Selected topics in solid state physics 2
Exercise 1

Consider a single electron transistor as described in the lecture notes. For simplicity assume $C_L = C_R$ and $V_L = -V_R = V/2$, where V is the applied bias voltage.

I. COULOMB BLOCKADE IN A SINGLE ELECTRON TRANSISTOR

Assume zero temperature, $T = 0$. Find out which conditions should the bias voltage V and the gate voltage V_g satisfy so that the current vanishes (in the sequential tunnelling approximation). Present these conditions graphically on the V-V_g plain.

II. LINEAR CONDUCTANCE AT LOW TEMPERATURES

Assume now that the temperature is much lower than the Coulomb energy, $k_BT \ll E_C \equiv e^2/(2C_\Sigma)$. Calculate the linear conductance of the SET as a function of V_g. Plot the result, discuss the positions and the width of the peaks.

III. CURRENT AND NOISE

Assume $k_BT \ll E_C$ and $eV \ll E_C$. The relation between k_BT and eV is arbitrary. Calculate the average current and the noise of current (at zero frequency) using the method of full counting statistics. Both quantities depend, of course, on the gate voltage V_g.

IV. CHARGE STATISTICS

Consider the third cumulant of the charge n that has tunnelled through the SET during time t. Show that it does not vanish in general. Why is it, then, still a good approximation to consider fluctuations of n and of the current as Gaussian after a long enough time t? How long should t be for the Gaussian statistics to become a good approximation? To answer this question you do not have to calculate the third cumulant explicitly.