Paper 1709 URSI 2OO2

SQUID ANTENNA PATTERN

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1-Introduction

Squids sensors are made of a pick-up coil magnetically coupled to the Josephson interferometer itself. When High Tc superconductors are used the coupling is often made by a flip chip configuration between the loop antenna and the squid [1,4]. In such a configuration it is necessary that the **La** antenna self inductance is matched to the primary inductance **Lt** of the transformer facing the squid to get the maximum flux through the squid [2] :

La= Lt

The general consensus is that to increase the sensor sensitivity, the antenna loop must be optimized [3] and must have a maximum area. However if one takes into account the Biot and Savart law it is more precise to say that the antenna perimeter must be as large as possible. This statement is easily understood if one considers the antenna not in the reception regime but in an emission regime : the larger the length, the higher the magnetic induction. According to the reciprocity theorem, the reception is more sensitive for a larger perimeter.

As a result the investigation of the antenna pattern of a squid antenna is a subject in itself . One must try to design antennas that increase the sensitivity. In the following the antennas are made of copper or superconducting materials.

2 -Antenna diagram

We have studied various antenna diagram in low and very low electromagnetic noise environment:

1- The conventional low noise chamber of Garchy (France) which is a wood cabin housing a set of 5 coils. The first one, 12.5m in diameter, to cancel the Z component of the earth magnetic field and its fluctuations up to typically 100 Hz . The others with horizontal axis constituting two orthogonal Helmholtz coils 1.8m in diameter to cancel the X and Y component . An additional pair of Helmhotz coils may produce AC horizontal magnetic field up to 1MHz uniform in a tube 5cm of diameter and 6cm of length. The squid antenna is located in the center of this tube and may be rotated around a vertical axis. It is thus possible to record the pattern of the antenna. Two kinds of measurements were done simultaneously : the amplitude of the detected magnetic field and of its phase with respect to the excitation magnetic field. (fig 1 and 2).
2- Similar measurements were performed in the underground exceptional shielded room of the Laboratoire Souterrain à bas Bruit of Rustrel (France) 60km east of Avignon. Its residual noise is better than 2ft/sqr Hz above 10 Hz in 1250 cubic meters [5]. The results obtained in Rustrel confirm the first experiment and other kinds of antenna were tested.

According to these results the antenna are well modelized by a magnetic dipole, excited by the current in the antenna. Indeed as one can see exactly on fig 1 the experimental diagram is exctly superimposed to the theoretical diagram of such a dipole.

3- Unconventional antennas:

According to the Biot and Savart law we designed other kind of antenna. These antennas were flip chip coupled to the same squid thus producing two sets of transformers. The base of the flip chip is the SQUID and its transformer, the lid is the additional antenna itself made of a large loop and its primary. For the lid structure one must have again as for the squid itself a matching of impedances betwwen the antenna pick'up loop and the primary of the transformer facing the base squid.

These antennas fall into two classes:

1- those made of multi turn loop
2- those which according to the Biot and Savart law are designed to get a maximum length and a minimal

inductance in a single turn. To achieve that goal we introduced for the first time for the Squid (to our knowledge) a fractal configuration. We made a fractal motif based on elementary squares. For each design we managed that the total length of a fractal antenna based on square motif has a length egal to a multiturn antenna. Thus we have a pair of antenna of a given length either conventional multi turn or fractally designed. Such a pair is presented on fig 3. One can notice the the number of turns of the primary is reduced in the fractal design with respect to its multi turn counterpart, due to the lower inductance of the fractal antenna. The sensitivity of these new sensors were evaluated in Rustrel.

4-Conclusion

We proposed for the first time a new configuration, the fractal one, for the loop antenna of a squid. Such a design offers lower inductance favorizing its coupling with a squid. We hope in a next phase of this program to improve again these fractal antennas by producing them in superconducting materials.

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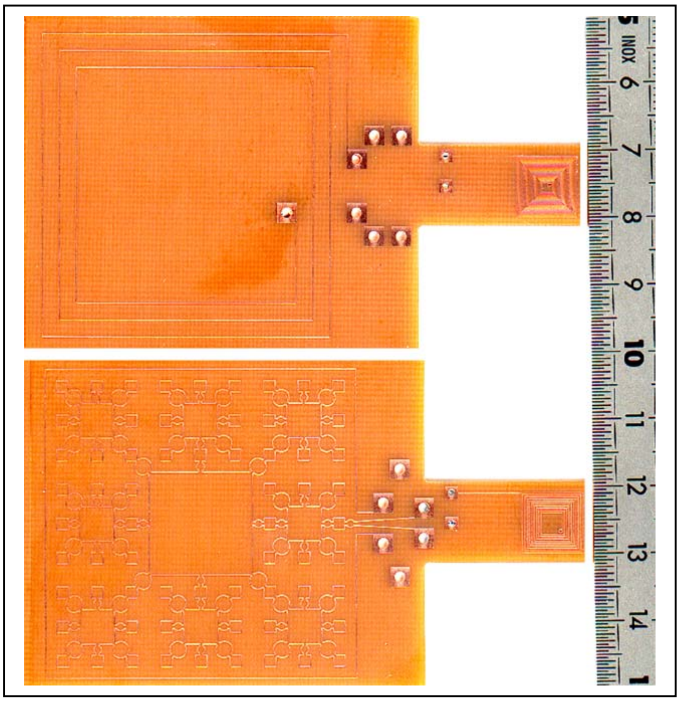

Fig 3

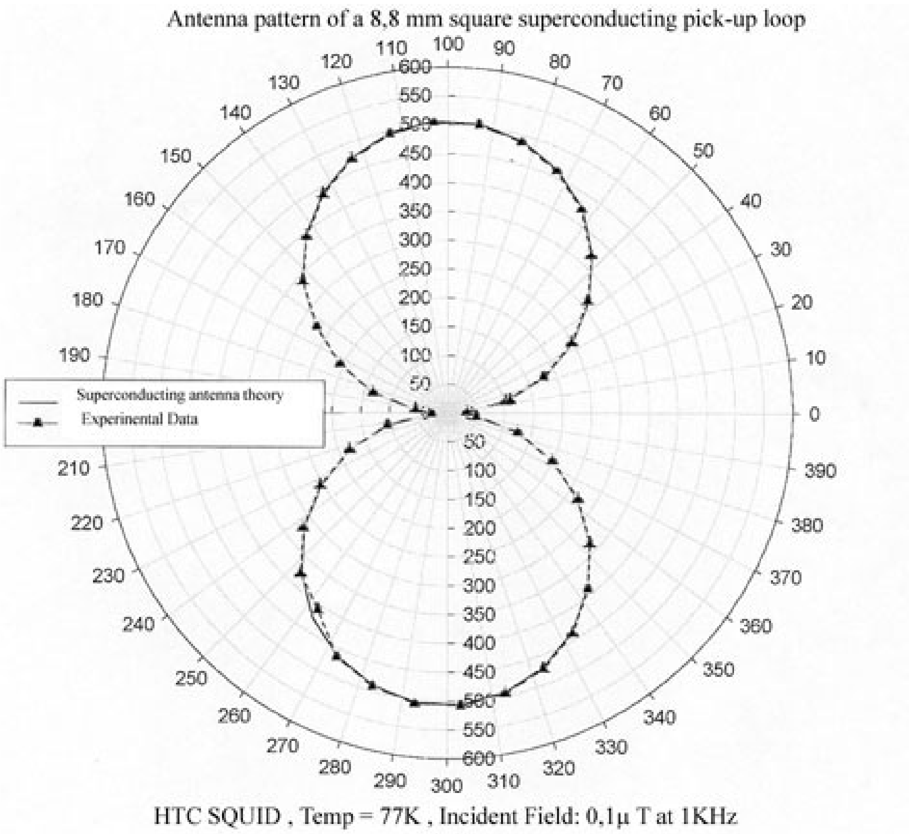

Fig 1

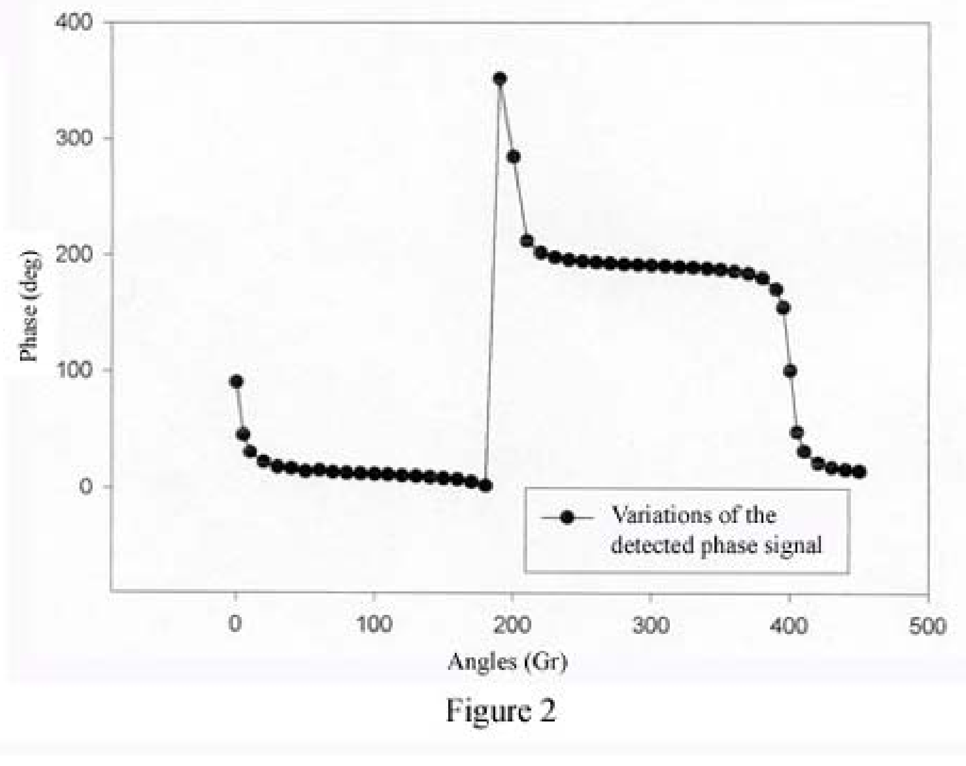

Figure 2