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# Analog Cavity Emulators to Support LLRF Development

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The goal of a LLRF system is to control an actual RF cavity with beam. While digital simulations have a place, having an analog circuit to stand in for the cavity can be tremendously helpful in validating hardware+firmware+software under development. A wide range of cavity emulators have been developed in collaboration with SLAC, and LBNL. Cavity emulators are typically based on quartz crystals and frequency conversion hardware. The choice of crystal frequency and coupling mechanism depends in part on the bandwidth and coupling of the cavity it's intended to emulate. Examples of bandwidth range from 800 Hz (SLAC) as a stand-in for a SRF cavity, to 31 kHz (LBNL) for a room-temperature accumulator-ring cavity. An external LO is used to tune the emulated cavity frequency. The coupling properties are also of interest if the scope includes emulating reverse power waveforms. LLRF system checks such as closed-loop bandwidth, and determining cavity detuning can be performed interactively and as part of a Continuous Integration (CI) process. This paper describes the design, implementation, and performance of the cavity emulators.

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