



A Computer Controlled System for Characterisation of Solid State Devices in the Range 4-300 K

Prof Daniel Camin, Dr Valerio Grassi and Mr C Colombo of the Physics Department of Milano University, INFN, have developed a highly stable temperature controller for accurate determination of the low temperature noise characteristics of FETs. Based on an Oxford Instruments' cryostat and temperature controller, the system is being used to investigate the cryogenic performance of different devices technologies, including Si JFETs, GaAs MESFETs and Ge JFETs^[1].

Knowledge of the behaviour of semiconductor devices at cryogenic temperatures is increasingly important in instrumentation development. Cooled transistors, for example, are used for amplification of signals from infrared and visible sensors, as well as in particle detectors for ground and space applications. At cryogenic temperatures the characteristics of such devices can be very strongly temperature dependent. Small operating temperature drifts, for example, cause random walk-like spectra, avoiding a correct measurement of low frequency noise of field effect transistors (FETs).

To enable accurate determination of the noise and DC parameters of FETs, in the range 4-300 K, Prof Camin's team have developed a computer-controlled system which maintains the device under test at a stable temperature (± 10 mK) for several hours.

The system is based on an Oxford Instruments' liquid helium cryostat, an Oxford Instruments' ITC 503 temperature controller, and other instruments linked via a GPIB bus (figure 1). Noise measurements are performed using an HP 3562A FFT Dynamic Signal Analyser, and the control and analysis software was developed using the LabView® G graphical language.

Rh-Fe temperature sensors in the sample space and near the heat exchanger connect to the ITC 503 controller. This enables minimisation of the thermal gradient between the



Fig. 1: Measurement and control instruments interfaced via GPIB bus to a virtual panel.

heat exchanger and the sample. Using this temperature information the computer controls heating coils placed at the bottom of the cryostat and outside the sample space near the heat exchanger. A proportional-integral-derivative (PID) algorithm is used which is autotuned using a Ziegler-Nichols procedure, and additionally, a software-selectable proportion of the power dissipated by the internal heater may be fed to the external one. Temperature stability is reached in about 15 minutes.

The temperature is plotted on the computer monitor in real time and the PID parameters, optimised for liquid nitrogen or liquid helium operation, can be fine tuned on the virtual front panel. Once temperature stability has been reached the external heater can be shut down automatically.

The team has also developed a LabView driver for the HP3562 Dynamic Signal Analyser in order to control measurements of noise power spectrum and transfer

function, and to store the data in the computer. Using different fit algorithms, this software can also extract other parameters such as transconductance, white noise level, generation-recombination noise time constants, and flicker noise level.

To enable remote monitoring of measurements made overnight (when environmental noise is at a minimum) the noise spectra, DC curves and the temperature variation are displayed in real time on the Internet (<http://pcelet06.mi.infn.it>). The data obtained may also be transmitted automatically as an E-mail attachment in a spreadsheet-compatible ASCII format.

References:

[1] R.R. Ward, R.K. Kirschman, M.D. Jhabvala, R.S. Babu, N.C. Das, D.V. Camin, G. Pessina, V. Grassi, K. Kandiah and J.J. Rosenberg, *Development of Cryogenic Ge JFETs- II*.

Presented at Electrochemical Society Fifth Symposium on Low Temperature Electronics, Honolulu, Hawaii USA 21 October 1999.

Abstract available at: <http://www.electrochem.org/meetings/196/pik1.html#1196>

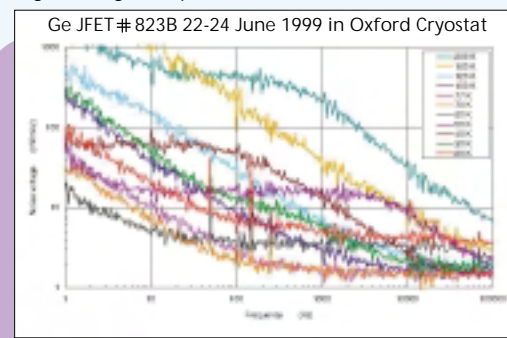


Fig. 2: Noise spectra of a Ge JFET, from 20K to 200K; this particular Ge JFET was chosen because it exhibits an interesting variation of spectra with temperature, rather than exhibiting the lowest noise^[1].

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