Theory of single-Josephson-junction-based microwave amplifier

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We present a theory describing the recently proposed and realized microwave amplifier based on the negative resistance of a selectively damped Josephson junction [P. Lahteenmaki et al., Sci. Rep. 2, 276 (2012)]. The standard linear theory using the Gaussian expansion around the limit cycle [A. Kamal et al. Phys. Rev. B 86, 144510 (2012)] does yield nearly perfect results for the gain characteristics of the device, but it completely fails for the noise. We show that an extended theory accounting for a subtle interplay between the linear response and nonlinear dynamics of the phase along the limit cycle gives features observed also the noise-temperature experimental data. Detailed comparison of our predictions with the experiment and implications of these findings on the prospects of achieving the originally intended quantum-limited amplification will be discussed.