SINIS turnstile and electromagnetic environment

E. Mykkänen[1], J. S. Lehtinen[1], A. Kemppinen[1], C.Krause[2], D.Drung[2] and A.J.Manninen[1]

1. VTT Technical Research Centre of Finland Ltd, Centre for Metrology MIKES, Tekniikantie 1, 02150 Espoo, Finland
2. Physikalisch-Technische Bundesanstalt (PTB), AbbestraÃe 2â12, 10587 Berlin, Germany

In the near future, the SI unit system will be redefined in terms of invariants of nature. One step in this process is the redefinition of unit ampere, where ampere will be tied to elementary charge, e. A natural way to realize this definition would be a quantum metrological device which produces currents $I = nef$, where n is integer and f is frequency. However, such currents are usually small (hundreds of nanoamperes) and special care needs to be taken with noise, both in cryogenic environments and in room temperature.

One approach to realize the current source is a hybrid single-electron transistor (SET) which is based on two NIS (normal metal – insulator – normal metal) tunnel junctions [1, 2]. A single SINIS turnstile can produce current of several pAs, which is too low for practical implementation. However, due to their simplicity these devices can be parallelized [3]. The predicted uncertainty of a SINIS turnstile is around 10^{-8} [4] but currently the best experimentally demonstrated results are of the order of hudreds of ppm. We are focusing on parallellisation of the SINIS turnstile and at the same time on the reduction of uncertainty.

Even as the fundamental limitation for accuracy of SINIS turnstile is due to quasiparticles [5], photon assisted tunneling can be a significant error source [6]. We have studied effectiveness of on-chip SQUID- and RC-filtering to reduce the residual microwave background using single photon SINIS-trap detector. For the measurements sample stage with state of the art high frequency filtering and shielding has been constructed. Low frequency noise does not contribute as an error source to SINIS turnstile operation but can significantly increase integration time required to achieve desired accuracy. We have studied noise performance of several low current noise cables to optimise the cryostat cabling for ultra small current measurements.

[1] J.P. Pekola et. al. Review of Modern Physics **85**, 1421 (2013).
[2] J. P. Pekola et. al. Nature Physics **4**, 120-124 (2008).
[3] V. F. Maisi et. al. New Journal of Physics **11**, 113057 (2009).
[4] D. V. Averin and J. P. Pekola Physical Review Letters **101**, 066801 (2008).
[5] H. Knowles et al. Applied Physics Letters **100**, 262601 (2012).
[6] J. P. Pekola et al. Physical Review Letters **105**, 026803 (2010).