Broken Photon-step Phenomenon in SIS Mixers

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In this paper, we discuss a "broken step" phenomenon in an SIS mixer. The broken step was observed in the SIS mixers used for ALMA Band 5. When studied this phenomenon, we used the production ALMA Band 5 2SB mixer, 159-211 GHz RF band, largely based on the 2SB SIS mixer presented in [1] and a data-acquisition software [2] specifically modified for ALMA Band 5 Project. The broken step appears typically at LO frequencies above 180 GHz and manifests itself as a sharp break in the DC current at the middle of the quasiparticle step. Correspondingly, this affects the mixer IF response in a similar fashion as the Josephson step however has different nature. Such behavior clearly upsets the SIS mixer dynamic range and complicates tuning of the 2SB mixer for the optimum performance, for both the receiver noise and the sideband rejection.

In order to understand the phenomenon, we operated the mixer at different modes, physical temperatures and discovered that the broken-step has its origin in the quasiparticle tunnel current. By varying the magnetic field and achieving accurate suppression of the Josephson effect, we ensured that this phenomenon has no coupling to the Cooper-pair current. Our experiments and simulations show that the broken-step phenomenon could be explained by the appearance of the twice-lower-than-LO frequency at the SIS junction mixer even though this frequency is substantially below the cut-off frequency of the waveguide mount (dimensions are close to WR-5). Such frequency corresponds to the pumping frequency of the last-stage LO chain doubler and is around 100 GHz.At the Conference, we report further details of our experiments, modelling and conclusions on the appearance of the broken-step behavior of the SIS mixer.

References

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