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A collocation-based algorithm for computing the pull-in range of a class of phase-locked loops.

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Summary: The pull-in range (ω_p) of a phase-locked loop (PLL) is defined as the maximum value of loop detuning ω_{0s} for which pull-in occurs from anywhere on the PLL's phase plane. That is, pull-in is guaranteed from anywhere on the phase plane if $\omega_{0s} < \omega_p$. Simple approximation is available for computing ω_p for the high gain PLL where saddle-node bifurcation occurs at $\omega_{0s} < \omega_p$. Unlike the high gain case, a simple approximation for ω_p is not available for the low gain case where bifurcation from a separatrix cycle occurs at $\omega_{0s} < \omega_p$. The vector field model for a class of second-order PLLs is shown to have rotational properties, which imply the existence of a separatrix cycle. The external stability of this separatrix cycle is an indicator of the type of bifurcation (saddle-node or separatrix cycle) which terminates the limit cycle associated with the PLL's stable false lock state and the PLL pulls-in (i.e. achieve phase lock). A formula is given for determining the separatrix cycle's stability, which indicates that these paratrix cycle is externally stable for small values of closed loop gain. A collocation-based algorithm is presented for computing the PLL's separatrix cycle and the value of pull-in range frequency $\omega_{0s} < \omega_p$ at which a stable separatrix cycle exists.

Keywords: Separatrix cycle; bifurcation; collocation method; phase-locked loop
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