Cryorefrigerator System Design and Test Results with COSL Gates

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ABSTRACT: We present a cryorefrigerator system design for the testing of niobium-based COSL and RSFQ digital circuits at 4 Kelvin, and report observed output signals for COSL circuits. Thermal design, noise reduction and effective electronic interfacing are discussed, and although logic errors are observed, we show that the system allows easy readout of superconductive digital electronic signals to room temperature electronics at low frequencies.

Introduction

Examples of cryorefrigerator-cooled superconductive digital electronics (SDE) have been demonstrated [1]. However, cryocooling without liquid helium still remains an obstacle to the deployment of SDE in industrial systems, primarily due to thermal and electrical noise. Furthermore, Complementary Output Switching Logic (COSL) [2] has not previously been demonstrated to function in a cryorefrigerator.

We present a cryorefrigerator system for the testing of COSL and RSFQ circuits, and highlight important design issues. A semiconductor controller is also presented, which allows testing automation, as well as COSL outputs to be measured by computer. We also show test results.

Cryorefrigerator setup

We use a two-stage CryoMech ST405 pulse tube refrigerator (PTR) with 0.5 Watt cooling power at 4K (second stage), and a 65 K first stage. See Fig. 1 for a system diagram. Other specifications are:

- Double pump vacuum system - Diffusion and turbo molecular pumps used to pull 10⁻⁸ atm vacuum.
- 3 phase, 50 Hz ac compressor unit, water cooled.
- Vacuum housing re-engineered to fit semiconductor controller motherboard inside vacuum, and reduce electrical connections entering the housing.
- The cryorefrigerator COSL/RSFQ test system is ready for circuit testing. Thermal and noise issues have been solved, but magnetic shielding still needs to be addressed. Low-frequency inputs can reliably be supplied to the device under test, and sub-millivolt outputs measured. However, correct circuit operation still needs to be observed. Furthermore, next-generation systems must address high-frequency interfacing.

Conclusion

The cryorefrigerator COSL/RSFQ test system is ready for circuit testing. Thermal and noise issues have been solved, but magnetic shielding still needs to be addressed. Low-frequency inputs can reliably be supplied to the device under test, and sub-millivolt outputs measured. However, correct circuit operation still needs to be observed. Furthermore, next-generation systems must address high-frequency interfacing.

References