Design of an impedance bridge based on Josephson voltage standards in a cryocooler with in-built Helium liquefier

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Introduction

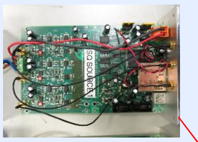
Josephson impedance bridges have recently extended the frequency range of two-terminal-pair impedance measurements at highest accuracy level from 20 Hz to 20 kHz [1]. These bridges have proven to be more flexible and user-friendly for measuring ratios of like impedances (R:R, C:C) than conventional coaxial bridges.

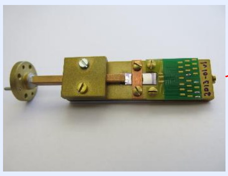
To reduce the dependence of Josephson bridges on the availability of liquid helium (LHe), and to make a Josephson bridge more mobile we have been developing a setup where two Josephson arrays are cooled with a cryocooler [2]. The challenge of extracting the heat dissipated at the arrays with a dry cryocooler turned out to be so large [3] that we decided to design and build a cryostat with an inbuilt helium liquefier. Performance of the arrays comparable to that in LHe dewars is expected.

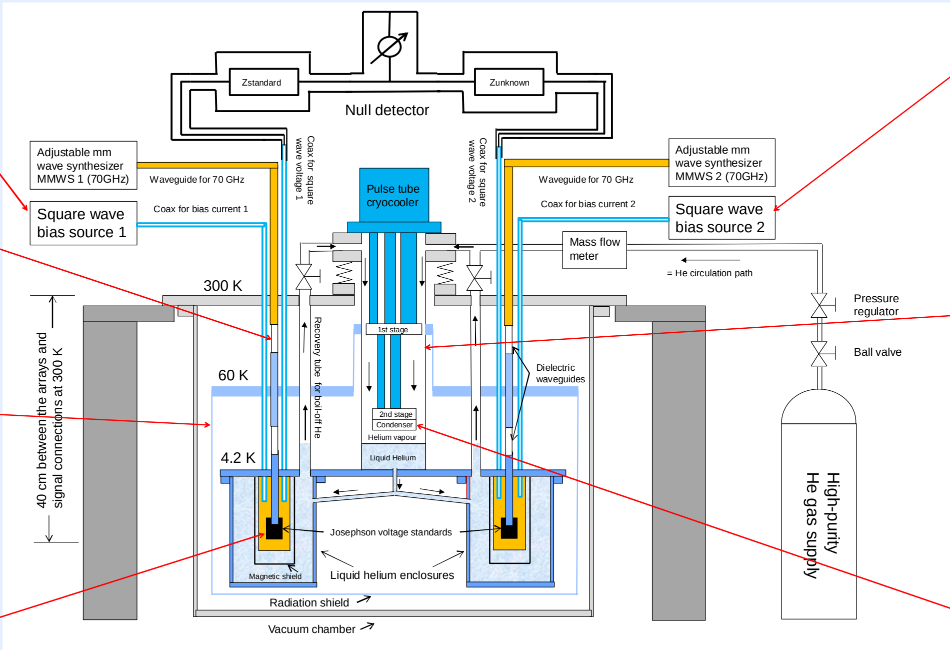
SETUP

Liquid helium bath provides best possible conditions for extracting heat out of the Josephson junctions. The schematic shown below describes our system where condensing copper elements and a helium liquefying sleeve have been mounted to a pulse tube cryocooler [4]. Helium gas from an external reservoir is supplied into the liquefier at a constant pressure (1 bar) and after initial cool down of the gas, helium starts to condense on the bottom of the sleeve. The Josephson junction arrays are located below the sleeve bottom and the copper enclosures around them become filled with LHe via separate tubing as well. The evaporating helium is returned to the upper part of the liquefier to be recondensed.

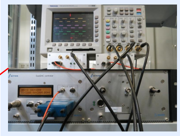
Relatively compact dimensions of the cryostat should allow using much shorter cables than typical when using LHe dewars. This is expected to improve the performance of the Josephson bridge.

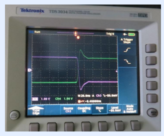






A simplified diagram illustrating the main functional elements of a two-terminal-pair Josephson impedance bridge with Josephson junction arrays immersed in a liquid helium bath created with an in-built liquefier mounted around a pulse tube cryocooler.





OUTLOOK

Once assembled and functioning we expect to have at least 500 mW of cooling power for the Josephson junction arrays in liquid helium. This should allow cooling two 10 V SNS programmable arrays. Therefore, good signal to noise ratio is expected even for impedance ratios of 1:10.

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EURAMET European Association of National Metrology Institutes

EMRP European Metrology Research Programme ▸ Programme of EURAMET

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