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Title:An improved model for non-resonant terahertz detection in field-effect transistors
Authors:Preu, S. (1); Kim, S. (3); Verma, R. (3); Burke, P.G. (2); Sherwin, M.S. (1); Gossard, A.C. (2)
Author affiliation:(1) Phys. Dept., Univ. of California, Santa Barbara, CA, United States; (2) Mater. Dept., Univ. of California, Santa Barbara, CA, United States; (3) Tanner Res., Monrovia, CA, United States
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Abstract:Transistors operating well above the frequencies at which they have gain can still rectify terahertz currents and voltages, and have attracted interest as room-temperature terahertz detectors. We show that such rectifying field-effect transistors may still be treated as a lumped element device in the limit where plasma resonances of the electron gas do not occur. We derive analytic formulas for important transistor parameters, such as effective rectification length and device impedance using a transmission-line model. We draw conclusions for plasma-resonant detection where possible. We derive the THz response of a field-effect transistor with a two-dimensional electron-gas channel by a Taylor expansion of the drain-source bias. We connect circuit theory to the existing theories that describe the bias in the gated region by differential equations. Parasitic effects, such as the access resistance, are included. With the approach presented in this paper, we derive the responsivity for a novel field detector that mixes a (THz) signal applied between gate and source with another signal applied between drain and source in homodyne or heterodyne operation mode. We further derive expressions for the expected noise-equivalent power (NEP) in direct detection and mixing mode, including parasitic effects, and find that sub-pW/Hz should be achievable for realistic device and material parameters for direct detection and less than 900 K noise temperature for mixing at 10 μW local oscillator power.
Number of references:27
Inspec controlled terms:circuit theory - differential equations - field effect transistors - rectification - terahertz wave detectors - transmission lines - two-dimensional electron gas
Uncontrolled terms:nonresonant terahertz detection - terahertz current - terahertz voltage - rectifying field effect transistor - lumped element device - plasma resonance - electron gas - transistor parameter - plasma-resonant detection - two dimensional electron gas channel - Taylor expansion - drain-source bias - circuit theory - differential equations - parasitic effects - homodyne

operation mode - heterodyne operation mode - realistic device - noise temperature - local oscillator power - transmission line model - power 10 muW - temperature 293 K to 298 K
Inspec classification codes:B2560R Insulated gate field effect transistors
Numerical data indexing:power 1.0E-05 W;temperature 2.93E+02 2.98E+02 K
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