

Quantum & Qubit Control

Ultra-low-phase-noise, phase-coherent multi-channel synthesizers for qubit drive, readout, and gate fidelity in superconducting and trapped-ion systems.



APPLICATION BRIEF · RF & MICROWAVE SIGNAL GENERATORS · dc-62022201

The Mission

Quantum processors are built on microwave control. Superconducting qubits are driven and read out with carefully timed microwave tones, and trapped-ion systems lean on stable RF and microwave fields. Gate fidelity, coherence times, and crosstalk rejection all trace back, in part, to the spectral purity and phase stability of the sources behind the experiment. As qubit counts grow, the control problem becomes a multi-channel problem.

The Challenge

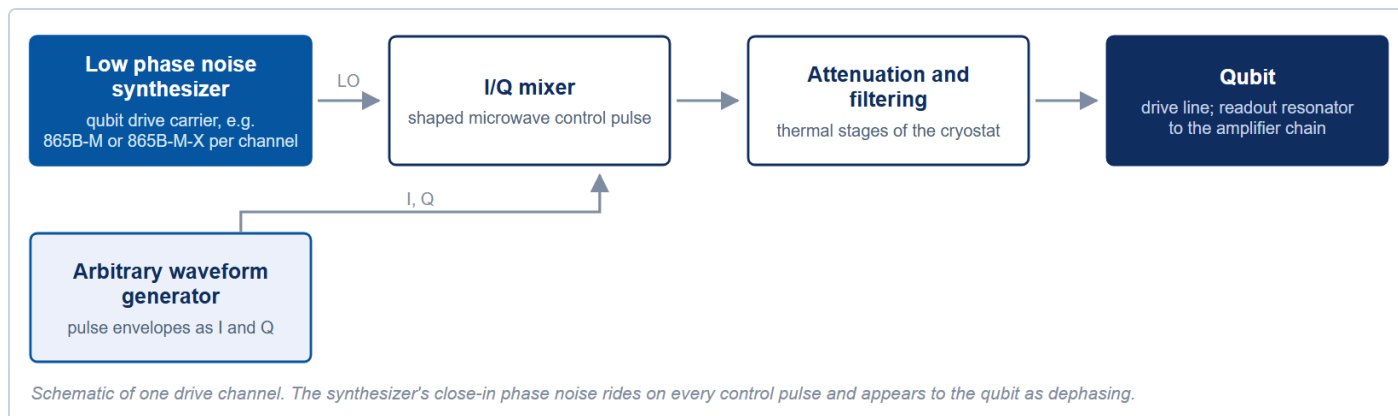
Close-in phase noise on the drive tone appears to the qubit as dephasing, so a source with poor 1 kHz performance erodes the coherence the whole system is trying to protect. Multi-qubit control then demands several outputs that stay phase-coherent with one another, with independent frequency, power, and phase per channel, so each qubit can be addressed without disturbing its neighbors. Channel-to-channel isolation is budgeted alongside phase noise.

Recommended Berkeley Nucleonics Solutions

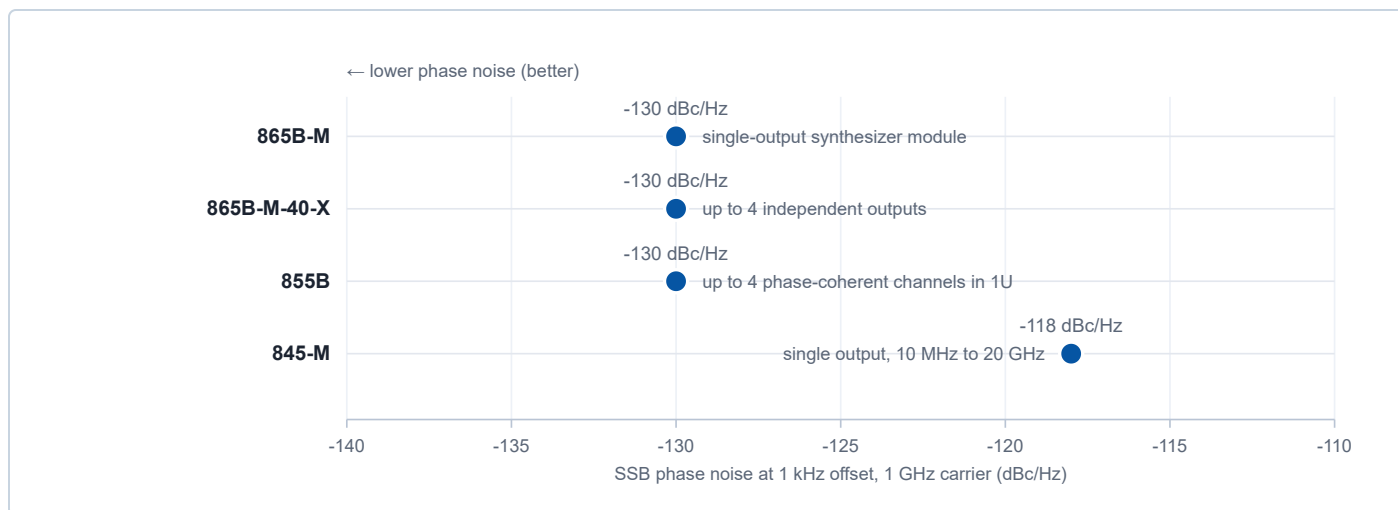
The Model 865B-M is specified at -130 dBc/Hz typical at 1 kHz offset (1 GHz carrier) in a 2.2 lb desktop module that runs from a single 24 V supply. For multi-qubit work, the Model 865B-M-40-X brings that same low-noise core to as many as four fully independent outputs, each with its own frequency, power, phase, and modulation, plus Option HI, a high-isolation enclosure, for tightly packed channels.

The Model 845-M is a small single-supply microwave synthesizer module (10 MHz to 20 GHz) with -118 dBc/Hz typical at 1 kHz (1 GHz carrier), suited to embedding inside a control rack. Where a full bench instrument with many synchronized channels is preferred, the Model 855B provides up to four phase-coherent outputs in 1U and 3 GHz clock ports for locking multiple units together. Figure 1 compares the four at 1 kHz offset from a 1 GHz carrier.

Two more numbers matter in a multi-channel rack. On the 855B, channel-to-channel isolation is 90 dB below 3 GHz and above 60 dB beyond 6 GHz, rising to 80 dB (90 dB typical) with Option HI, and the relative phase between channels holds to 3 mrad at 5 GHz over 5 hours. The 865B-M reference holds ± 20 ppb from 0 to 50 °C with Option LN or LN+, and every source here locks to a common 10 or 100 MHz reference, or to the 3 GHz clock ports on the 855B and 865B-M-X, so the whole rack shares one timebase.



■ **SCHEMATIC** **Figure 2.** One qubit drive channel, a low phase noise synthesizer as the local oscillator, an arbitrary waveform generator supplying I and Q envelopes, an I/Q mixer, the attenuation stages of the cryostat and the qubit.



■ **DERIVED** **Figure 1.** Typical SSB phase noise at 1 kHz offset from a 1 GHz carrier, from the current datasheets.

Why It Works

The 865B-M and 865B-M-40-X reach -130 dBc/Hz typical at 1 kHz from a 1 GHz carrier, matched by the 855B in Figure 1. Independent-per-channel control on the 865B-M-40-X lets one instrument address several qubits at different frequencies while staying phase-coherent, and the high-isolation option keeps neighboring channels from leaking into one another. Compact single-supply modules slot into existing control electronics rather than forcing a rack of separate generators.

Getting Started

Berkeley Nucleonics applications engineers help match the right source, channel count, and options to your test plan. Tell us your frequency span, switching budget, and channel needs, and we will recommend a configuration and arrange a demo.

Contact info@berkeleynucleonics.com or call 800-234-7858. Browse the full family on the RF & Microwave Signal Generators documentation page.

Berkeley Nucleonics Corp.

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Application Brief

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