PRECISION CONTROL OF LINEAR MOTOR DRIVEN HIGH-SPEED/ACCELERATION ELECTRO-MECHANICAL SYSTEMS

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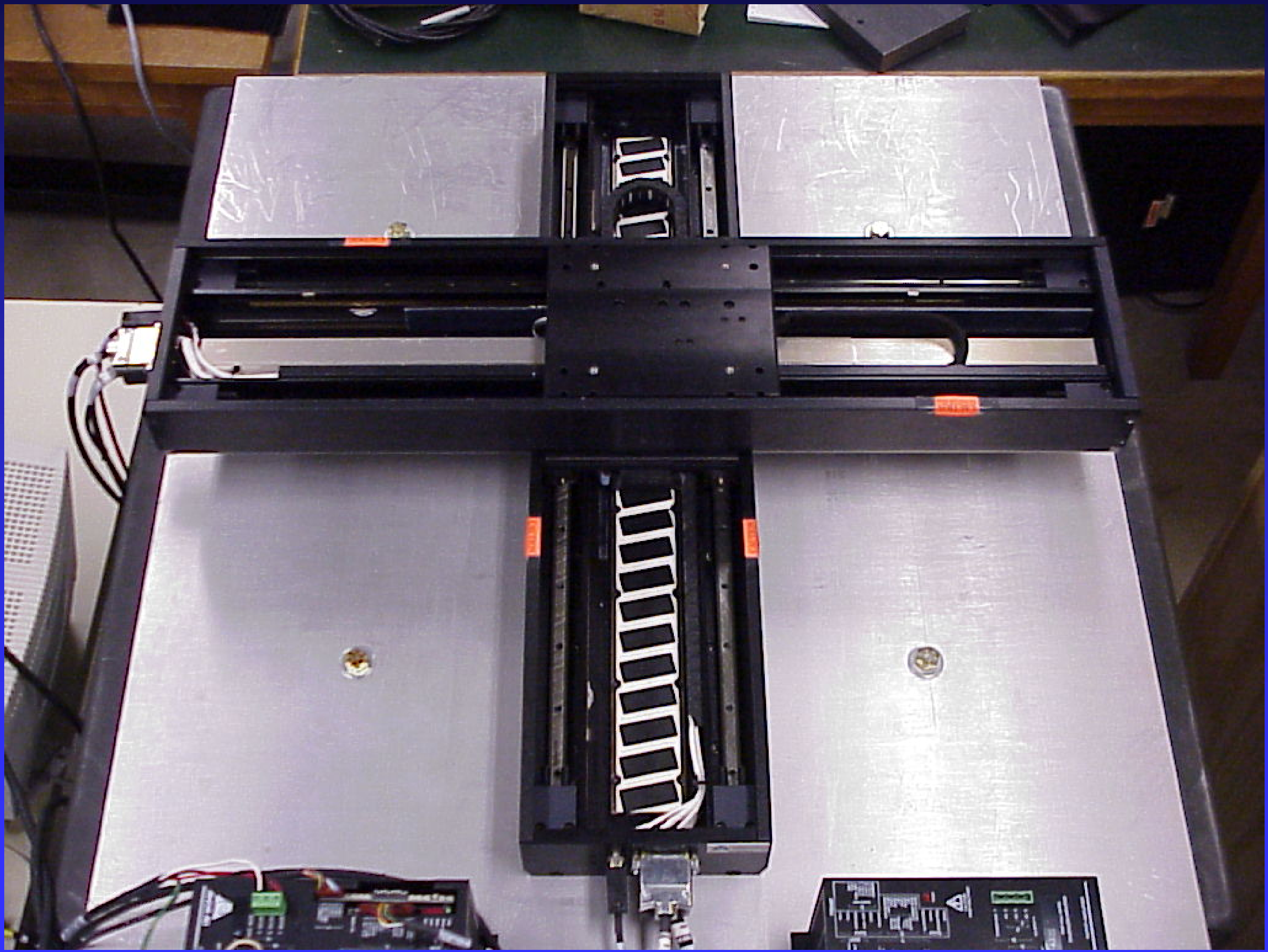
LINEAR MOTOR POSITIONING STAGE



LINEAR MOTOR DRIVE SYSTEMS

- Mechanical simplicity (no mechanical transmission mechanisms), higher reliability, and longer lifetime
- No backlash and less friction, resulting in the potential of having high load positioning accuracy
- No mechanical limitations on achievable acceleration and velocity
- Bandwidth is only limited by encoder resolution, measurement noise, calculation time, and frame stiffness

CONTROL ISSUES OF LINEAR MOTOR

- Model Uncertainties

    Parametric uncertainties (e.g., *load inertia*)

    Discontinuous disturbances (e.g., *Coulomb friction*); external disturbances (e.g., *cutting force*)

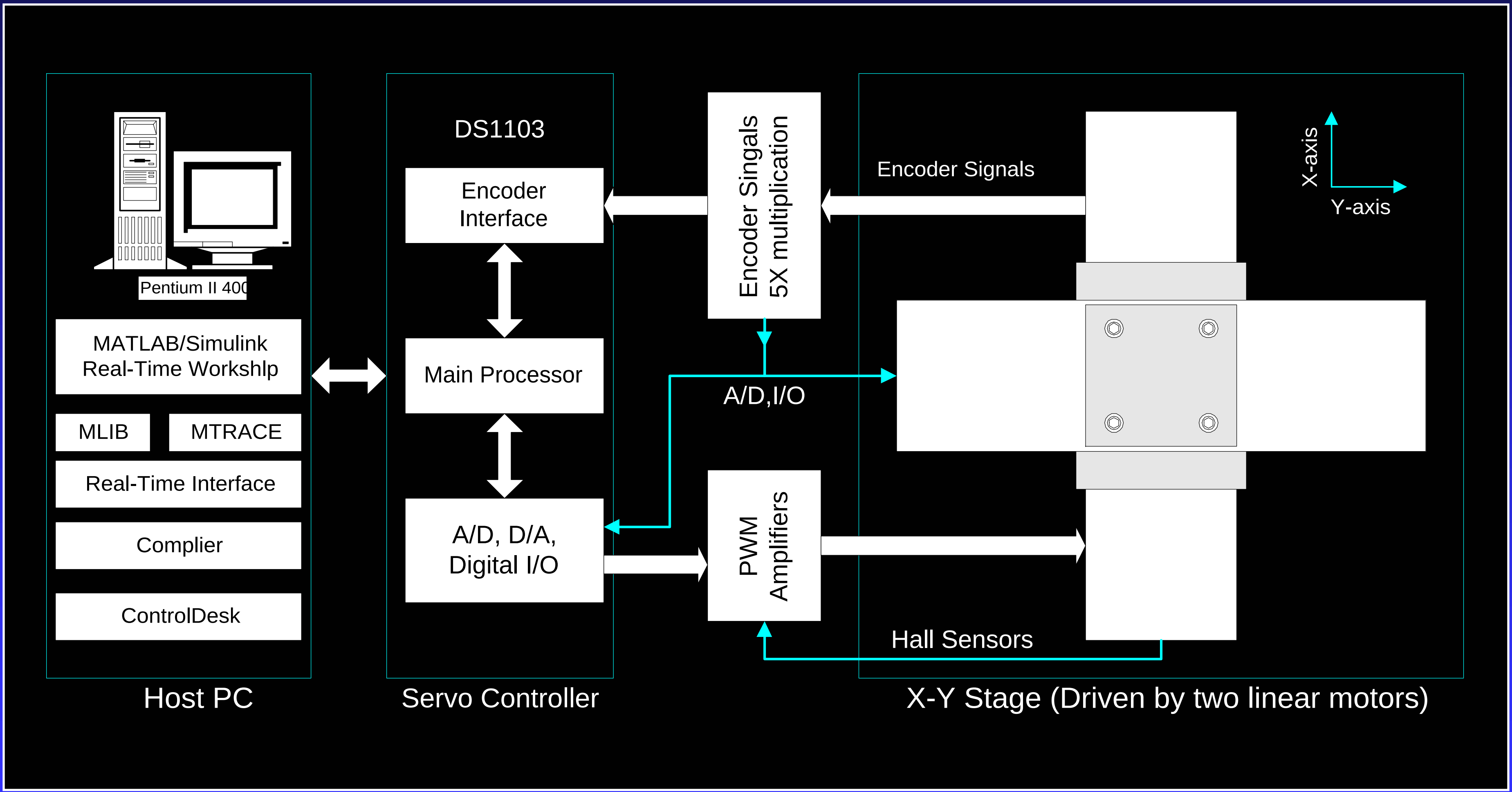
- Drawback of without mechanical transmissions

    Gear reduction reduces the effect of model uncertainties and external disturbance

- Significant uncertain nonlinearities due to position dependent electro-magnetic *force ripples* (e.g. iron-core linear motors)

- Implementation issues (e.g., *measurement noise*)

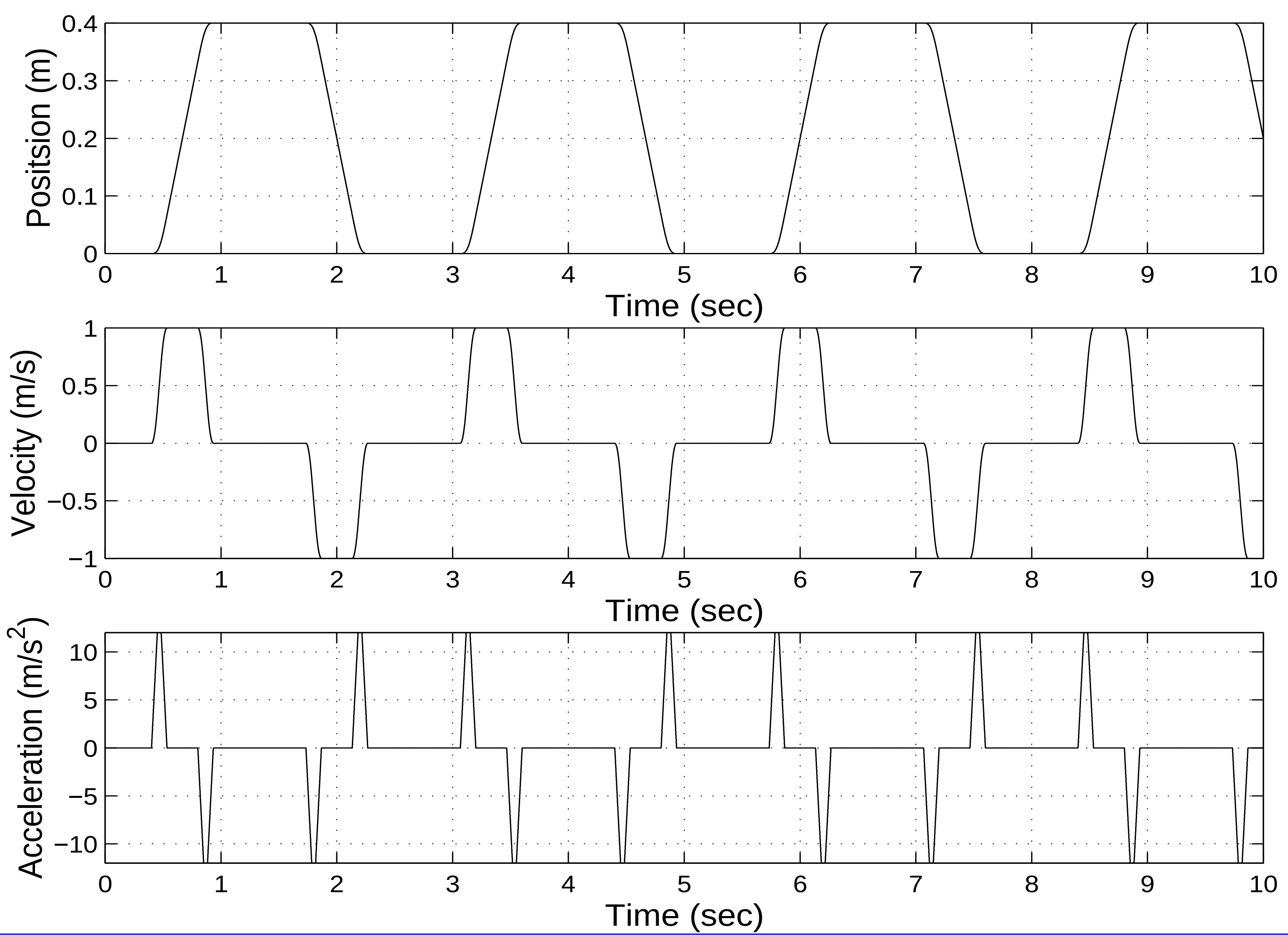
EXPERIMENTAL SETUP



UNLOADED EXPERIMENTS

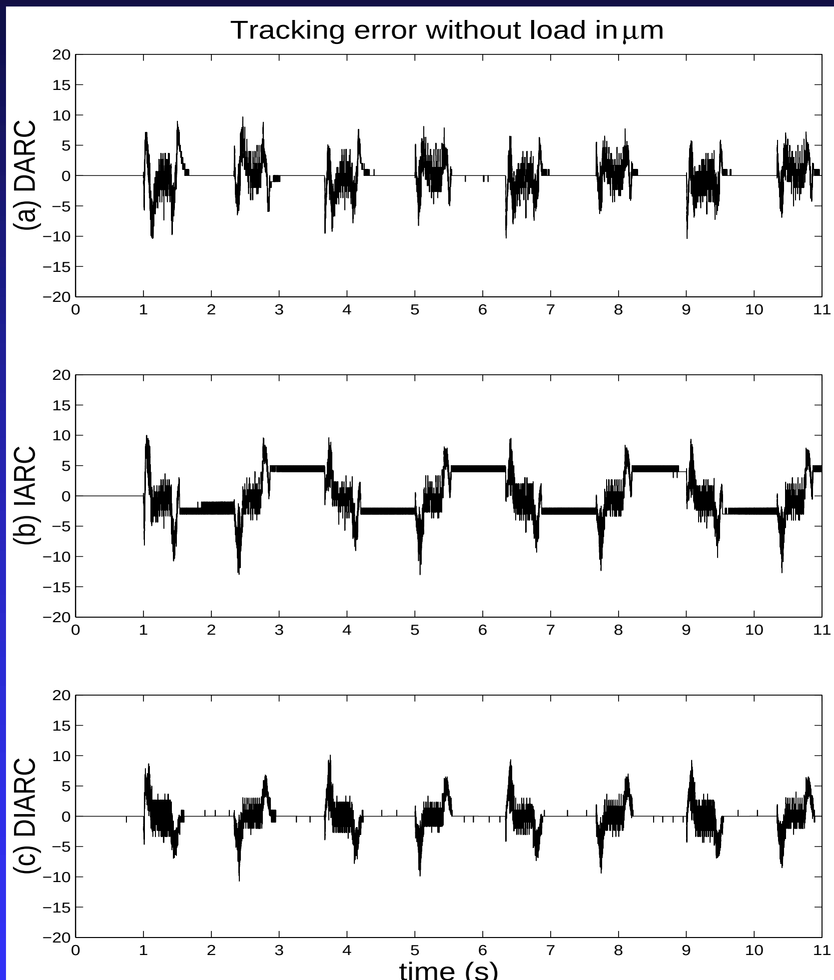
LOADED EXPERIMENTS

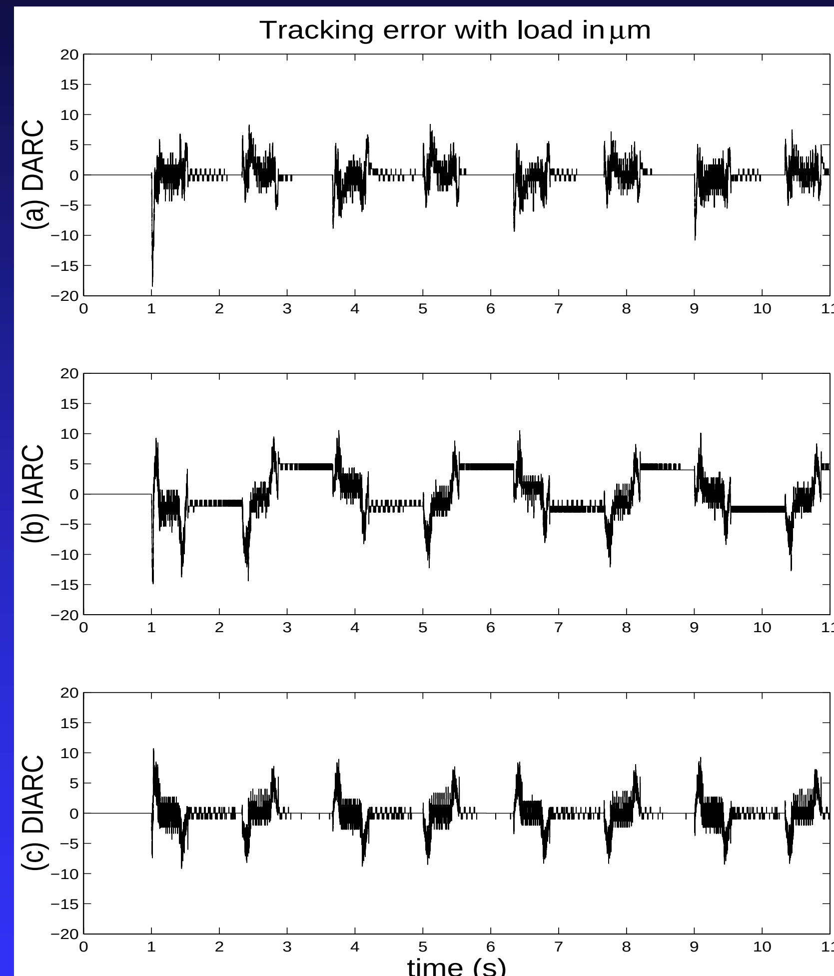
POINT-TO-POINT MOTION TRAJECTORY



TRACKING ERRORS FOR TYPICAL INDUSTRIAL MOTION

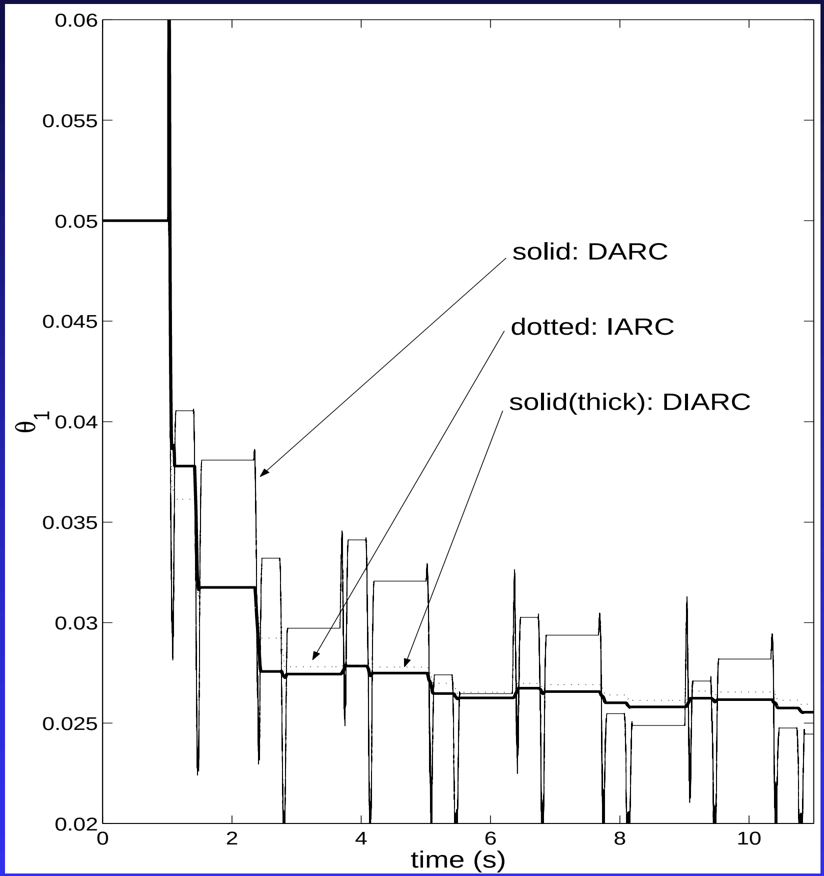
(Point-to-Point with Velocity of 1m/sec and Acceleration of 12m/sec^2)

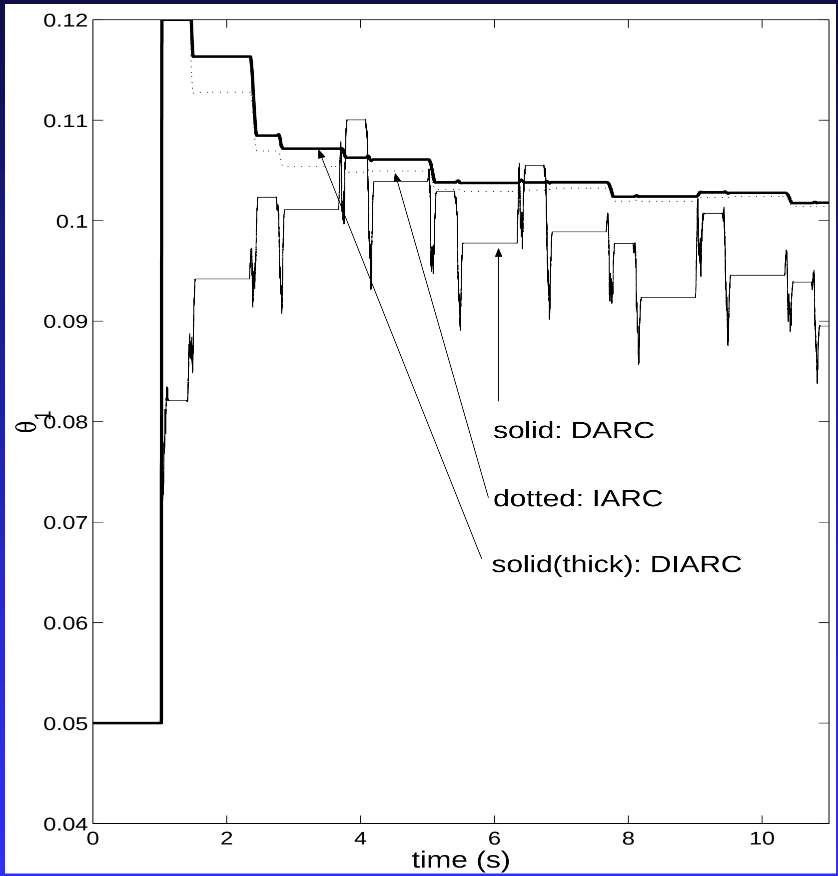




The above results demonstrate the excellent robust tracking performance of the proposed ARC algorithms – Tracking errors are mostly within 10 micrometers with final tracking error around the encoder resolution of 1 micrometer for both loaded and unloaded cases

ON-LINE INERTIA ESTIMATES

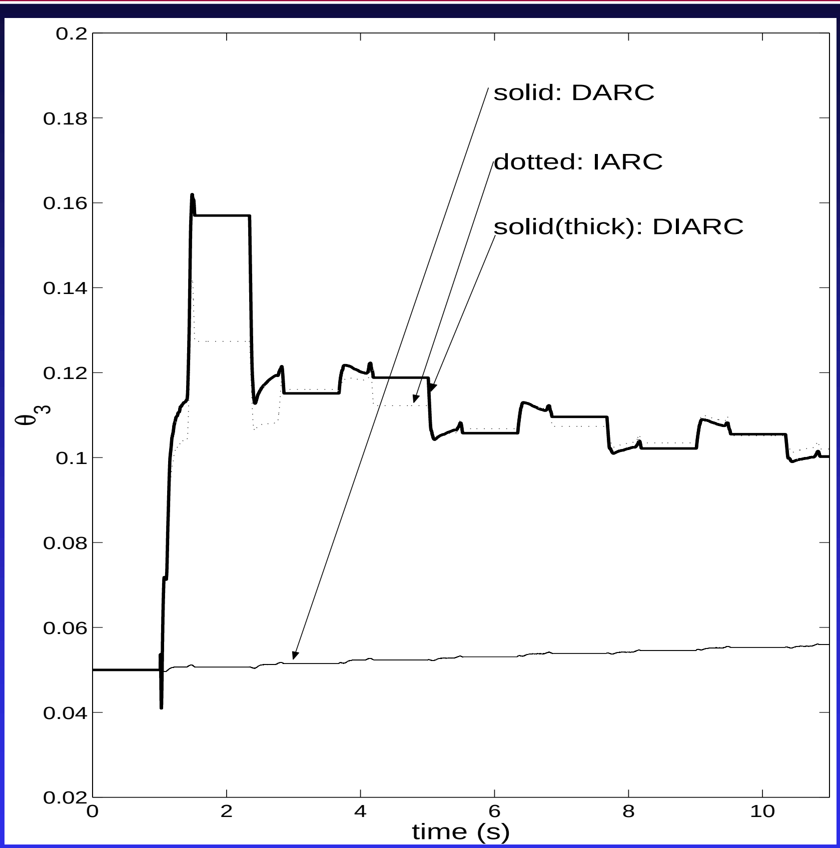


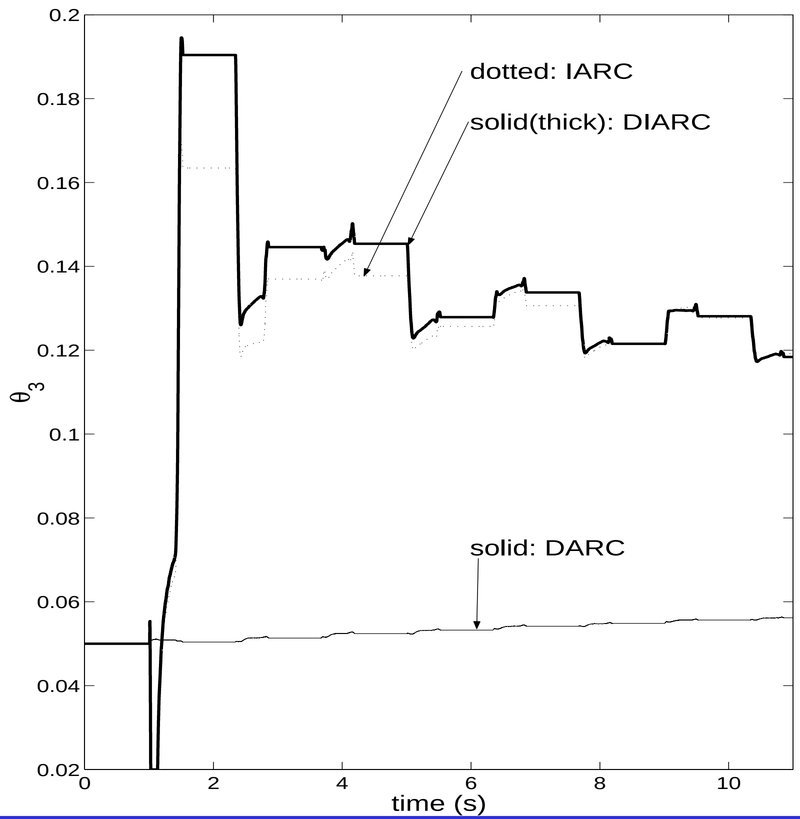


The above plots show the accurate parameter estimation capability of the proposed DIARC and IARC – estimates of the inertia load converge to their actual values for both loaded and unloaded cases

$\Rightarrow$ Non-Conservative Task Planning and Controller Gain Tuning

ON-LINE FRICTION ESTIMATES





On-line estimates of the Coulomb friction converge to their actual values for both loaded and unloaded cases

$\Longrightarrow$ Features like prognostics, machine health monitoring, fault detection, etc, can be added when one knows the time history of certain critical parameters (e.g., accurate friction estimate can be used to schedule service of the motor on-demand)