Superconducting Distributed Output Amplifier for RSFQ*

February 5, 2010 (HP27). Quentin Herr of Northrop Grumman Corporation (Baltimore, MD, USA) published in *Superconductor Science and Technology* (*SuST*) a Rapid Communication on a superconducting distributed output amplifier that solves the problem of superconducting RSFQ* digital circuitry output to a room-temperature low-noise amplifier (LNA) at 10 Gb/s serial data rate [1]. The amplifier circuit was fabricated in a 1.5 μm commercial Nb integrated circuit process with 4.5 kA cm^{-2} Josephson junctions [2], and operated at liquid helium temperature of 4.2 K. The bit error rate was measured using a Delta–Sigma data pattern to be less than 1×10^{-9} at 10 Gb/s per channel. Analysis of the textbook voltage *versus* time "eye diagram" at 10 GB/s suggested that the actual bit error rate may be much lower. The output amplitude measured at the top of the probe before amplification was a flat, 1.75 mV over a wide bias current range of ±12%.

The data link uses a twelve-stage distributed amplifier configuration shown in Figure 1. Distributed amplifiers are known in transistor design as a way to increase gain using multiple stages while maintaining bandwidth, but the method has not been previously reported for superconductor technology. The superconductor gain element (the dc SQUID) is in fact ideally suited to a distributed amplifier configuration as it is a low-impedance, floating voltage source. The implementation turns parasitic capacitance in the series array to advantage, in conjunction with a large isolation inductor at every stage, which is the essential innovation. The design requires a 50 Ω source termination resistor not typically found in superconductor amplifiers, but this makes the device compatible with room-temperature LNAs, which typically have large reflections at the input. The design is dc-powered and uses non-return-to-zero data encoding. The overall design suppresses deleterious oscillatory modes and enforces the desired oscillatory mode in the active Josephson junction devices. The amplifier has a power efficiency of 12% neglecting dissipation in the termination resistor, which may be eliminated from the circuit *via* a small modification.

[1] Q. Herr, "A high-efficiency superconductor distributed amplifier", *Supercond. Sci. Technol*. **23**, 022004 (2010).
[2] Hypres, Inc., Elmsford, NY, USA.

* RSFQ is the acronym for Rapid Single Flux Quantum superconducting digital electronics.

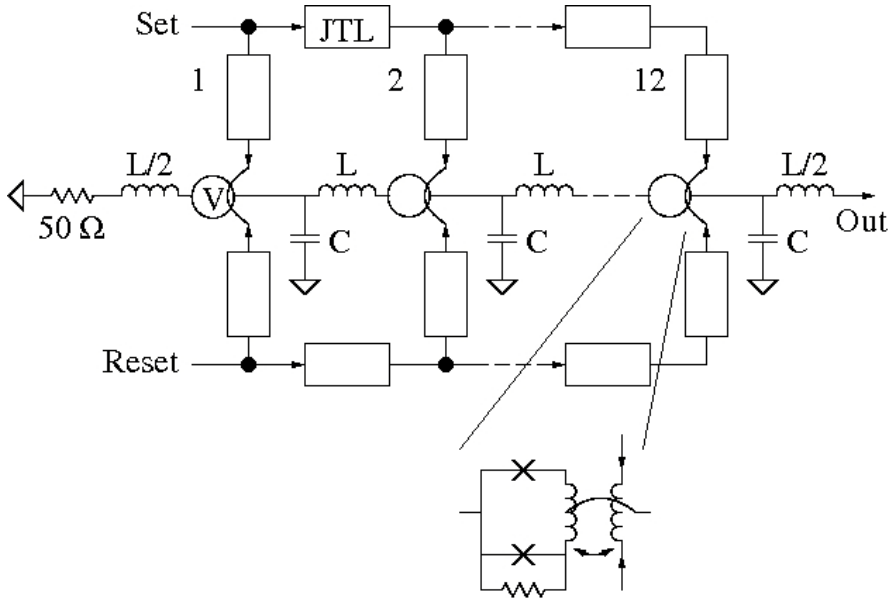

Fig. 1. The twelve-stage distributed amplifier matches JTL delay at the input to *LC* delay at the output. The rectangles represent two-stage JTLs that together make a splitter network. The gain element (expanded) is a SQUID, which is a low-impedance, floating voltage source.