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Double universality of $1/f$ noise percolation-like exponent in systems with exponentially wide spectrum of resistances

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Abstract

Theory and numerical simulations of $1/f$ noise in random networks in which bonds take resistances $r \sim \exp(-\lambda x)$, where x is a random variable and $\lambda \gg 1$ are presented. For microscopic noise generating mechanism which obeys the form of $\{\delta r^2\} \sim r^{2+\theta}$, it is shown that the overall noise intensity of the network is given by $C_e \sim \lambda^m \exp(-\lambda\theta x_c)$, where $1 - x_c$ is the percolation threshold. In the range $0 \leqslant \theta < 2$ exponent m is "double universal", i.e. it is independent of the lattice geometry and of microscopic noise generating mechanism. Numerical simulations give $m \cong 2.5$.

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1. Introduction

We consider the network in which the bonds between adjacent sites i,j are occupied in a random way by resistance

$$r_{ij} = r(x) = r_0 \exp(-\lambda x), \tag{1}$$

where x is the random variable sampled between 0 and 1 according to a smooth distribution $D(x)$, and $\lambda \gg 1$. The effective resistivity of such a network is given by [1,2]

$$\rho_e \sim \lambda^{\nu} \exp(-\lambda x_c), \tag{2}$$

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