + 50n)) * (W4))) + ((((1) / 2) - floor((1) / 2)
```

```
        != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
         (W4)) : 0)) / 1 \
    ps=((W4) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
        - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
         + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
        > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
        1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
        ) + (2 * (W4))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
        0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W4)))) + ((((1) / 2)
         - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
         (((60n) - 0) + 80n))) + (2 * (W4))) : 0)) / 1 \
    pd=((W4) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
        440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
         0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
        ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
        + 50n))) + (2 * (W4)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
         (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
        W4))) : 0)) / 1 \
    nrd=((W4) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
        ) + ((W4) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
        (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W4) *
        50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
         60n : (((60n) - 0) + 50n)) * (W4))) + ((((1) / 2) - floor((1) / 2)
        != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
         (W4)) : 0)) / 1 / ((W4) * (1) * (W4) * (1)) \
    nrs=((W4) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
        0) + 60n)) * 120n) + ((W4) * 50n)) + (floor(((1) - 1) / 2.0) *
        (((((60n) - 0) + 60n) * 120n) + ((W4) * 100n))) + ((((1) / 2) -
        floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
        - 0) + 60n)) * 120n) + ((W4) * 50n)) : 0)) / 1 : (((100n > (((60n) -
         0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W4)) + (floor(((1) - 1)
        / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
        (W4))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
        + 80n) ? 100n : (((60n) - 0) + 80n)) * (W4)) : 0)) / 1 / ((W4) * (1)
         * (W4) * (1)) \
    sa=((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
        60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
        80n)) \
    sb=((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
        60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
        80n)) \
    sd=((W4) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
         0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
    sca=(( (W4) * ( (((1u) * (1u) / (((W4) < 119.5n) ? (50n > (((60n) - 0)
        + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
         80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W4) <
         119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
         5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
        +60n)+LV12))) + ((1u) * (1u) / (((W4) < 119.5n) ? (50n > (((60n) -
        0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
        0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W4
        ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
        ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
        )+60n)+LV12)))) + ( LV12 * ( (((1u) * (1u) / (60n)) - ((1u) * (1u) /
         ((60n)+(W4)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W4))
        )))) / ((W4) * LV12) \
    scb=(((W4) * (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
```

```
        - 0) + 80n))+60n)+LV12)/10 + (1u)/100)*exp(-10 * ((((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
         / (1u)) + ((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+LV12)/10 + (1u)/100)*exp(-10 * ((((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
         / (1u)))) + (LV12 * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u))
        - (((60n)+(W4))/10 + (1u)/100)*exp(-10 * ((60n)+(W4)) / (1u)) + ((60
        n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W4))/10 + (1u)
        /100)*exp(-10 * ((60n)+(W4)) / (1u))))) / ((W4) * LV12) \
    scc=(((W4) * (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+LV12)/20 + (1u)/400)*exp(-20 * ((((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
         / (1u)) + ((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W4) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+LV12)/20 + (1u)/400)*exp(-20 * ((((W4) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
         / (1u)))) + (LV12 * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u))
        - (((60n)+(W4))/20 + (1u)/400)*exp(-20 * ((60n)+(W4)) / (1u)) + ((60
        n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W4))/20 + (1u)
        /400)*exp(-20 * ((60n)+(W4)) / (1u))))) / ((W4) * LV12) \
    m=(1)
NM2 (Vcont X Vcont 0) g45n1svt w=((W3) * (1)) l=LV12 nf=1 as=((W3) < 119.5n) ?
    ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W3) *
    50n)) + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W3) * 100
    n))) + ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50
    n : (((60n) - 0) + 60n)) * 120n) + ((W3) * 50n)) : 0)) / 1 : (((100n > (((60n
    ) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W3)) + (floor(((1) - 1) / 2.0)
     * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W3))) + ((((1)
     / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n)
    - 0) + 80n)) * (W3)) : 0)) / 1 \
    ad=((W3) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
         + ((W3) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
        (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W3) *
        50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
         60n : (((60n) - 0) + 50n)) * (W3))) + ((((1) / 2) - floor((1) / 2)
        != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
         (W3)) : 0)) / 1 \
    ps=((W3) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
        - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
         + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
        > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
        1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
```

```
            ) + (2 * (W3))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W3)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W3))) : 0)) / 1 \
        pd=((W3) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
            ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
            + 50n))) + (2 * (W3)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
            W3))) : 0)) / 1 \
        nrd=((W3) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
            ) + ((W3) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W3) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W3))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W3)) : 0)) / 1 / ((W3) * (1) * (W3) * (1)) \
        nrs=((W3) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
            0) + 60n)) * 120n) + ((W3) * 50n)) + (floor(((1) - 1) / 2.0) *
            (((((60n) - 0) + 60n) * 120n) + ((W3) * 100n))) + ((((1) / 2) -
            floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n)) * 120n) + ((W3) * 50n)) : 0)) / 1 : (((100n > (((60n) -
             0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W3)) + (floor(((1) - 1)
            / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
            (W3))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
            + 80n) ? 100n : (((60n) - 0) + 80n)) * (W3)) : 0)) / 1 / ((W3) * (1)
             * (W3) * (1)) \
        sa=((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sb=((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sd=((W3) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
             0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
        sca=(( (W3) * ( (((1u) * (1u) / (((W3) < 119.5n) ? (50n > (((60n) - 0)
            + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
             80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W3) <
             119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
             5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            +60n)+LV12))) + ((1u) * (1u) / (((W3) < 119.5n) ? (50n > (((60n) -
            0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
            0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W3
            ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
            ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
            )+60n)+LV12)))) + ( LV12 * ( (((1u) * (1u) / (60n)) - ((1u) * (1u) /
             ((60n)+(W3)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W3))
            )))) / ((W3) * LV12) \
        scb=(((W3) * (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+LV12)/10 + (1u)/100)*exp(-10 * ((((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
             / (1u)) + ((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
```

```
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+LV12)/10 + (1u)/100)*exp(-10 * ((((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
             / (1u)))) + (LV12 * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u))
            - (((60n)+(W3))/10 + (1u)/100)*exp(-10 * ((60n)+(W3)) / (1u)) + ((60
            n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W3))/10 + (1u)
            /100)*exp(-10 * ((60n)+(W3)) / (1u))))) / ((W3) * LV12) \
        scc=(((W3) * (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+LV12)/20 + (1u)/400)*exp(-20 * ((((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
             / (1u)) + ((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W3) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+LV12)/20 + (1u)/400)*exp(-20 * ((((W3) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+LV12)
             / (1u)))) + (LV12 * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u))
            - (((60n)+(W3))/20 + (1u)/400)*exp(-20 * ((60n)+(W3)) / (1u)) + ((60
            n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W3))/20 + (1u)
            /400)*exp(-20 * ((60n)+(W3)) / (1u))))) / ((W3) * LV12) \
        m=(1)
NM1 (X Y Ibias 0) g45n1svt w=((W1) * (1)) l=L12 nf=1 as=((W1) < 119.5n) ? ((((50
    n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W1) * 50n))
    + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W1) * 100n))) +
     ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n :
    (((60n) - 0) + 60n)) * 120n) + ((W1) * 50n)) : 0)) / 1 : (((100n > (((60n) -
    0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W1)) + (floor(((1) - 1) / 2.0) *
    ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W1))) + ((((1) /
    2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) -
    0) + 80n)) * (W1)) : 0)) / 1 \
        ad=((W1) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
            + ((W1) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W1) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W1))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W1)) : 0)) / 1 \
        ps=((W1) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
             + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
            > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
            1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            ) + (2 * (W1))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W1)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W1))) : 0)) / 1 \
        pd=((W1) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
```

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        ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
        + 50n))) + (2 * (W1)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
         (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
        W1))) : 0)) / 1 \
    nrd=((W1) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
        ) + ((W1) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
        (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W1) *
        50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
         60n : (((60n) - 0) + 50n)) * (W1))) + ((((1) / 2) - floor((1) / 2)
        != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
         (W1)) : 0)) / 1 / ((W1) * (1) * (W1) * (1)) \
    nrs=((W1) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
        0) + 60n)) * 120n) + ((W1) * 50n)) + (floor(((1) - 1) / 2.0) *
        (((((60n) - 0) + 60n) * 120n) + ((W1) * 100n))) + ((((1) / 2) -
        floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
        - 0) + 60n)) * 120n) + ((W1) * 50n)) : 0)) / 1 : (((100n > (((60n) -
         0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W1)) + (floor(((1) - 1)
        / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
        (W1))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
        + 80n) ? 100n : (((60n) - 0) + 80n)) * (W1)) : 0)) / 1 / ((W1) * (1)
         * (W1) * (1)) \
    sa=((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
        60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
        80n)) \
    sb=((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
        60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
        80n)) \
    sd=((W1) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
         0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
    sca=(( (W1) * ( (((1u) * (1u) / (((W1) < 119.5n) ? (50n > (((60n) - 0)
        + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
         80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W1) <
         119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
         5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
        +60n)+(45n)))) + ((1u) * (1u) / (((W1) < 119.5n) ? (50n > (((60n) -
        0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
        0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W1
        ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
        ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
        )+60n)+(45n))))) + ( (45n) * ( (((1u) * (1u) / (60n)) - ((1u) * (1u)
         / ((60n)+(W1)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W1
        )))))) / ((W1) * (45n)) \
    scb=(((W1) * (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W1) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W1) < 119.5n)
         ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
         (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
        )) / (1u)) + ((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W1) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W1) < 119.5n)
         ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
         (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
        )) / (1u))) + ((45n) * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u
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            )) - (((60n)+(W1))/10 + (1u)/100)*exp(-10 * ((60n)+(W1)) / (1u)) +
            ((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W1))/10 +
            (1u)/100)*exp(-10 * ((60n)+(W1)) / (1u)))) / ((W1) * (45n)) \
        scc=(((W1) * (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W1) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W1) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)) + ((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W1) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W1) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W1) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)))) + ((45n) * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u
            )) - (((60n)+(W1))/20 + (1u)/400)*exp(-20 * ((60n)+(W1)) / (1u)) +
            ((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W1))/20 +
            (1u)/400)*exp(-20 * ((60n)+(W1)) / (1u)))) / ((W1) * (45n)) \
        m=(1)
NM0 (Y X Ibias 0) g45n1svt w=((W2) * (1)) l=L12 nf=1 as=((W2) < 119.5n) ? ((((50
    n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W2) * 50n))
    + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W2) * 100n))) +
     ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n :
    (((60n) - 0) + 60n)) * 120n) + ((W2) * 50n)) : 0)) / 1 : (((100n > (((60n) -
    0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W2)) + (floor(((1) - 1) / 2.0) *
    ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W2))) + ((((1) /
    2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) -
    0) + 80n)) * (W2)) : 0)) / 1 \
        ad=((W2) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
             + ((W2) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W2) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W2))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W2)) : 0)) / 1 \
        ps=((W2) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
             + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
            > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
            1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            ) + (2 * (W2))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W2)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W2))) : 0)) / 1 \
        pd=((W2) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
            ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
            + 50n))) + (2 * (W2)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
            W2))) : 0)) / 1 \
        nrd=((W2) < 119.5n) ? ((floor((1) / 2.0) * ((((60n) - 0) + 60n) * 120n
            ) + ((W2) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W2) *
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    50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
     60n : (((60n) - 0) + 50n)) * (W2))) + ((((1) / 2) - floor((1) / 2)
    != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
     (W2)) : 0)) / 1 / ((W2) * (1) * (W2) * (1)) \
nrs=((W2) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
    0) + 60n)) * 120n) + ((W2) * 50n)) + (floor(((1) - 1) / 2.0) *
    (((((60n) - 0) + 60n) * 120n) + ((W2) * 100n))) + ((((1) / 2) -
    floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
    - 0) + 60n)) * 120n) + ((W2) * 50n)) : 0)) / 1 : (((100n > (((60n) -
     0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W2)) + (floor(((1) - 1)
    / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
    (W2))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
    + 80n) ? 100n : (((60n) - 0) + 80n)) * (W2)) : 0)) / 1 / ((W2) * (1)
     * (W2) * (1)) \
sa=((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
    60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
    80n)) \
sb=((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
    60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
    80n)) \
sd=((W2) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
     0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
sca=(( (W2) * ( (((1u) * (1u) / (((W2) < 119.5n) ? (50n > (((60n) - 0)
    + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
     80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W2) <
     119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
     5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
    +60n)+(45n)))) + ((1u) * (1u) / (((W2) < 119.5n) ? (50n > (((60n) -
    0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) -
    0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W2
    ) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)
    ) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)
    )+60n)+(45n))))) + ( (45n) * ( (((1u) * (1u) / (60n)) - ((1u) * (1u)
     / ((60n)+(W2)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W2
    )))))) / ((W2) * (45n)) \
scb=(((W2) * (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
    (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
    (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W2) < 119.5n)
    ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
    (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
    )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
     - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
     - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W2) < 119.5n)
     ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
     (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
    )) / (1u)) + ((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
    (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
    (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W2) < 119.5n)
    ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
    (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
    )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
     - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
     - 0) + 80n))+60n)+(45n))/10 + (1u)/100)*exp(-10 * ((((W2) < 119.5n)
     ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
     (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
    )) / (1u)))) + ((45n) * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u
    )) - (((60n)+(W2))/10 + (1u)/100)*exp(-10 * ((60n)+(W2)) / (1u)) +
    ((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W2))/10 +
    (1u)/100)*exp(-10 * ((60n)+(W2)) / (1u)))) / ((W2) * (45n)) \
scc=(((W2) * (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
    (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
    (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W2) < 119.5n)
    ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
```

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            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W2) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)) + ((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W2) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W2) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+(45n))/20 + (1u)/400)*exp(-20 * ((((W2) < 119.5n)
             ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+(45n
            )) / (1u)))) + ((45n) * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u
            )) - (((60n)+(W2))/20 + (1u)/400)*exp(-20 * ((60n)+(W2)) / (1u)) +
            ((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W2))/20 +
            (1u)/400)*exp(-20 * ((60n)+(W2)) / (1u)))) / ((W2) * (45n)) \
        m=(1)
PM1 (X Y vdd! vdd!) g45p1svt w=((W6) * (1)) l=L34 nf=1 as=((W6) < 119.5n) ?
    ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W6) *
    50n)) + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W6) * 100
    n))) + ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50
    n : (((60n) - 0) + 60n)) * 120n) + ((W6 * 50n)) : 0)) / 1 : (((100n > (((60n
    ) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W6)) + (floor(((1) - 1) / 2.0)
     * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W6))) + ((((1)
     / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n)
    - 0) + 80n)) * (W6)) : 0)) / 1 \
        ad=((W6) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
             + ((W6) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W6) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W6))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W6)) : 0)) / 1 \
        ps=((W6) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
             + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
            > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
            1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            ) + (2 * (W6))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W6)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W6))) : 0)) / 1 \
        pd=((W6) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
            ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
            + 50n))) + (2 * (W6)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
            W6))) : 0)) / 1 \
        nrd=((W6) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
            ) + ((W6) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W6) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W6))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W6)) : 0)) / 1 / ((W6) * (1) * (W6) * (1)) \
        nrs=((W6) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
            0) + 60n)) * 120n) + ((W6) * 50n)) + (floor(((1) - 1) / 2.0) *
            (((((60n) - 0) + 60n) * 120n) + ((W6) * 100n))) + ((((1) / 2) -
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        floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
        - 0) + 60n)) * 120n) + ((W6) * 50n)) : 0)) / 1 : (((100n > (((60n) -
         0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W6)) + (floor(((1) - 1)
        / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
        (W6))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
        + 80n) ? 100n : (((60n) - 0) + 80n)) * (W6)) : 0)) / 1 / ((W6) * (1)
         * (W6) * (1)) \
    sa=((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
        60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
        80n)) \
    sb=((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
        60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
        80n)) \
    sd=((W6) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
         0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
    sca=(( (W6) * ( (((1u) * (1u) / (((W6) < 119.5n) ? (50n > (((60n) - 0)
        + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
         80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W6) <
         119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
         5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
        +60n)+L34))) + ((1u) * (1u) / (((W6) < 119.5n) ? (50n > (((60n) - 0)
         + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0)
        + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W6) <
         119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
         5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
        +60n)+L34)))) + ( L34 * ( (((1u) * (1u) / (60n)) - ((1u) * (1u) /
        ((60n)+(W6)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W6)))
        ))) / ((W6) * L34) \
    scb=(((W6) * (((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W6) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+L34)/10 + (1u)/100)*exp(-10 * ((((W6) < 119.5n) ?
         (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
        / (1u)) + ((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W6) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+L34)/10 + (1u)/100)*exp(-10 * ((((W6) < 119.5n) ?
         (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
        / (1u)))) + (L34 * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) -
        (((60n)+(W6))/10 + (1u)/100)*exp(-10 * ((60n)+(W6)) / (1u)) + ((60n)
        /10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W6))/10 + (1u)
        /100)*exp(-10 * ((60n)+(W6)) / (1u))))) / ((W6) * L34) \
    scc=(((W6) * (((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
        (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
        (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W6) < 119.5n)
        ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
        )) - (((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
         - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
         - 0) + 80n))+60n)+L34)/20 + (1u)/400)*exp(-20 * ((((W6) < 119.5n) ?
         (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
        (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
        / (1u)) + ((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
```

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            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W6) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W6) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+L34)/20 + (1u)/400)*exp(-20 * ((((W6) < 119.5n) ?
             (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
            / (1u)))) + (L34 * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) -
            (((60n)+(W6))/20 + (1u)/400)*exp(-20 * ((60n)+(W6)) / (1u)) + ((60n)
            /20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W6))/20 + (1u)
            /400)*exp(-20 * ((60n)+(W6)) / (1u))))) / ((W6) * L34) \
        m=(1)
PM0 (Y X vdd! vdd!) g45p1svt w=((W5) * (1)) l=L34 nf=1 as=((W5) < 119.5n) ?
    ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W5) *
    50n)) + (floor(((1) - 1) / 2.0) * (((((60n) - 0) + 60n) * 120n) + ((W5) * 100
    n))) + ((((1) / 2) - floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50
    n : (((60n) - 0) + 60n)) * 120n) + ((W5) * 50n)) : 0)) / 1 : (((100n > (((60n
    ) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W5)) + (floor(((1) - 1) / 2.0)
     * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) * (W5))) + ((((1)
     / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n)
    - 0) + 80n)) * (W5)) : 0)) / 1 \
        ad=((W5) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n)
             + ((W5) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W5) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W5))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W5)) : 0)) / 1 \
        ps=((W5) < 119.5n) ? (((2 * (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n))) + 340n) + (floor(((1) - 1) / 2.0) * ((2 * (((60n) - 0)
             + 60n)) + 440n)) + ((((1) / 2) - floor((1) / 2) == 0) ? ((2 * (50n
            > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) /
            1 : (((2 * (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            ) + (2 * (W5))) + (floor(((1) - 1) / 2.0) * ((2 * (60n > (((60n) -
            0) + 50n) ? 60n : (((60n) - 0) + 50n))) + (2 * (W5)))) + ((((1) / 2)
             - floor((1) / 2) == 0) ? ((2 * (100n > (((60n) - 0) + 80n) ? 100n :
             (((60n) - 0) + 80n))) + (2 * (W5))) : 0)) / 1 \
        pd=((W5) < 119.5n) ? ((floor((1) / 2.0) * ((2 * (((60n) - 0) + 60n)) +
            440n)) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 * (50n > (((60n) -
             0) + 60n) ? 50n : (((60n) - 0) + 60n))) + 340n) : 0)) / 1 : ((floor
            ((1) / 2.0) * ((2 * (60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0)
            + 50n))) + (2 * (W5)))) + ((((1) / 2) - floor((1) / 2) != 0) ? ((2 *
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))) + (2 * (
            W5))) : 0)) / 1 \
        nrd=((W5) < 119.5n) ? ((floor((1) / 2.0) * (((((60n) - 0) + 60n) * 120n
            ) + ((W5) * 100n))) + ((((1) / 2) - floor((1) / 2) != 0) ? (((50n >
            (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) * 120n) + ((W5) *
            50n)) : 0)) / 1 : ((floor((1) / 2.0) * ((60n > (((60n) - 0) + 50n) ?
             60n : (((60n) - 0) + 50n)) * (W5))) + ((((1) / 2) - floor((1) / 2)
            != 0) ? ((100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n)) *
             (W5)) : 0)) / 1 / ((W5) * (1) * (W5) * (1)) \
        nrs=((W5) < 119.5n) ? ((((50n > (((60n) - 0) + 60n) ? 50n : (((60n) -
            0) + 60n)) * 120n) + ((W5) * 50n)) + (floor(((1) - 1) / 2.0) *
            (((((60n) - 0) + 60n) * 120n) + ((W5) * 100n))) + ((((1) / 2) -
            floor((1) / 2) == 0) ? (((50n > (((60n) - 0) + 60n) ? 50n : (((60n)
            - 0) + 60n)) * 120n) + ((W5) * 50n)) : 0)) / 1 : (((100n > (((60n) -
             0) + 80n) ? 100n : (((60n) - 0) + 80n)) * (W5)) + (floor(((1) - 1)
            / 2.0) * ((60n > (((60n) - 0) + 50n) ? 60n : (((60n) - 0) + 50n)) *
            (W5))) + ((((1) / 2) - floor((1) / 2) == 0) ? ((100n > (((60n) - 0)
            + 80n) ? 100n : (((60n) - 0) + 80n)) * (W5)) : 0)) / 1 / ((W5) * (1)
             * (W5) * (1)) \
```

```
        sa=((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sb=((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) +
            60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) +
            80n)) \
        sd=((W5) < 119.5n) ? (((60n) - 0) + 60n) + (2*5e-08) : (60n > (((60n) -
             0) + 50n) ? 60n : (((60n) - 0) + 50n)) \
        sca=(( (W5) * ( (((1u) * (1u) / (((W5) < 119.5n) ? (50n > (((60n) - 0)
            + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) +
             80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u) / ((((W5) <
             119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
             5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            +60n)+L34))) + ((1u) * (1u) / (((W5) < 119.5n) ? (50n > (((60n) - 0)
             + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0)
            + 80n) ? 100n : (((60n) - 0) + 80n))+60n)) - ((1u) * (1u)/ ((((W5) <
             119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) +
             5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))
            +60n)+L34)))) + ( L34 * ( (((1u) * (1u) / (60n)) - ((1u) * (1u) /
            ((60n)+(W5)))) + ((1u) * (1u) / (60n)) - ((1u) * (1u)/ ((60n)+(W5)))
            ))) / ((W5) * L34) \
        scb=(((W5) * (((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W5) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+L34)/10 + (1u)/100)*exp(-10 * ((((W5) < 119.5n) ?
             (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
            / (1u)) + ((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/10 + (1u)/100)*exp(-10 * (((W5) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+L34)/10 + (1u)/100)*exp(-10 * ((((W5) < 119.5n) ?
             (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
            / (1u)))) + (L34 * (((60n)/10 + (1u)/100)*exp(-10 * (60n) / (1u)) -
            (((60n)+(W5))/10 + (1u)/100)*exp(-10 * ((60n)+(W5)) / (1u)) + ((60n)
            /10 + (1u)/100)*exp(-10 * (60n) / (1u)) - (((60n)+(W5))/10 + (1u)
            /100)*exp(-10 * ((60n)+(W5)) / (1u))))) / ((W5) * L34) \
        scc=(((W5) * (((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W5) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+L34)/20 + (1u)/400)*exp(-20 * ((((W5) < 119.5n) ?
             (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
            / (1u)) + ((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n :
            (((60n) - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n :
            (((60n) - 0) + 80n))+60n)/20 + (1u)/400)*exp(-20 * (((W5) < 119.5n)
            ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
            (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n) / (1u
            )) - (((((W5) < 119.5n) ? (50n > (((60n) - 0) + 60n) ? 50n : (((60n)
             - 0) + 60n)) + 5e-08 : (100n > (((60n) - 0) + 80n) ? 100n : (((60n)
             - 0) + 80n))+60n)+L34)/20 + (1u)/400)*exp(-20 * ((((W5) < 119.5n) ?
```

```
              (50n > (((60n) - 0) + 60n) ? 50n : (((60n) - 0) + 60n)) + 5e-08 :
             (100n > (((60n) - 0) + 80n) ? 100n : (((60n) - 0) + 80n))+60n)+L34)
             / (1u)))) + (L34 * (((60n)/20 + (1u)/400)*exp(-20 * (60n) / (1u)) -
             (((60n)+(W5))/20 + (1u)/400)*exp(-20 * ((60n)+(W5)) / (1u)) + ((60n)
             /20 + (1u)/400)*exp(-20 * (60n) / (1u)) - (((60n)+(W5))/20 + (1u)
             /400)*exp(-20 * ((60n)+(W5)) / (1u))))) / ((W5) * L34) \
         m=(1)
L1 (net20 Y) inductor l=L q=10 fq=100M mode=1
L0 (X net20) inductor l=L q=10 fq=100M mode=1
V2 (Vcont 0) vsource dc=vcont type=dc
V0 (vdd! 0) vsource dc=vdd type=dc
I17 (Ibias 0) isource dc=Ibias type=dc
I19 (X Y) isource type=pulse val0=0 val1=1n rise=1p fall=1p width=3p
simulatorOptions options reltol=1e-3 vabstol=1e-6 iabstol=1e-12 temp=27 \
    tnom=27 scalem=1.0 scale=1.0 gmin=1e-12 rforce=1 maxnotes=5 maxwarns=5 \
    digits=5 cols=80 pivrel=1e-3 sensfile="../psf/sens.output" \
    checklimitdest=psf
tran tran stop=100m errpreset=conservative write="spectre.ic" \
    writefinal="spectre.fc" annotate=status maxiters=5
finalTimeOP info what=oppoint where=rawfile
hb  (  X  Y  )  hb  autotstab=yes  oversample=[1]  fundfreqs=[(F0)]
+   maxharms=[20]  errpreset=conservative  oscic=lin  oscmethod=onetier
+   annotate=status
pss  (  X  Y  )  pss  fund=F0  harms=20  autosteady=yes  oscic=lin
+    annotate=status
pnoise  (  X  Y  )  pnoise  sweeptype=relative  relharmnum=1
+       start=100k  stop=1M  noisetype=timeaverage  noiseout=[am  pm  usb
+       lsb]  annotate=status
modelParameter info what=models where=rawfile
element info what=inst where=rawfile
outputParameter info what=output where=rawfile
designParamVals info what=parameters where=rawfile
primitives info what=primitives where=rawfile
subckts info what=subckts where=rawfile
saveOptions options save=allpub
```

Listing 7.2 — Example Circuit Netlist