A switched control scheme to handle quantisation in the design of high-precision computing system components

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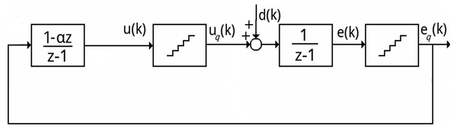
Problem statement

- ♢ Performance of computing system components in e.g. memory management, thread scheduling, and time synchronisation can be improved by adopting a control-system perspective
- ♢ Problem translates in controlling discrete-time integrators to achieve set point tracking and disturbance rejection capabilities
- ♢ Due to the high precision achieved, quantisation becomes relevant and may cause possibly periodic fluctuations that need to be reduced

Objective

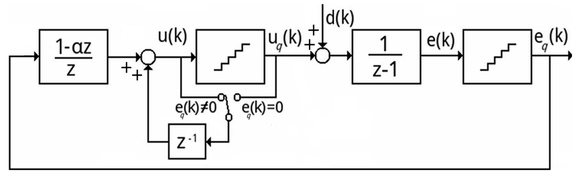
Reduce the synchronization error oscillations in the FLOPSYNC scheme for wireless sensor networks time synchronisation (Terraneo and Leva, 2013)



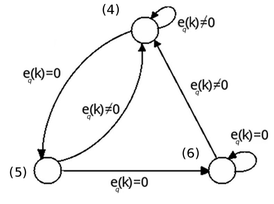
The disturbance $d(k)$, due to ageing, thermal stress, and short-term jitter, is not quantised ⇒ synchronisation error oscillations around zero

Proposed solution

♢ Conditionally reset the integrator of the FLOPSYNC controller



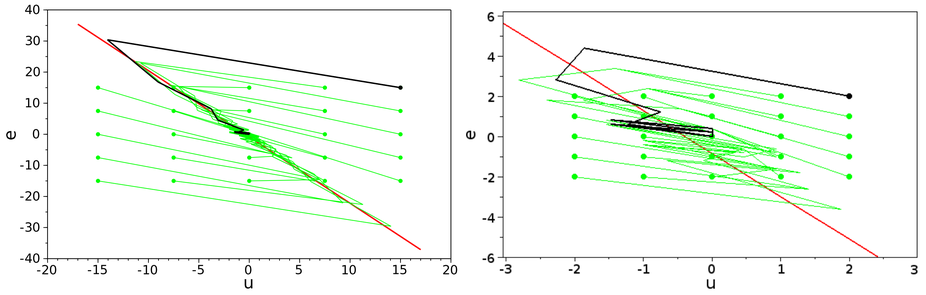
♢ Invariance and reachability analysis of the resulting switching system:



Invariance and reachability analysis

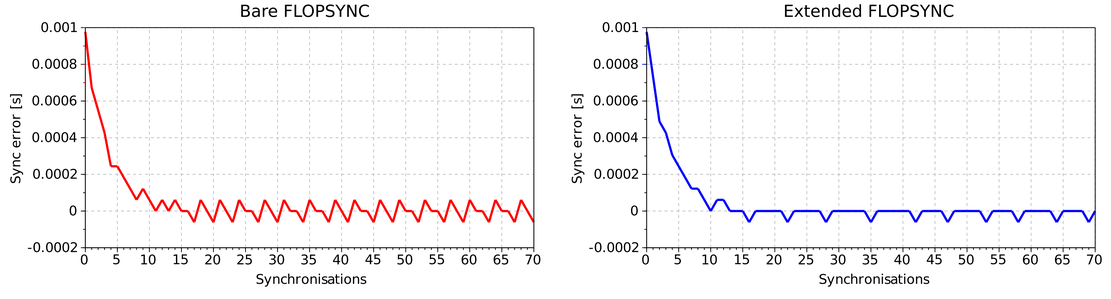
When the disturbance is constant, then, the system

- admits an invariant set with $e_q \in \{0, 1\}$ or $\{-1, 0\}$, depending on the value of the disturbance
- eventually reaches the invariant set from any initial state in a bounded region of the (u, e) plane



Experimental results

Synchronization error in the basic (left) and improved (right) FLOPSYNC



Conclusions

♢ The proposed switching extension improves the FLOPSYNC precision (experimental evidence)

♢ Future research involves studying the behavior of the trajectories inside the invariant set looking e.g. for limit cycles

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