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Adjustable Josephson Coupler for Transmon Qubit Measurement

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Transmon qubits are measured via a dispersive interaction with a linear resonator. In order to be scalable this measurement must be fast, accurate, and not disrupt the state of the qubit. Speed is of particular importance in a scalable architecture with error correction as the measurement accounts for substantial portion of the cycle time and waiting time associated with measurement is a major source of decoherence. We have found that measurement speed and accuracy can be improved by driving the qubit beyond the critical photon number $n_{crit} = \frac{\Delta}{4g}$ by a factor of 2-3 without compromising the QND nature of the measurement. While it is expected that such strong drive will cause qubit state transitions, we find that as long as the readout is sufficiently fast, those transitions are negligible, however they grow rapidly with time, and are not described by a simple rate. Measuring in this regime requires parametric amplifiers with very high saturation power, on the order of -105 dBm in order to avoid losing SNR when increasing the power. It also requires a Purcell filter to allow fast ring-up and ring-down. Adjustable couplers can be used to further increase the measurement performance, by switching the dispersive interaction on and off much faster than the cavity ring-down time. This technique can also be used to investigate the dynamics of the qubit cavity interaction beyond the weak dispersive limit $n_{cavity} \geq n_{crit}$ not easily accessible to standard dispersive measurement due to the cavity time constant.