

Temperature Dependent GaAs pHEMT Liner Model for Cryogenic Low-noise Amplifier

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Abstract This paper proposes a novel GaAs pHEMT linear equivalent circuit model with noise sources to realize more accurate device characteristics at cryogenic temperature. Each component of the proposed circuit model has temperature dependent characteristics based on its material property. The proposed model can exhibit the device characteristics from room temperature to cryogenic temperature. Therefore, the model can predict the device performances at cryogenic temperature by using its room temperature characteristics. The proposed model accuracy was evaluated by using reported cryogenic device performances at 77K and 25K below 20 GHz. That results in good agreement between the model characteristics and

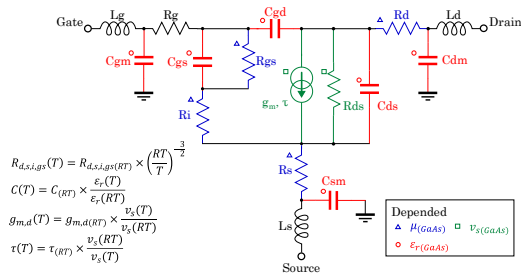


Fig. 1 Proposed equivalent circuit model

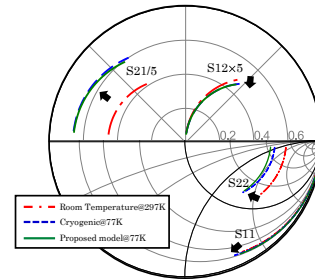


Fig. 4 Comparison of S-parameter characteristics.

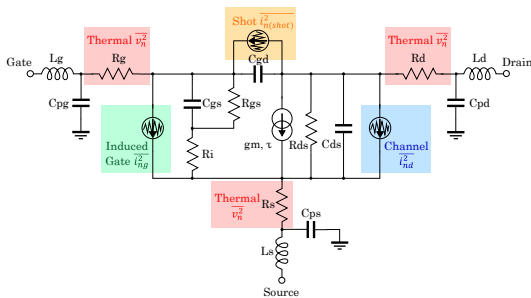


Fig. 2 Proposed equivalent circuit model with noise sources.

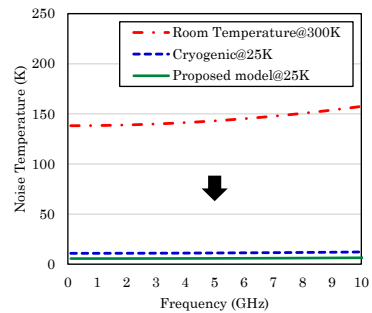


Fig. 5 Comparison of noise temperature characteristics.

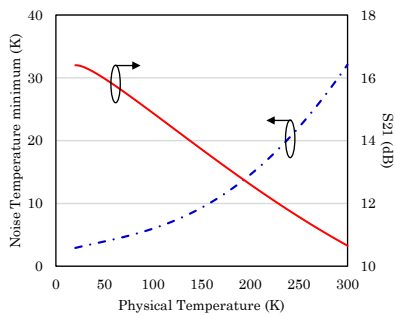


Fig. 3 Calculated minimum noise temperature and associated gain.

measurement.

References

- [1] I. Akasaki and T. Hara, "GaAs 結晶成長技術," J of IEEJ, vol. 90, no. 2, pp. 231-236, Feb. 1970.
- [2] I.Strzaikowski, S.Joshi, and C.R.Crowell, "Dielectric constant and its temperature dependence for GaAs, CdTe, and ZnSe", Applied Physics Letters, Vol.28, No.6, pp350-352, 1976.
- [3] T.H.Windhorn, T.J.Roth, L.M.Zinkiewicz, O.L.Gaddy, and G.E.Stillman, "High field temperature dependent electron drift velocities in GaAs", Applied Physics Letters, Vol.40, No.6, pp.513-515, 1982.
- [4] S. Maas, "Noise in Linear and Nonlinear Circuits," Artech House, pp. 23-29, 2005.
- [5] <http://www.ums-gaas.com>
- [6] J.W.Smuk,et al., "S-Parameter Characterization and modeling of three-terminal semiconductive devices at cryogenic temperatures", IEEE MGWL, Vol. 2, No. 3, pp.111-113, Mar. 1992.
- [7] A.H.Akgiray,et al., "Noise measurements of discrete HEMT transistors and application to wideband very low-noise amplifiers", IEEE Trans. on MTT, Vol.61, No.9, pp.3285-3297, Sep. 2013.