We identify and describe the principal bifurcations of bursting rhythms in multi-functional central pattern generators (CPG) composed of three neurons connected by fast inhibitory or excitatory synapses. We develop a set of computational tools that reduce high-order dynamics in biologically relevant CPG models to low-dimensional return mappings that measure the phase lags between cells. We examine bifurcations of fixed points and invariant curves in such mappings as coupling properties of the synapses are varied. These bifurcations correspond to changes in the availability of the network’s phase locked rhythmic activities such as periodic and aperiodic bursting patterns. As such, our findings provide a systematic basis for understanding plausible biophysical mechanisms for the regulation of, and switching between, motor patterns generated by various animals.