Test Results of HICUM Level2 V2.23

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General Comments

The corresponding ASCII data may be found in the HICUM website. Any modification of the code and corresponding results will be updated with newer version names.

ASCII file nomenclature:

General format: Netlist_name_x_y.elpa

where,

y=1: T=300K

y=2: T=200K

y=3: T=400K

y=4: T=600K

y=5: Electrothermal/Self-heating effect

y=6: NQS effect

y=7: Collector current spreading effect

y=8: Substrate transistor effect without substrate network

y=9: Effects with substrate transistors and substrate network

and

x=1: Intrinsic transistor

x=2: Internal Transistor:

Thermal data for x=2:

y=3: T=200K, y=4: T=400K, y=5: T=600K, y=6: T=300K.

x=3: Complete transistor

Section 1: Results of Intrinsic Transistor

- Results in this section are identical with the “previous” version.

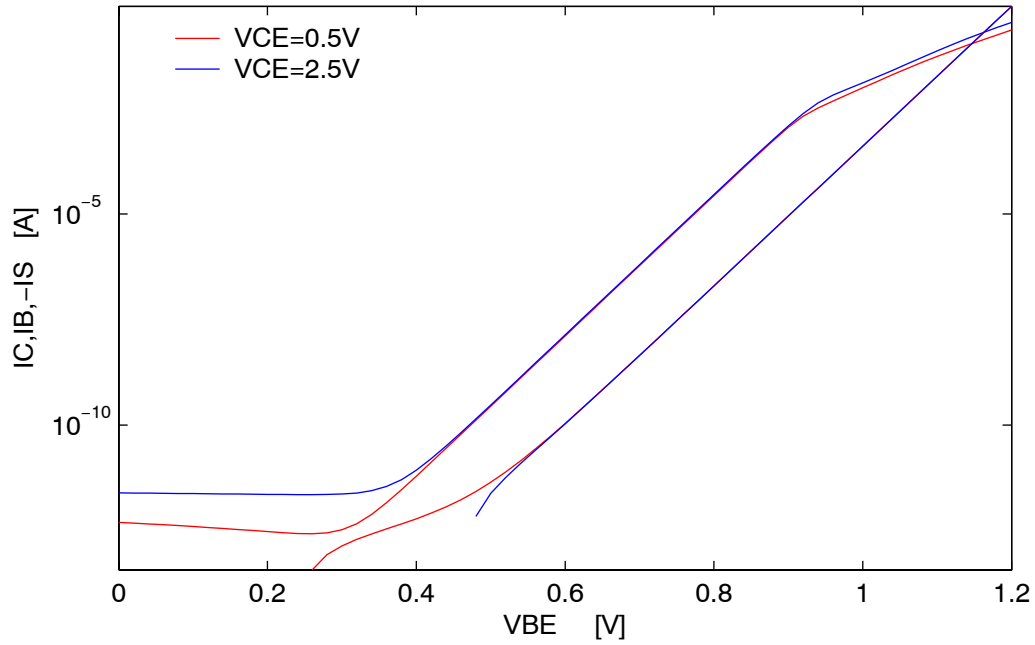

FIGURE 1. Forward Gummel plots at VCE=0.5,2.5 Volt and T=300K.

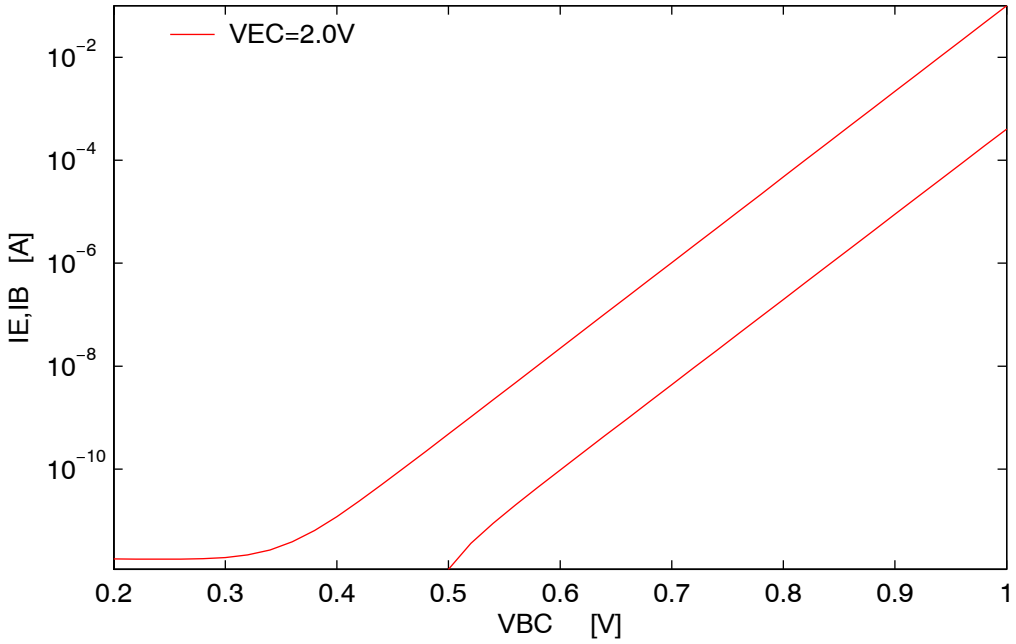

FIGURE 2. Reverse Gummel plots at VEC=2.0V at T=300K.

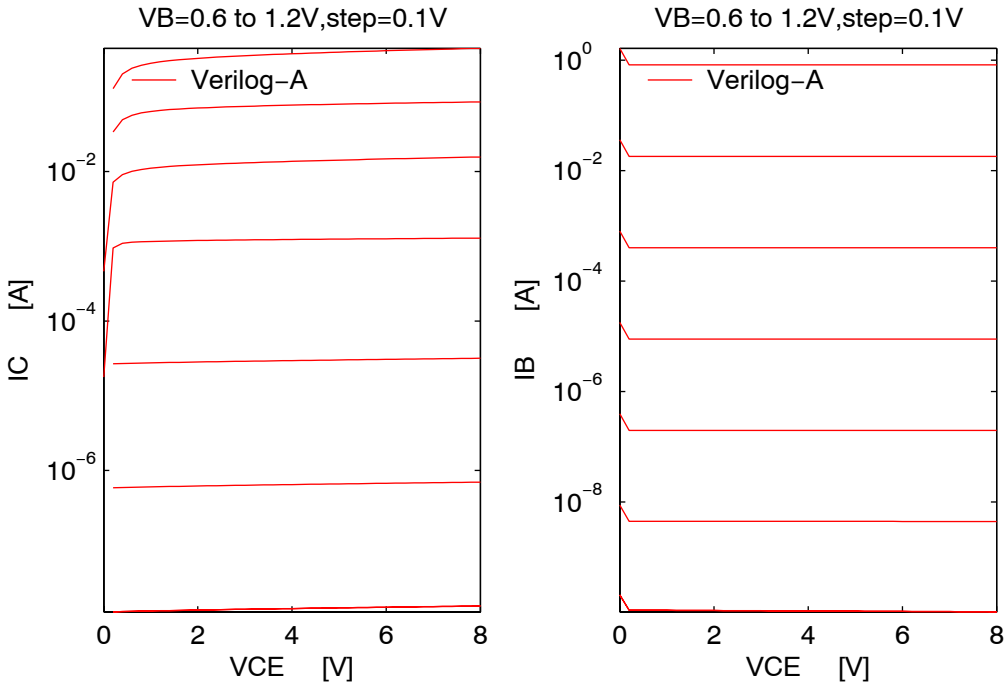

FIGURE 3. Forced-VB output characteristics and Ib-VCE plots at T=300K.

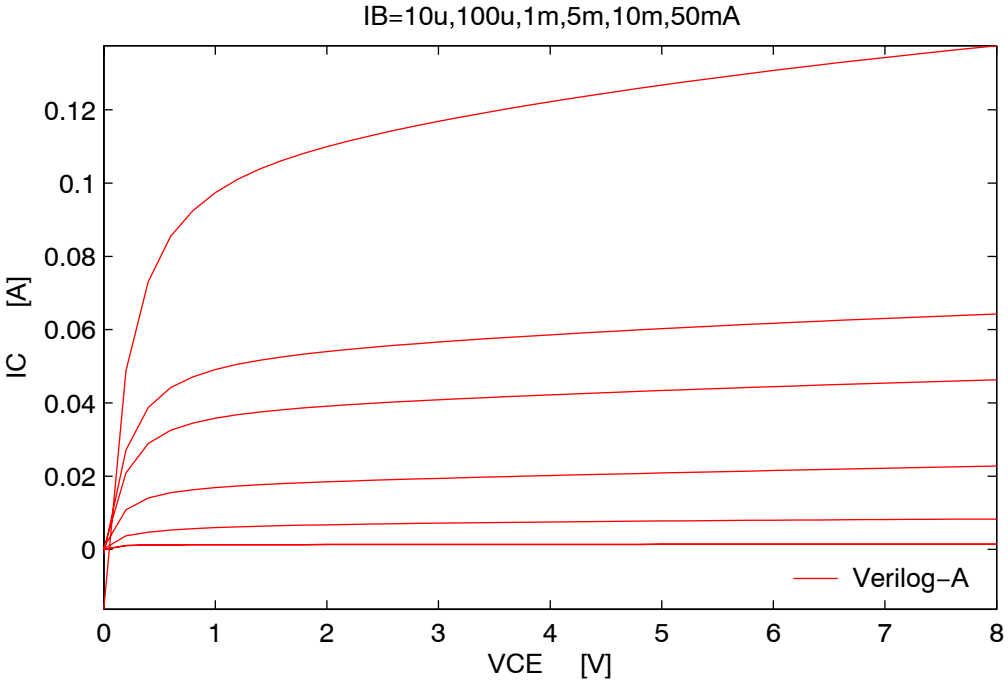

FIGURE 4. Forced-IB output characteristics at T=300K.

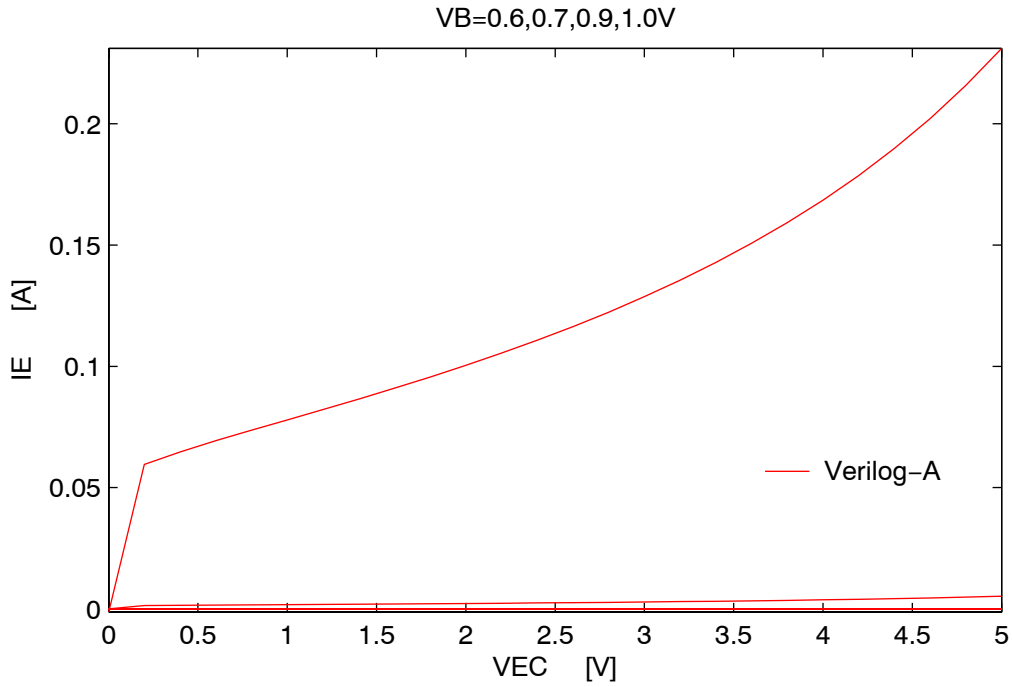

FIGURE 5. Reverse output characteristics at T=300K.

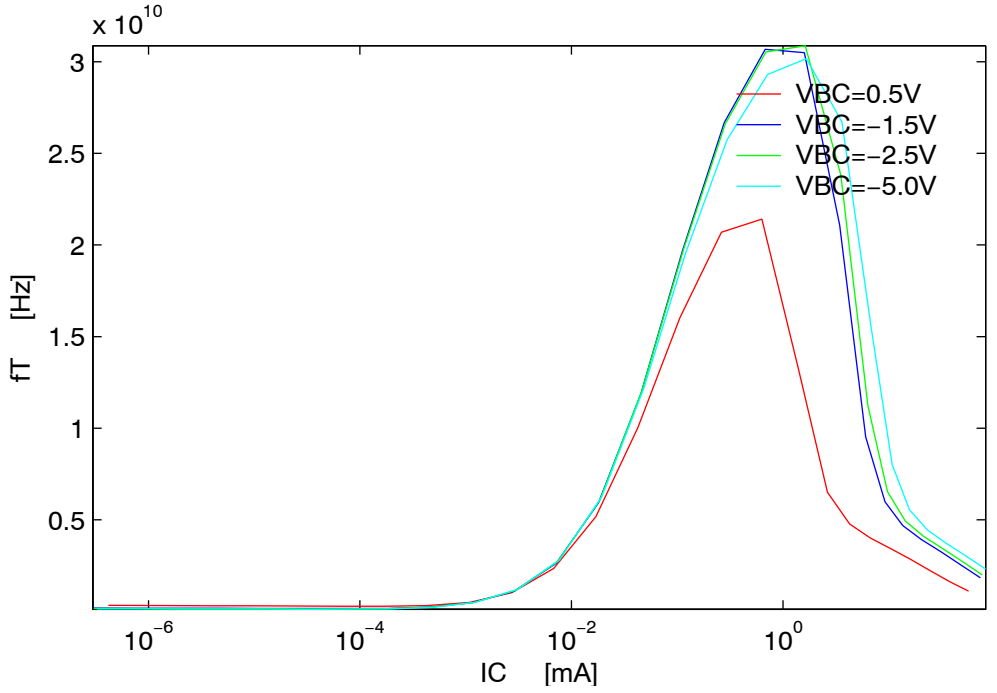

FIGURE 6. f_T(Hz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V, f_T extracted at f=2.8GHz.

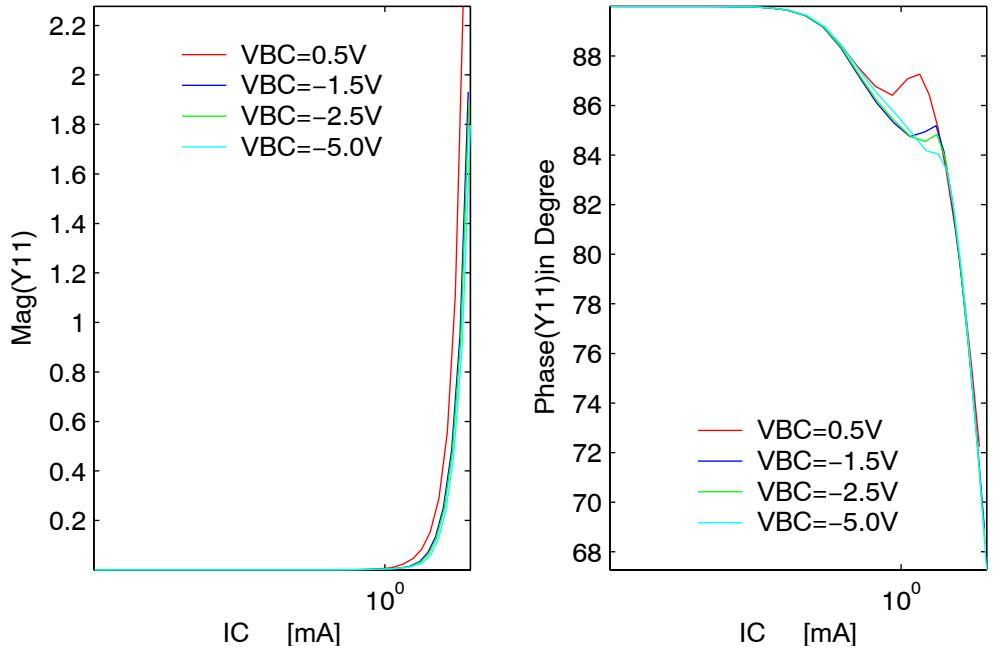

FIGURE 7. Y11 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

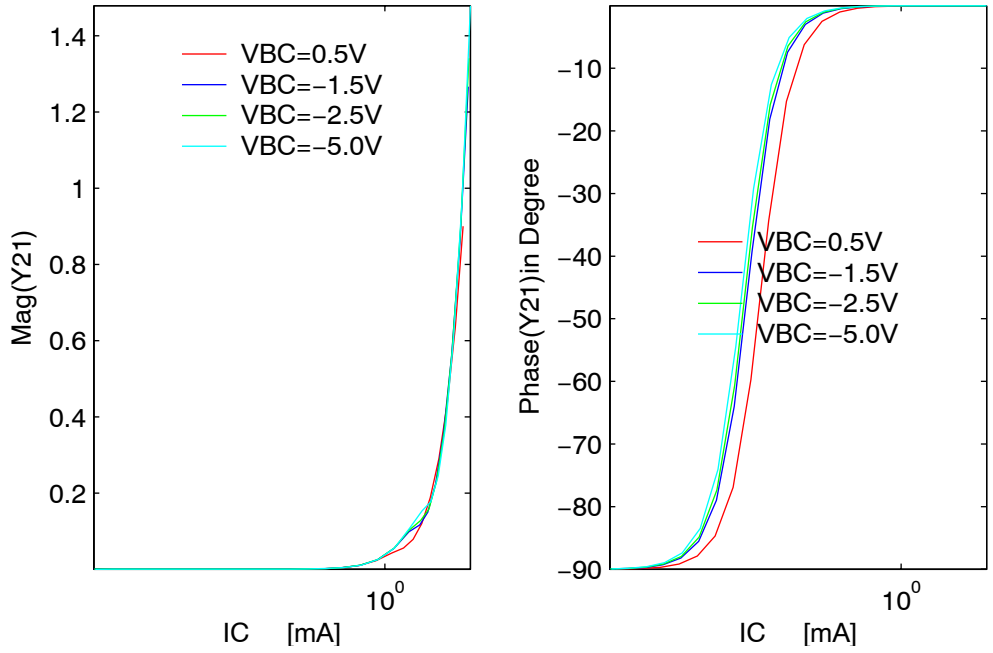

FIGURE 8. Y21 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

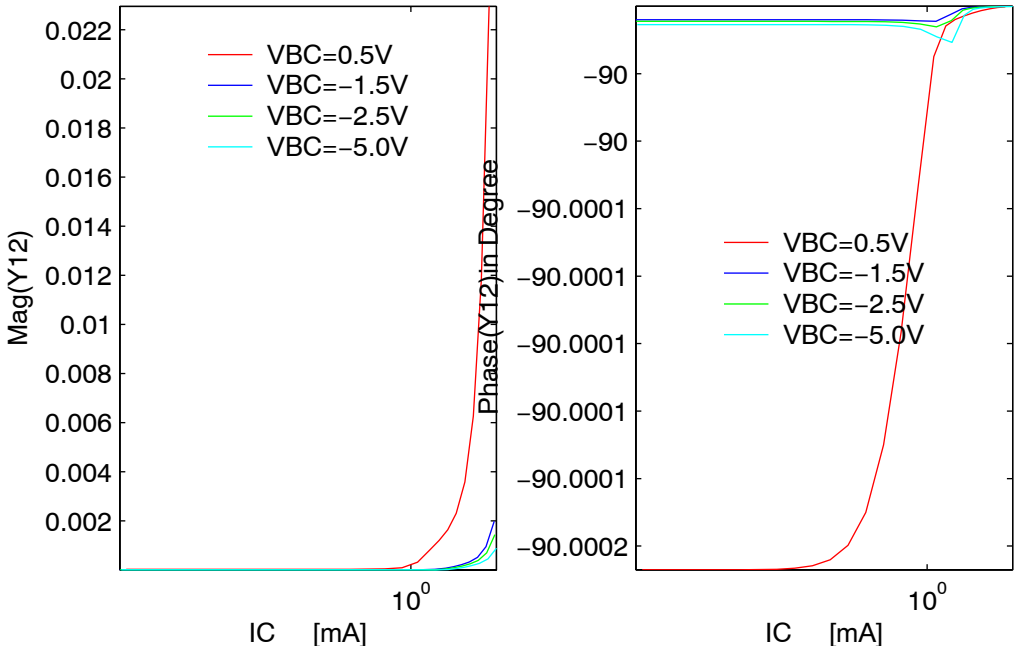

FIGURE 9. Y12 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

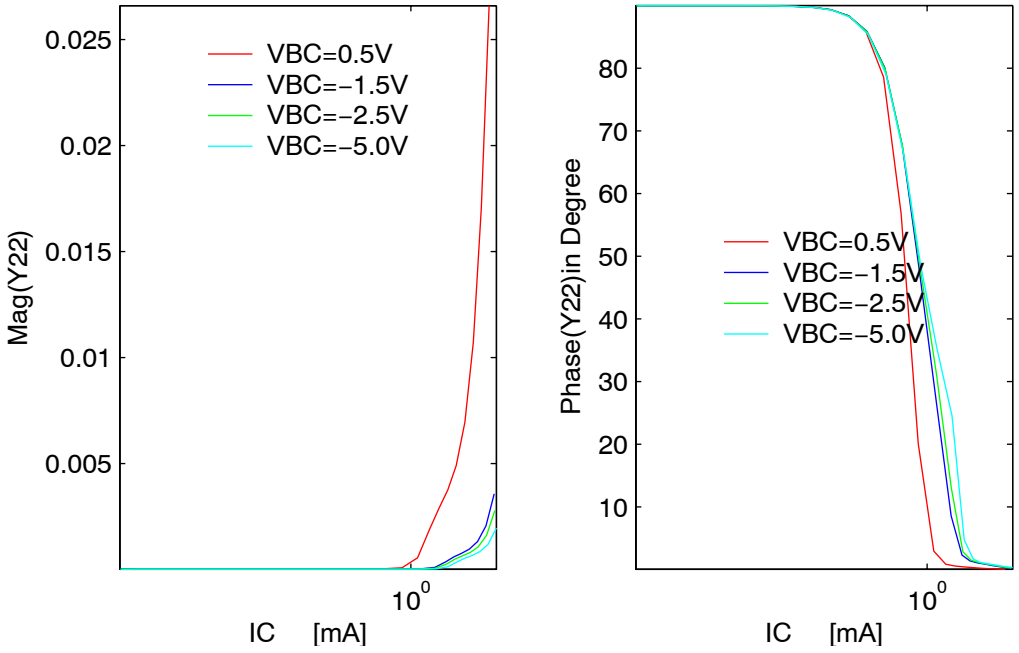

FIGURE 10. Y22 (extracted at f=2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

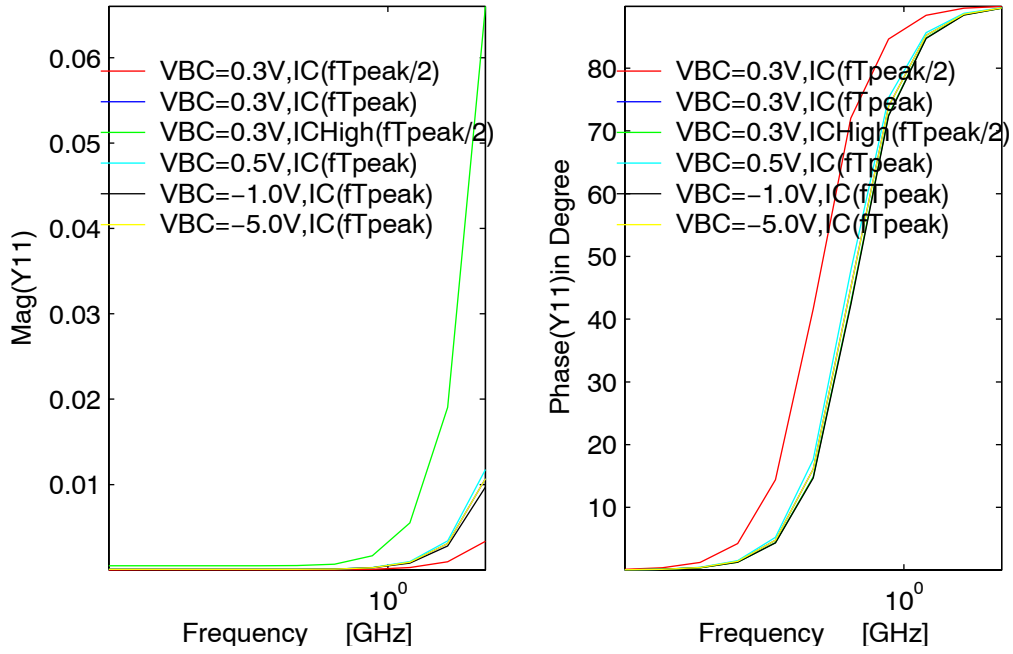

FIGURE 11. Y11 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

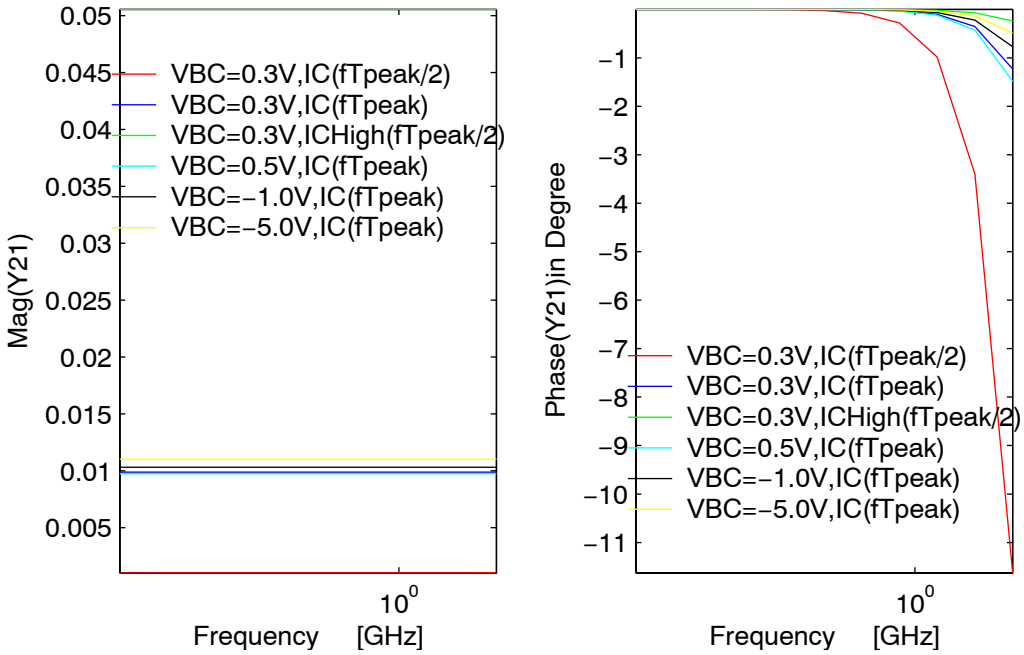

FIGURE 12. Y21 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

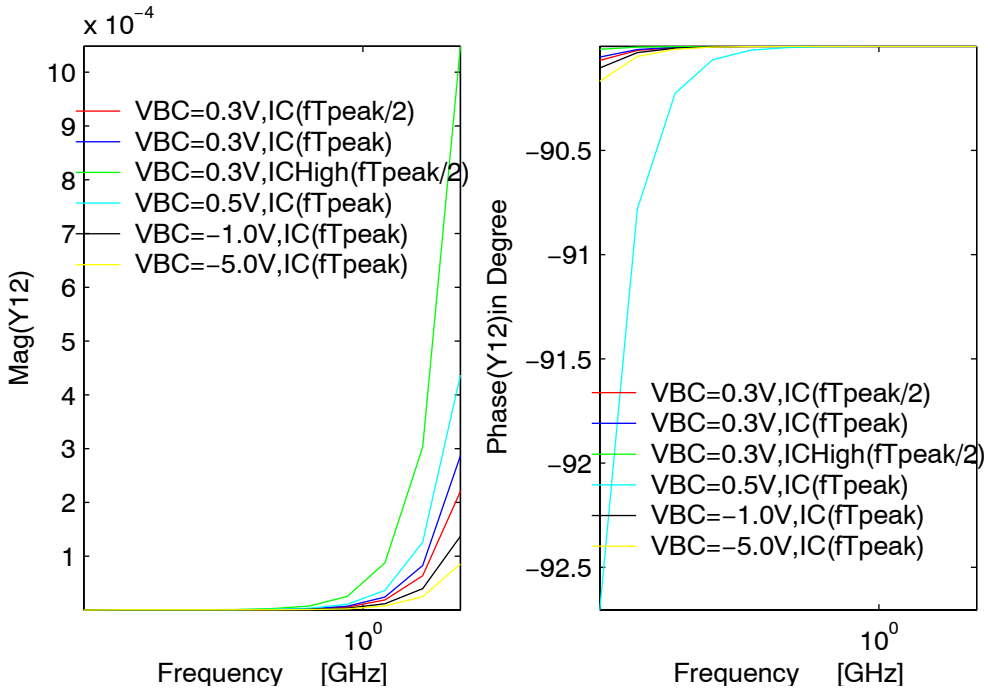

FIGURE 13. Y12 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0, -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

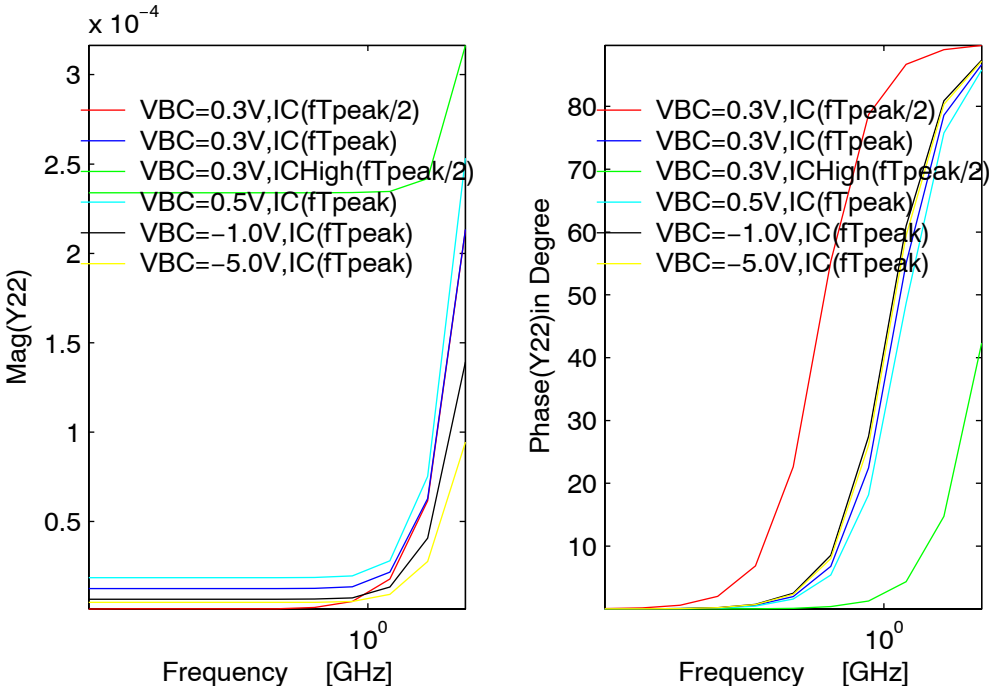

FIGURE 14. Y22 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

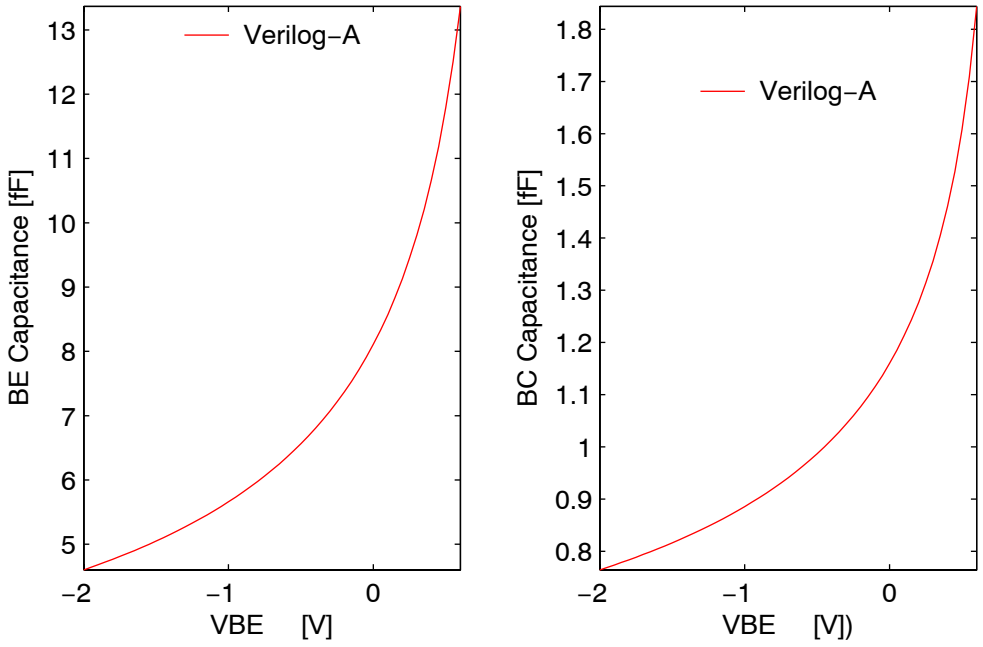

FIGURE 15. Depletion capacitances, Cbe and Cbc (fF) vs BE voltages (Volt) plots at T=300K.

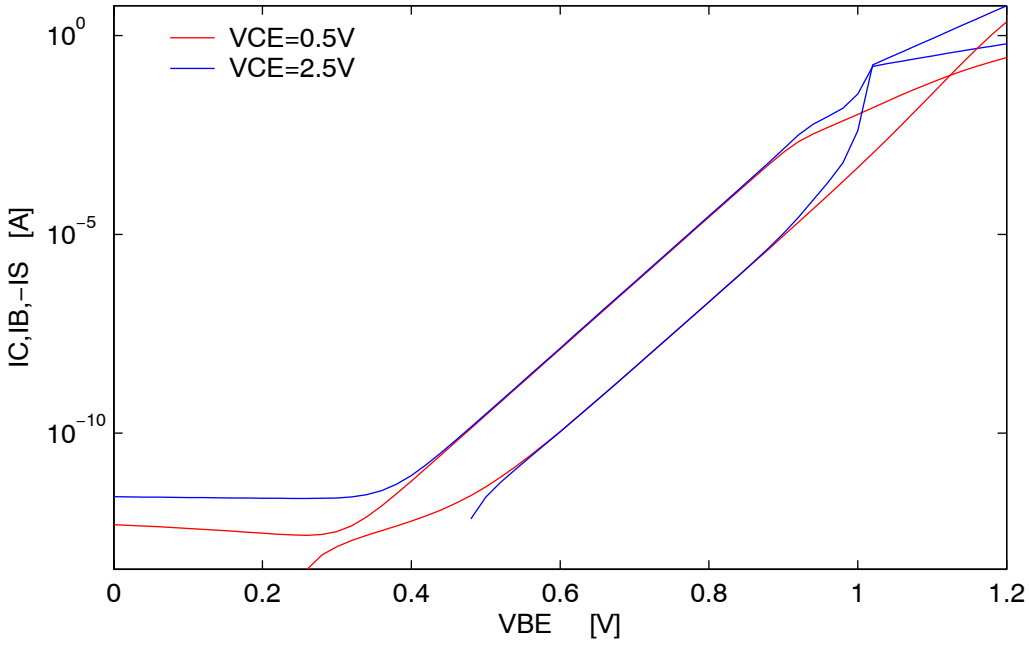

FIGURE 16. Forward Gummel plots at VCE=0.5,2.5 Volt and T=300K with self-heating effect.

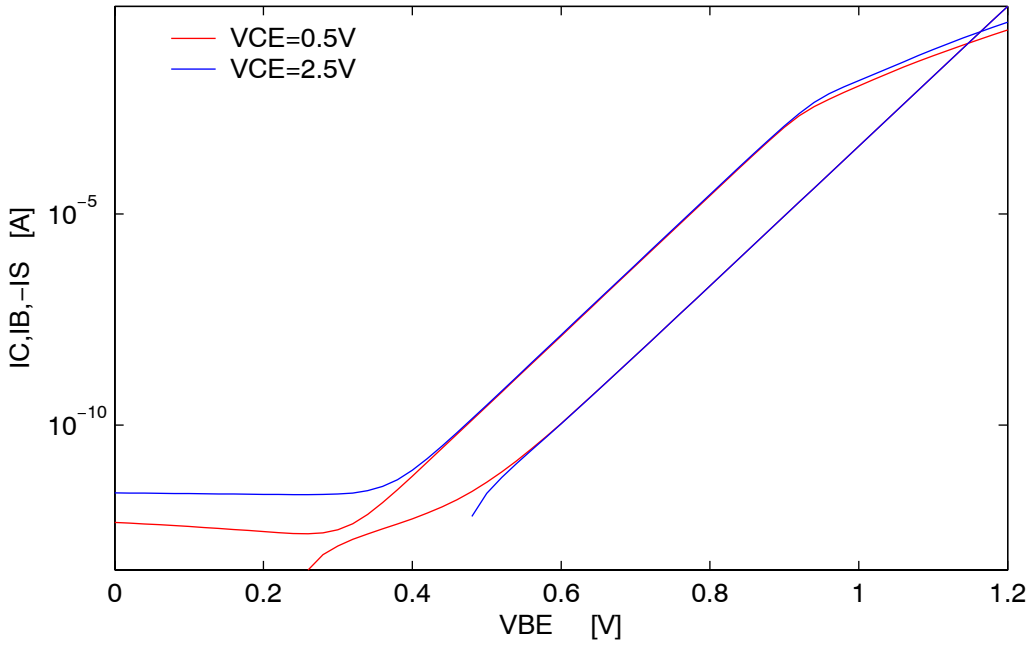

FIGURE 17. Forward Gummel plots at VCE=0.5,2.5 Volt and T=300K with collector current spreading effect.

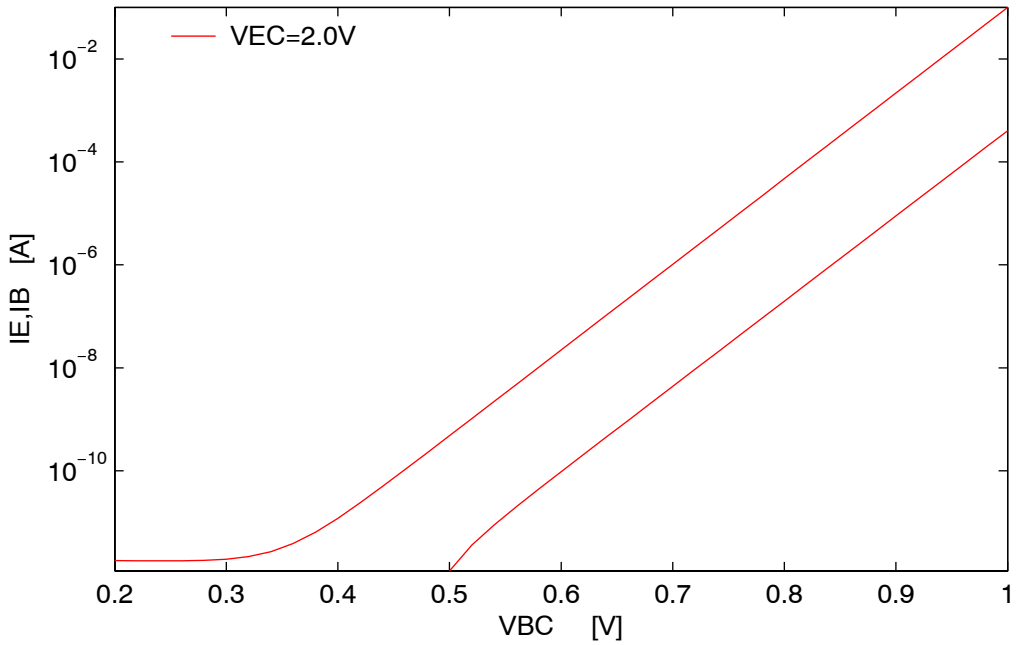

FIGURE 18. Reverse Gummel plots at VEC=2.0V at T=300K with collector current spreading effect.

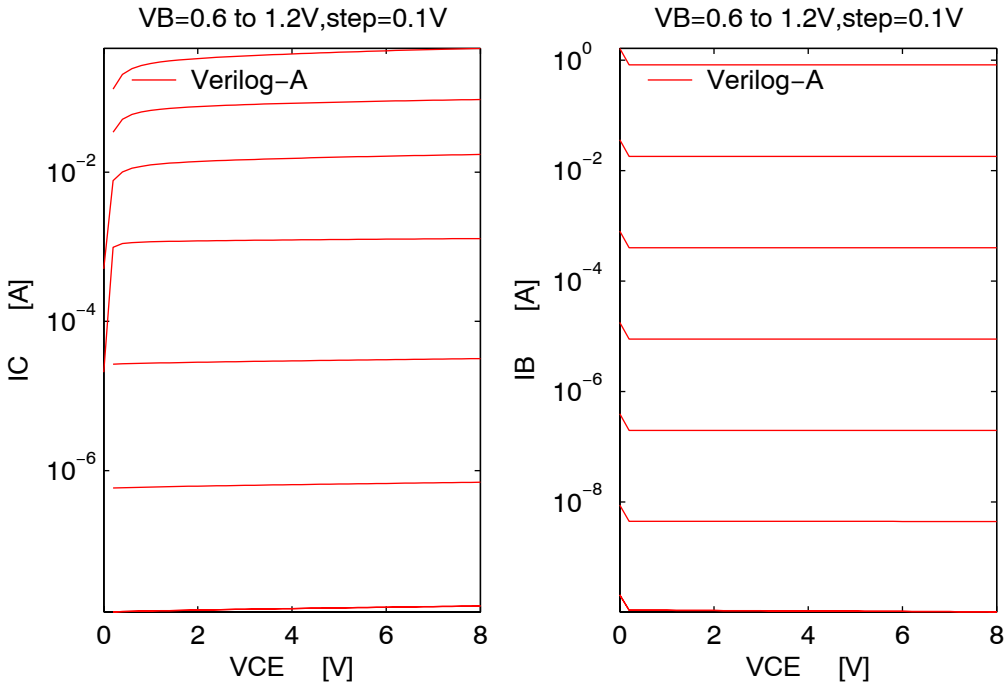

FIGURE 19. Forced-VB output characteristics and Ib-VCE plots at T=300K with collector current spreading effect.

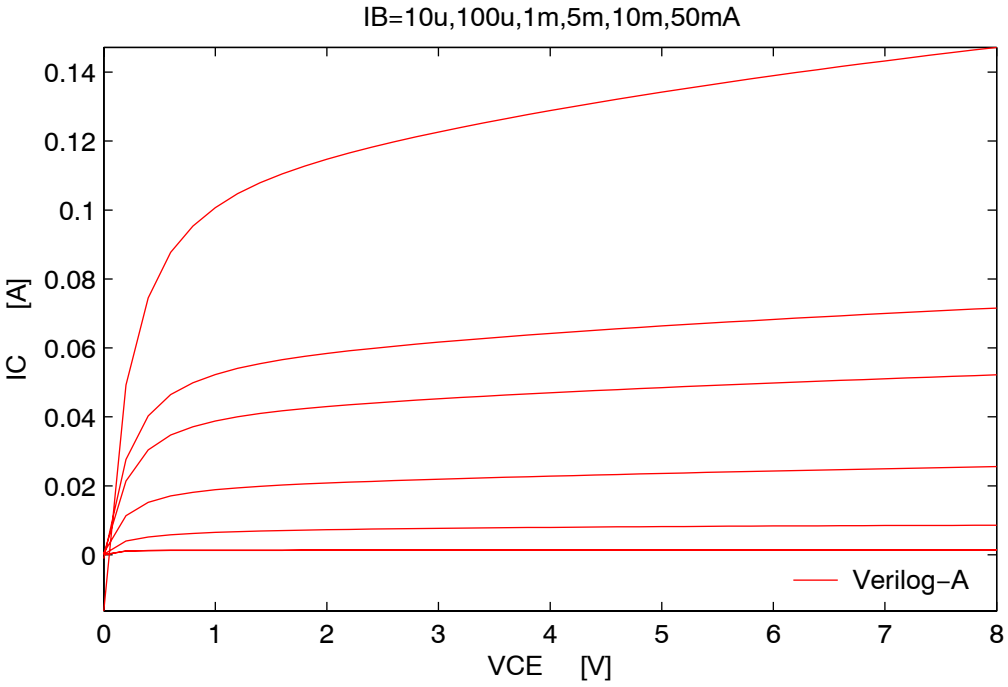

FIGURE 20. Forced-IB output characteristics at T=300K with collector current spreading effect.

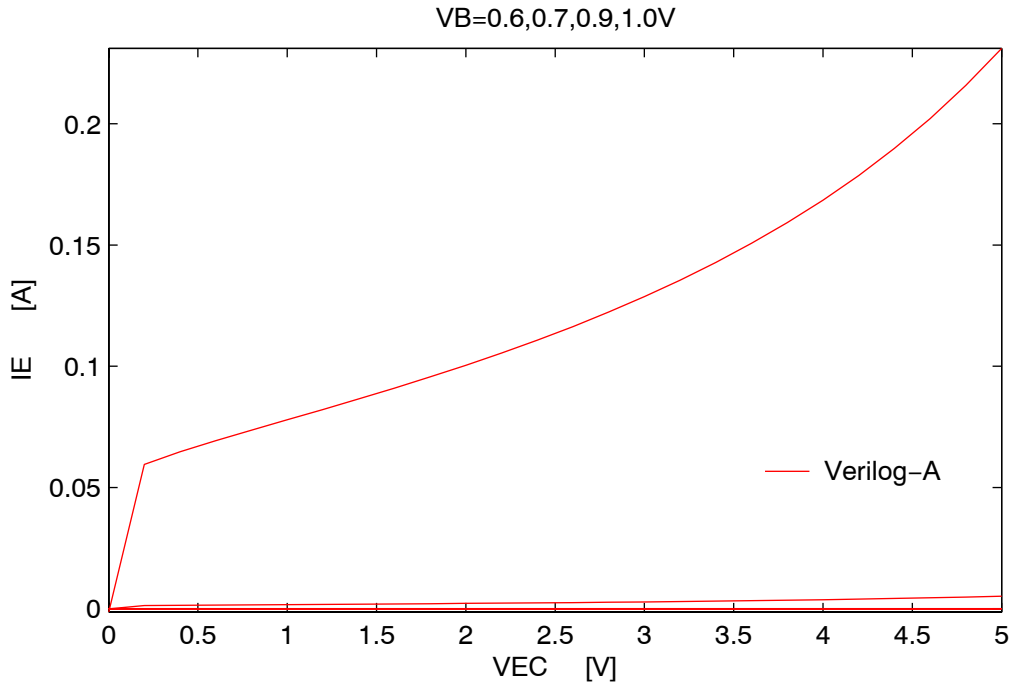

FIGURE 21. Reverse output characteristics at T=300K with collector current spreading effect.

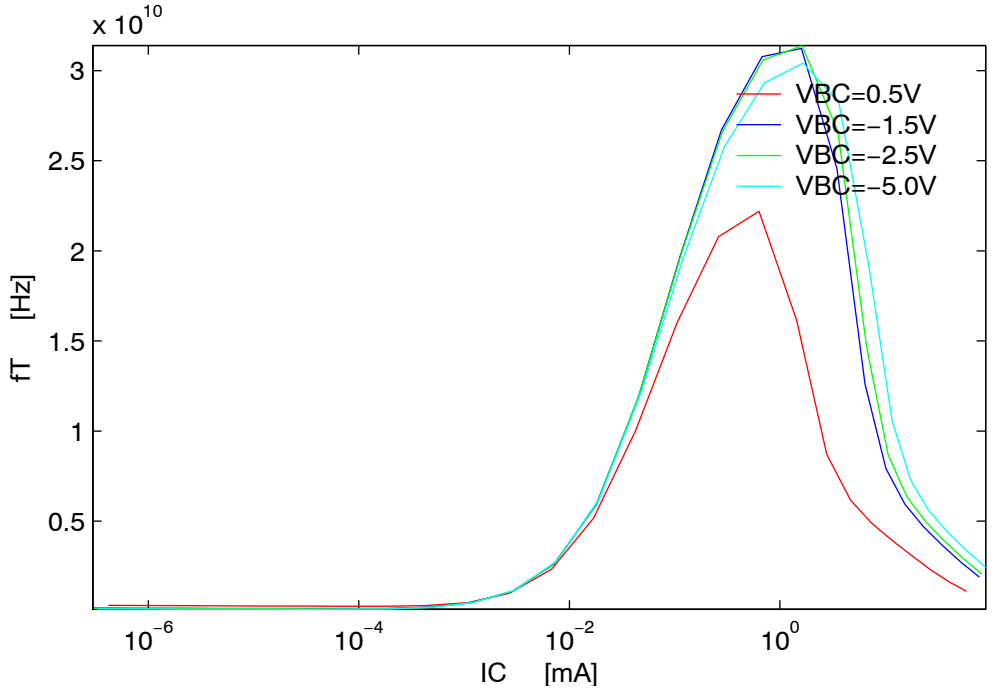

FIGURE 22. fT(Hz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V, fT extracted at f=2.8GHz with collector current spreading effect.

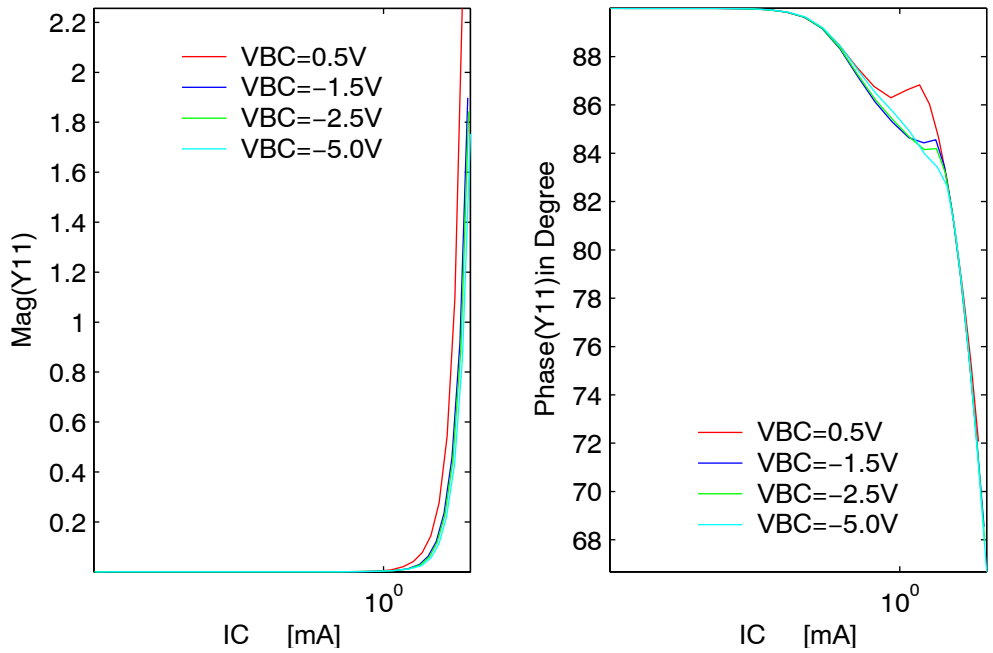

FIGURE 23. Y11 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

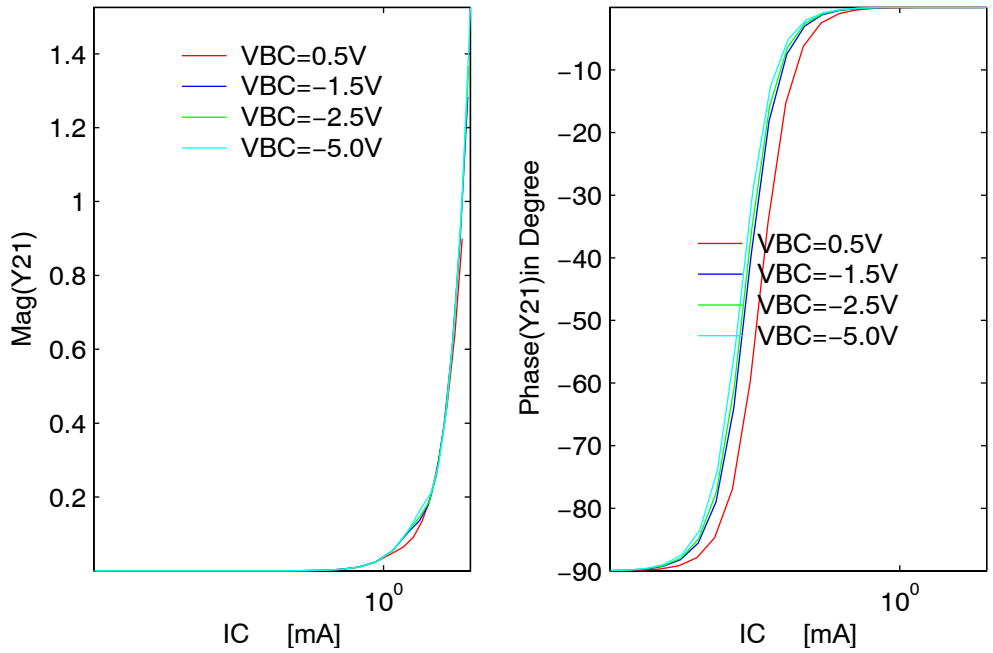

FIGURE 24. Y21 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

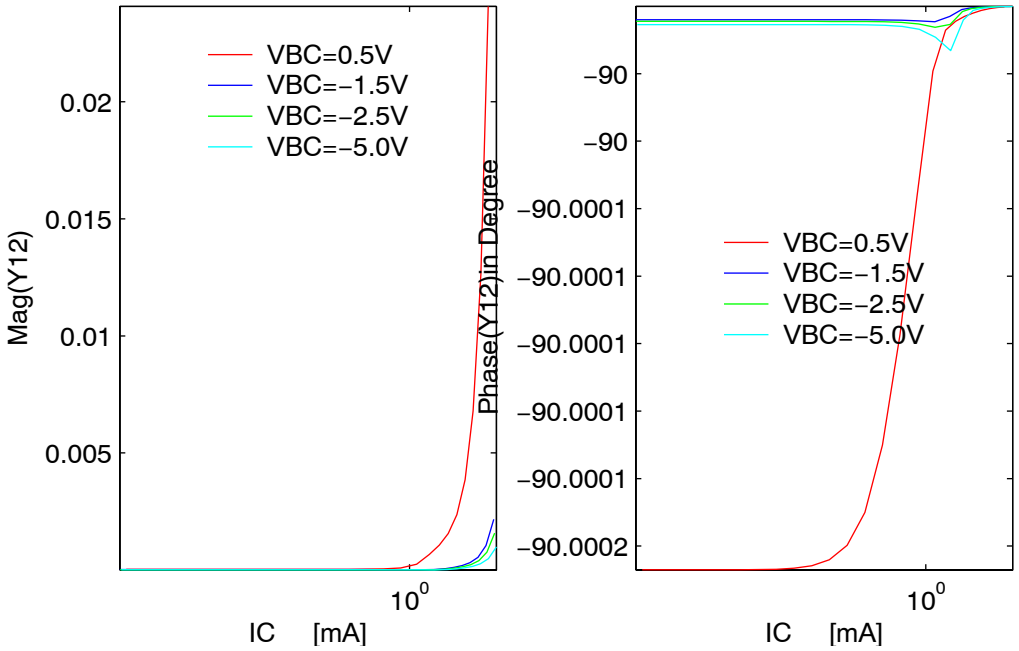

FIGURE 25. Y12 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

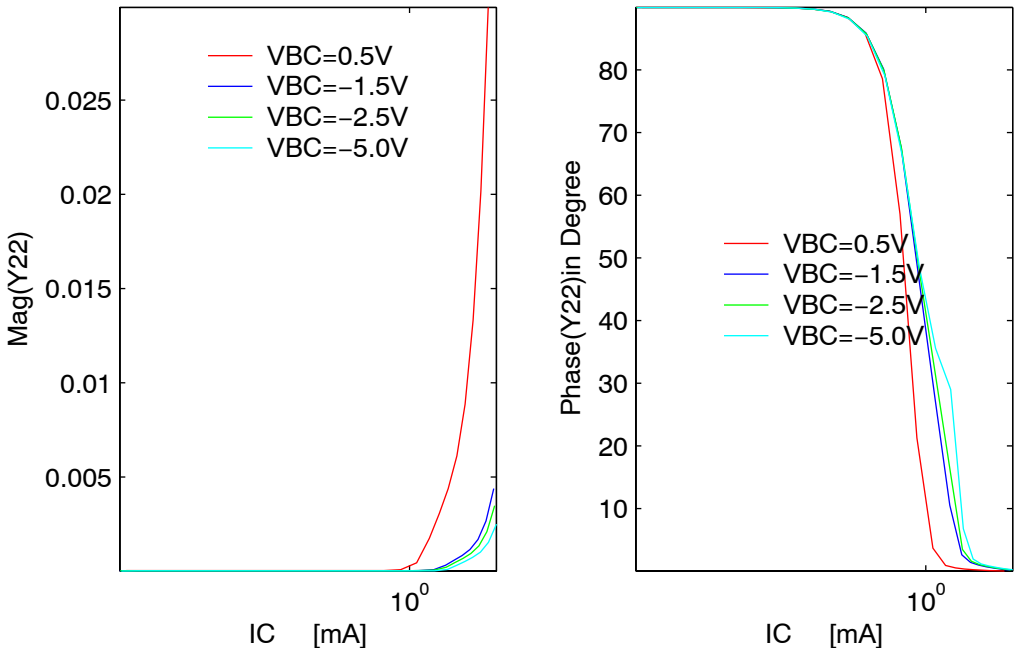

FIGURE 26. Y22 (extracted at f=2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

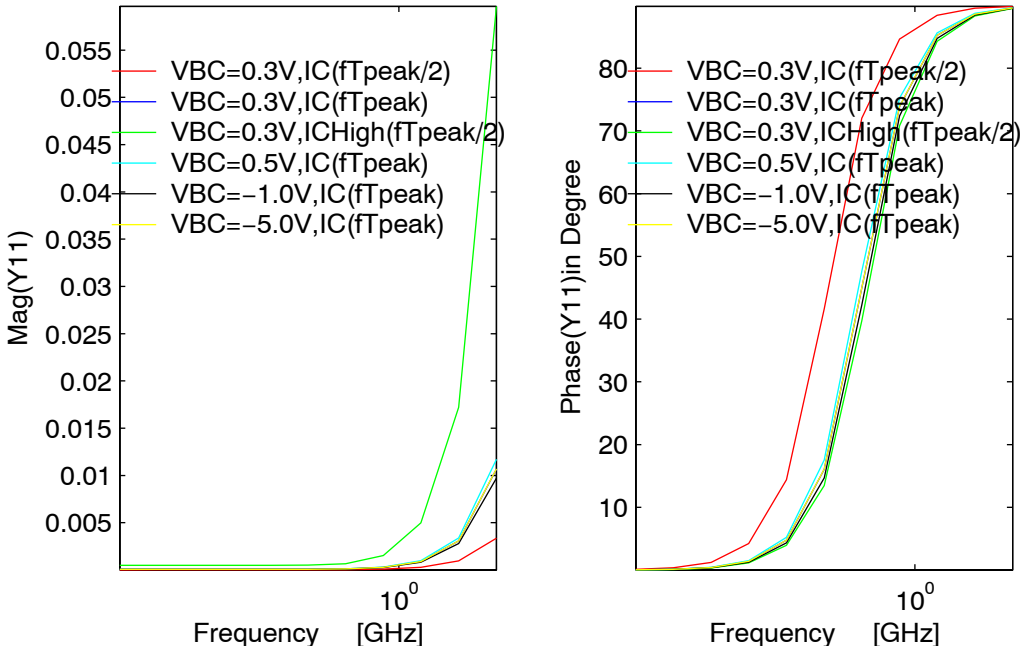

FIGURE 27. Y11 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

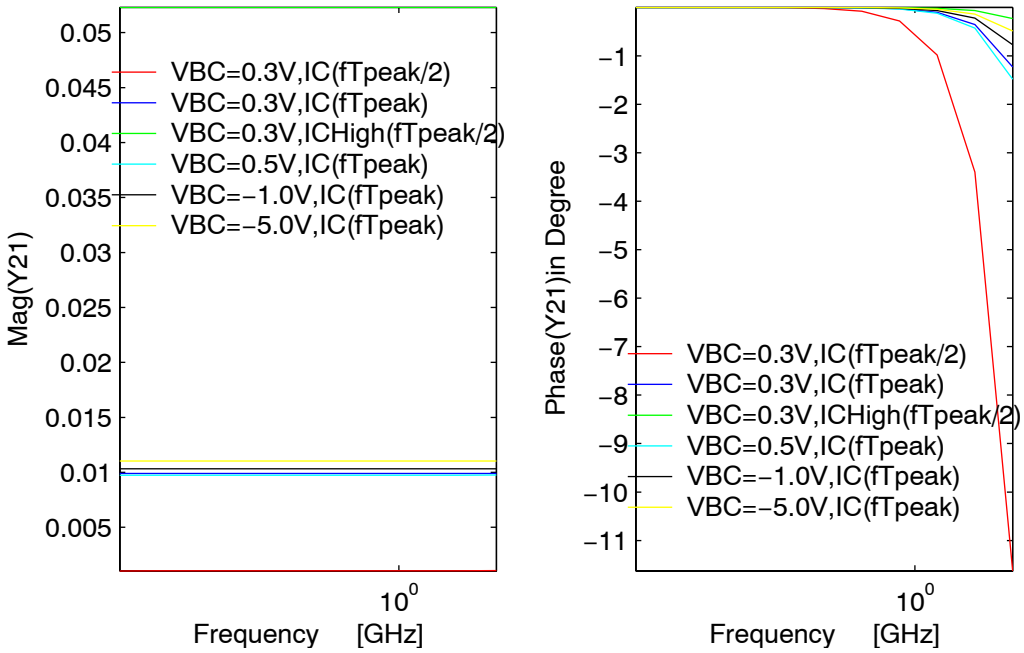

FIGURE 28. Y21 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

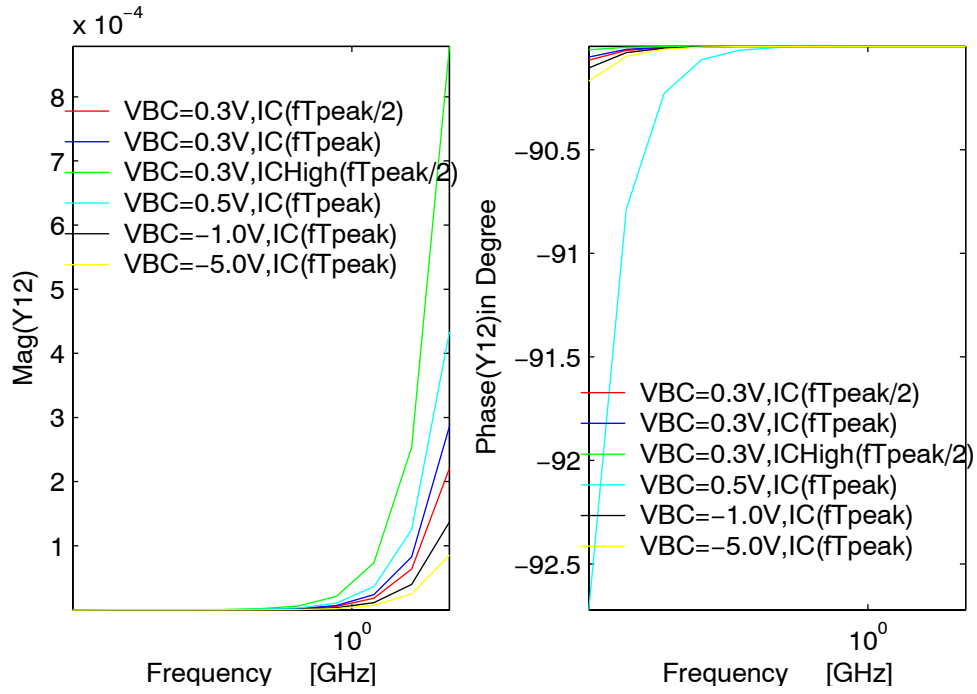

FIGURE 29. Y12 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0, -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

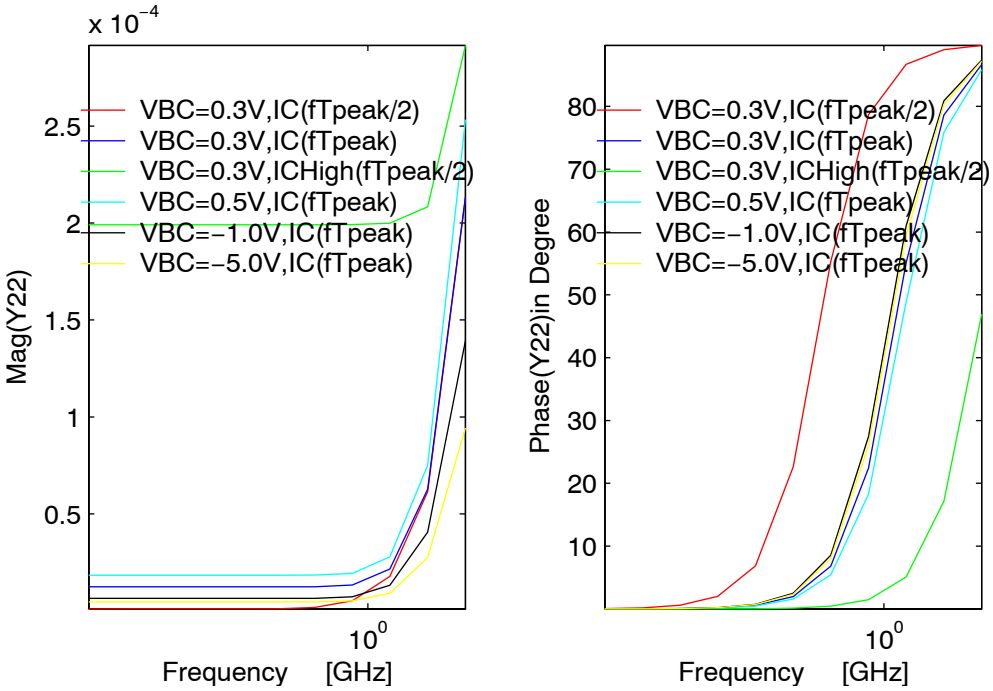

FIGURE 30. Y22 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

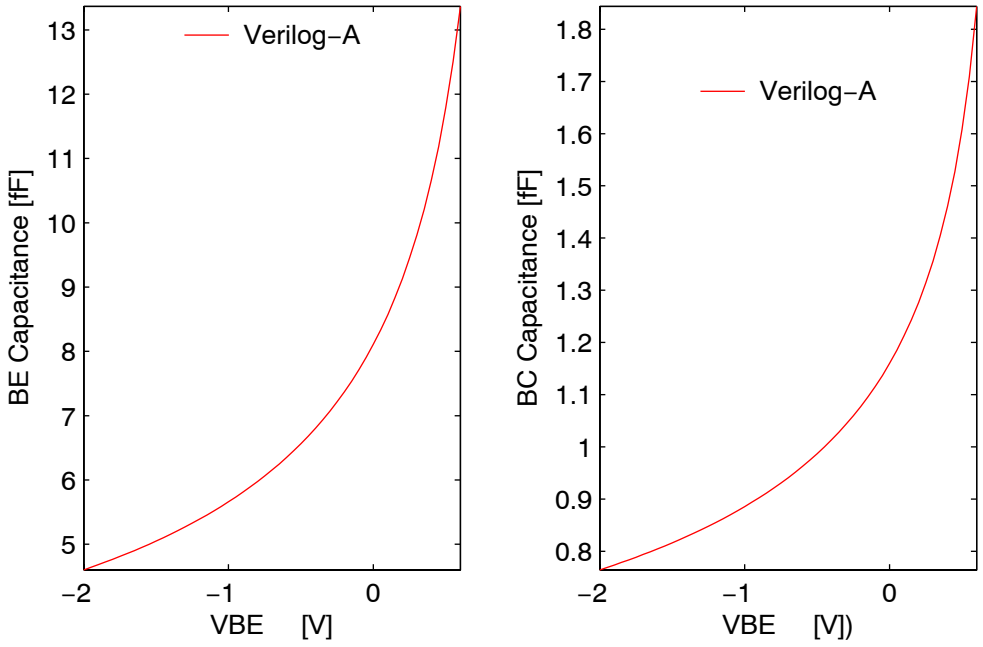

FIGURE 31. Depletion capacitances, Cbe and Cbc (fF) vs BE voltages (Volt) plots at T=300K with collector current spreading effect.

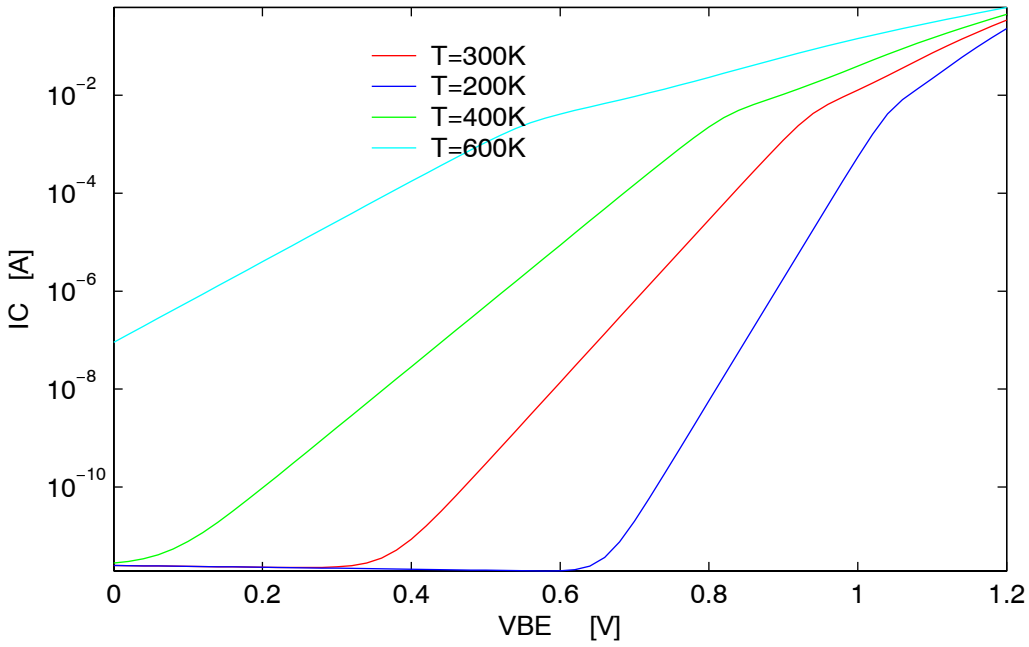

FIGURE 32. IC vs. VBE at VCE=2.5V and T=200K, 300K, 400K, 600K.

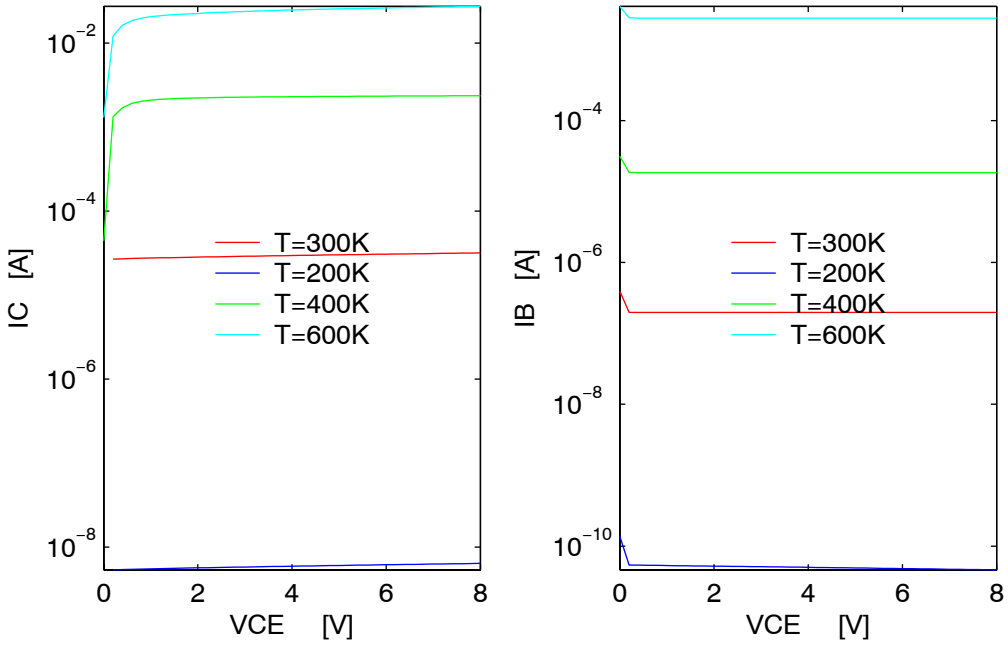

FIGURE 33. IC and IB vs. VCE at VB=0.8V and T=200K, 300K, 400K, 600K.

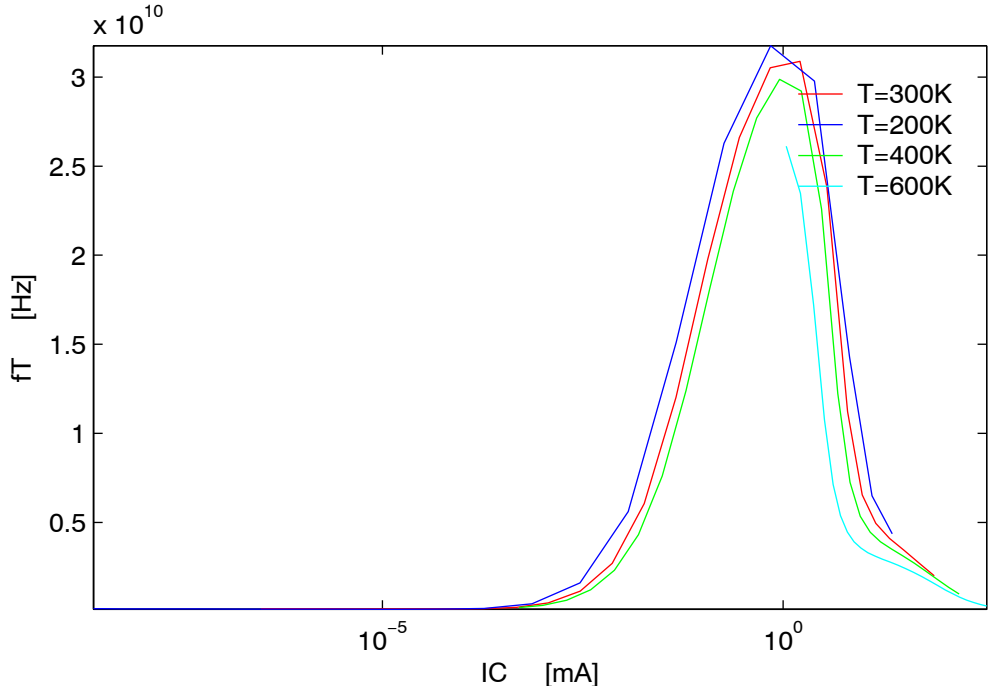

FIGURE 34. fT(Hz) vs. IC(mA) at VBC=-2.5V and T=200K, 300K, 400K, 600K.

Section 2: Results of Internal Transistor

- Internal base resistance added. Tunneling current source tagged to the peripheral base node.
- Results in this section are identical with the “previous” version.

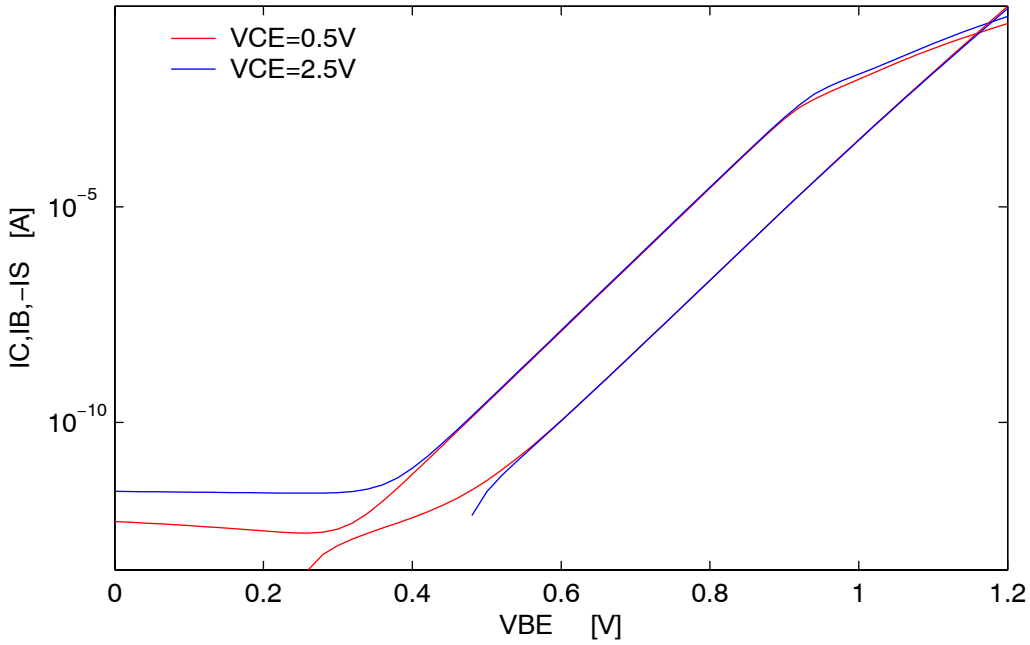

FIGURE 35. Forward Gummel plots at VCE=0.5,2.5 Volt and T=300K.

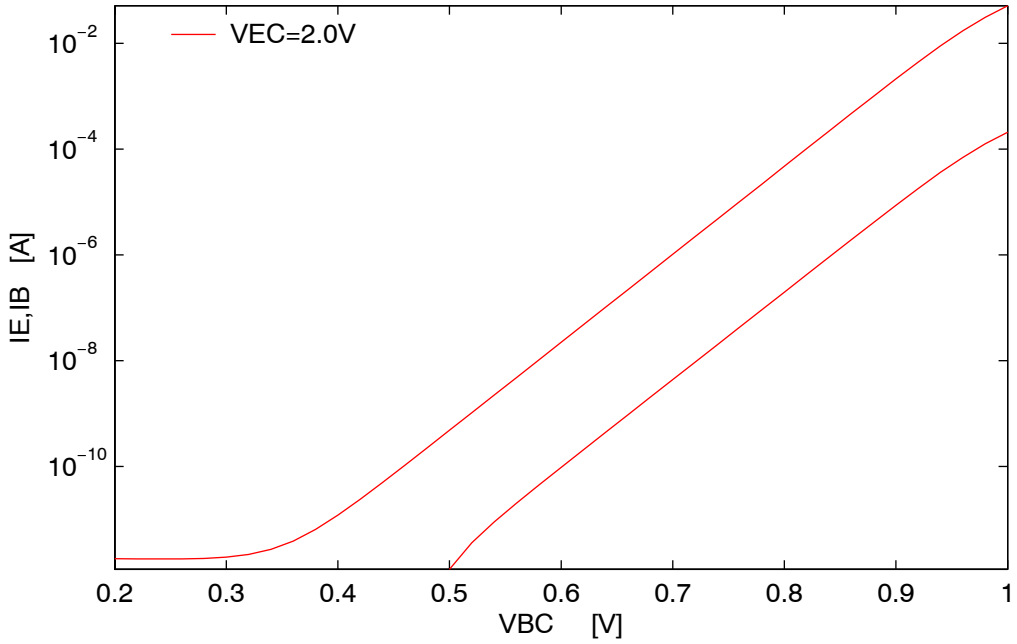

FIGURE 36. Reverse Gummel plots at VEC=2.0V at T=300K.

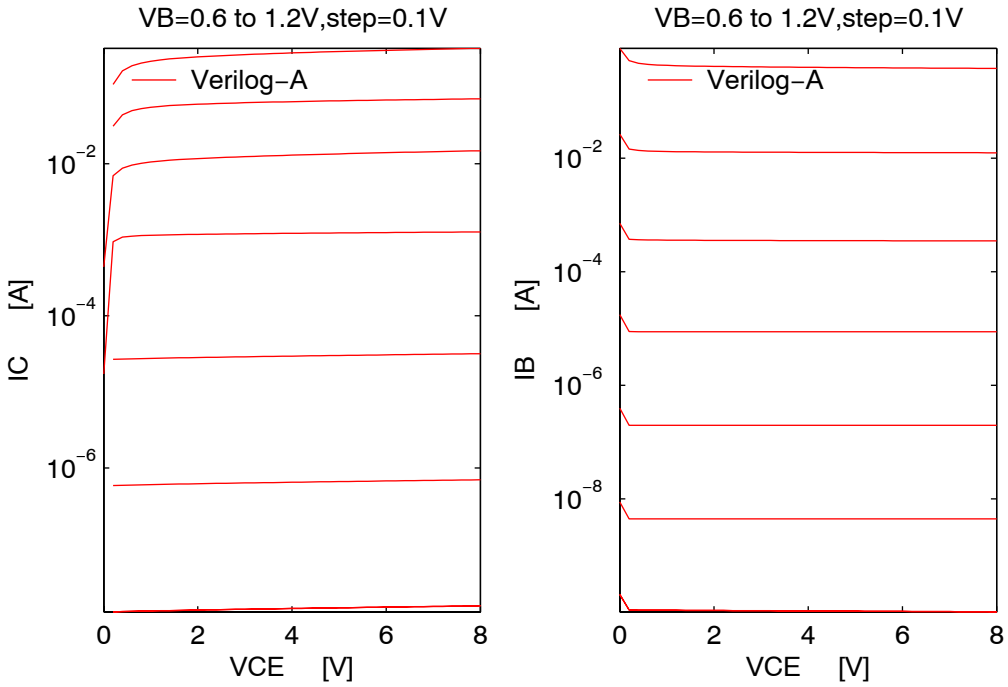

FIGURE 37. Forced-VB output characteristics and Ib-VCE plots at T=300K.

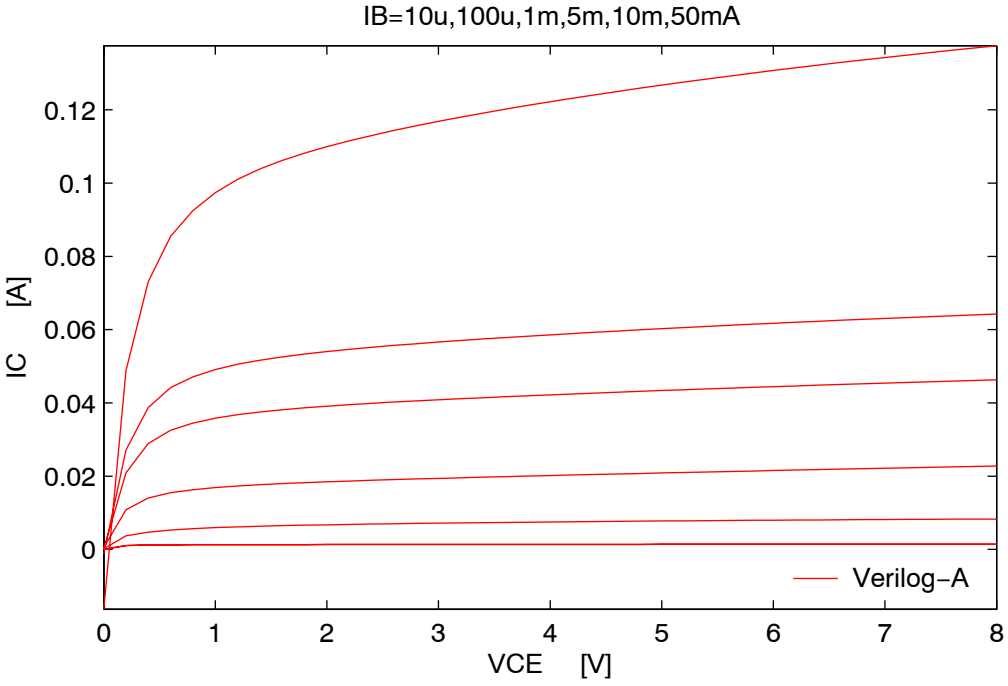

FIGURE 38. Forced-IB output characteristics at T=300K.

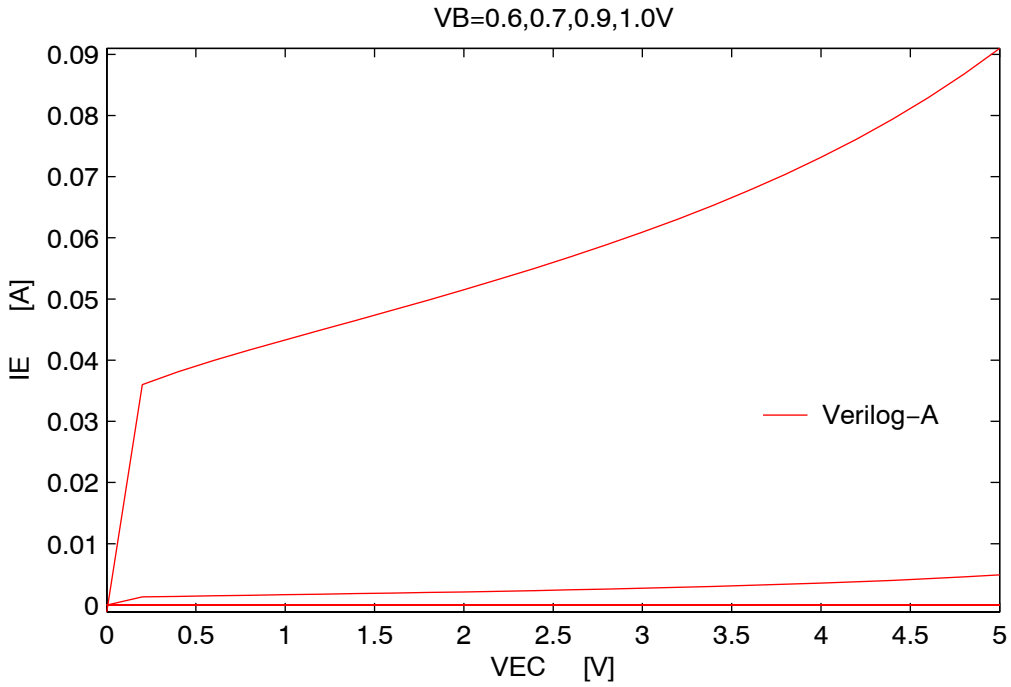

FIGURE 39. Reverse output characteristics at T=300K.

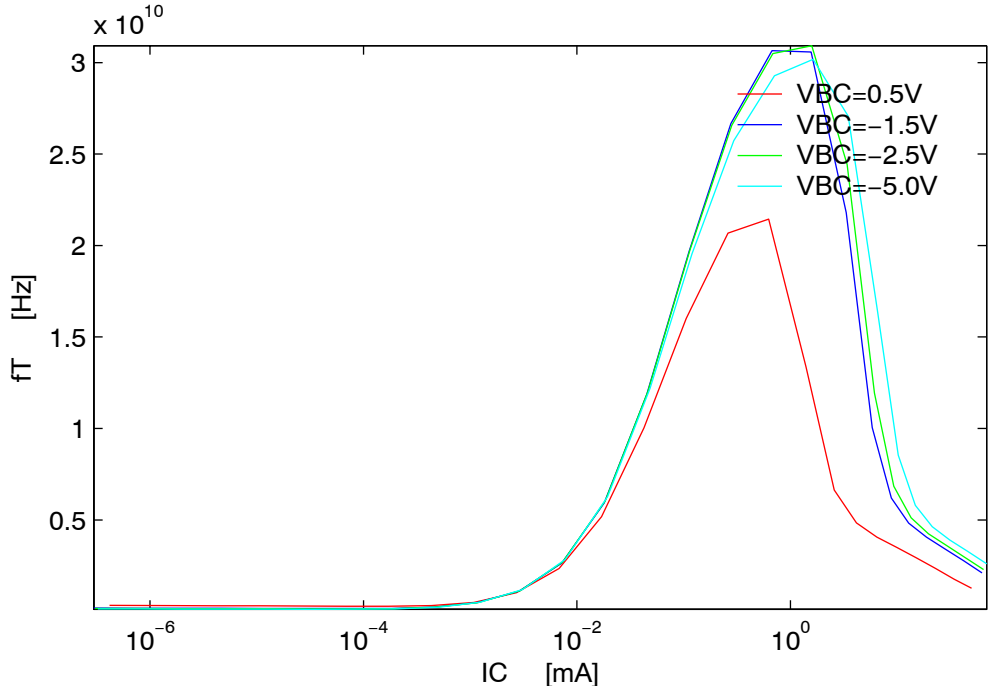

FIGURE 40. fT(Hz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V, fT extracted at f=2.8GHz.

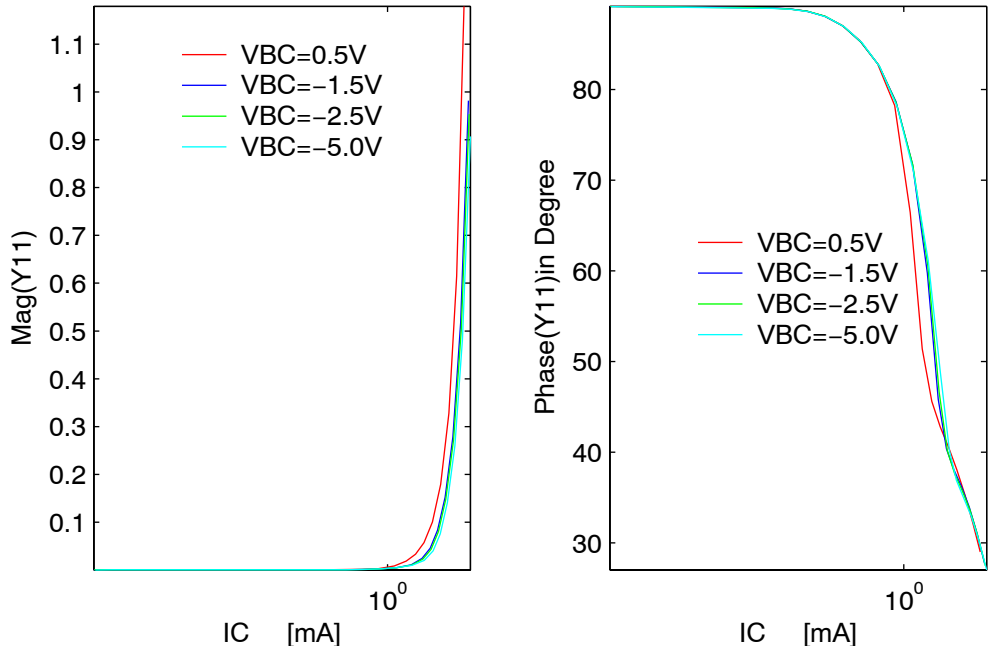

FIGURE 41. Y11 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

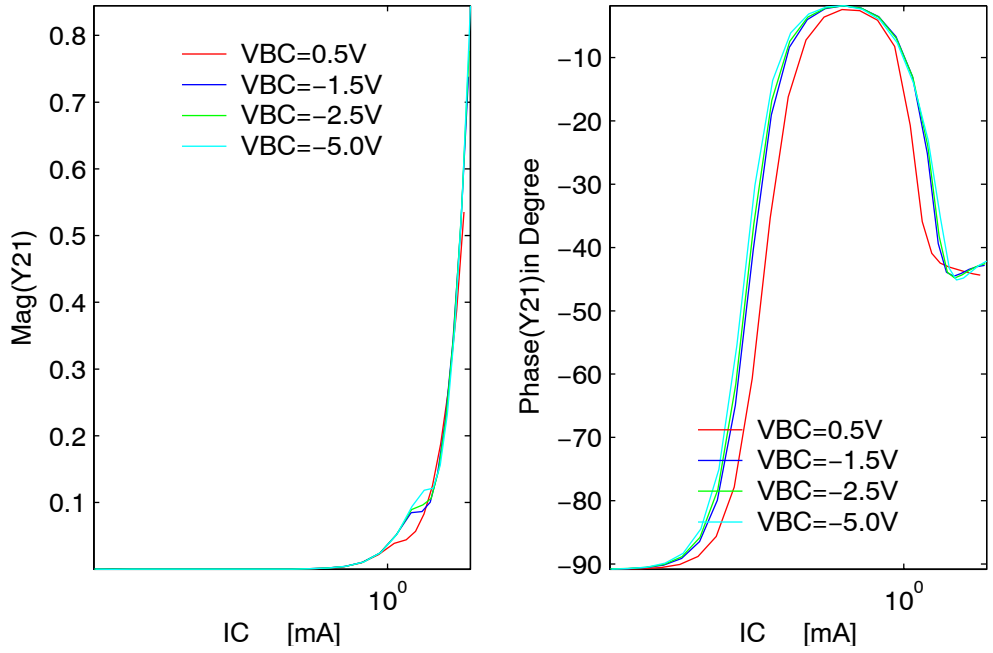

FIGURE 42. Y21 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

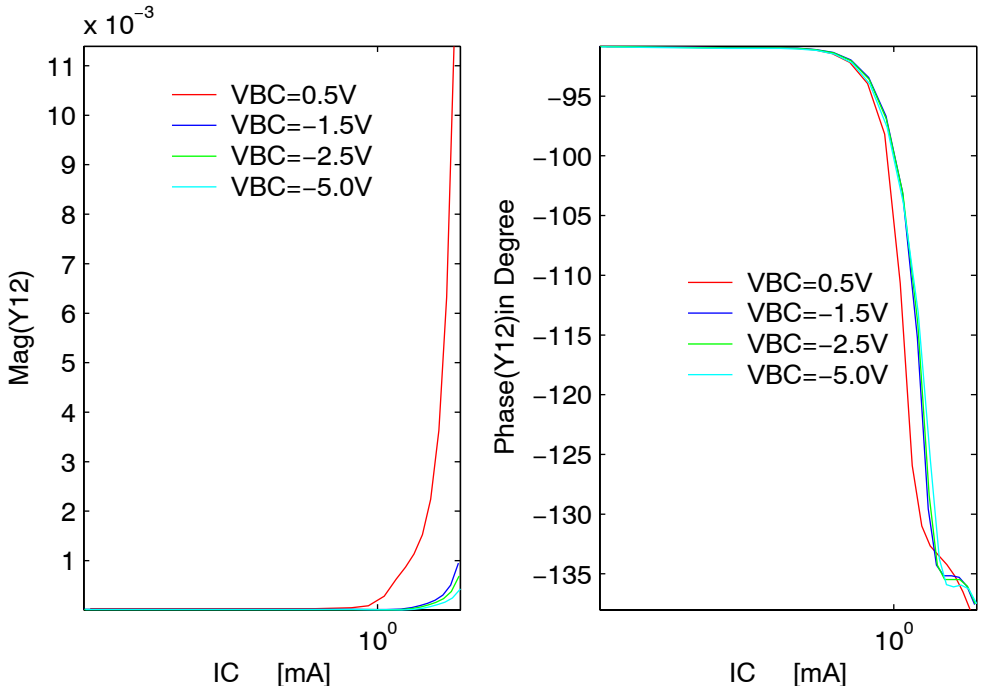

FIGURE 43. Y12 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

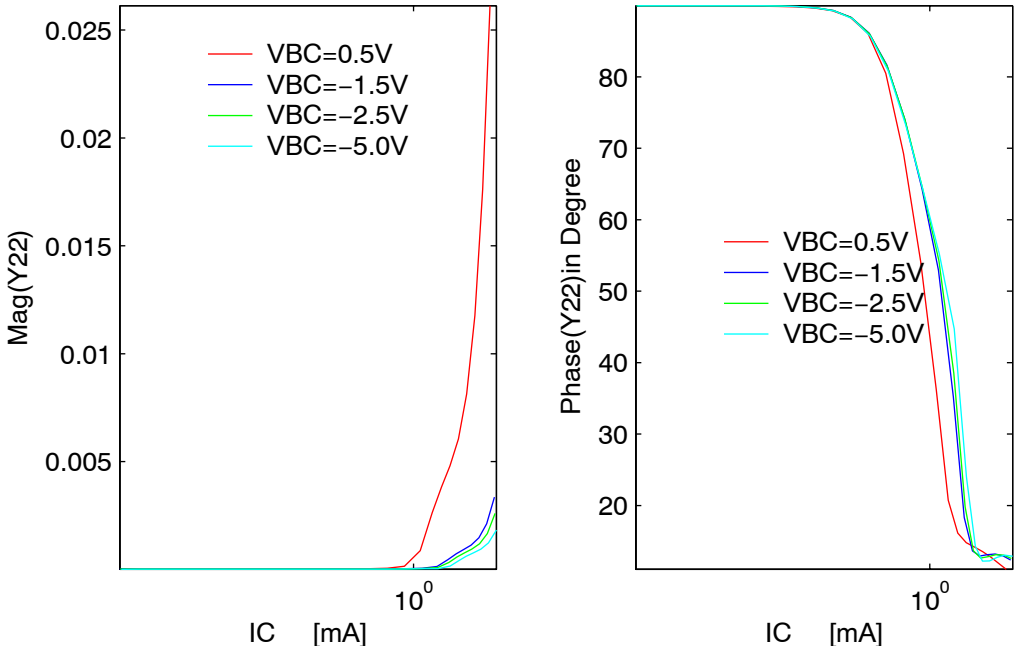

FIGURE 44. Y22 (extracted at f=2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

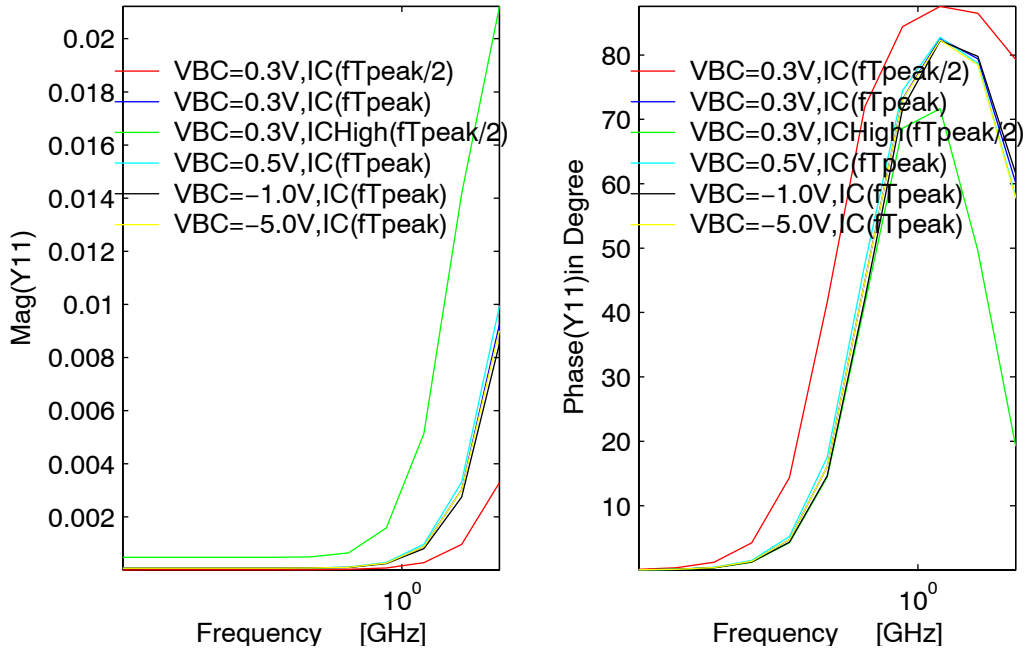

FIGURE 45. Y11 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

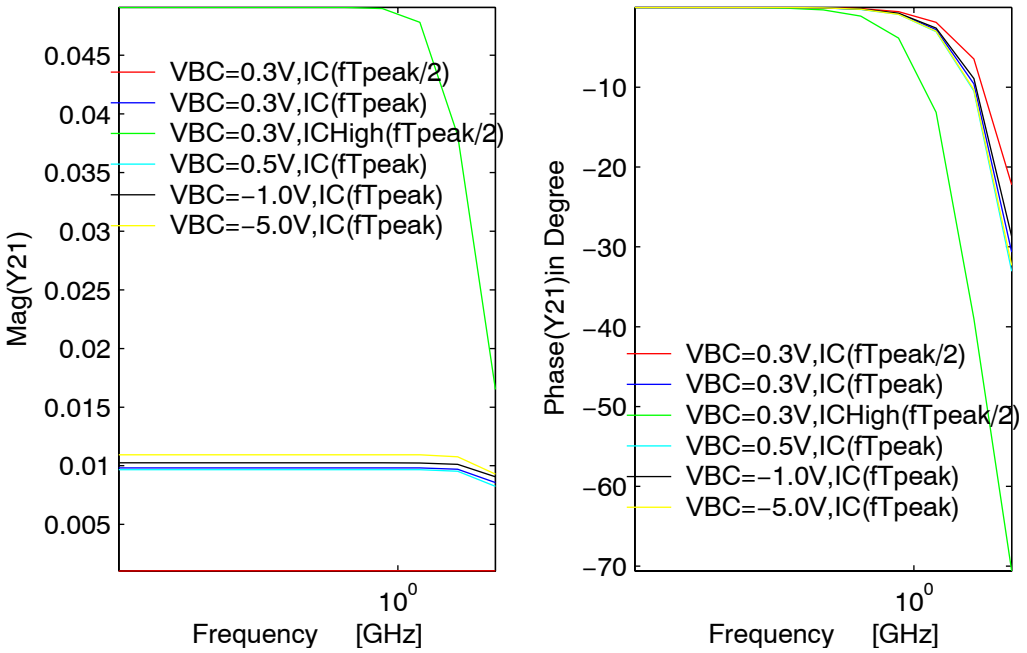

FIGURE 46. Y21 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

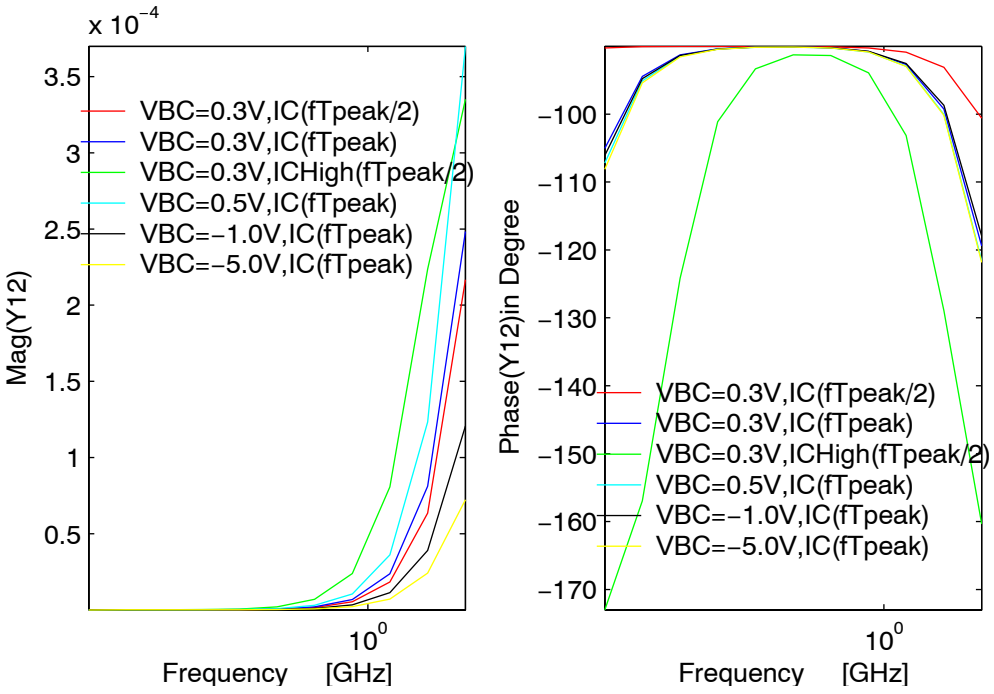

FIGURE 47. Y12 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0, -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

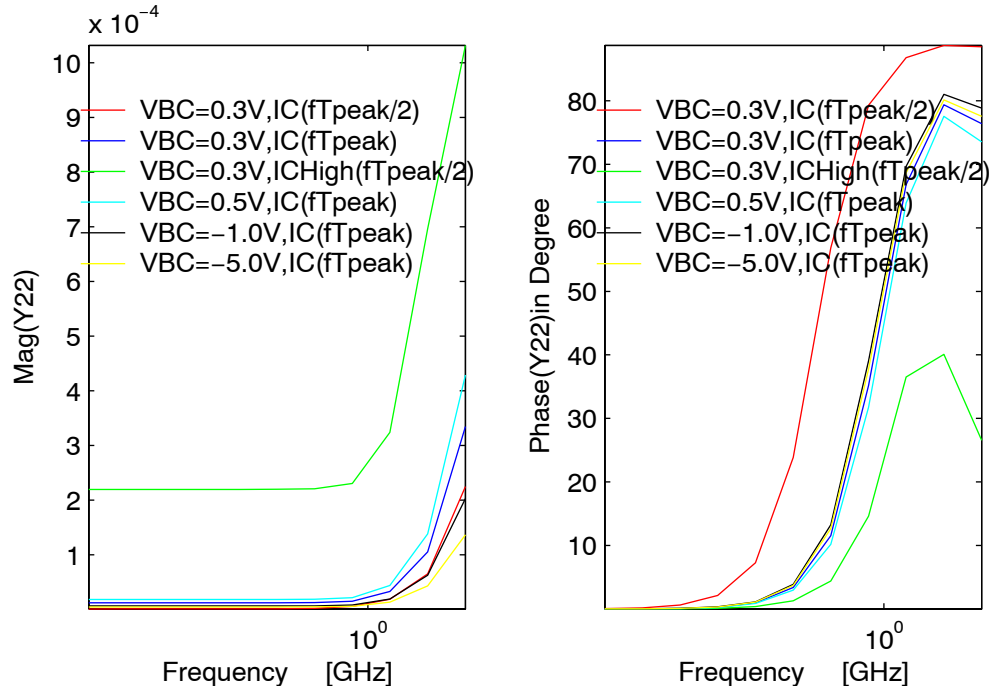

FIGURE 48. Y22 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

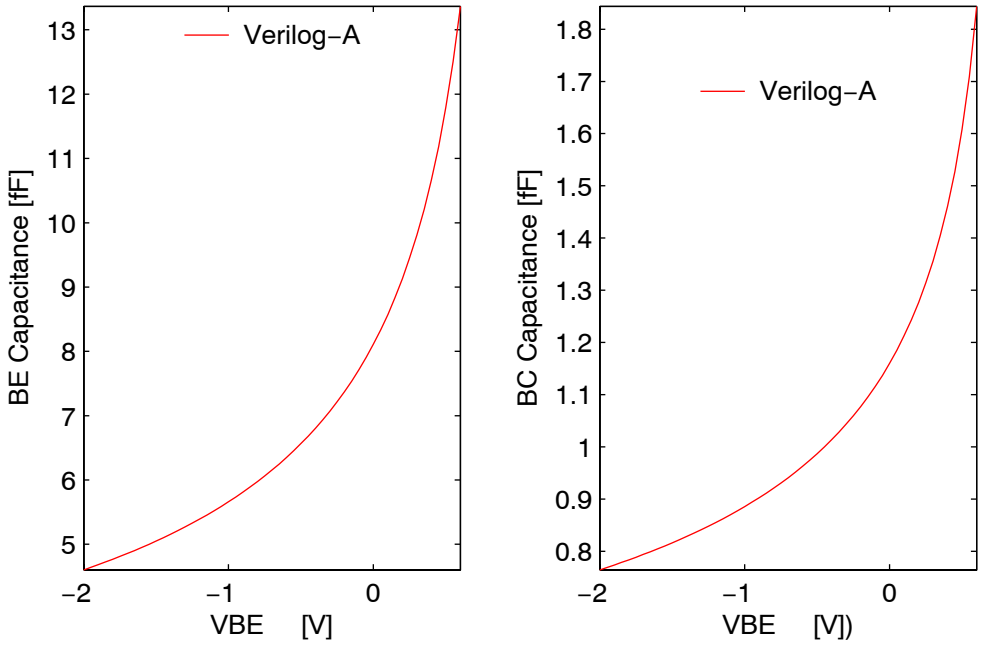

FIGURE 49. Depletion capacitances, Cbe and Cbc (fF) vs BE voltages (Volt) plots at T=300K.

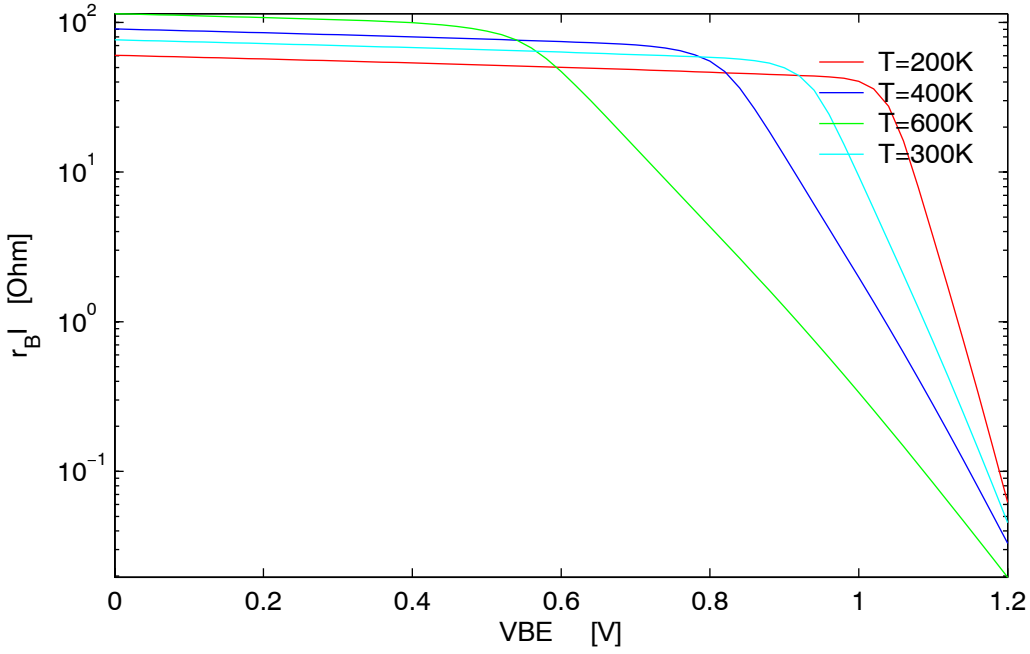

FIGURE 50. RBi vs. VBE for T=200K, 300K, 400K and 600K.

Section 3: Results of Complete Transistor

- Results in this section are identical with the “previous” version.

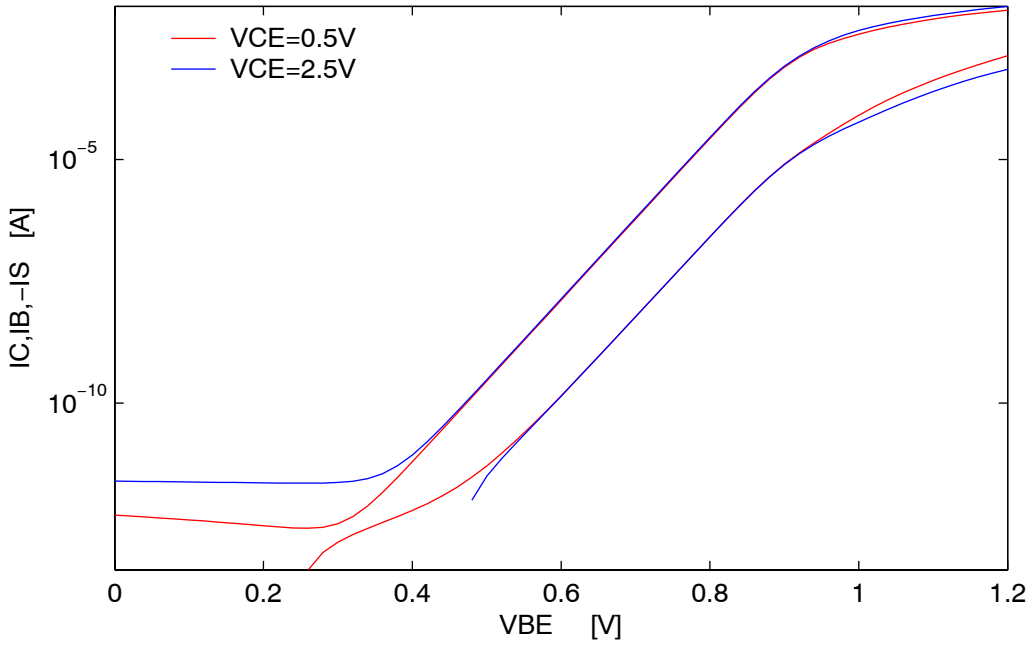

FIGURE 51. Forward Gummel plots at VCE=0.5,2.5 Volt and T=300K.

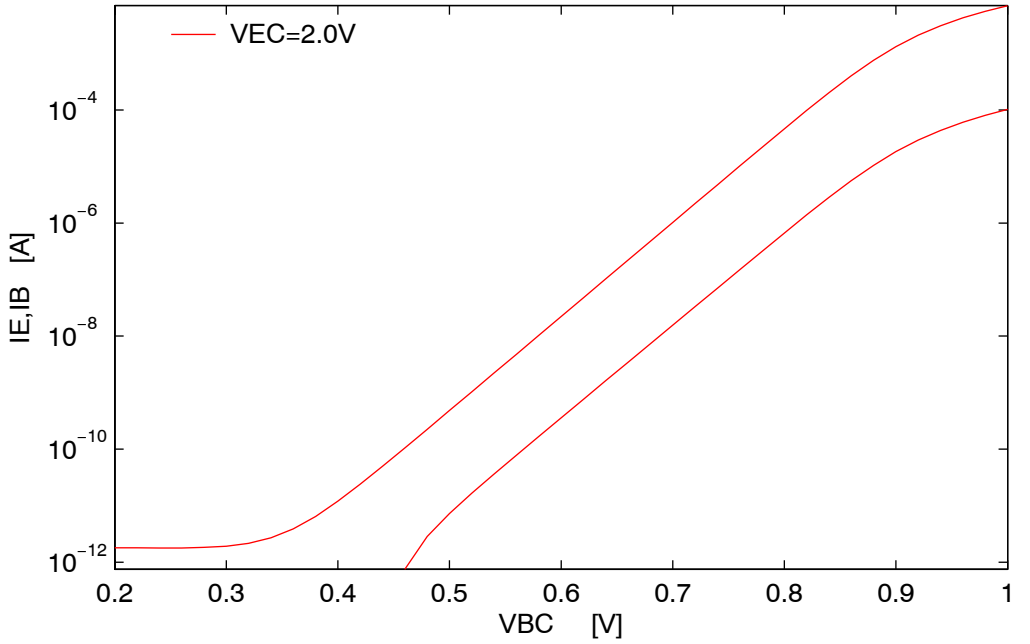

FIGURE 52. Reverse Gummel plots at VEC=2.0V at T=300K.

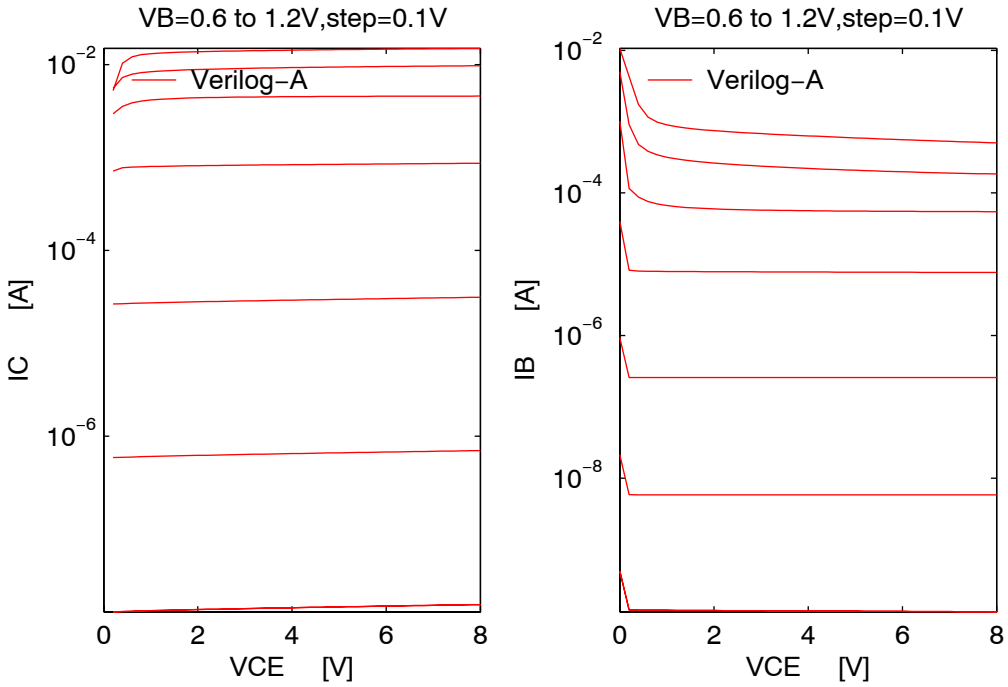

FIGURE 53. Forced-VB output characteristics and Ib-VCE plots at T=300K.

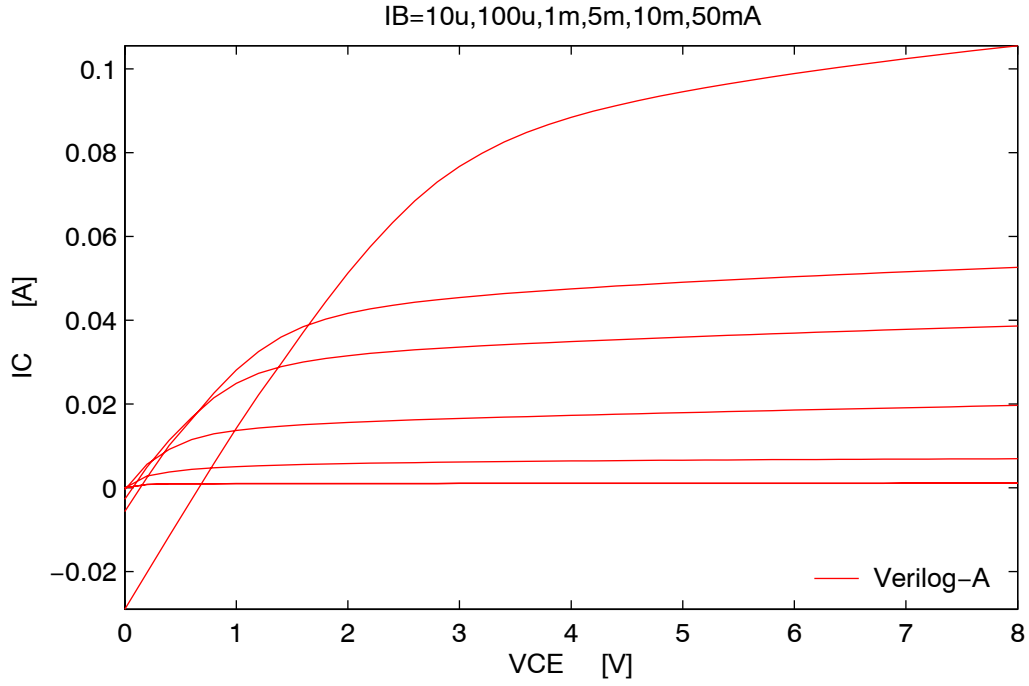

FIGURE 54. Forced-IB output characteristics at T=300K.

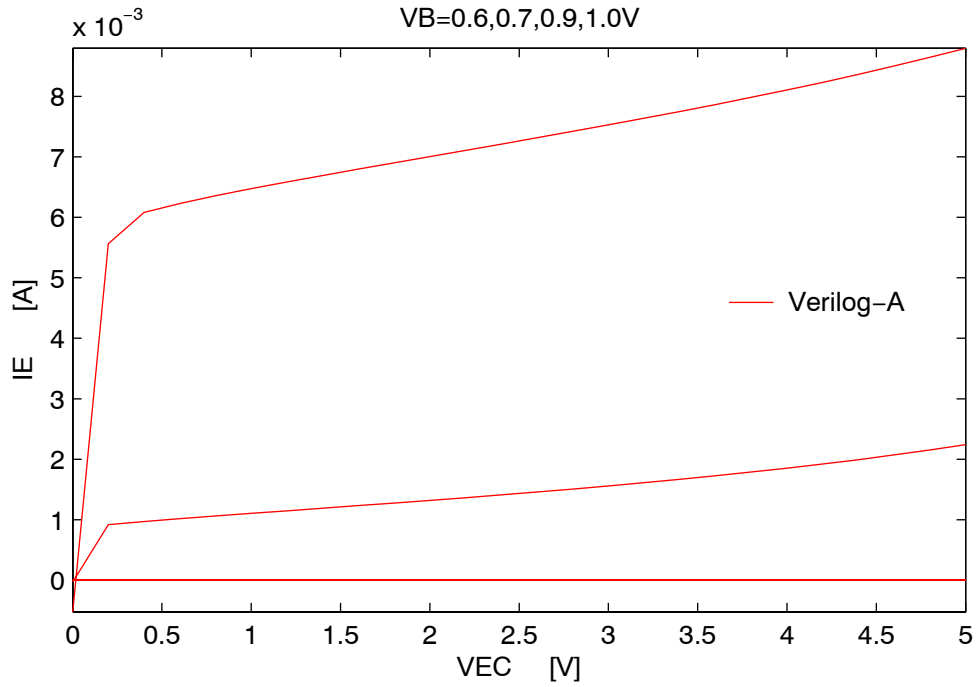

FIGURE 55. Reverse output characteristics at T=300K.

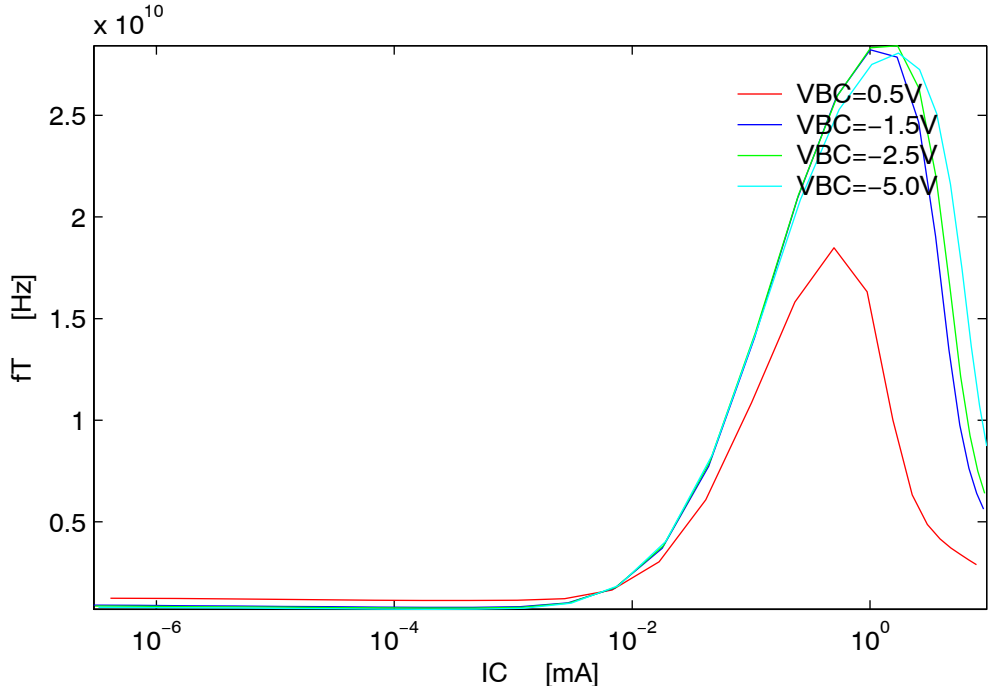

FIGURE 56. fT(Hz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V, fT extracted at f=2.8GHz.

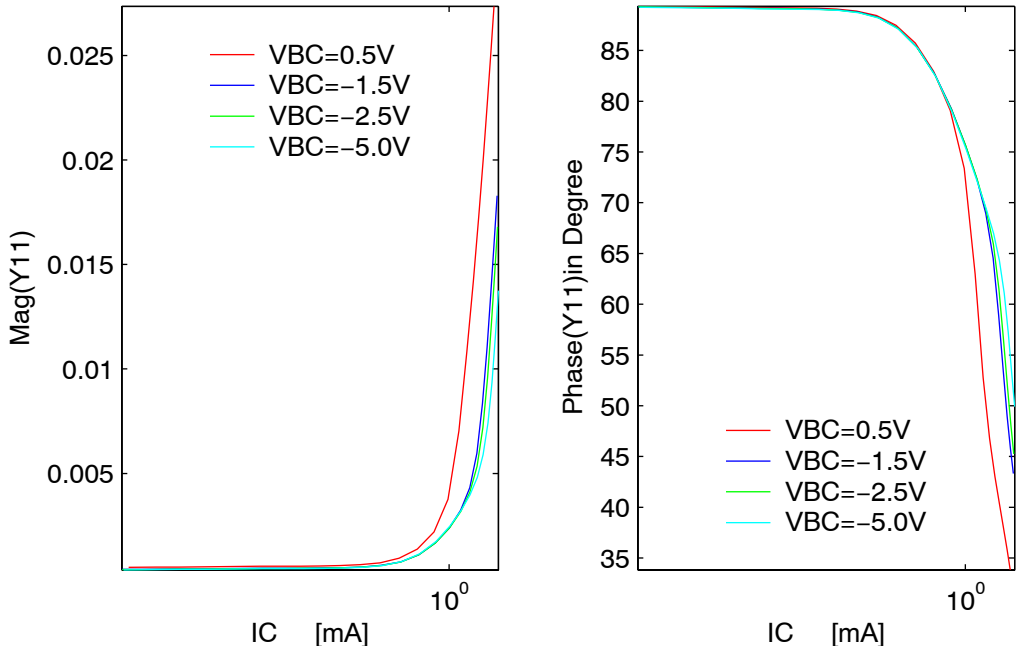

FIGURE 57. Y11 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

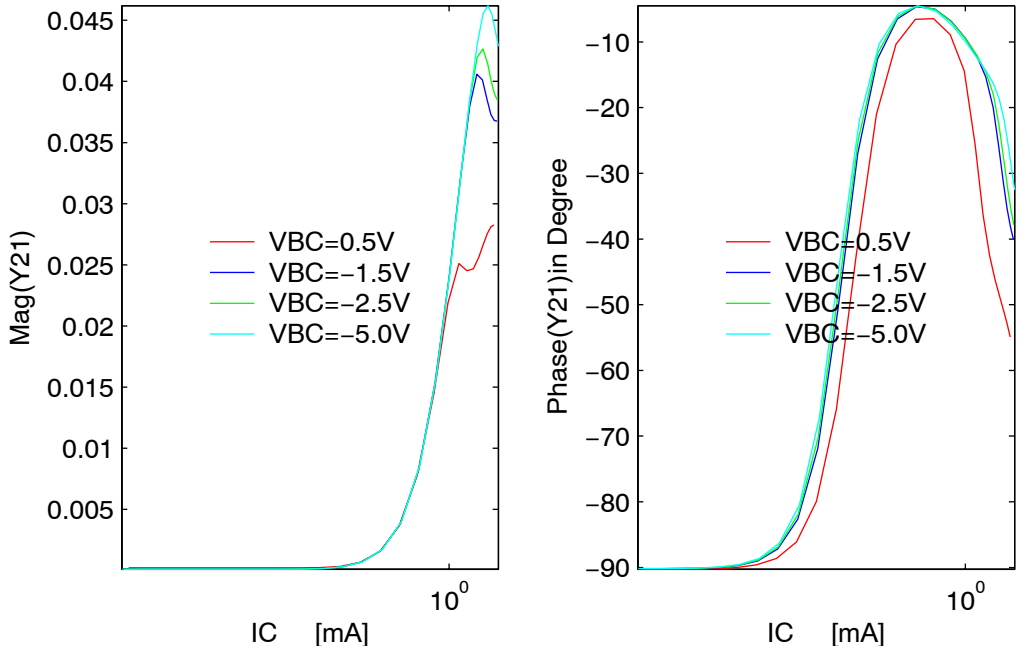

FIGURE 58. Y21 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

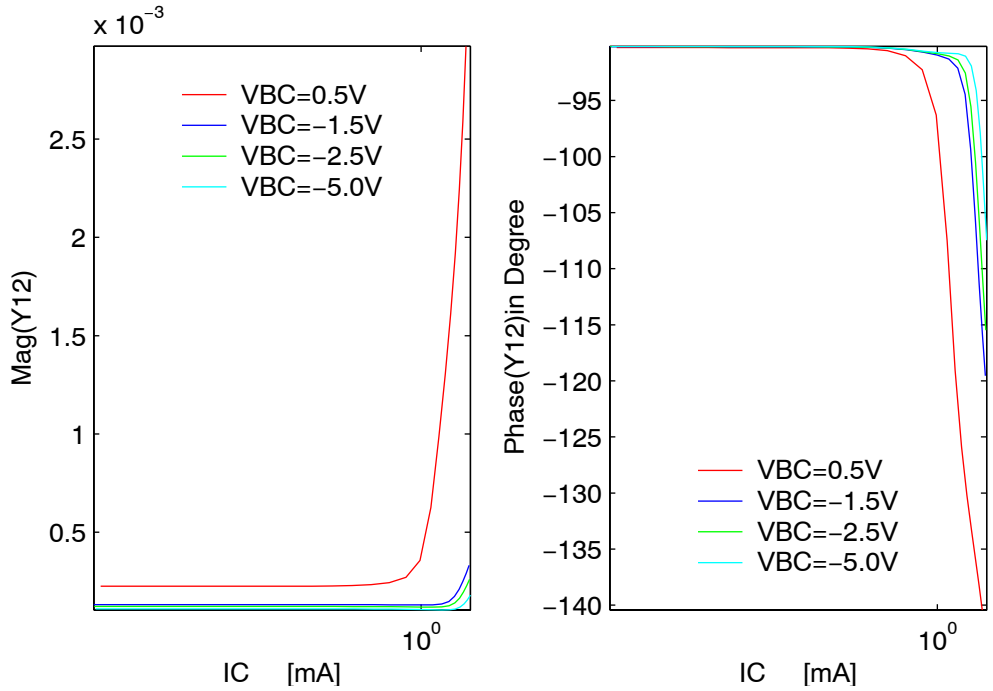

FIGURE 59. Y12 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

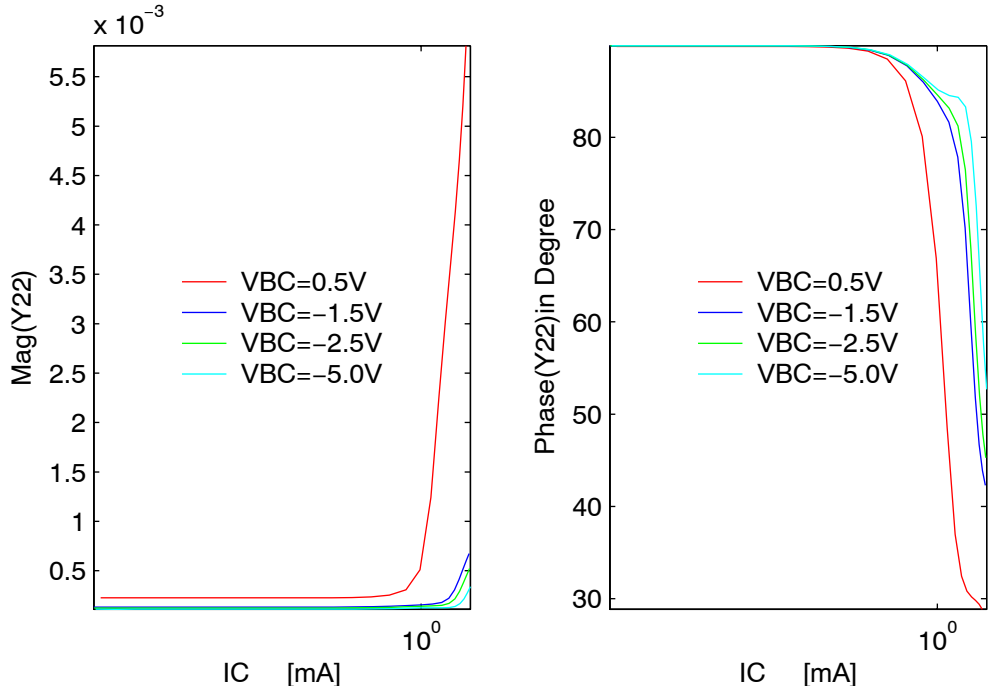

FIGURE 60. Y22 (extracted at f=2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V.

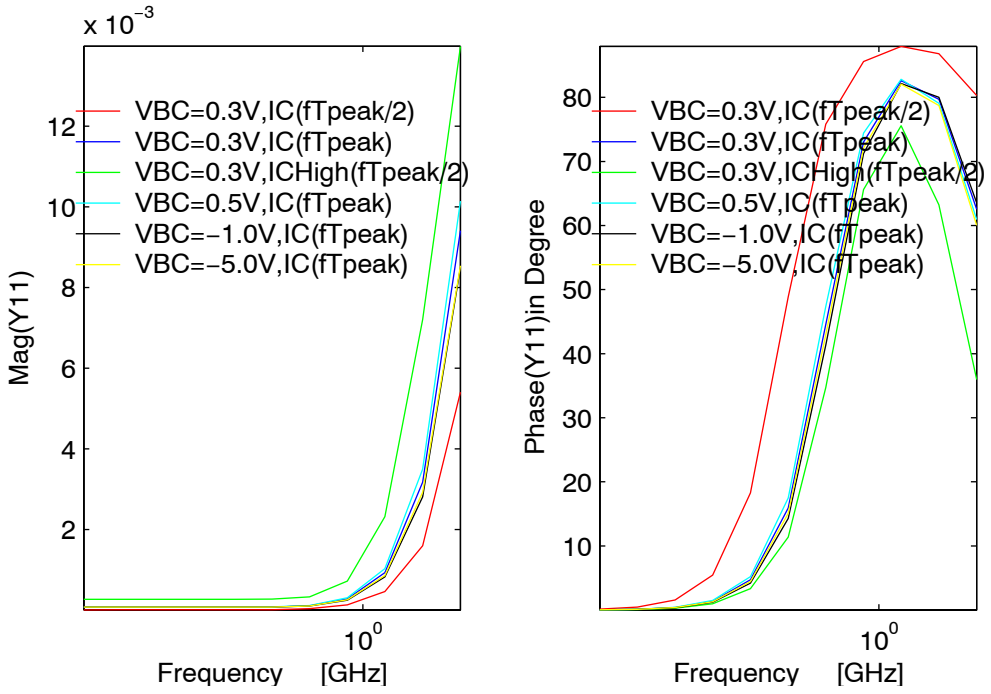

FIGURE 61. Y11 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

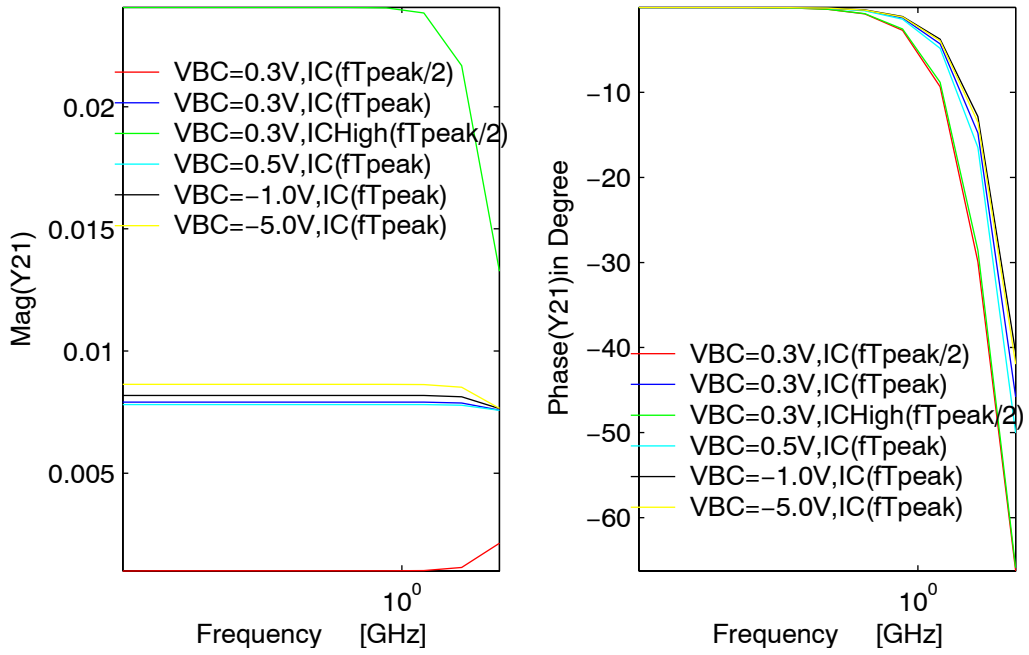

FIGURE 62. Y21 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

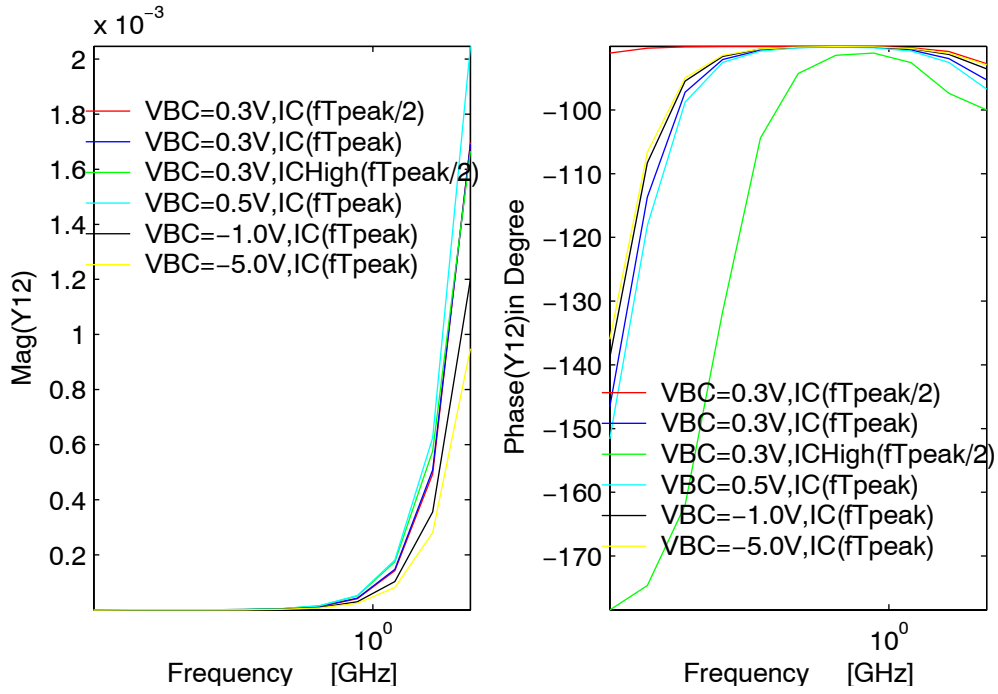

FIGURE 63. Y12 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0, -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

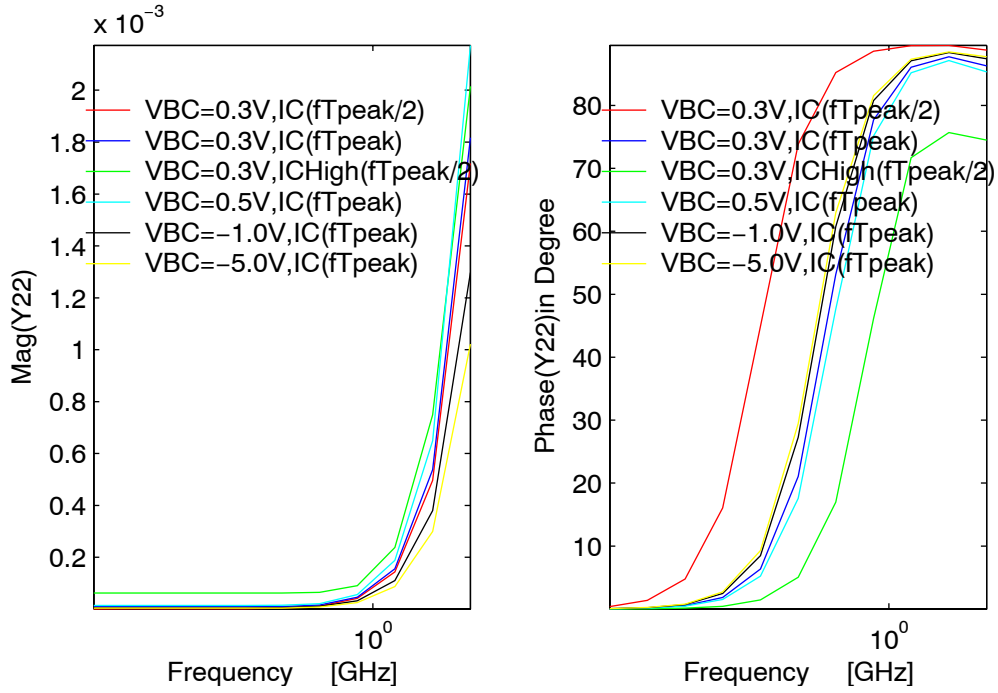

FIGURE 64. Y22 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2).

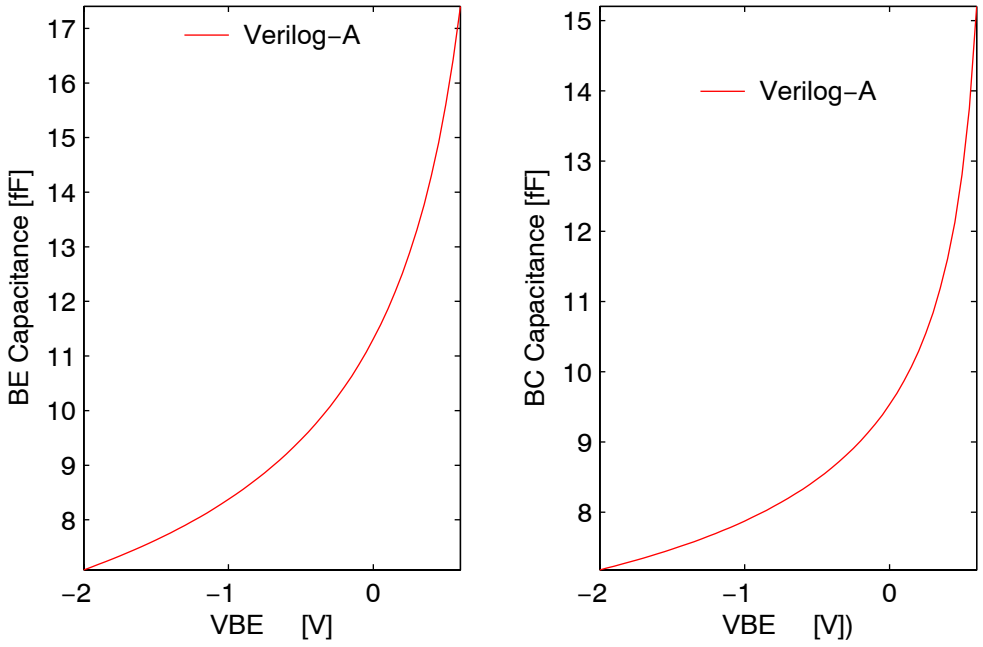

FIGURE 65. Depletion capacitances, Cbe and Cbc (fF) vs BE voltages (Volt) plots at T=300K.

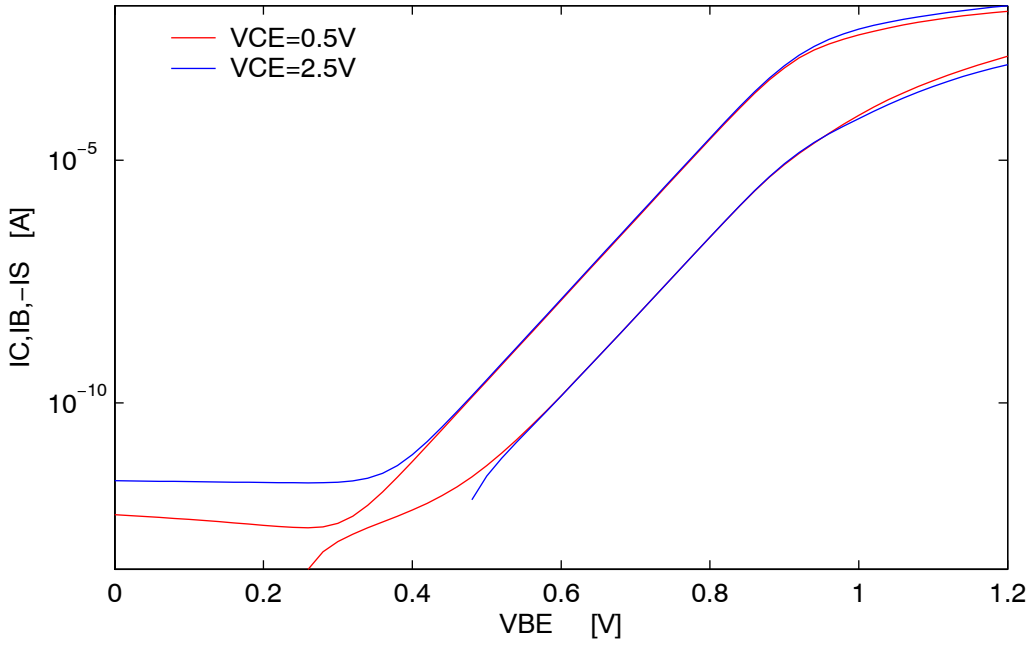

FIGURE 66. Forward Gummel plots at VCE=0.5,2.5 Volt and T=300K with self-heating effect.

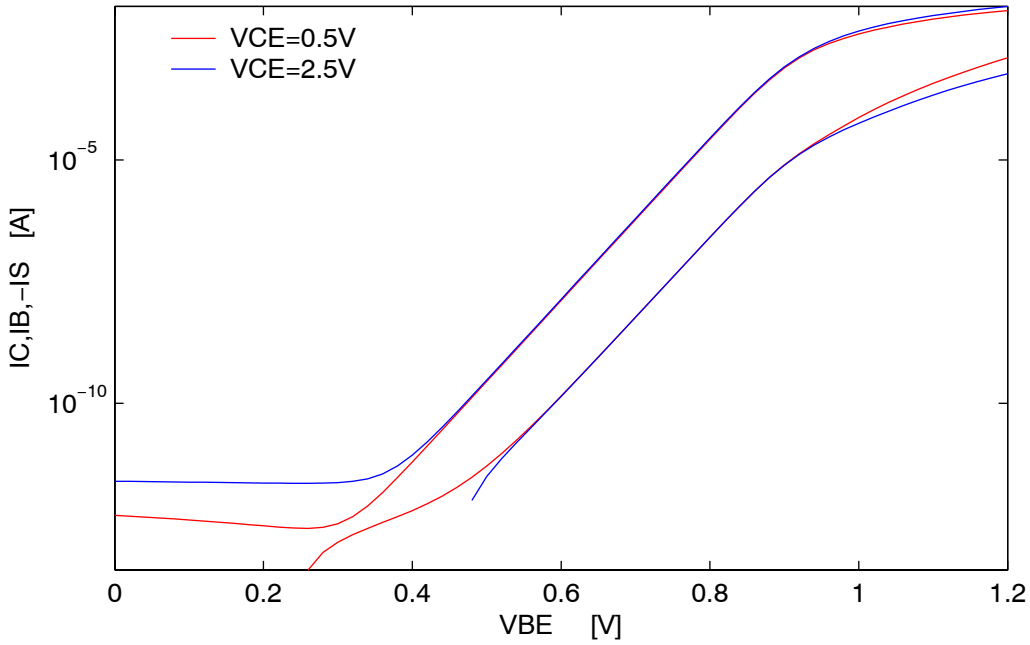

FIGURE 67. Forward Gummel plots at VCE=0.5,2.5 Volt and T=300K with collector current spreading effect.

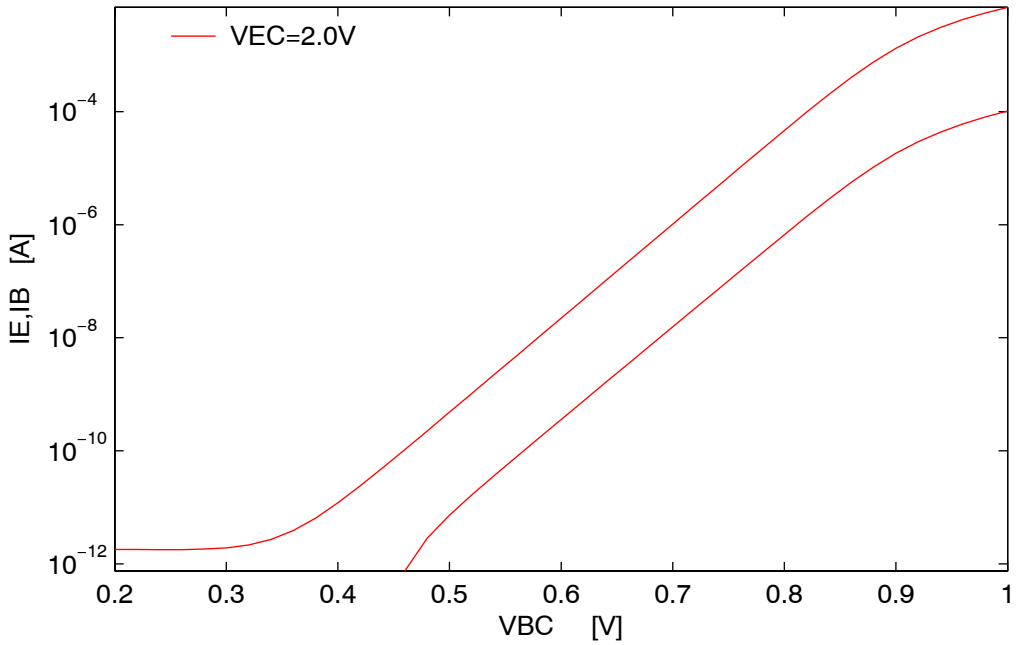

FIGURE 68. Reverse Gummel plots at VEC=2.0V at T=300K with collector current spreading effect.

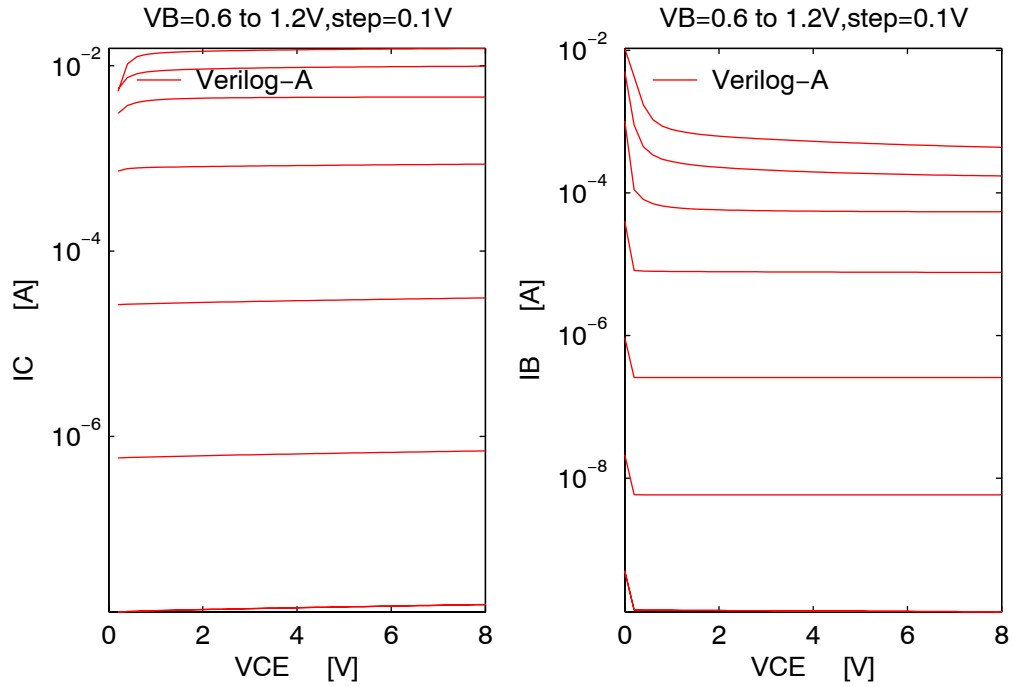

FIGURE 69. Forced-VB output characteristics and Ib-VCE plots at T=300K with collector current spreading effect.

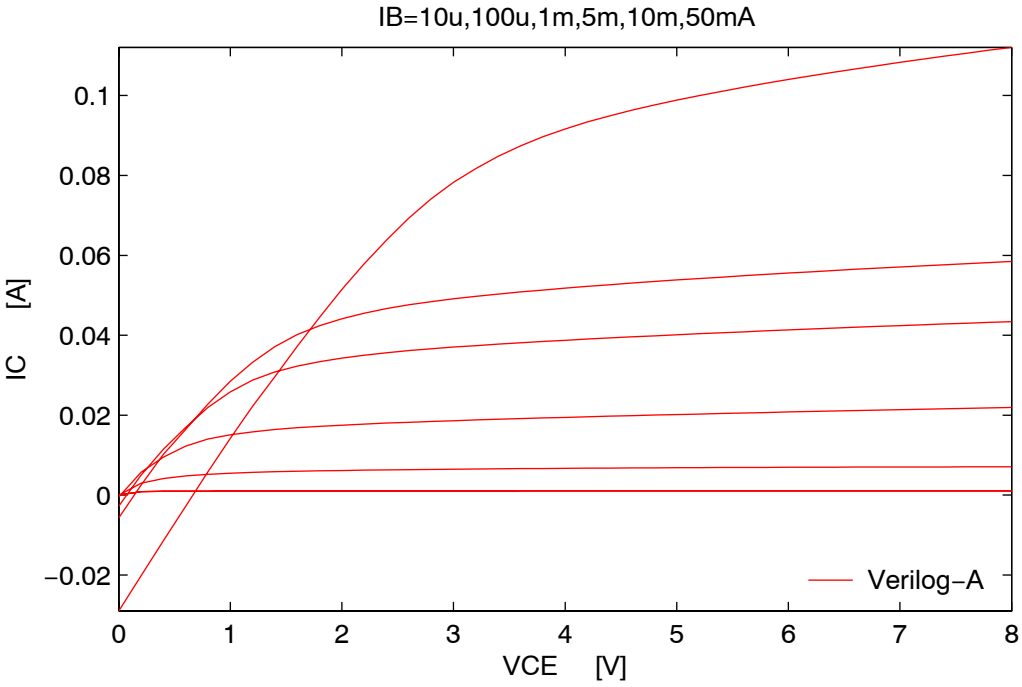

FIGURE 70. Forced-IB output characteristics at T=300K with collector current spreading effect.

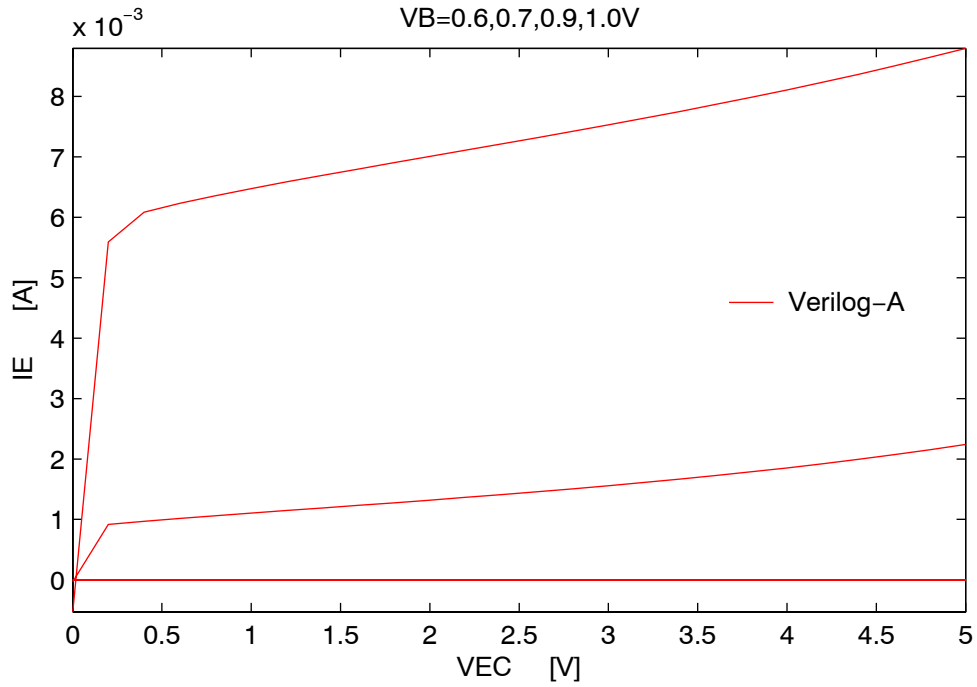

FIGURE 71. Reverse output characteristics at T=300K with collector current spreading effect.

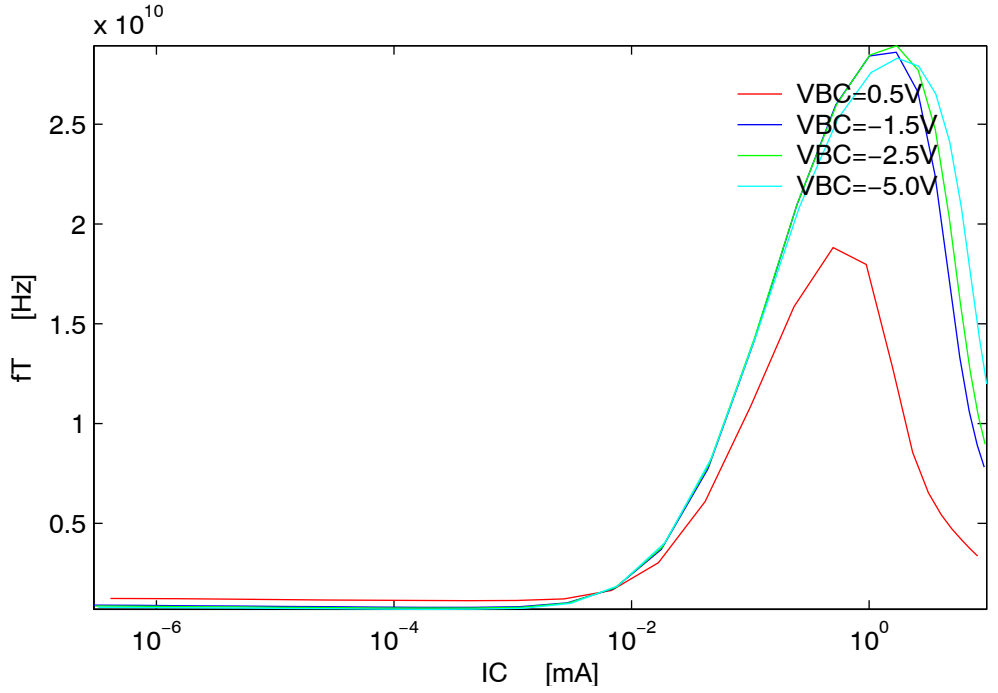

FIGURE 72. fT(Hz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V, fT extracted at f=2.8GHz with collector current spreading effect.

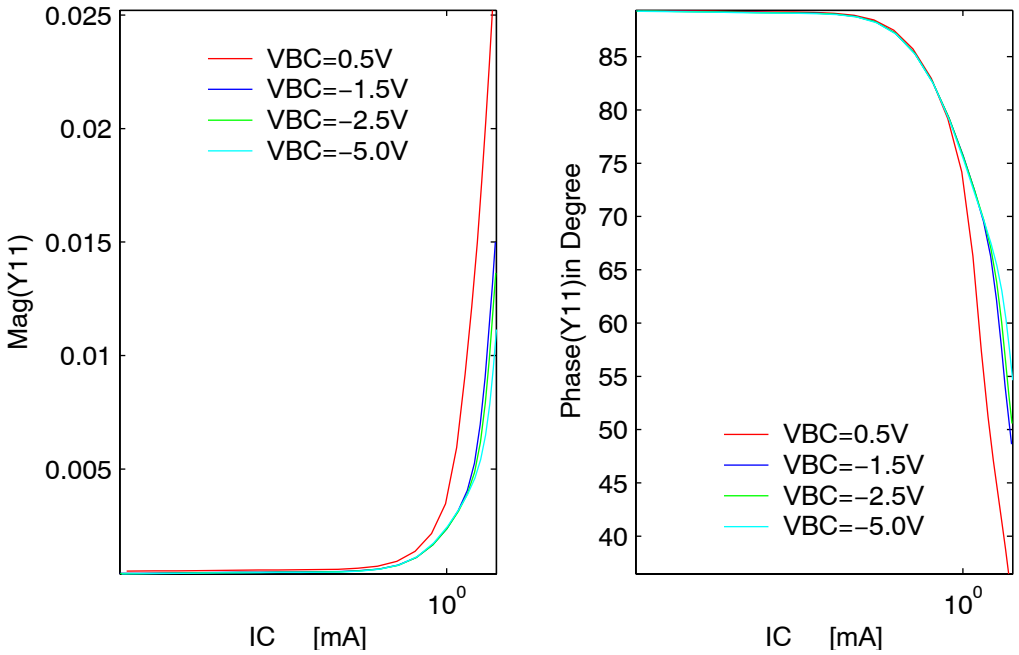

FIGURE 73. Y11 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

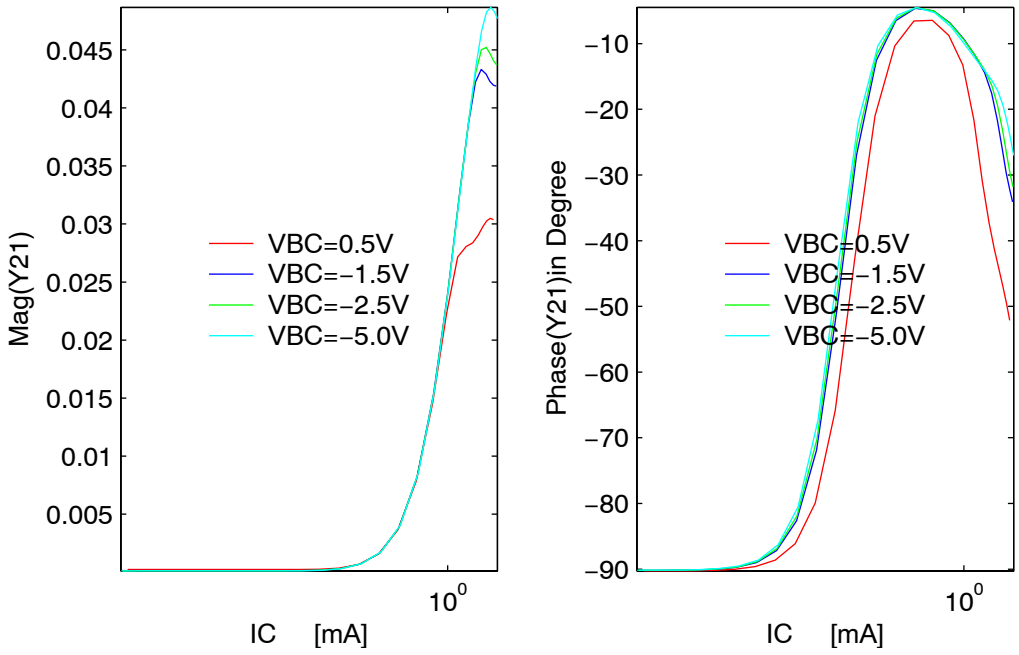

FIGURE 74. Y21 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

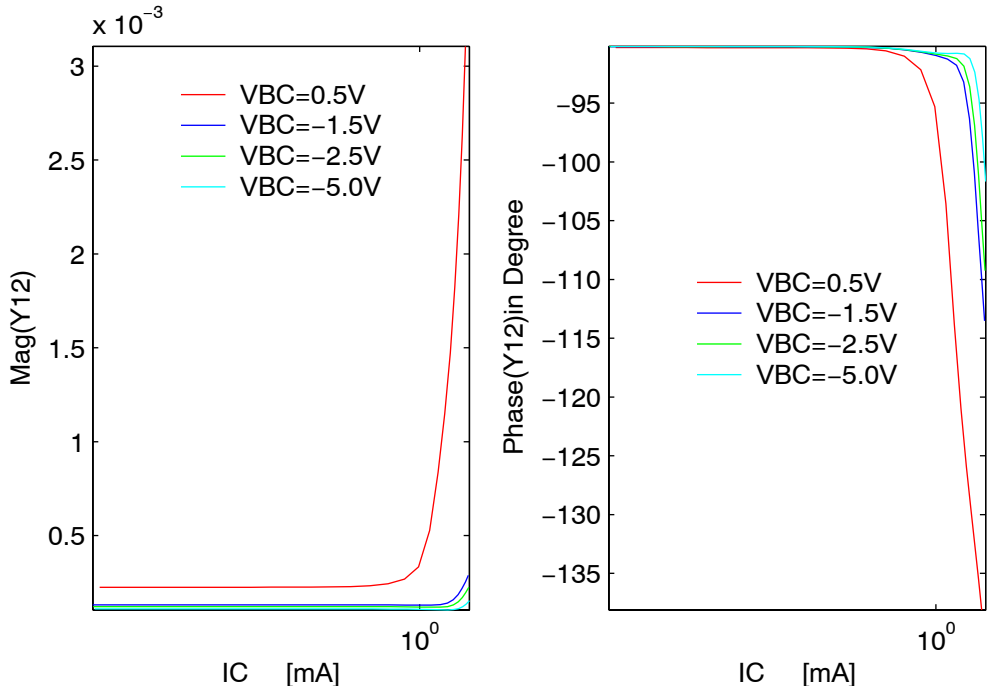

FIGURE 75. Y12 (extracted at 2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

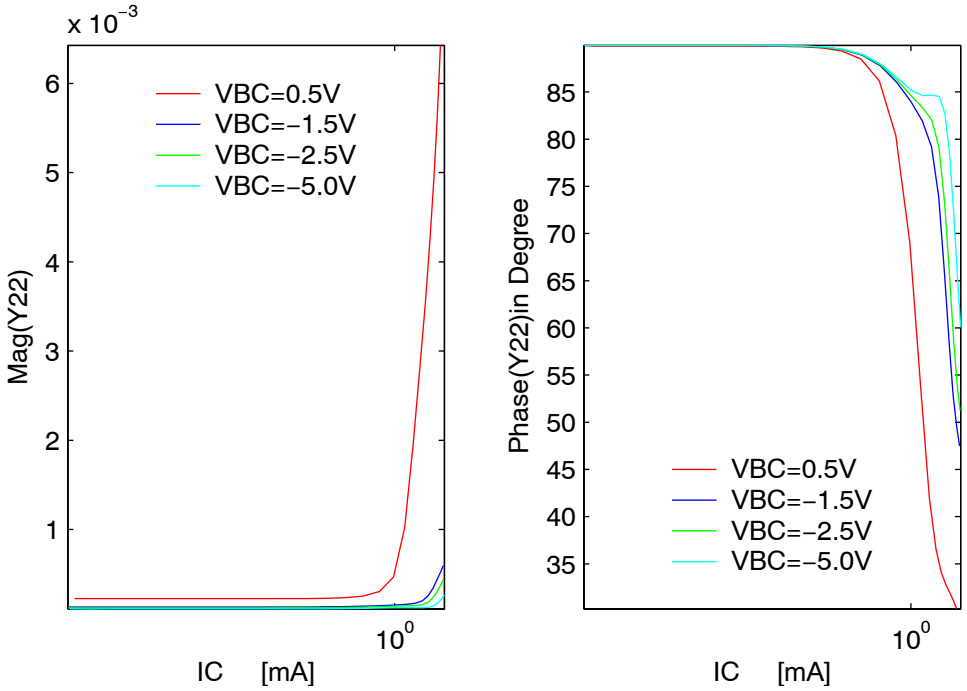

FIGURE 76. Y22 (extracted at f=2.8GHz) vs IC(mA) plots at T=300K for Vbc=0.5,-1.5,-2.5, and -5V with collector current spreading effect.

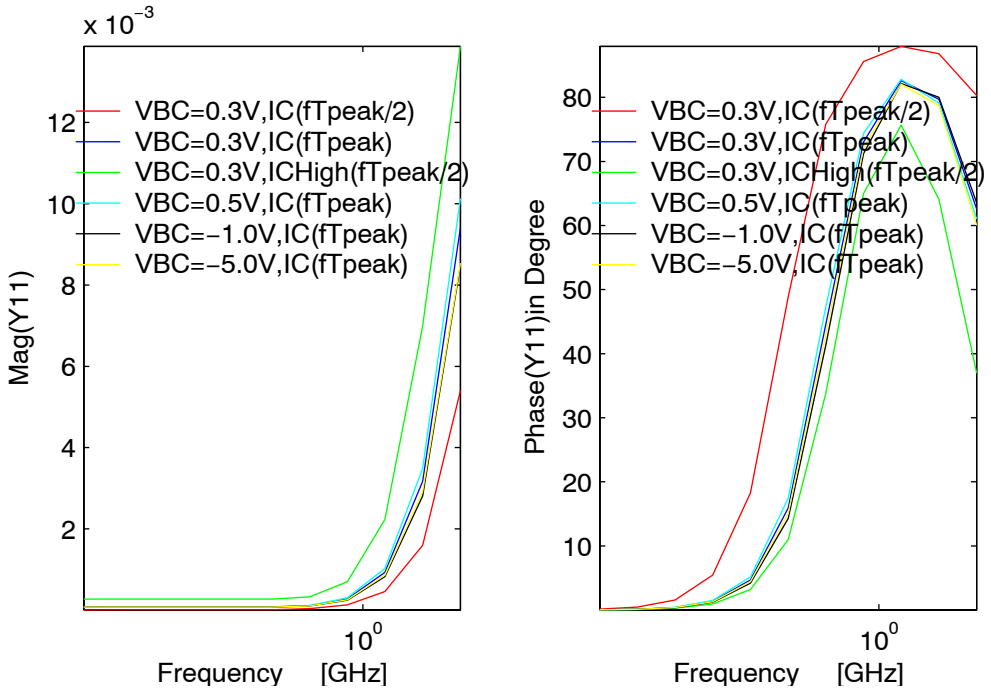

FIGURE 77. Y11 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

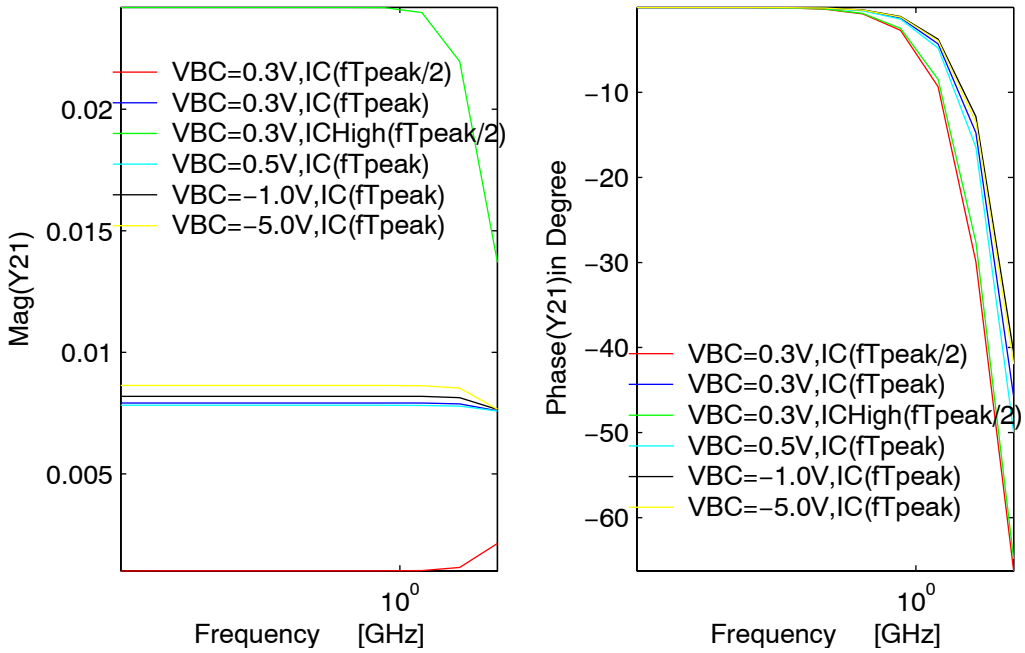

FIGURE 78. Y21 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

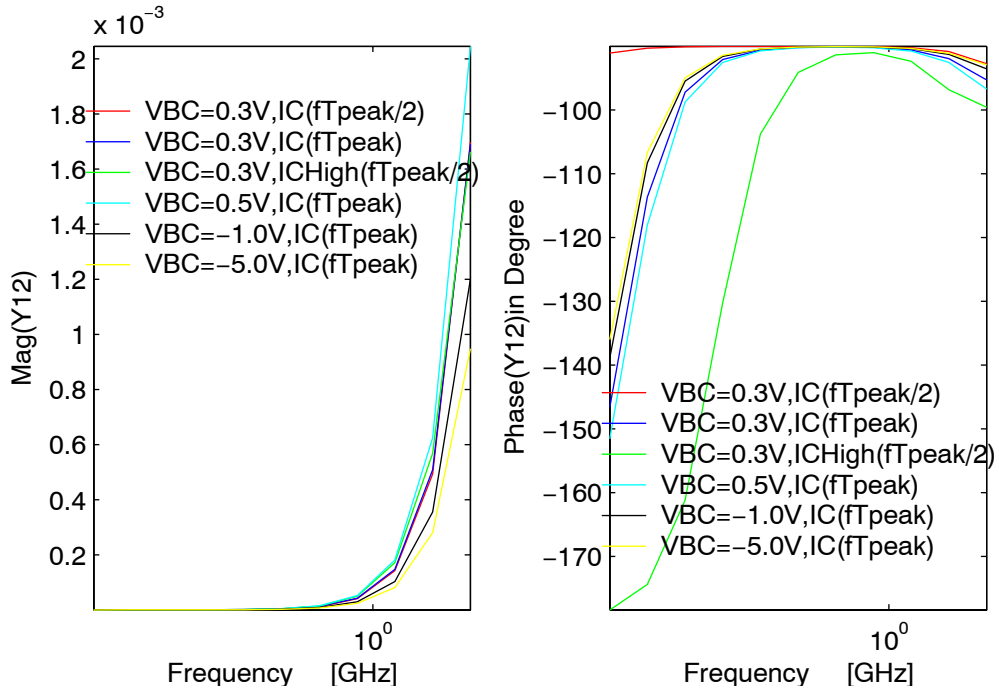

FIGURE 79. Y12 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0, -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

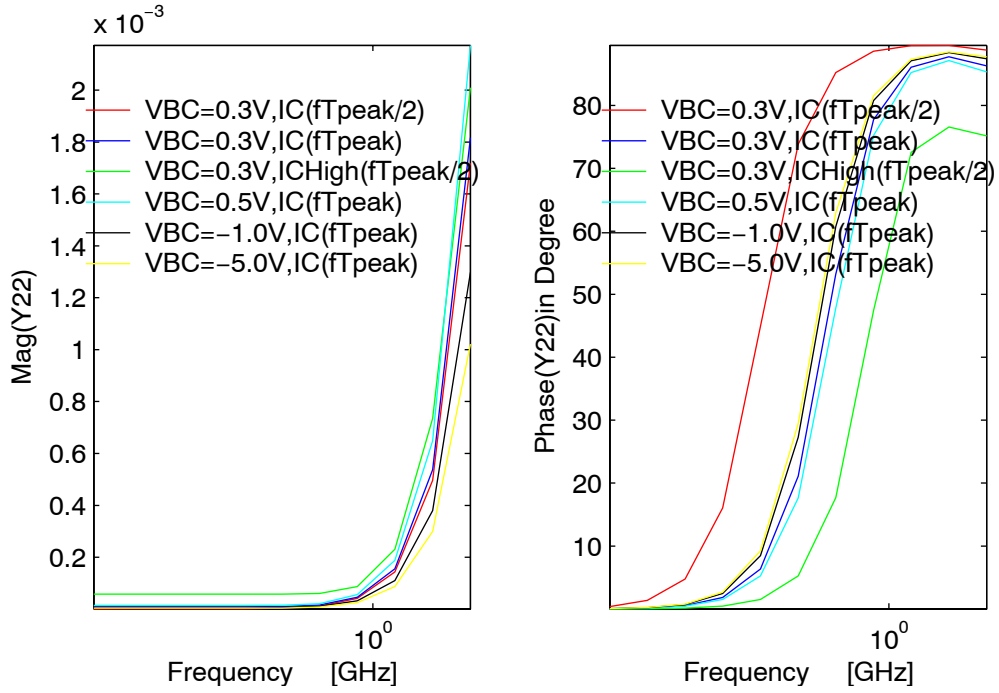

FIGURE 80. Y22 vs Frequency(GHz) plots at T=300K, Vbc=0.3, 0.5, -1.0 and -5.0V for IC(fTpeak),IC(ftpeak/2)and IChigh(fTpeak/2) with collector current spreading effect.

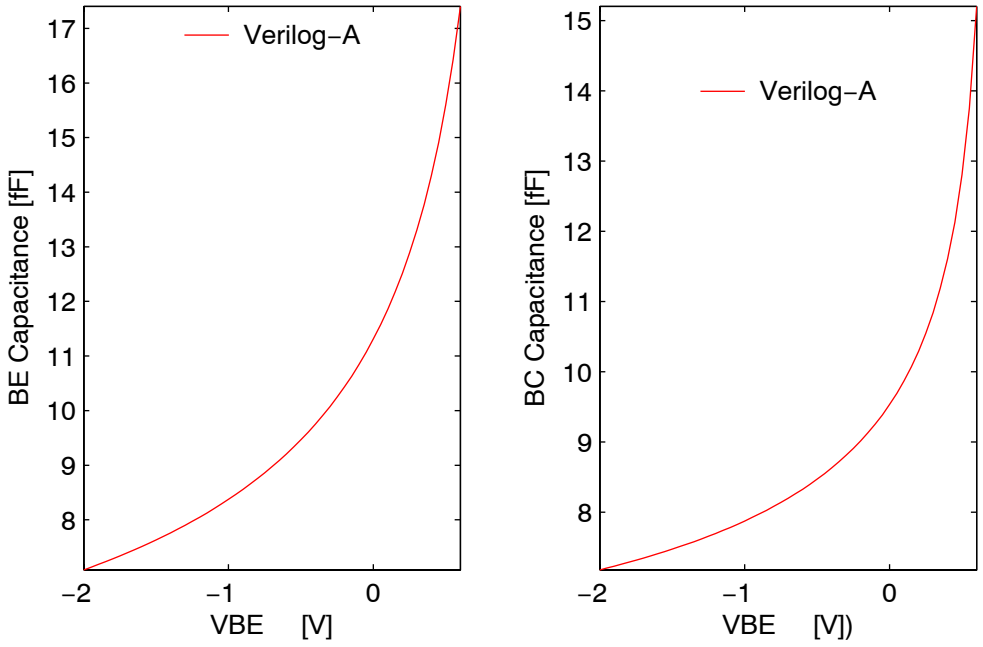

FIGURE 81. Depletion capacitances, Cbe and Cbc (fF) vs BE voltages (Volt) plots at T=300K with collector current spreading effect.

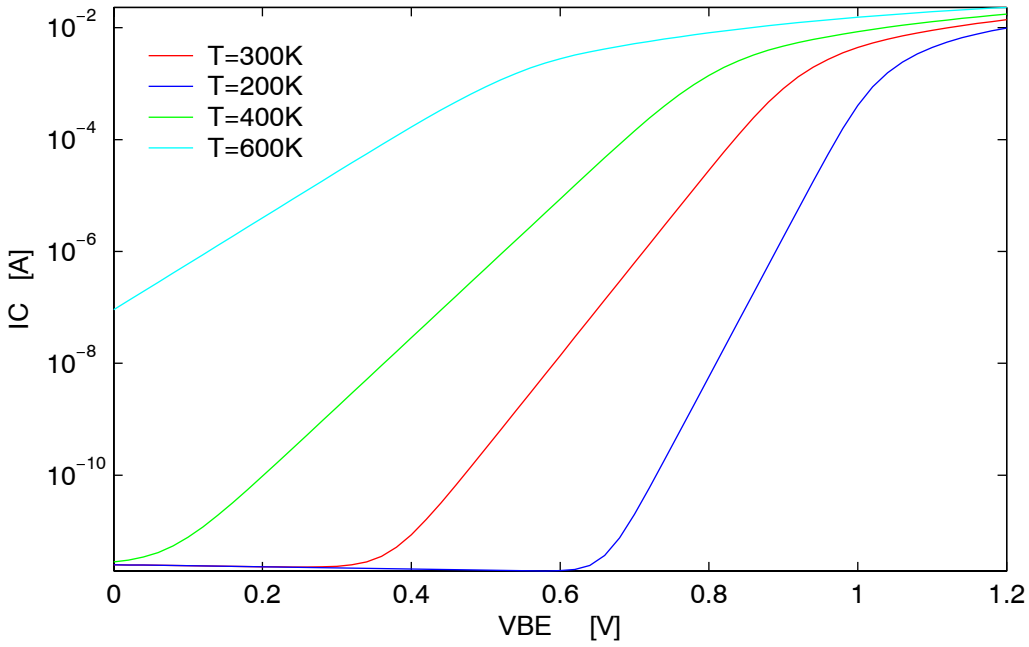

FIGURE 82. IC vs. VBE at VCE=2.5V and T=200K, 300K, 400K, 600K.

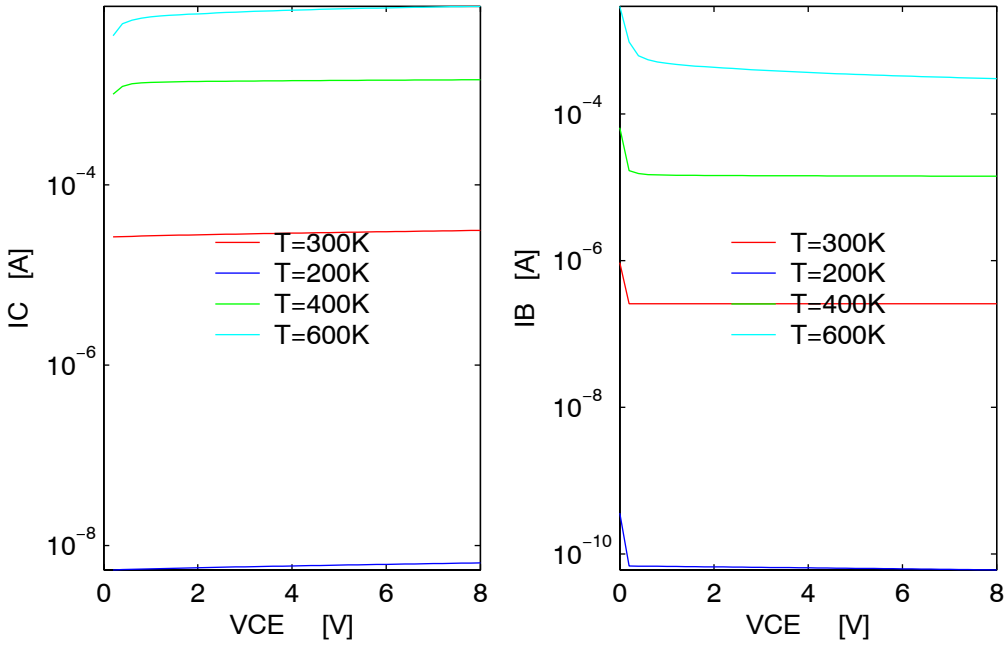

FIGURE 83. IC and IB vs. VCE at VB=0.8V and T=200K, 300K, 400K, 600K.

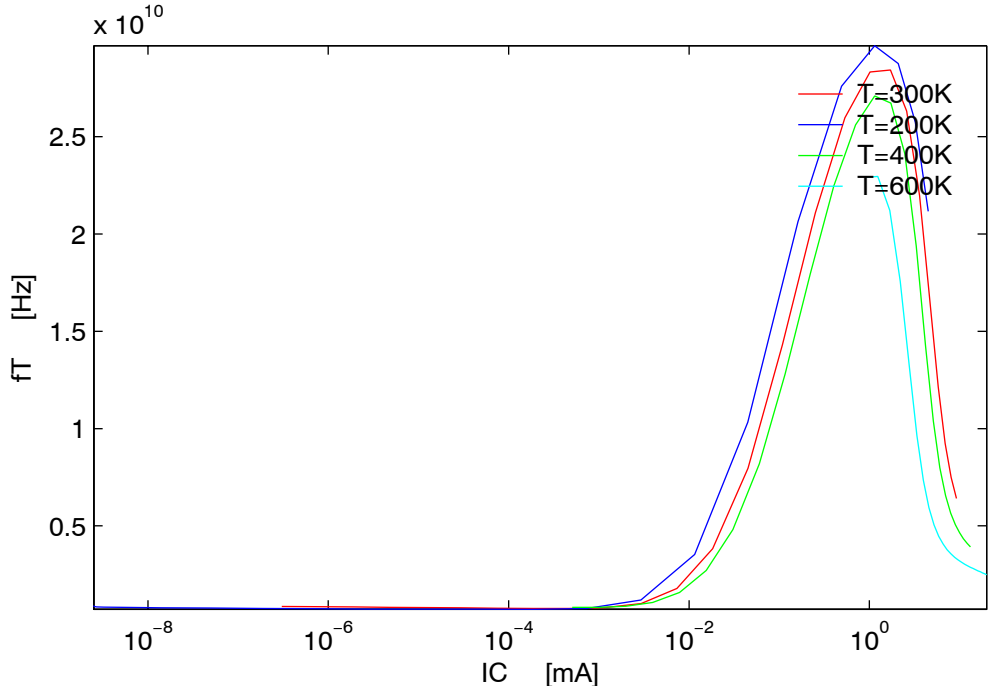

FIGURE 84. fT(Hz) vs. IC(mA) at VBC=-2.5V and T=200K, 300K, 400K, 600K.

Section 4: Results of NQS Effects both in time and frequency domain

- Intrinsic transistor has been considered during simulation in order to minimize the influence by other elements and effects.
- In the plots of this section, **“SPECTRE”** means built-in Weil implementation of HICUM/L2 model and **“VA”** means HICUM/L2v2.23 model.

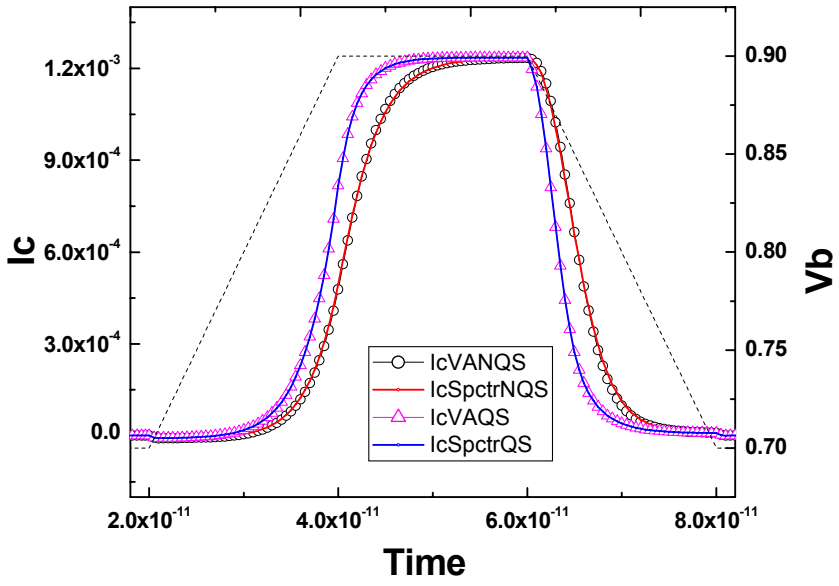

FIGURE 85. Collector current waveform for rising time of the input ramp=20ps.

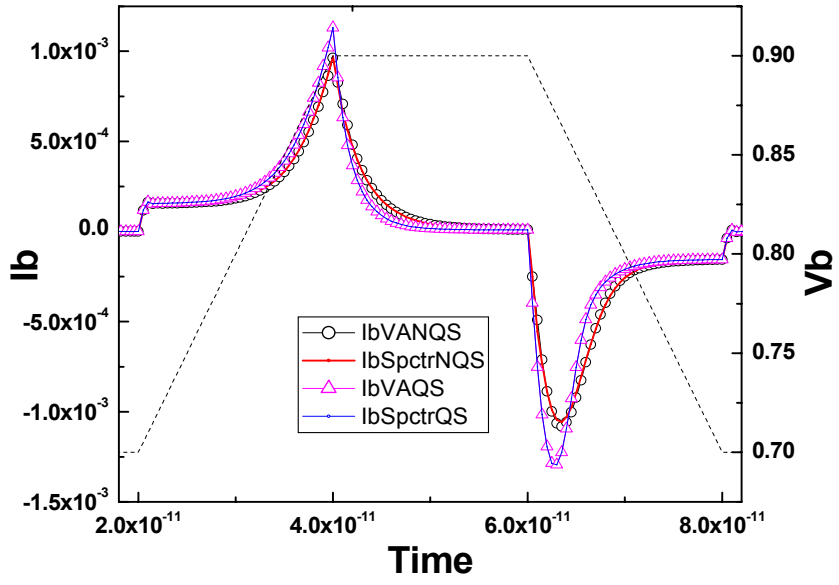

FIGURE 86. Base current waveform for rising time of the input ramp=20ps

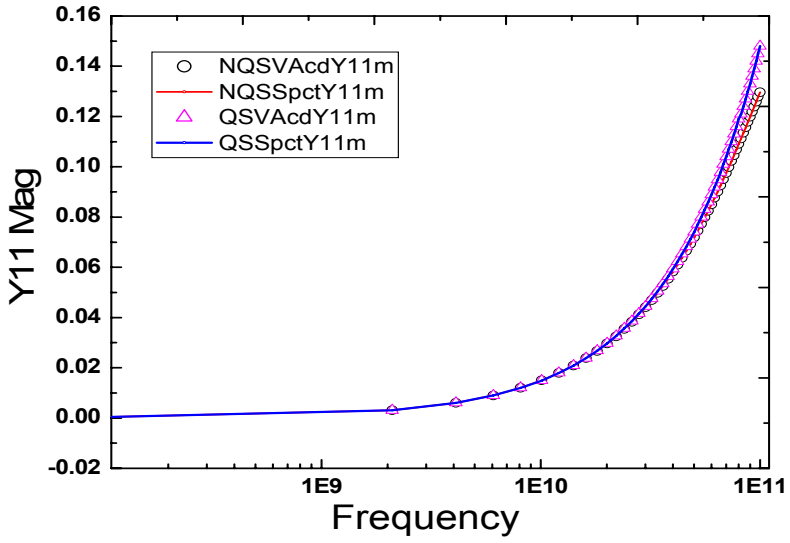

FIGURE 87. Small signal y11 (magnitude) parameter for VBC=0V

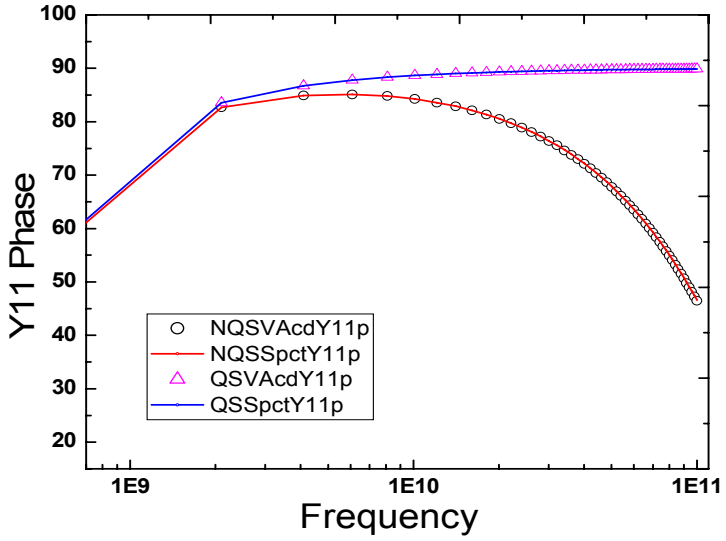

FIGURE 88. Small signal y11 (phase) parameter for VBC=0V

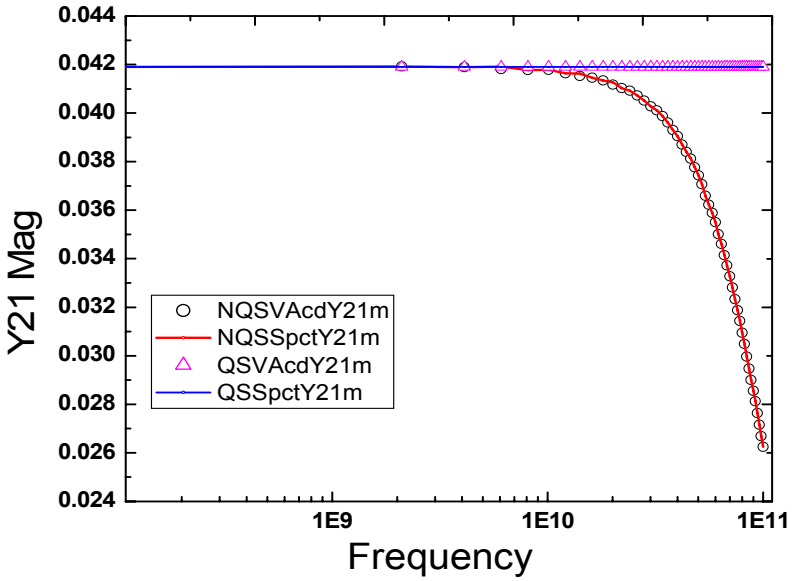

FIGURE 89. Small signal y21 (magnitude) parameter for VBC=0V

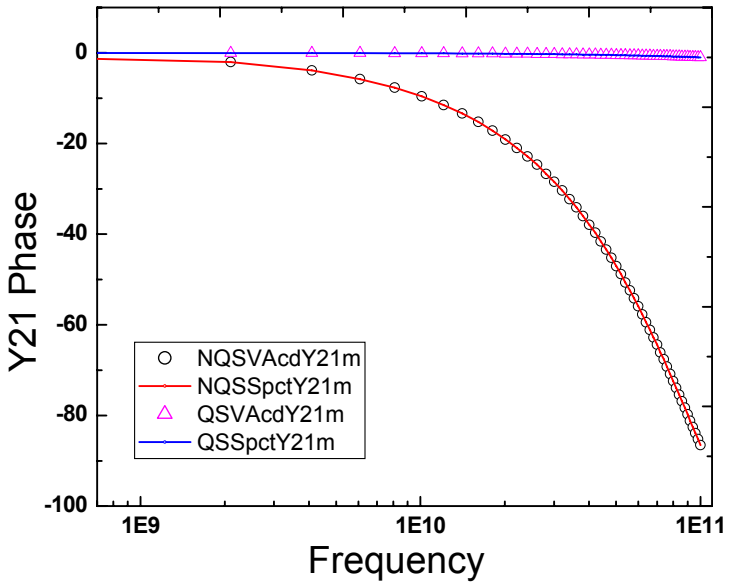

FIGURE 90. Small signal y21 (phase) parameter for VBC=0V

Section 5: Results of correlated noise implementation

- Measured data (hardware was provided by Jazz Semiconductor) have been used for comparison with the simulation.

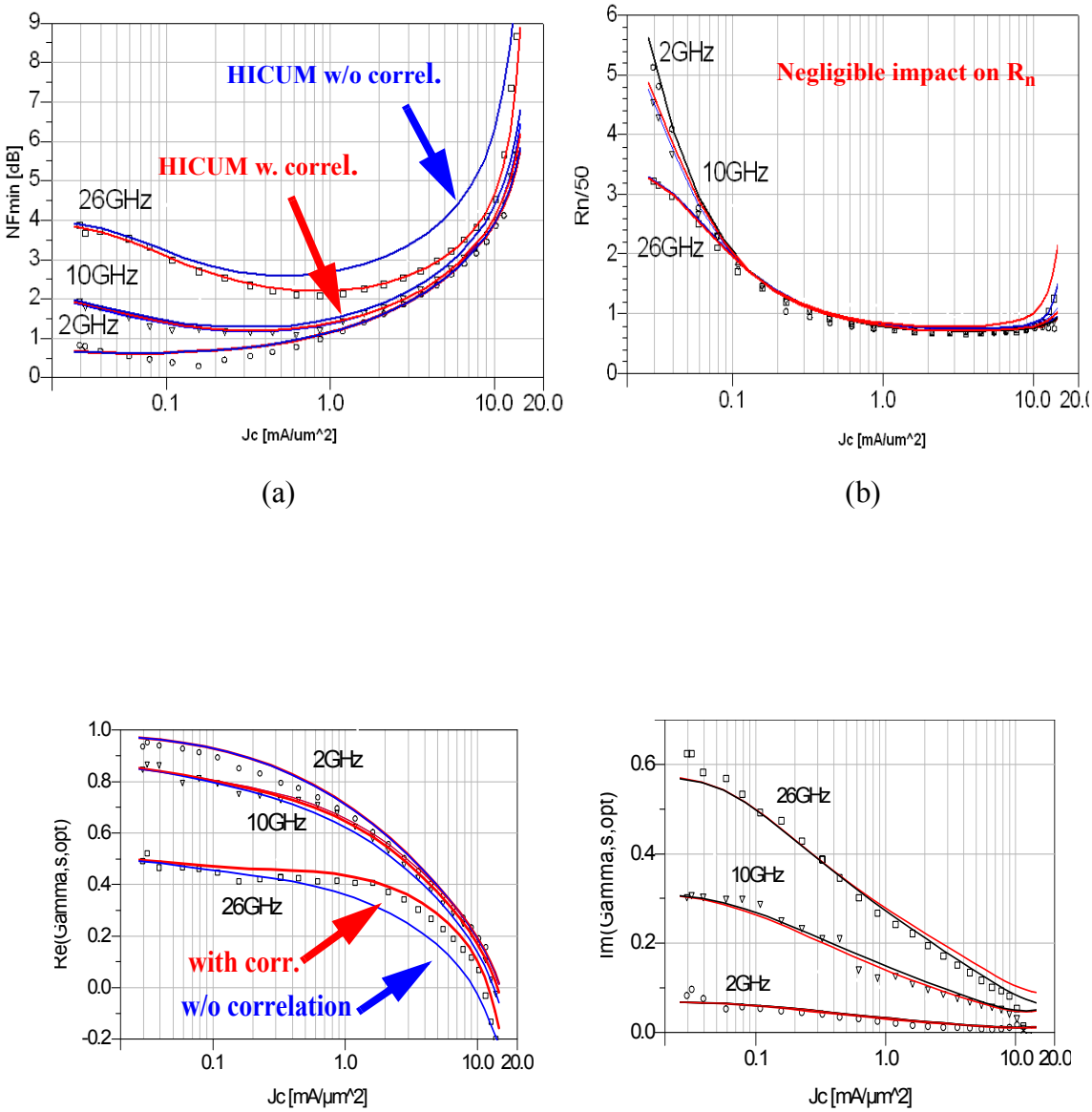

FIGURE 91. Comparison of measured noise parameters (symbols) with simulated data from HICUM without correlation (blue lines) and with correlation (red lines). (a) Minimum Noise factor; (b) Equivalent noise resistance; (c), (d) real and imaginary part of optimum source reflection coefficient.

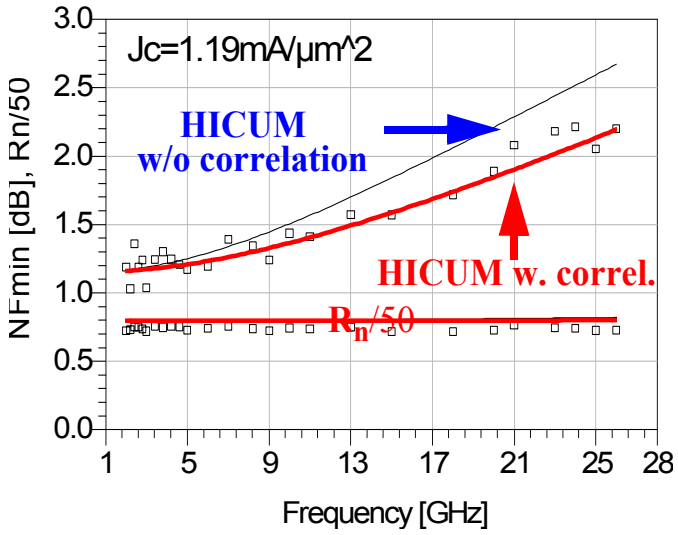

FIGURE 92. Frequency dependence of NF_{min} and R_n at the optimum bias point in terms of noise.