EE223 Homework 3

Designed of a Beta Multiplier

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10/13/18

1. Run a Dc simulation with VDD = 1V, Temperature = 27c in Typical Corner.

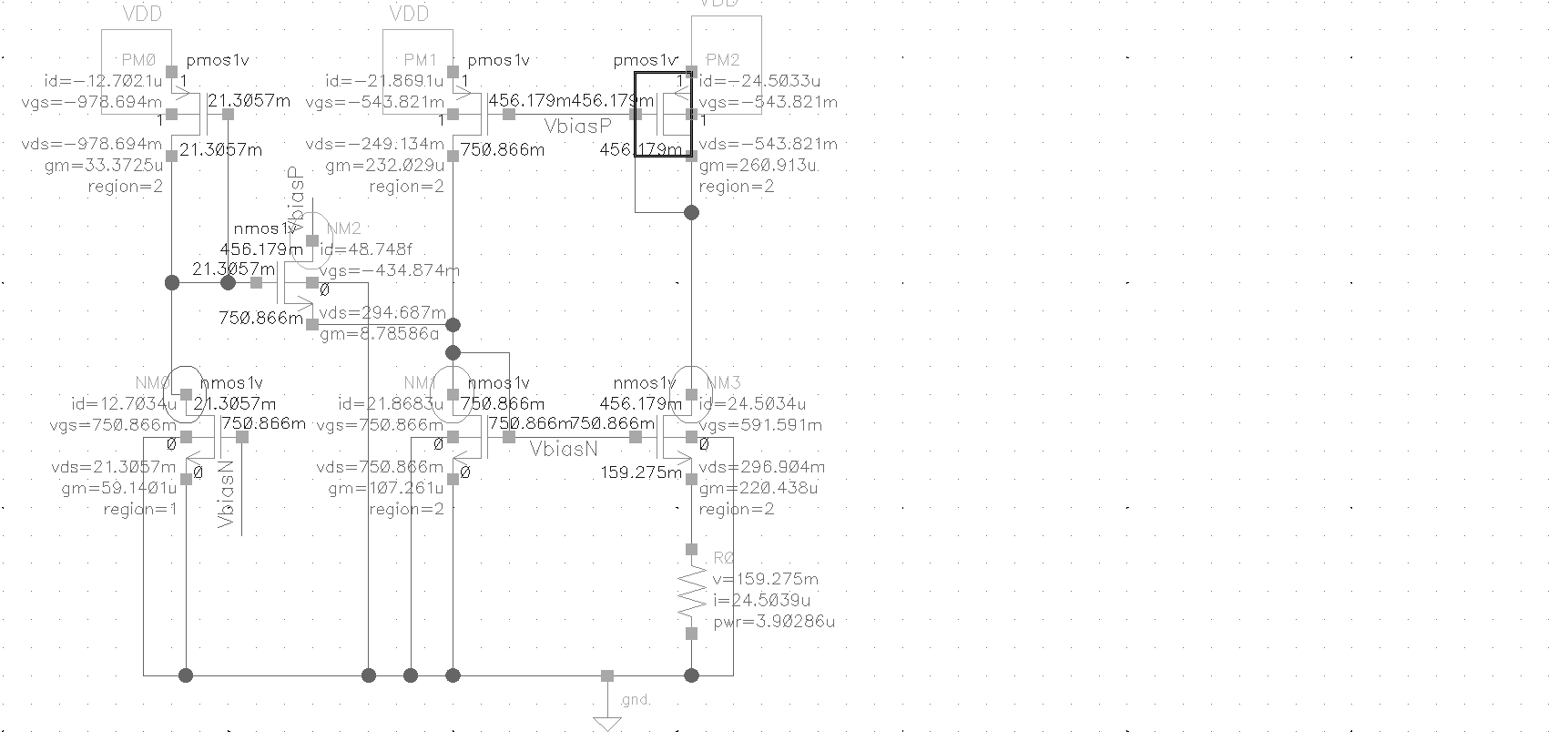


Figure 1: Operating Point information and node voltages

1. ADE-XL transient simulation for 1u

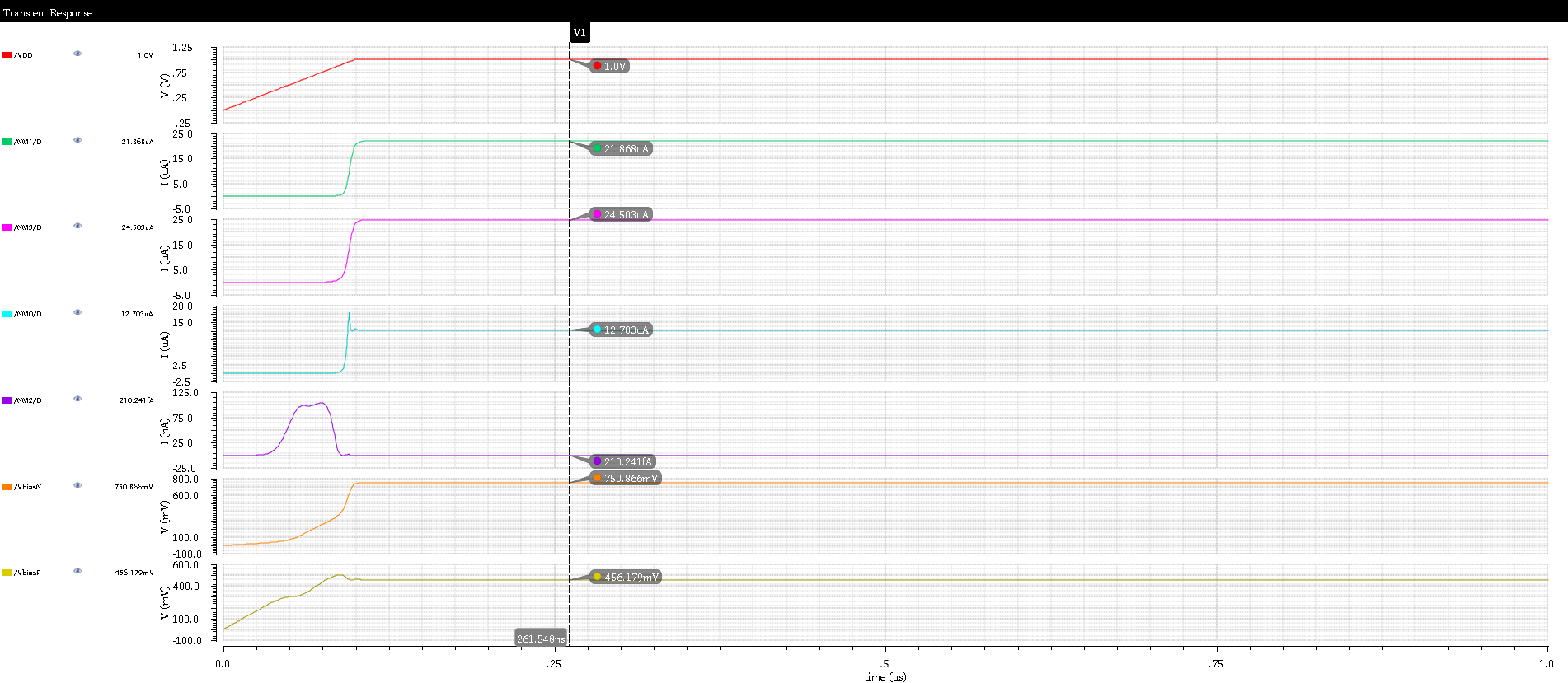


Figure 2: Transient waveforms with startup circuit. (VDD= red trace, Vbiasn =orange trace, Vbiasp=yellow trace, NM1 =green trace, NM3=violate trace, NMo=blue trance, NM2=purple trance)

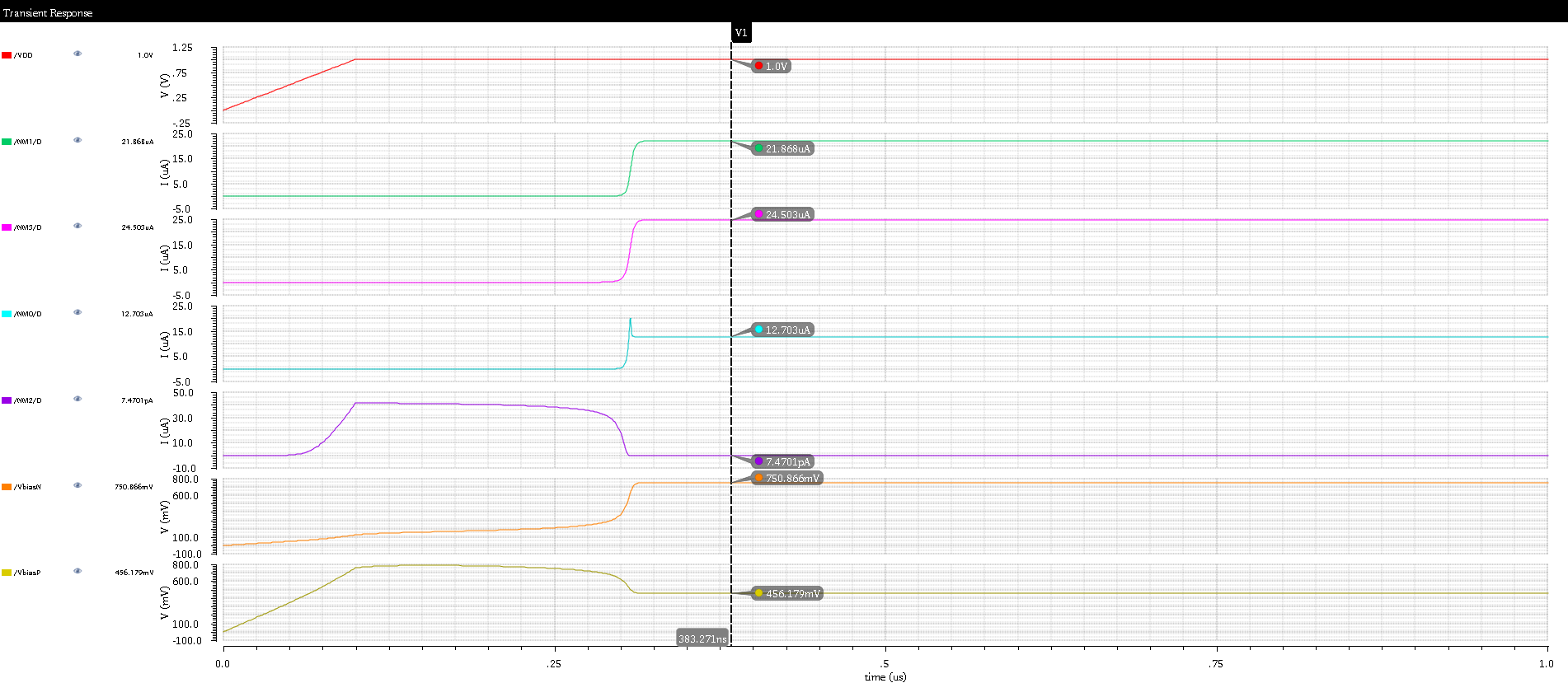


Figure 3: Transient waveforms with startup circuit. (VDD= red trace, Vbiasn =orange trace, Vbiasp=yellow trace, NM1 =green trace, NM3=violate trace, NMo=blue trance, NM2=purple trance)

1. From simulation find Kp value

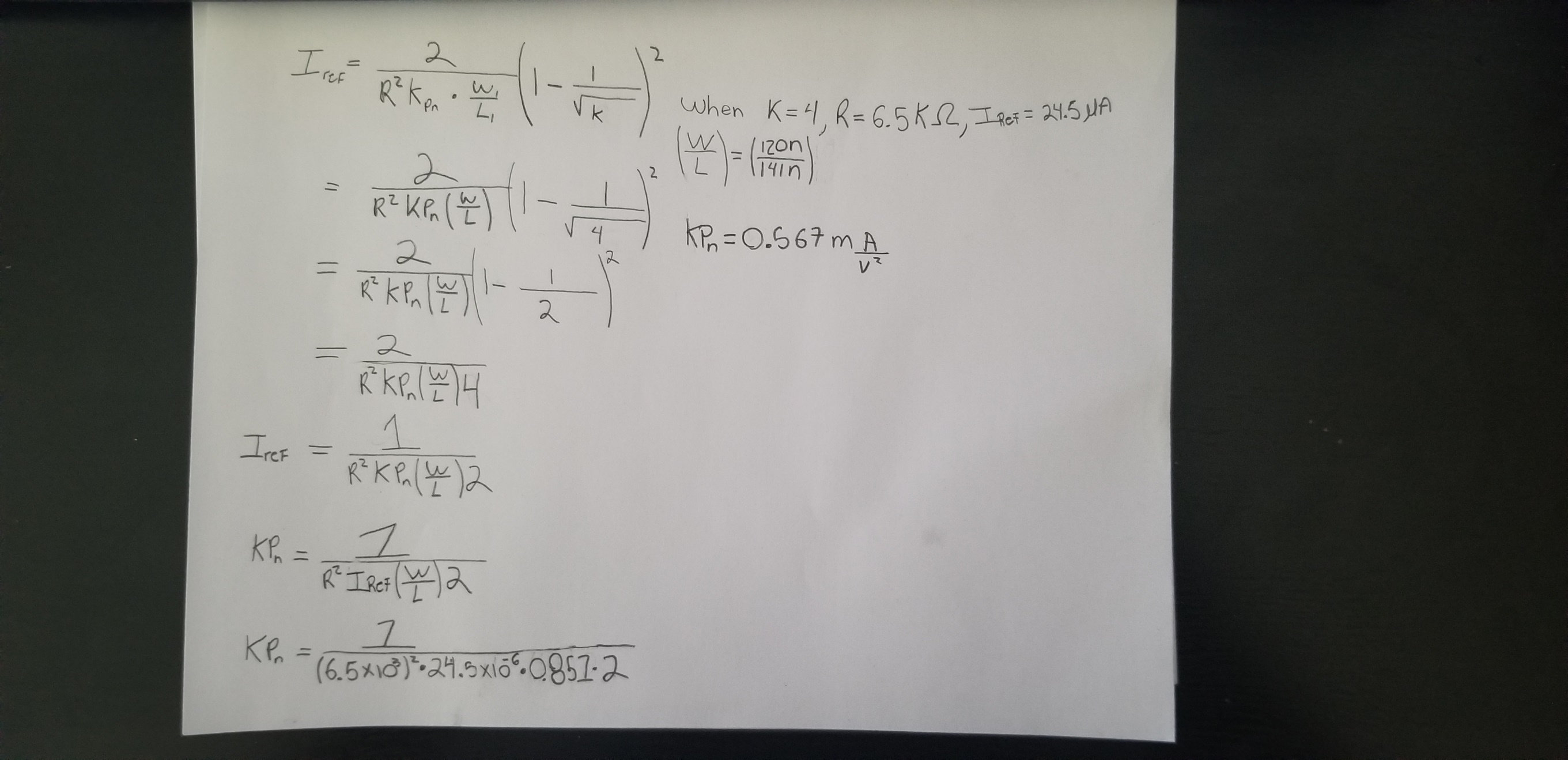


Figure 4: Kp value using simulation Iref

1. Using ADL-XL, simulate the circuit in the fallowing conditions and check if the circuit starts without problem. Measure the current through M4 at 1us and Plot it over the fallowing PVT corners.
   1. Process variation:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Min | Max | C5\_0 | C5\_1 | C5\_2 | C5\_3 | C5\_4 |
| VDD |  |  | 1 | 1 | 1 | 1 | 1 |
| gpdk045.scs |  |  | ff | fs | sf | ss | tt |
| temperature |  |  | 27 | 27 | 27 | 27 | 27 |
| value(IT("/NM3/S") 1e-06) | -2.54E-05 | -2.35E-05 | -2.54E-05 | -2.44E-05 | -2.46E-05 | -2.35E-05 | -2.45E-05 |

* 1. Supply variation:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter |  |  | C6\_0 | C6\_1 | C6\_2 | C6\_3 | C6\_4 |
| VDD |  |  | 8.00E-01 | 9.00E-01 | 1 | 1.1 | 1.2 |
| gpdk045.scs |  |  | tt | tt | tt | tt | tt |
| temperature |  |  | 27 | 27 | 27 | 27 | 27 |
| Output | Min | Max | C6\_0 | C6\_1 | C6\_2 | C6\_3 | C6\_4 |
| value(IT("/NM3/S") 1e-06) | -2.96E-05 | -1.66E-05 | -1.66E-05 | -2.10E-05 | -2.45E-05 | -2.73E-05 | -2.96E-05 |

* 1. Temperature Variation:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Min | Max | C7\_0 | C7\_1 | C7\_2 | C7\_3 | C7\_4 |
| VDD |  |  | 1 | 1 | 1 | 1 | 1 |
| gpdk045.scs |  |  | tt | tt | tt | tt | tt |
| temperature |  |  | -40 | 0 | 25 | 50 | 100 |
| value(IT("/NM3/S") 1e-06) | -2.73E-05 | -1.85E-05 | -1.85E-05 | -2.22E-05 | -2.44E-05 | -2.60E-05 | -2.73E-05 |

* 1. All PVT variations:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Min | Max | C9\_0 | C9\_1 | C9\_2 | C9\_3 | C9\_4 | C9\_5 |
| VDD |  |  | 9.00E-01 | 9.00E-01 | 9.00E-01 | 9.00E-01 | 1 | 1 |
| gpdk045.scs |  |  | ff | ff | ff | ff | ff | ff |
| temperature |  |  | -40 | 0 | 50 | 100 | -40 | 0 |
| value(IT("/PM2/D") 1e-06) | -3.39E-05 | -1.55E-05 | -1.73E-05 | -2.06E-05 | -2.35E-05 | -2.43E-05 | -1.92E-05 | -2.30E-05 |
| C9\_6 | C9\_7 | C9\_8 | C9\_9 | C9\_10 | C9\_11 | C9\_12 | C9\_13 | C9\_14 |
| 1 | 1 | 1.1 | 1.1 | 1.1 | 1.1 | 9.00E-01 | 9.00E-01 | 9.00E-01 |
| ff | ff | ff | ff | ff | ff | fs | fs | fs |
| 50 | 100 | -40 | 0 | 50 | 100 | -40 | 0 | 50 |
| -2.72E-05 | -2.93E-05 | -2.10E-05 | -2.51E-05 | -3.02E-05 | -3.39E-05 | -1.64E-05 | -1.95E-05 | -2.18E-05 |
| C9\_15 | C9\_16 | C9\_17 | C9\_18 | C9\_19 | C9\_20 | C9\_21 | C9\_22 | C9\_23 |
| 9.00E-01 | 1 | 1 | 1 | 1 | 1.1 | 1.1 | 1.1 | 1.1 |
| fs | fs | fs | fs | fs | fs | fs | fs | fs |
| 100 | -40 | 0 | 50 | 100 | -40 | 0 | 50 | 100 |
| -2.20E-05 | -1.84E-05 | -2.21E-05 | -2.59E-05 | -2.73E-05 | -2.01E-05 | -2.42E-05 | -2.92E-05 | -3.22E-05 |
| C9\_24 | C9\_25 | C9\_26 | C9\_27 | C9\_28 | C9\_29 | C9\_30 | C9\_31 | C9\_32 |
| 9.00E-01 | 9.00E-01 | 9.00E-01 | 9.00E-01 | 1 | 1 | 1 | 1 | 1.1 |
| sf | sf | sf | sf | sf | sf | sf | sf | sf |
| -40 | 0 | 50 | 100 | -40 | 0 | 50 | 100 | -40 |
| -1.64E-05 | -1.94E-05 | -2.15E-05 | -2.19E-05 | -1.86E-05 | -2.24E-05 | -2.59E-05 | -2.71E-05 | -2.05E-05 |
| C9\_33 | C9\_34 | C9\_35 | C9\_36 | C9\_37 | C9\_38 | C9\_39 | C9\_40 | C9\_41 |
| 1.1 | 1.1 | 1.1 | 9.00E-01 | 9.00E-01 | 9.00E-01 | 9.00E-01 | 1 | 1 |
| sf | sf | sf | ss | ss | ss | ss | ss | ss |
| 0 | 50 | 100 | -40 | 0 | 50 | 100 | -40 | 0 |
| -2.48E-05 | -2.97E-05 | -3.22E-05 | -1.55E-05 | -1.83E-05 | -1.98E-05 | -1.98E-05 | -1.78E-05 | -2.15E-05 |
| C9\_42 | C9\_43 | C9\_44 | C9\_45 | C9\_46 | C9\_47 | C9\_48 | C9\_49 | C9\_50 |
| 1 | 1 | 1.1 | 1.1 | 1.1 | 1.1 | 9.00E-01 | 9.00E-01 | 9.00E-01 |
| ss | ss | ss | ss | ss | ss | tt | tt | tt |
| 50 | 100 | -40 | 0 | 50 | 100 | -40 | 0 | 50 |
| -2.45E-05 | -2.51E-05 | -1.98E-05 | -2.41E-05 | -2.86E-05 | -3.03E-05 | -1.64E-05 | -1.95E-05 | -2.17E-05 |
| C9\_51 | C9\_52 | C9\_53 | C9\_54 | C9\_55 | C9\_56 | C9\_57 | C9\_58 | C9\_59 |
| 9.00E-01 | 1 | 1 | 1 | 1 | 1.1 | 1.1 | 1.1 | 1.1 |
| tt | tt | tt | tt | tt | tt | tt | tt | tt |
| 100 | -40 | 0 | 50 | 100 | -40 | 0 | 50 | 100 |
| -2.21E-05 | -1.84E-05 | -2.22E-05 | -2.60E-05 | -2.73E-05 | -2.03E-05 | -2.45E-05 | -2.94E-05 | -3.23E-05 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mean | sum of squares | sum of squares /(n-1) | Mean + sigma | Mean - sigma |
| -2.33168E-05 | 1.24249E-09 | 4.58902E-06 | -1.87278E-05 | -2.79059E-05 |

* 1. Plot Gm vs Temp of Mn1

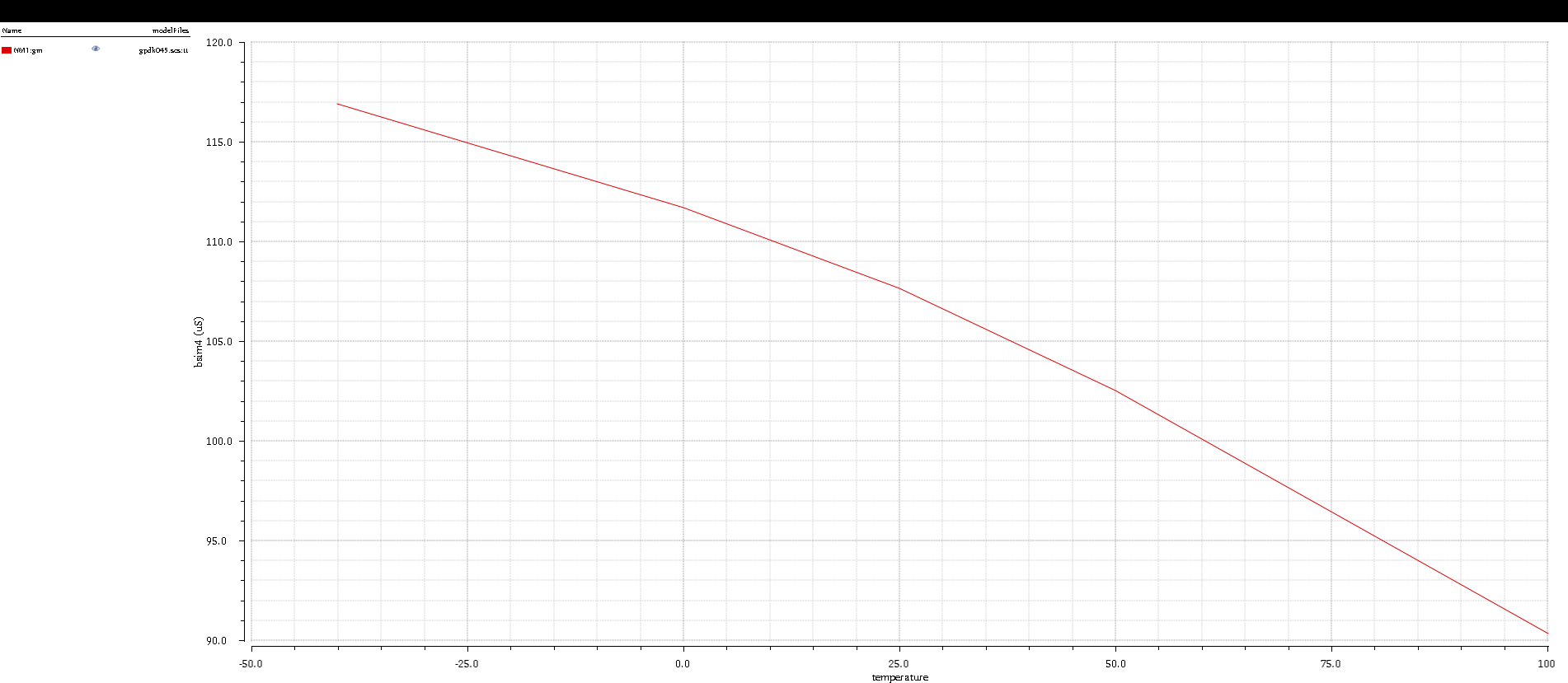


Figure 5: NM1 Gm vs Temp