LETTER TO THE EDITOR

ON EXPRESSIONS FOR 1/f NOISE IN MOBILITY

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Mobility fluctuations can be defined in two ways, giving expressions with or without a factor \( 1/N \), \( N \) being the total number of charge carriers. No revision of literature is necessary.

In two recent publications [1, 2] Van der Ziel, Van Vliet and Zijlstra object to the expression for mobility fluctuations [3]:

\[
\frac{S_\mu}{\mu^2} = \frac{\alpha}{Nf},
\]

where \( \mu \) is the mobility, the constant \( \alpha \) is of the order of \( 10^{-3} \) in the case of lattice scattering, \( N \) is the total number of free charge carriers and \( f \) is the frequency at which the spectral density \( S_\mu \) is measured.

In particular, they argue that \( N \) should not appear in the denominator. They claim that analyses of 1/f noise in devices based on relation (1) should therefore be revised. Since these publications might give rise to confusion, it is appropirate to point out that mobility fluctuations are defined in two ways.

One way has been followed by Van der Ziel, Van Vliet and Zijlstra. The current \( I \) in a rectangular sample \( (L \times A) \) is then given by

\[
I = nq\bar{\mu}^N \xi A = \left( \frac{q \xi}{L} \right) N\bar{\mu}^N,
\]

\[
\bar{\mu}^N = \left( \frac{L}{q \xi} \right) \frac{I}{N}.
\]

This definition (5) closely follows the experimental practice of determining \( \mu \) from conductivity and concentrations. The average mobility of the \( N \) electrons considered fluctuates in time. The deviation from the time average of \( \bar{\mu}^N \) is denoted by \( \Delta \bar{\mu}^N \).

For average values the distinction is only formal and leads to the trivial relation

\[
N\bar{\mu}^N = \sum_{i=1}^{N} \mu_i.
\]

But for fluctuations the situation is different.

\[
\mu_i = \frac{v_i}{\xi}.
\]
Relation (2) gives
\[ \left< (\Delta I)^2 \right> = \left( \frac{q \xi}{L} \right)^2 \sum_{i-1}^{N} \left< (\Delta \mu_i)^2 \right> , \]  
(7)
whereas relation (4) gives
\[ \left< (\Delta I)^2 \right> = \left( \frac{q \xi}{L} \right)^2 N^2 \left< (\Delta \mu^N)^2 \right> . \]  
(8)
Since all terms in the summation of relation (7) are equal, we obtain
\[ \left< (\Delta \mu^N)^2 \right> = \frac{1}{N} \left< (\Delta \mu_i)^2 \right> . \]  
(9)
When Van der Ziel, Van Vliet and Zijlstra use \( \mu \) they mean \( \mu_i \), whereas in the papers criticized by them [4, 5] the same symbol \( \mu \) stands for \( \mu^N \).

If the empirical relation [3]
\[ \frac{S_f}{\bar{I}^2} = \frac{\alpha}{Nf} \]  
(10)
is expressed in terms of mobility fluctuations, we obtain
\[ \frac{S_{\mu i}}{\bar{\mu}^2} = \frac{\alpha}{f} , \]  
(11)
\[ \frac{S_{\mu^N}}{(\bar{\mu}^N)^2} = \frac{\alpha}{Nf} . \]  
(12)
Such expressions and the ideas underlying them can already be found in the summary of the publication that proposed mobility fluctuations for the first time [3]. No revision of literature is necessary. In most cases, \( \mu^N \) has been used, but never printed in this form.

References