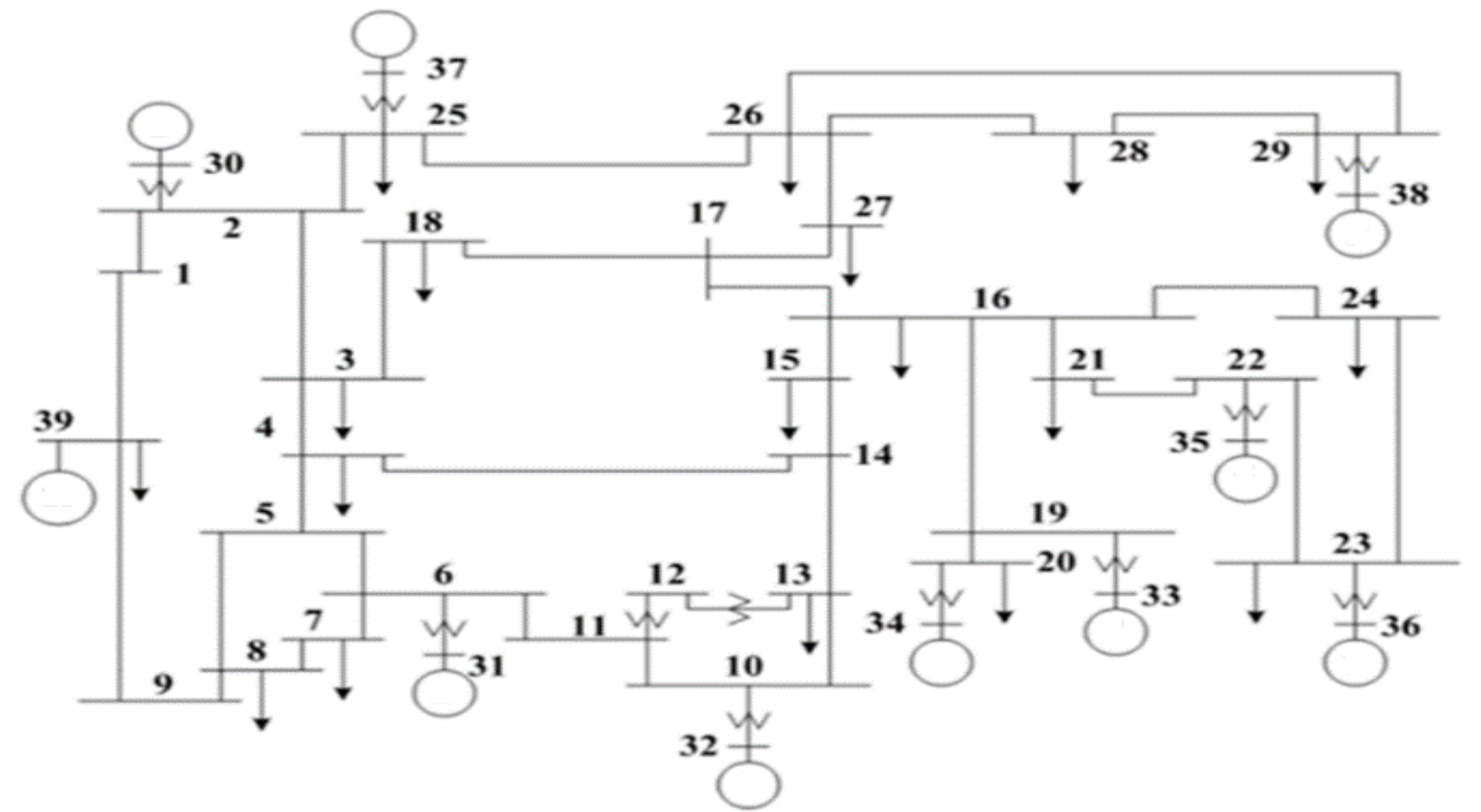


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Introduction

- Traditional power system simulation methods, e.g. R-K4, employing iterative numerical integration are time-consuming and may suffer from numerical instability.
- We propose a new non-iterative simulation approach:
 - Apply the Adomian Decomposition Method to offline derive a Semi-Analytic Solution (SAS) of power system DAEs, i.e. an approximate explicit solution of the state as a function of time and other parameters
 - Evaluate the same SAS over sequential time intervals of T until making the desired simulation period
- It demonstrates better performance than R-K4 on both classic and detailed generator models

IEEE 39-bus System



Algorithm (illustrated on a SMIB system)

$$\ddot{x} + D\dot{x} = f(x) = \sum_{n=0}^{\infty} A_n(x_0, x_1, \dots, x_n)$$

$$\text{where } A_n = \frac{1}{n!} \left[\frac{\partial^n}{\partial \lambda^n} f \left(\sum_{i=0}^n x_i \lambda^i \right) \right]_{\lambda=0}$$

$$L[x_0] = x(0)/s$$

$$L[x_1] = \dot{x}(0)/s^2 + DL[\dot{x}_0]/s^2 + L[A_0]/s^2$$

$$L[x_{n+2}] = DL[\dot{x}_{n+1}]/s^2 + L[A_{n+1}]/s^2, n \geq 0$$

$$x^{SAS}(t) = \sum_{n=0}^{N-1} x_n(t)$$

$$\delta^{SAS}(t) = \delta_0(t) + \delta_1(t) + \delta_2(t)$$

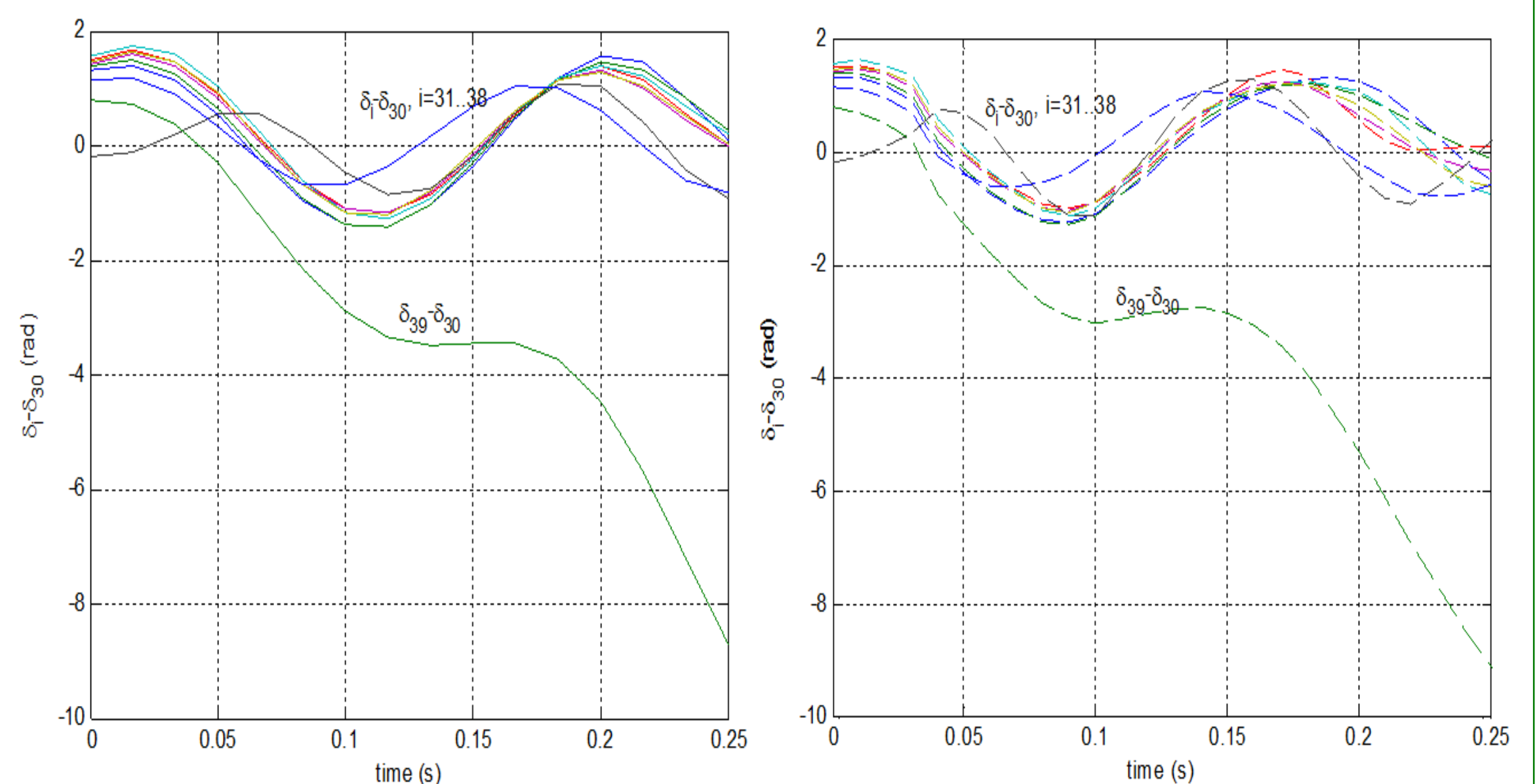
$$\delta_0 = a$$

$$\delta_1 = bt + \frac{P_m - P_{\max} \sin a}{4H} t^2$$

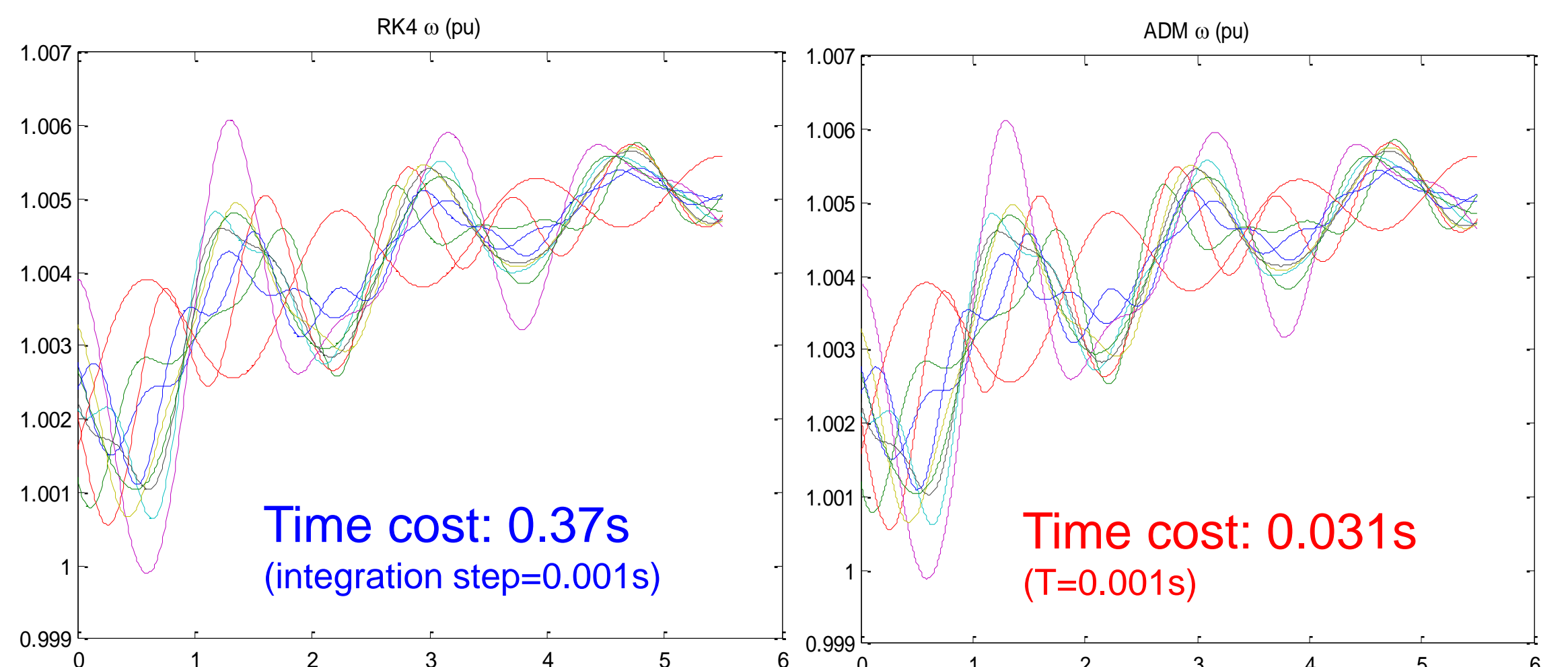
$$\delta_2 = \frac{P_{\max} \cos a (P_{\max} \sin a - P_m)}{96H^2} t^4$$

$$+ \left[\frac{D(P_{\max} \sin a - P_m)}{24H^2} - \frac{bP_{\max} \cos a}{12H} \right] t^3 - \frac{Db}{4H} t^2$$

where $a = \delta(0)$ and $b = \dot{\delta}(0)$

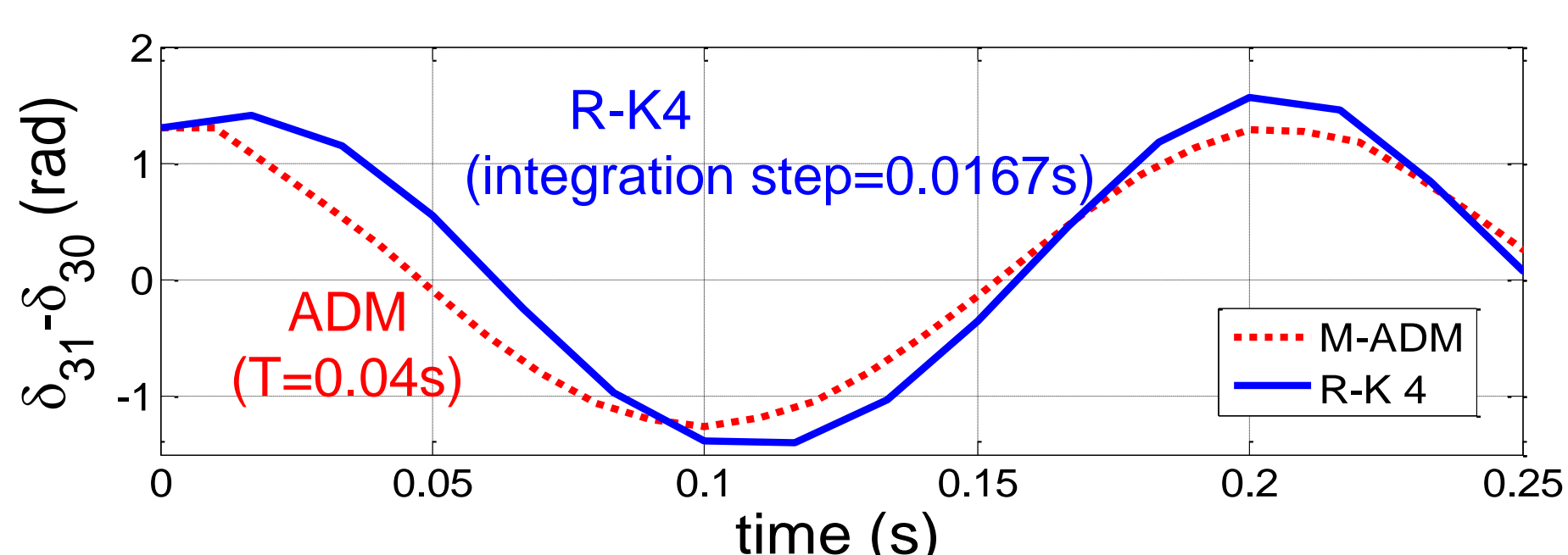


Test on the detailed 4th order generator model



Test on the classic generator model

	Only symbolizing time	Symbolizing all
SAS derivation	211.66 s	395.64 s
SAS evaluation	0.0015 s	0.0047 s
X faster than RT	26.7	8.5



Findings and Conclusions

- The new approach provides a systematic scheme to find approximate explicit solutions of the power system DAEs
- It could be an alternative simulation approach.
- Computational burden is moved to the offline stage if sufficient storage is available
- May be integrated with the numerical integration into a hybrid scheme: e.g. the ADM gives the approximate envelop and then R-K4 gives refined trajectories

Publication

N. Duan, K. Sun, "Application of the Adomian Decomposition Method for Semi-Analytic Solutions of Power System Differential Algebraic Equations", 2015 IEEE Powertech, Eindhoven