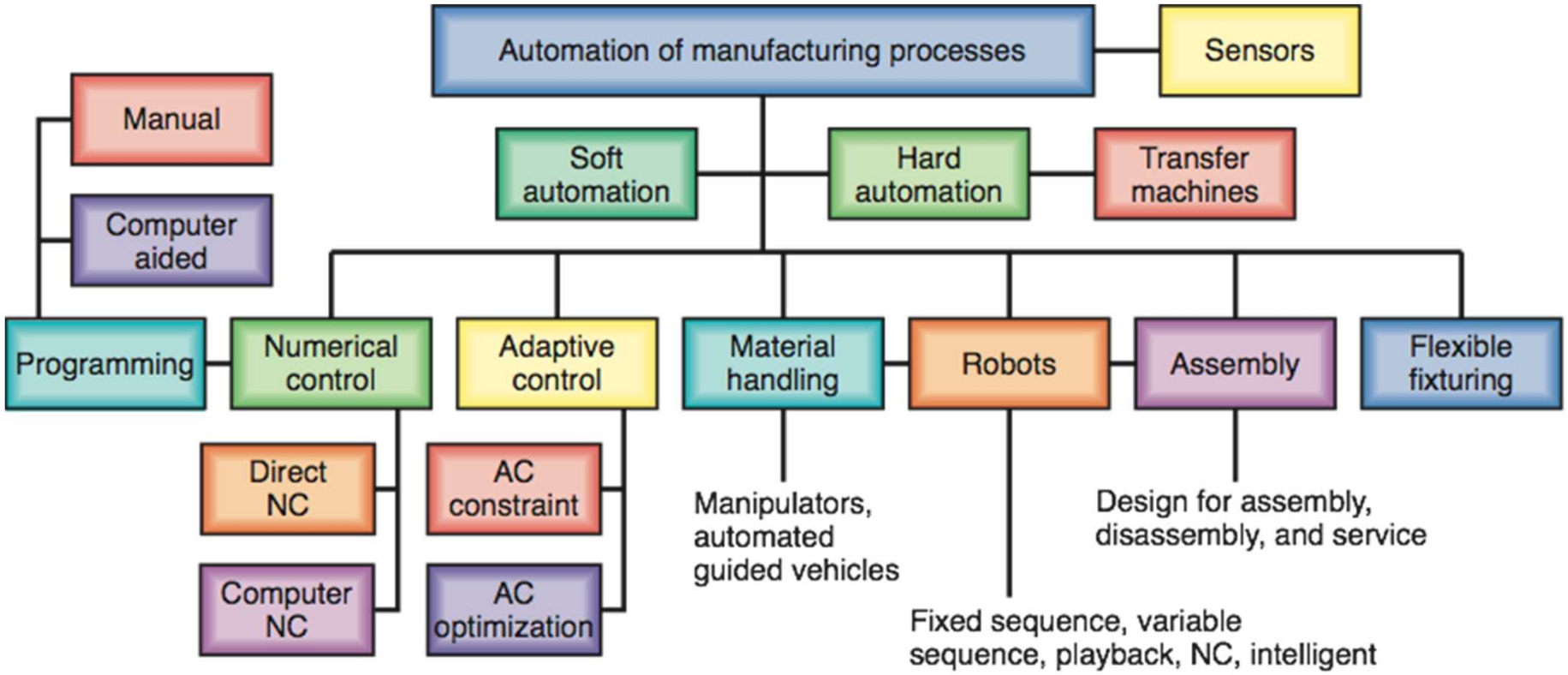
12. 적응제어

Contents

- **Automation**
- **What is adaptive control?**
- **Adaptive control systems**
  - Sensor-based
  - Model-based

Automation

◆ Automation in manufacturing



Automation

Date	Development
1500-1600	Water power for metalworking; rolling mills for coinage strips.
1600-1700	Hand lathe for wood; mechanical calculator.
1700-1800	Boring, turning, and screw cutting lathe, drill press.
1800-1900	Copying lathe, turret lathe, universal milling machine; advanced mechanical calculators.
1808	Sheet-metal cards with punched holes for automatic control of weaving patterns in looms.
1863	Automatic piano player (Pianola).
1900-1920	Geared lathe; automatic screw machine; automatic bottle-making machine.
1920	First use of the word robot.
1920-1940	Transfer machines; mass production.
1940	First electronic computing machine.
1943	First digital electronic computer.
1945	First use of the word automation.
1947	Invention of the transistor.
1952	First prototype numerical control machine tool.
1954	Development of the symbolic language APT (Automatically Programmed Tool); adaptive control.
1957	Commercially available NC machine tools.
1959	Integrated circuits; first use of the term group technology.
1960	Industrial robots.
1965	Large-scale integrated circuits.
1968	Programmable logic controllers.
1970s	First integrated manufacturing system; spot welding of automobile bodies with robots; microprocessors; minicomputer-controlled robot; flexible manufacturing system; group technology.
1980s	Artificial intelligence; intelligent robots; smart sensors; untended manufacturing cells.
1990-2000s	Integrated manufacturing systems; intelligent and sensor-based machines; telecommunications and global manufacturing networks; fuzzy-logic devices; artificial neural networks; Internet tools; virtual environments; high-speed information systems.

Automation

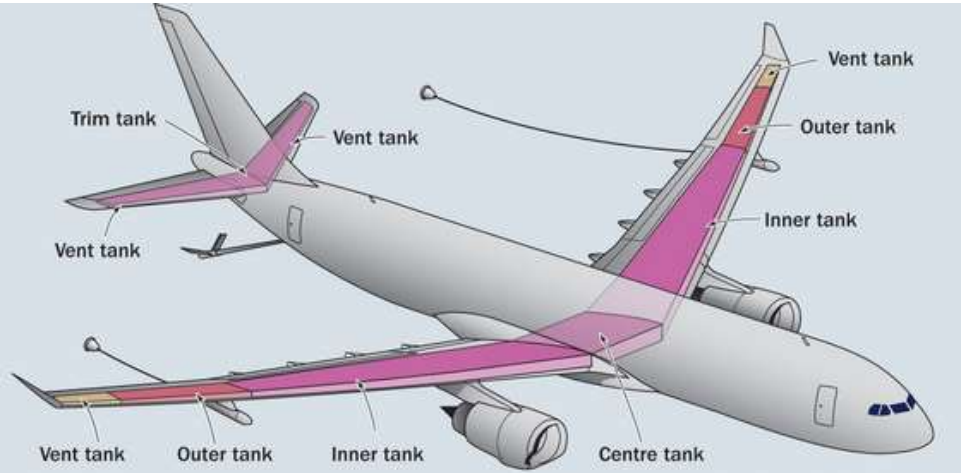
◆ 9 reasons for automation

- To increase labor productivity
- To reduce labor cost
- To mitigate the effects of labor shortages
- To reduce or eliminate routine manual and clerical tasks
- To improve worker safety
- To improve product quality
- To reduce manufacturing lead time
- To accomplish processes that cannot be done manually
- To avoid the high cost of not automating

What is adaptive control?

◆ Adaptive control

– Control method used by a controller which must adapt to a controlled system with parameters which vary, or are initially uncertain



Control system parameters optimized for **full** fuel tank

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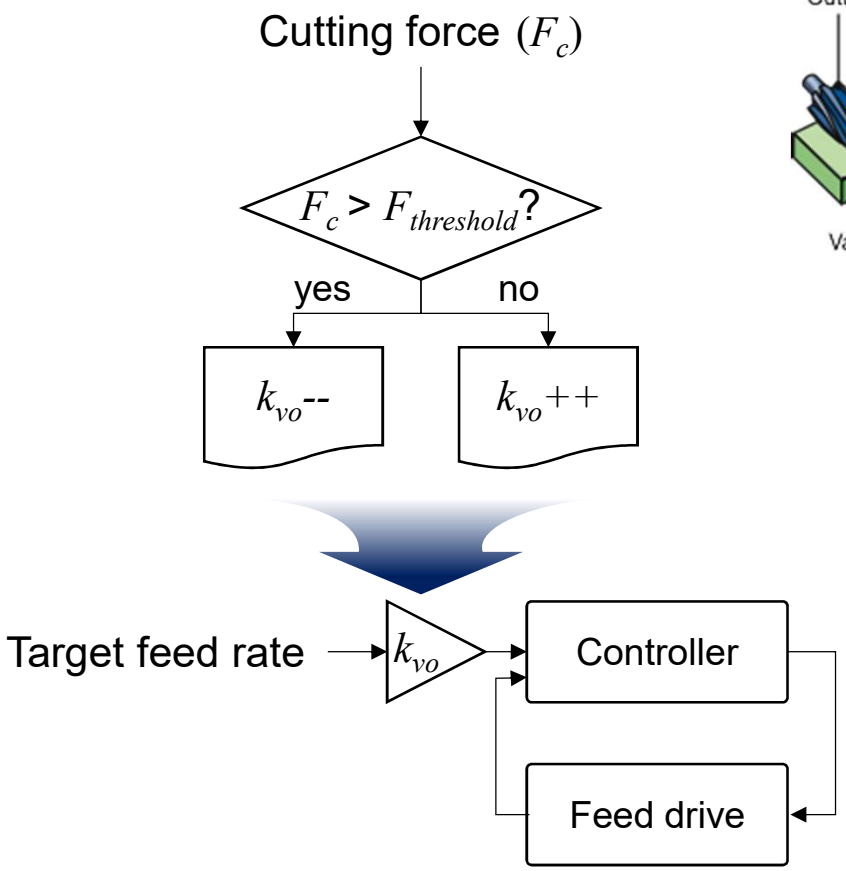
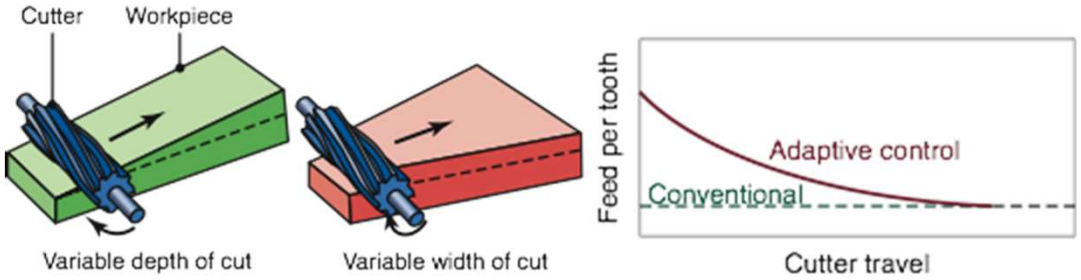
Control system parameters optimized for **empty** fuel tank

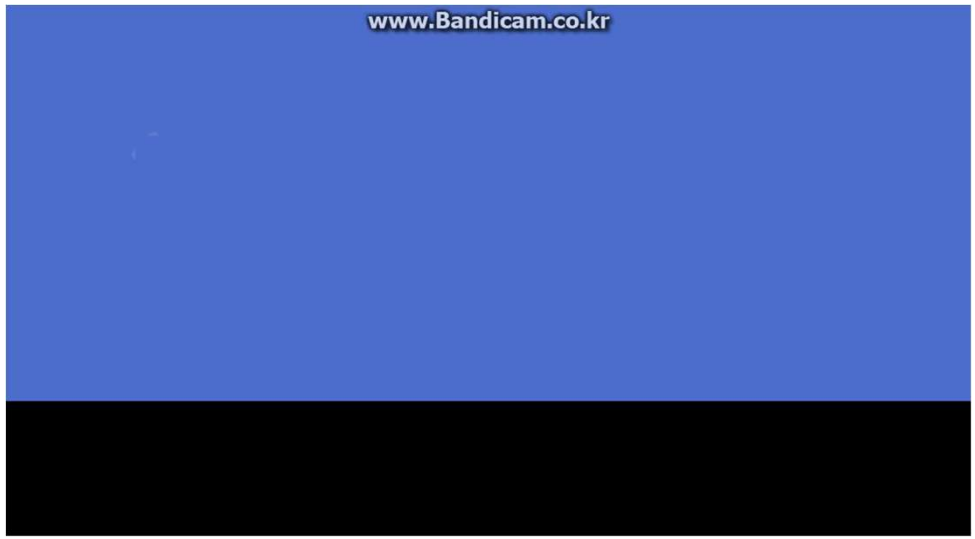
→ The control system parameters should be adapted to the current state

Feedrate optimization in milling process

◆ Algorithm & application

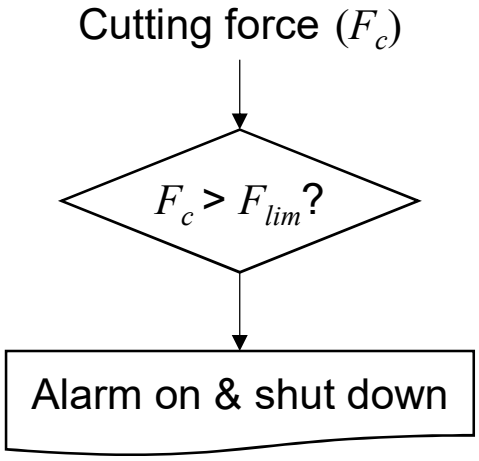






Tool failure avoidance

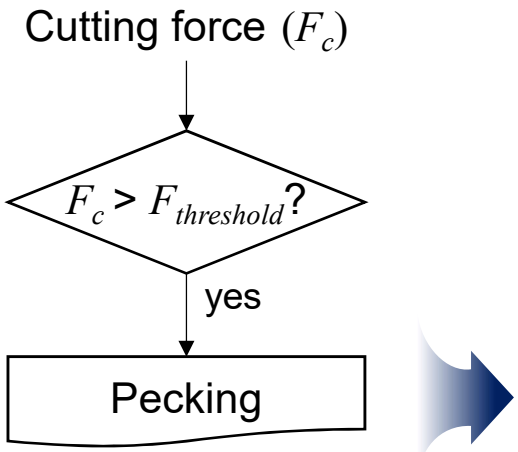
◆ Algorithm & application

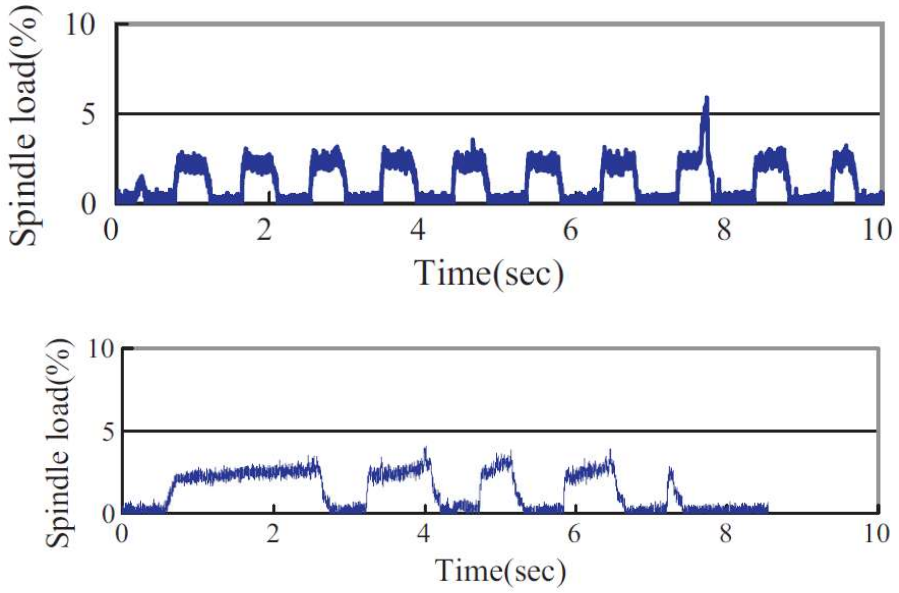


Adaptive pecking in drilling process

◆ Algorithm & result

– Peck drilling: used to keep swarf from detrimentally building up when drilling deep holes



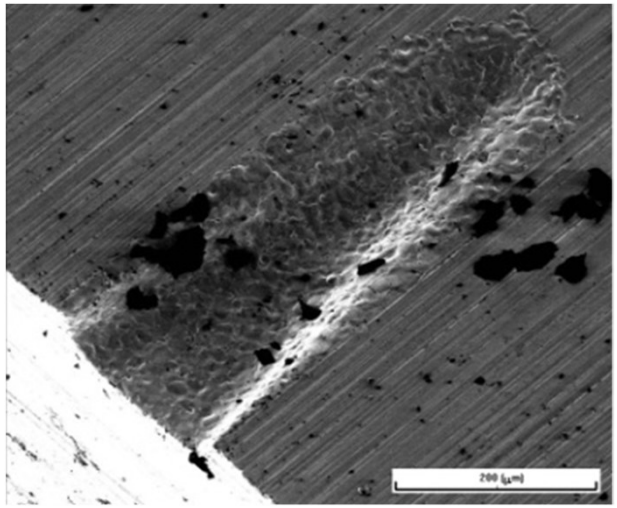


Tool wear compensation in EDM process (1)

◆ Tool wear

– The electrode as well as the workpiece are eroded due to the thermal energy of electrical discharges.

→ Tool wear deteriorates machining accuracy.

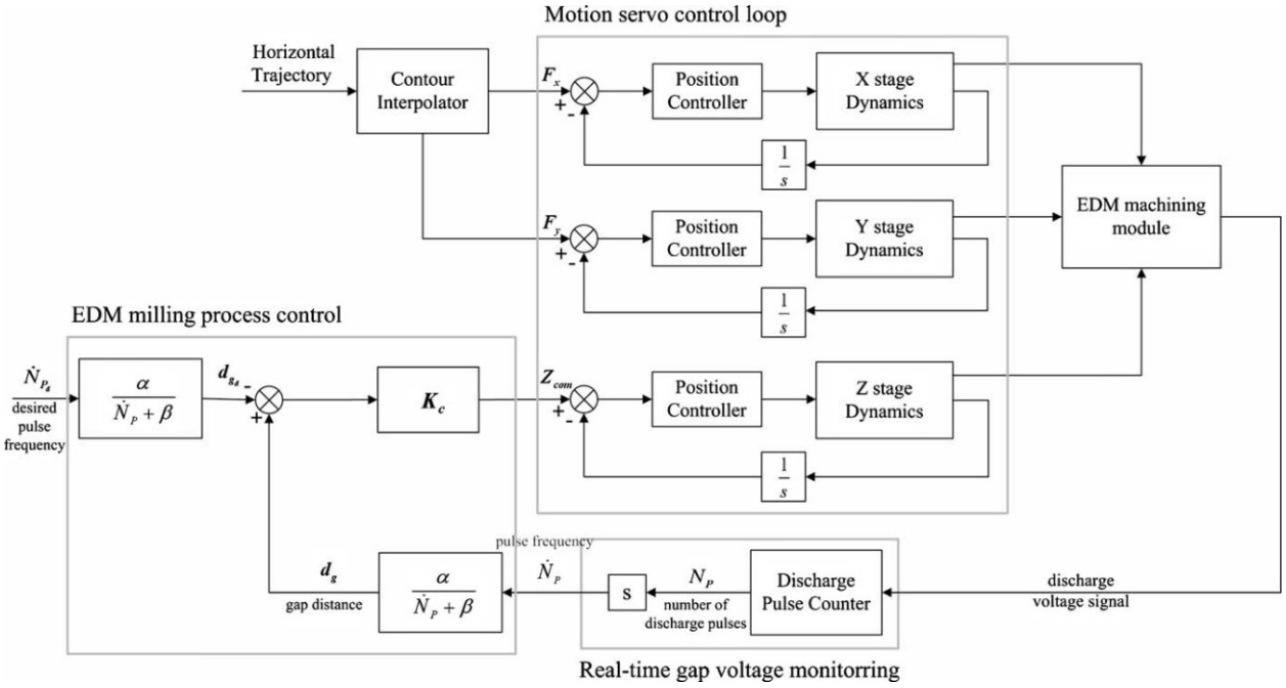


Tool wear during EDM milling

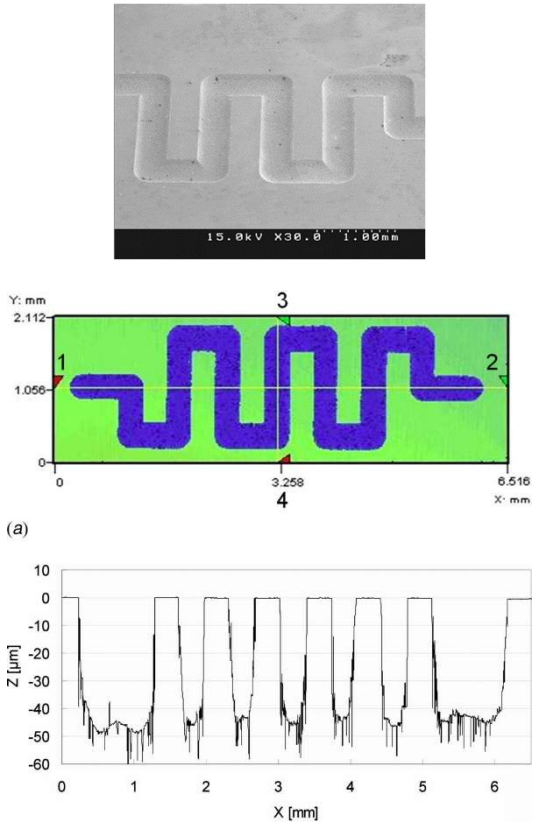
Tool wear compensation in EDM process (2)

◆ Tool wear compensation

– On-line compensation



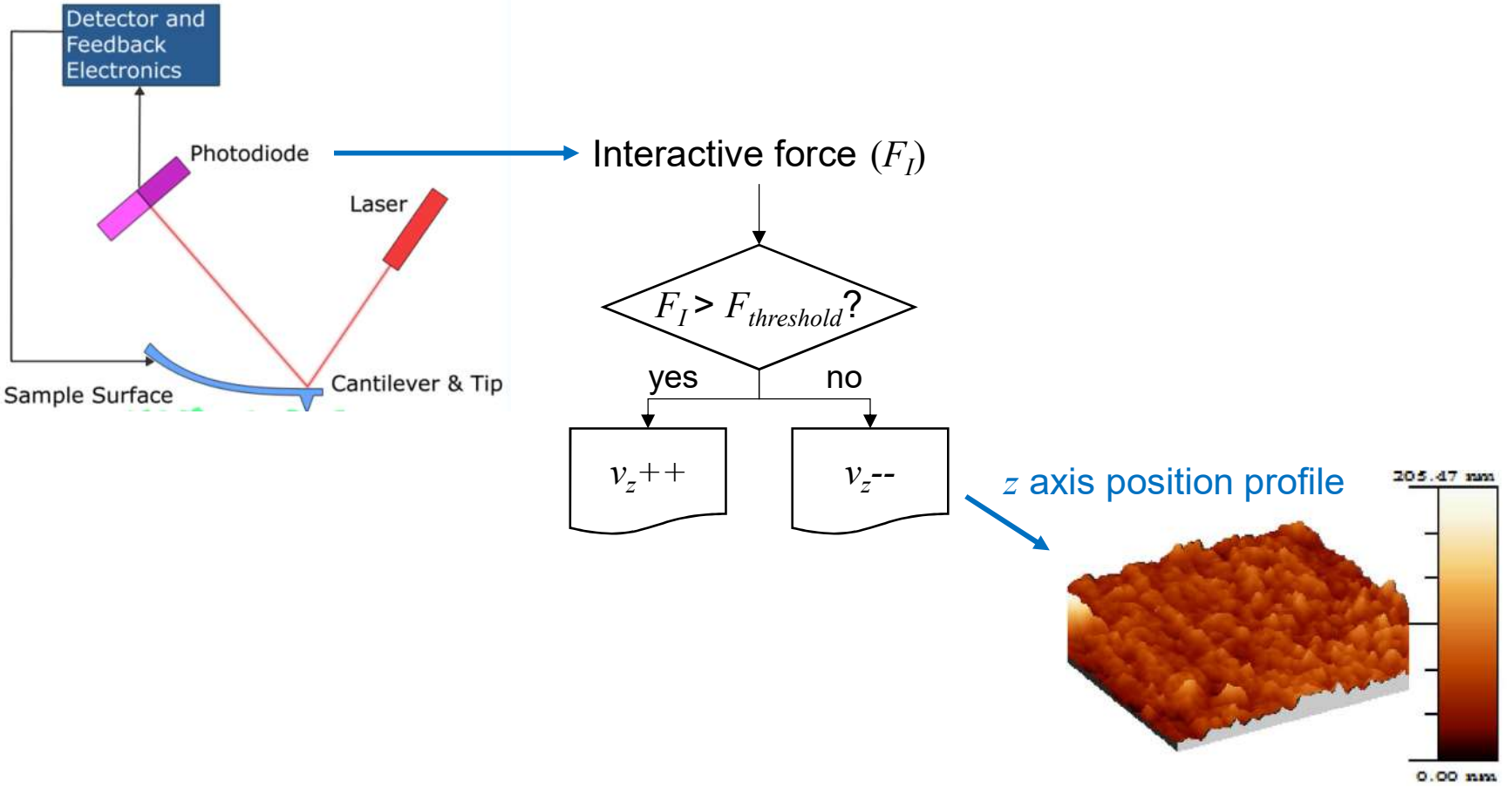
Control system for real-time tool wear compensation



Machining result

Surface measurement

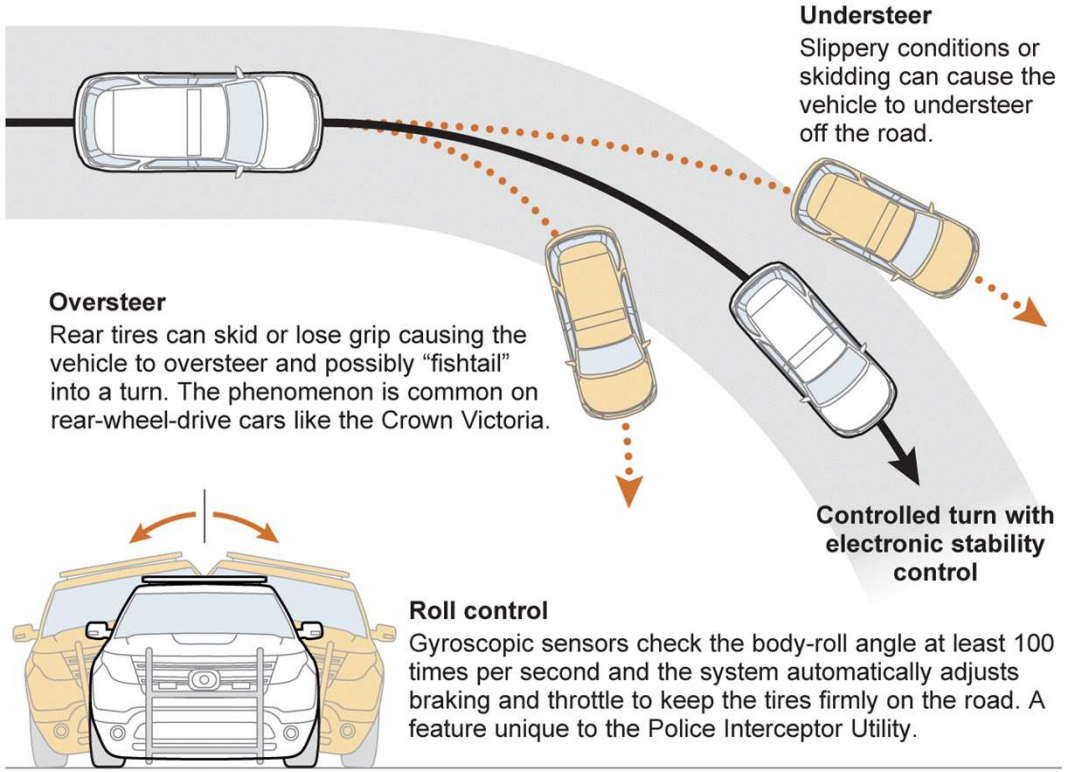
◆ Atomic force microscope (AFM)



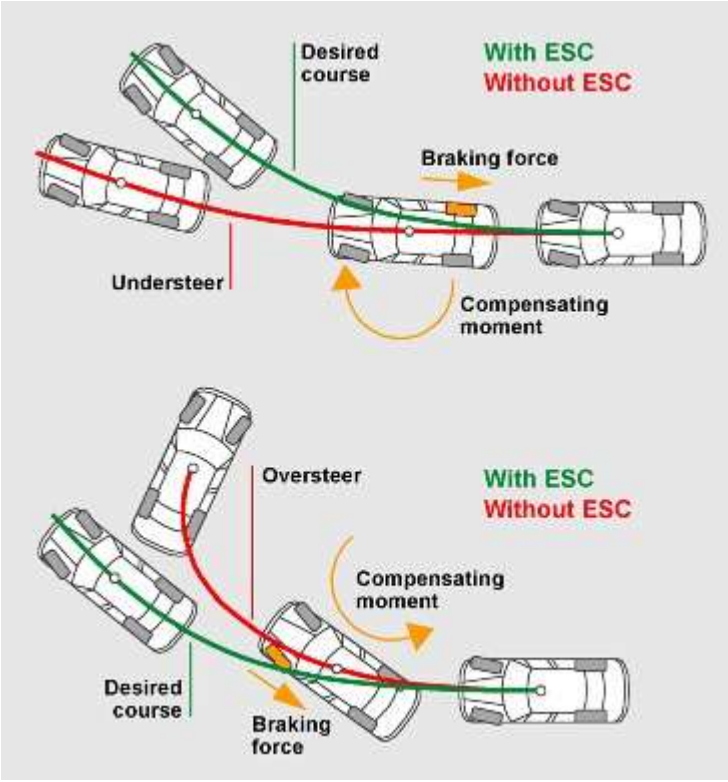
Automotive control system (1)

◆ Electronic stability control (ESC)

- Oversteer and understeer

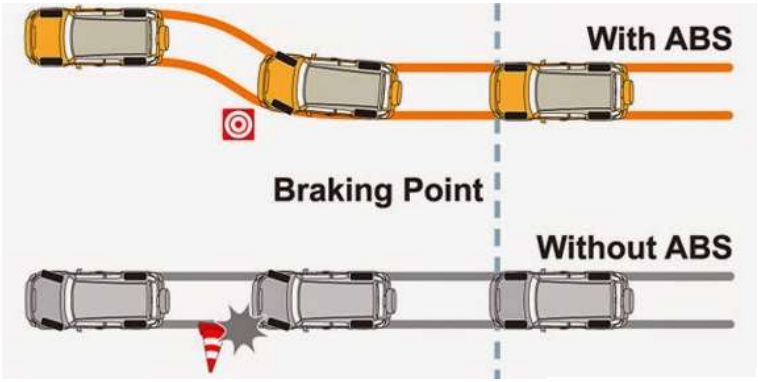


- ESC algorithm



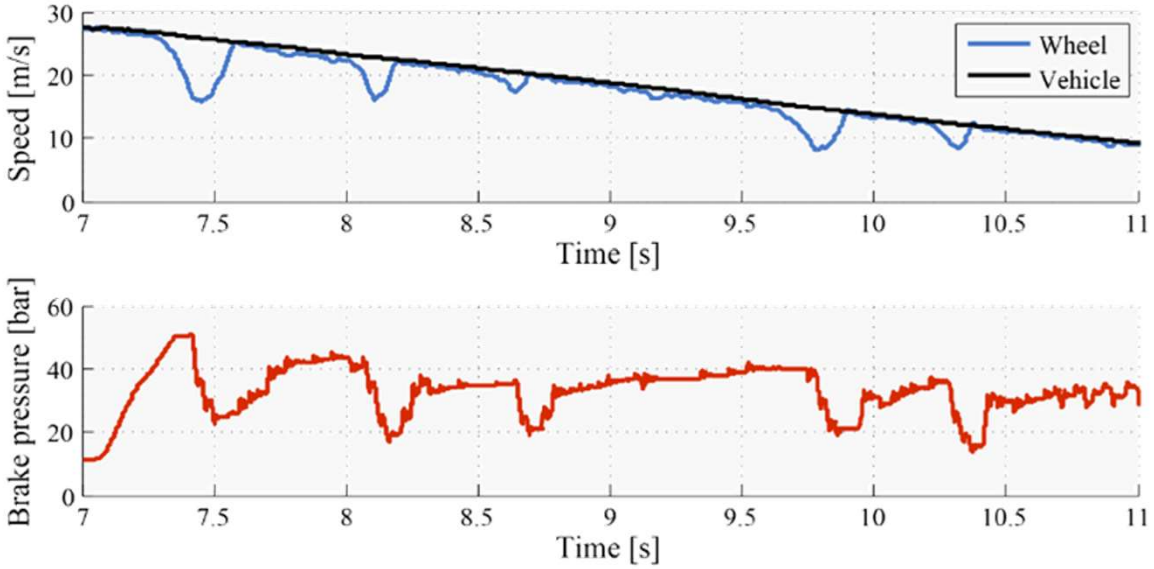
Automotive control system (2)

◆ Anti-lock brake system (ABS)



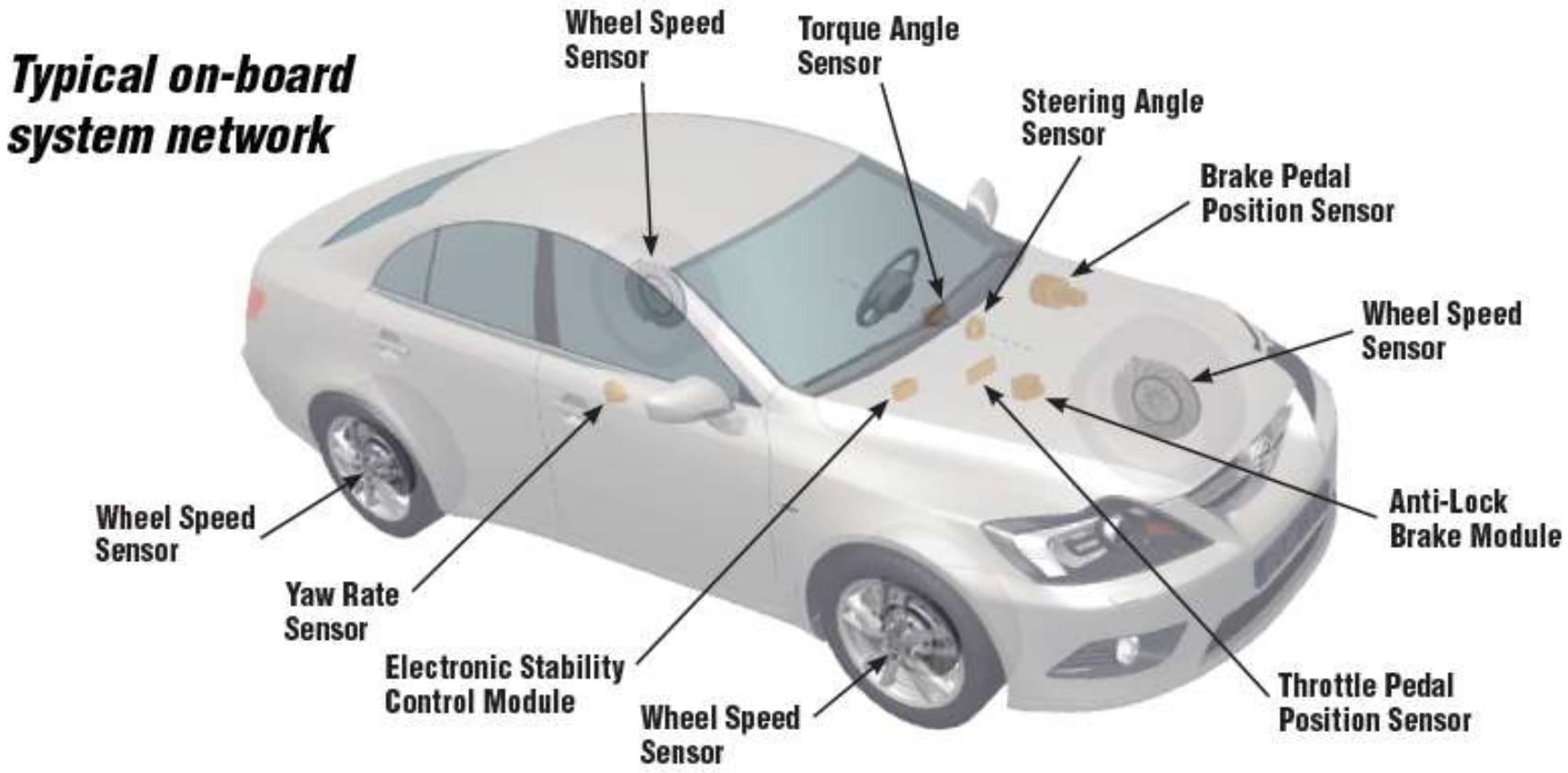
→ Effect of ABS

Operation of ABS →



Automotive control system (3)

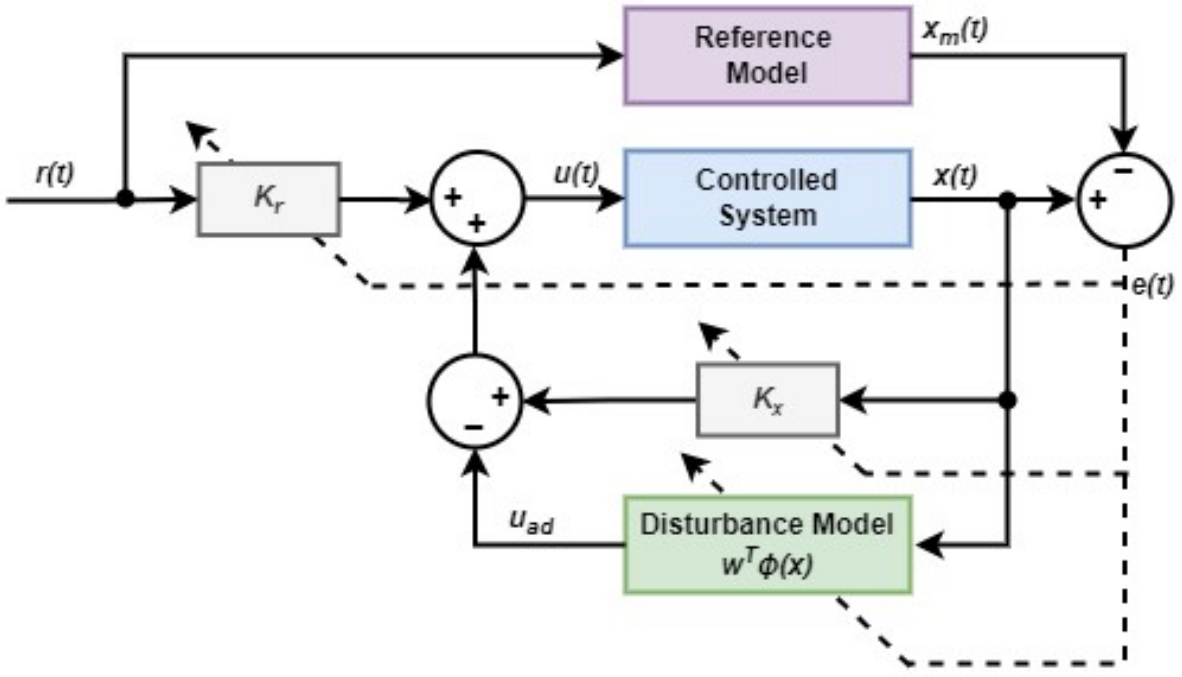
◆ Sensors



Model reference adaptive control

◆ Model reference adaptive control

– The Model Reference Adaptive Control block computes control actions to make an uncertain controlled system track the behavior of a given reference plant model.



Auto gain tuning

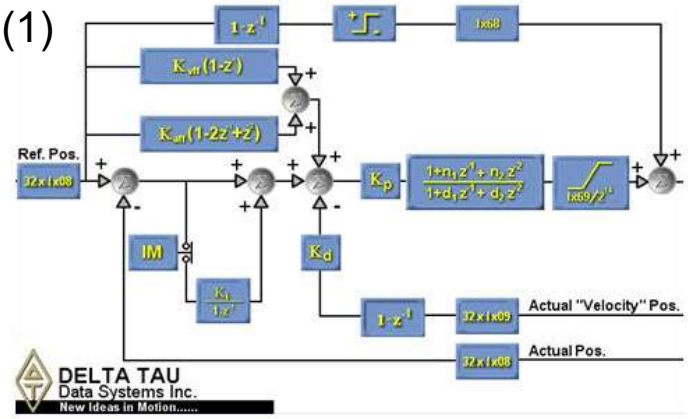
◆ Effect of controller gain on system dynamics

- High controller gains
  - High robustness
  - Fast reaction
  - Causes vibration

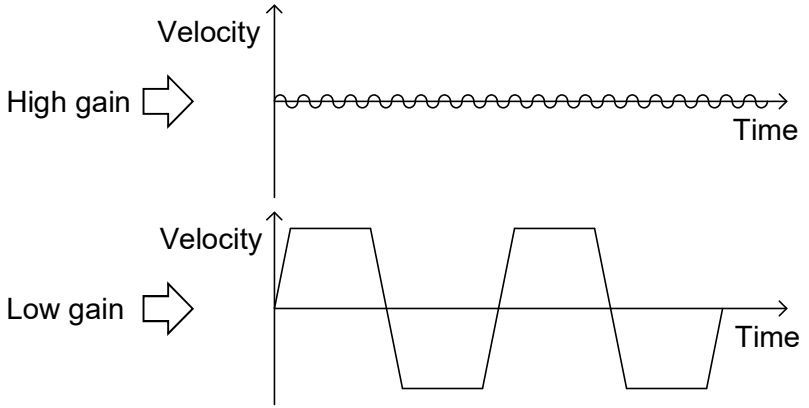
→ Proper to slow & precision motion

◆ Auto gain tuning systems

(1)



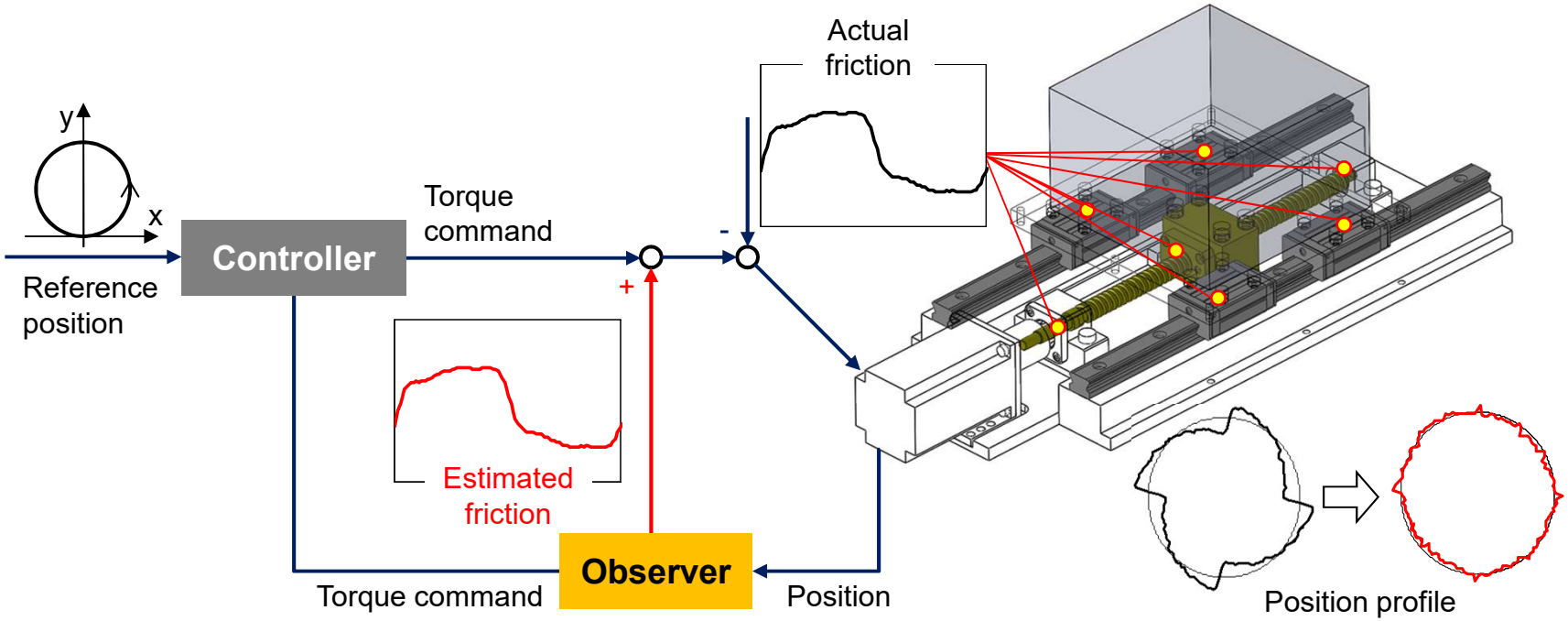
(2)



Adaptive friction compensation (1)

◆ Friction compensation control

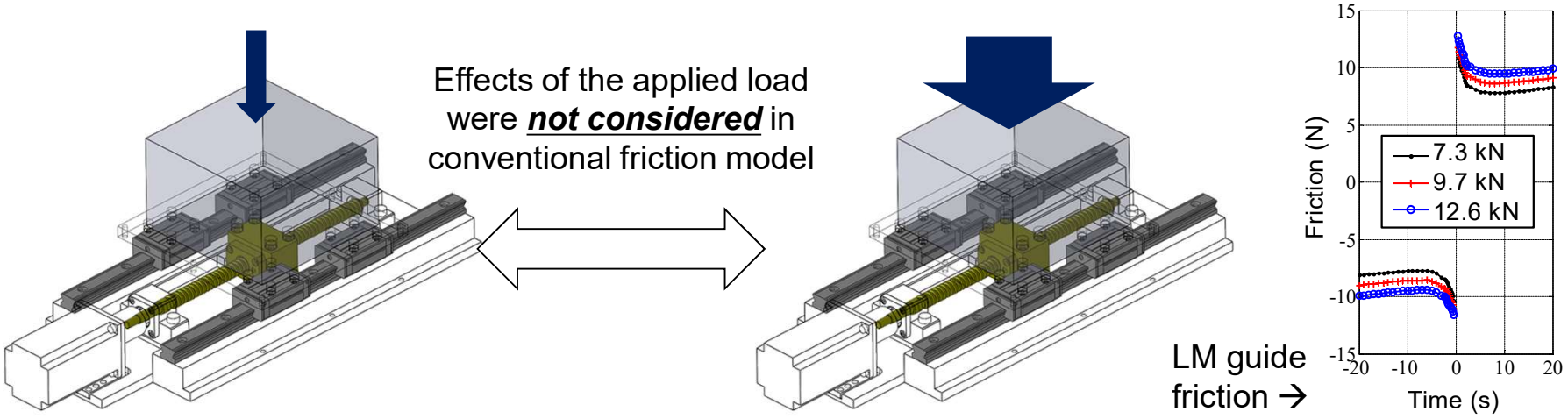
– Friction force is estimated and compensated before it degrades the position accuracy.



Adaptive friction compensation (2)

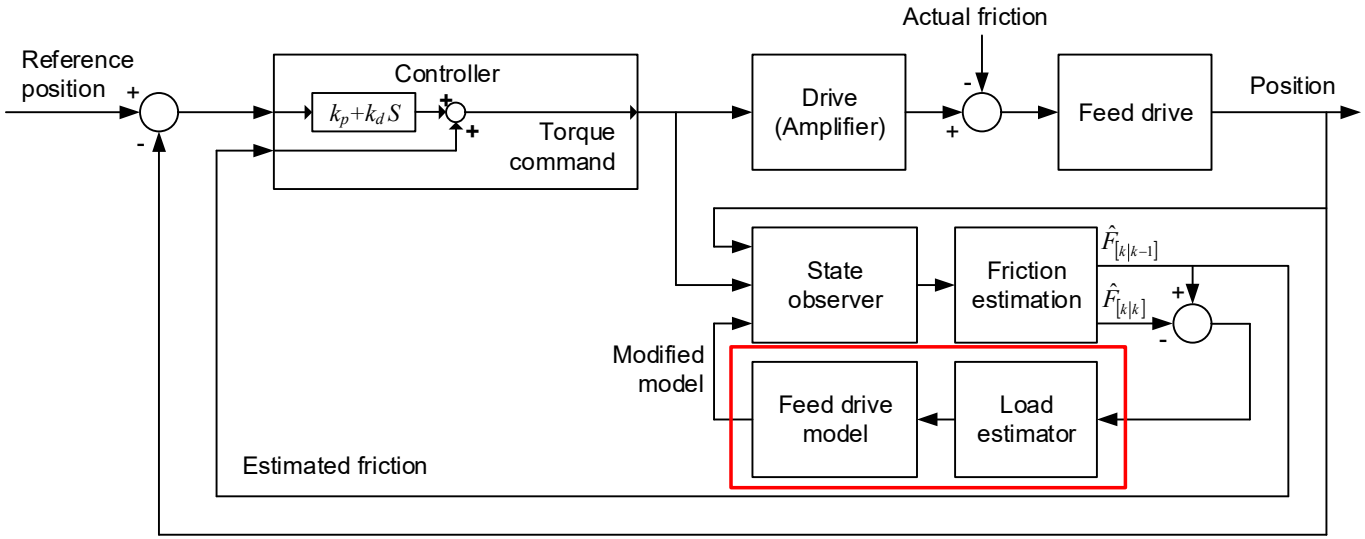
◆ Limitation of the conventional friction model

– Lack of consideration of the applied load

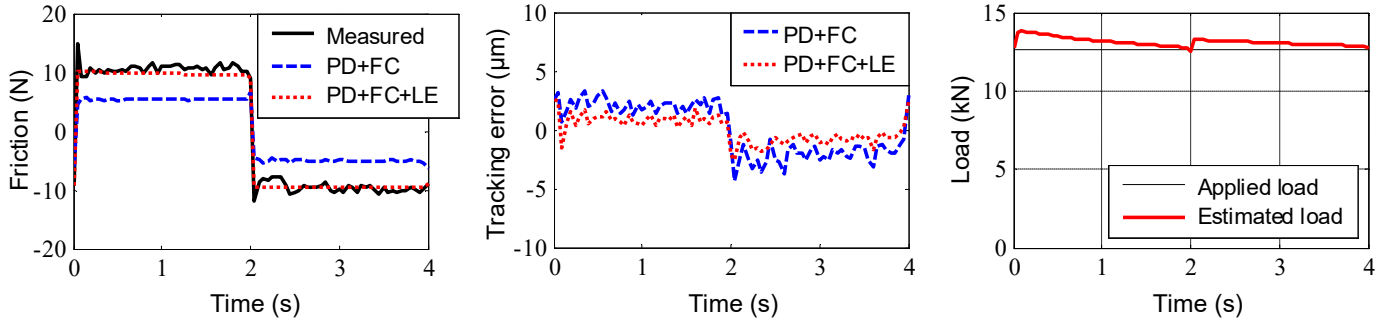


Adaptive friction compensation (3)

◆ Algorithm & results



Applied load
: 12.6 kN



→ **Tracking errors have halved.**