# Design issues of superconducting quantum antennas based on bi-SQUIDs and differential quantum cells

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To provide broadband high frequency electromagnetic signals measurements, superconductive quantum arrays (SQA) can be used. Due to macroscopic quantum effects in superconductors they allow to deal with frequencies up to THz and are able to perform transformation of input signal with a high linearity [1, 2].

Linearity is a key characteristic helping to describe level of non-liner transformation of the input signal. It can be defined as a ratio of the main harmonic amplitude of the output signal to the maximum amplitude of its subsequent harmonics. In practice, when noise exists, it is more convenient to use a value called spurious free dynamic range (SFDR). This is a ratio between the fundamental harmonic amplitude and either the noise value or major nonlinear signal distortion if larger.

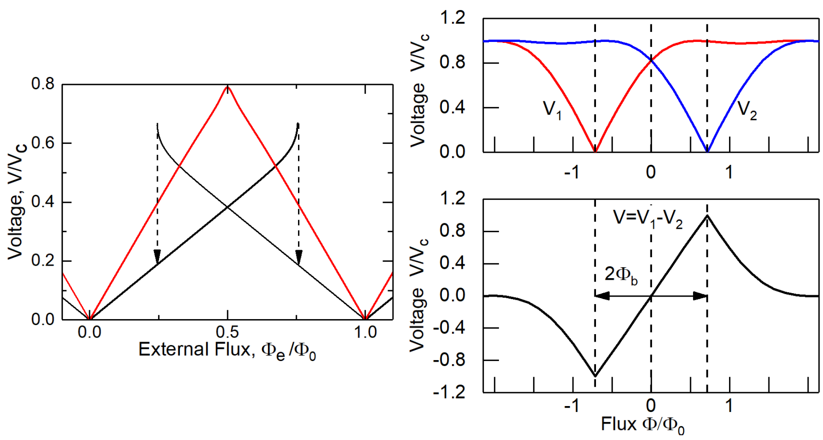


Figure 1: Periodic hysteretic and triangle voltage response of bi-SQUID (left) and voltage responses of the DQC arms (right top) and resulting response (right bottom).

SQAs consist of several identical cells connected in serial, parallel or serial-parallel ways. In this report, bi-SQUIDs and differential quantum cells (DQC) are suggested as such elements. Bi-SQUID is capable to transform external magnetic flux into voltage with a high linearity (up to 100 dB) by an addition of non-linear transformation of an external signal into a conventional dc SQUID but requires very precise selection of its parameters[3, 4]. Voltage responses of such bi-SQUID cell are shown on figure 1. DQC includes two identical arms which are parallel arrays of N Josephson junctions with low coupling inductances. Both arms are magnetically frustrated (see fig. 1). An external signal is applied to each arm with a different sign and a resulting output signal is the difference between voltages of arms[1, 5].

Combining single cells into arrays allows to increase dynamic range, sensitivity and signal-noise ratio. Otherwise, it can lead to appearance of parasitic resonances which cause distortion of the output signal. Therefore, designing SQAs requires responsible approach including computer simulation to avoid these problems.

We present design of SQAs consisting of both bi-SQUID and DQC cells made on Nb thin film technology[6]. Output signal characteristics of both elements depends highly on their inductive parameters; thus, it is required to provide calculation of elements inductances. An optimization of each type of cell was performed and several topologies with different parameters are suggested. We investigate influence of different configurations of SQAs such as number of elements, non-zero resistivity between cells, type of cells and their inner parameters on an achievable level of the SFDR.

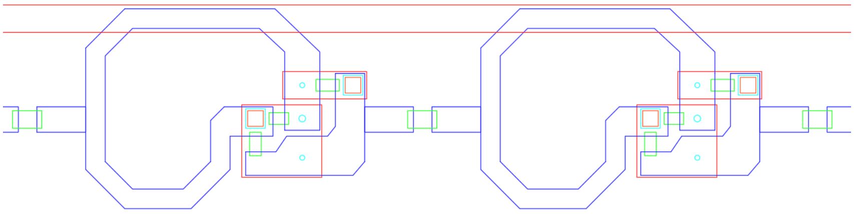

Figure 2: A fragment (two cells) of an SQA consisting of bi-SQUID cells with added resistance between cells. An external signal is applied via control line.

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# References

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