Inkjet Printing Mechatronics

Part 1 of 2 Printer Mechatronics

Overview

- Basics on frame construction
- Axis
- Drives
- Sensors
- Dynamics
- Resolution
- Repeatability
- Quality issues
- Introduction to the test rig
- Let’s start …

Basic Printer frame constructions

- Requirements of the frame:
- provide the basic structure
- guarantee enough stiffness
  - steel frame?
  - stone frame?
  - light weight frame?
- allow mounting of components
- Substrate handling

Frame construction depends on the type of printer

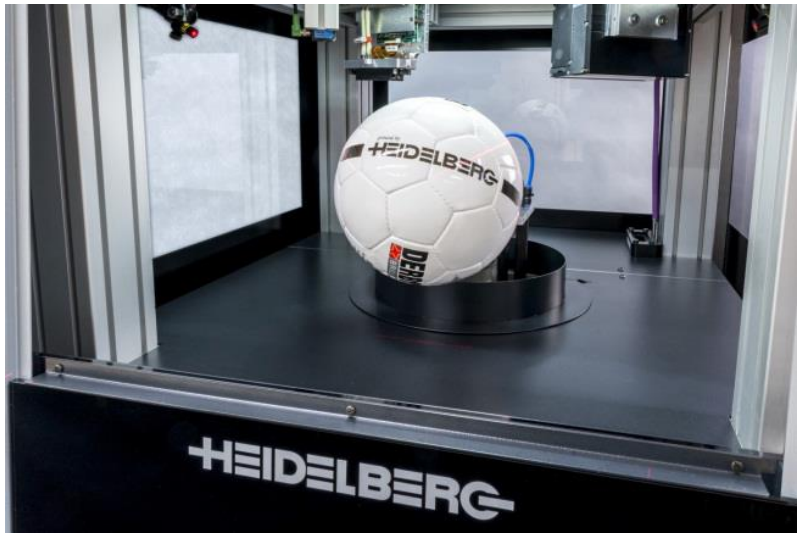
Printer Examples

Desktop Printer

Wide Format Printer

Printer Examples - Specifics

Industrial 3D Surface Pritner

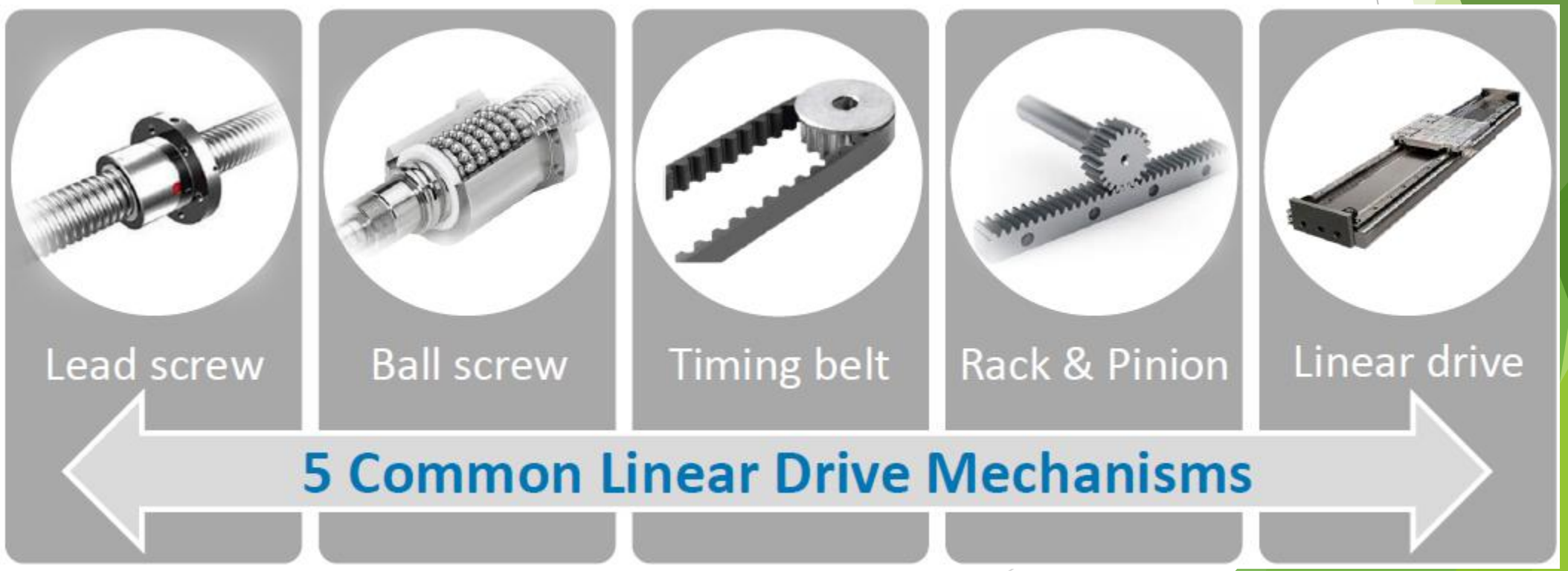


Ceramic Printer

Printer Axis

- X axis: scan axis (only in multi pass application)
- Y axis: substrate feed
- Z axis (normally manual adjustment of the printing gap, rarely automated)
- An axis consists of: axis frame, mechanical guides, drive system, motor, drive electronics, encoder, cabling and cable chain, …

- A drive system consists of: linear drive, motor, drive electronics and encoder
- Options for linear drive:



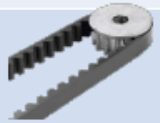
Most commonly used principles for printers

- Ball screw

- Timing belt

- Linear drive (direct drive)

Precision of Drives

Technology	Image Example	Resolution	Repeatability	Accuracy per 300 mm	Velocity control
Lead screw		Good (≈ 5 µm)	Moderate (≈ 20 µm)	Moderate (≈ 30 µm)	Moderate (< 2 %)
Ball screw		Good (≈ 5 µm)	Good (≈ 5 µm)	Good (≈ 15 µm)	Good (≈ 1 %)
Timing belt		Low (≈ 50 µm)	Low (≈ 100 µm)	Low (≈ 250 µm)	Low (< 5 %)
Rack & Pinion		Moderate (≈ 20 µm)	Moderate (≈ 50 µm)	Low (≈ 150 µm)	Moderate (< 3 %)
Linear drive		Excellent (< 1 µm)	Excellent (≈ 1 µm)	Excellent (≈ 5 µm)	Excellent (< 1 %)

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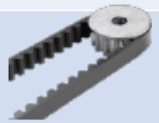
Expected Drive Life

Technology	Image Example	Mechanical Efficiency	Wear Resistance	Dirt Resistance	Maintenance
Lead screw		Low (10 - 50 %)	High (Sliding)	Moderate (Sliding)	Moderate (Preload Adj.)
Ball screw		Excellent (80 – 95 %)	Good (Rolling)	Moderate (Seale)	Moderate (Lubrification)
Timing belt		Excellent (80 – 90 %)	Excellent (Tension)	Excellent (Harsh Env.)	Good (Belt Tension)
Rack & Pinion		Good (70 – 80 %)	Moderate (Pinion)	Moderate (Jamming)	High (Lubrification)
Linear drive		Excellent (Non-contact)	Excellent (Cables)	Poor (Need Cover)	Excellent (None)

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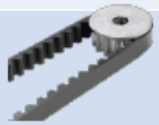
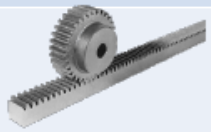
Drive Throughput

Technology	Image Example	Speed	Acceleration / Deceleration	Frequency Response	Duty Cycle
Lead screw		Low (< 0.5 m/s)	Moderate (≈ 2 g)	Low (0 – 30 Hz)	Low (50 %)
Ball screw		Moderate (< 1.5 m/s)	Good (≈ 3 g)	Good (30 – 50 Hz)	Excellent (100 %)
Timing belt		Excellent (> 10 m/s)	Good (> 3 g)	Low (20 – 30 Hz)	Excellent (100 %)
Rack & Pinion		Excellent (> 10 m/s)	Good (> 3 g)	Low (20 – 30 Hz)	Excellent (100 %)
Linear drive		Excellent (> 10 m/s)	Excellent (> 5 g)	Excellent (50 – 80 Hz)	Excellent (100 %)

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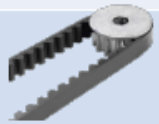
Special Drive Conditions

Technology	Image Example	Material Costs	Travel Length	Force Density	Needs to Implement
Lead screw		Good	Low (≈ 3 feet)	Excellent	Motor, Bearings (linear / rotary)
Ball screw		Moderate	Moderate (≈ 5 feet)	Excellent	Motor, Bearings (linear / rotary)
Timing belt		Excellent	Excellent (≈ 30 feet)	Moderate	Motor, Bearings (linear / rotary), Gearbox
Rack & Pinion		Moderate	Excellent (> 40 feet)	Moderate	Motor, Bearings (linear / rotary), Cable Management
Linear drive		High	Excellent (> 40 feet)	Low	Bearings (linear), Feedback, Cable Management

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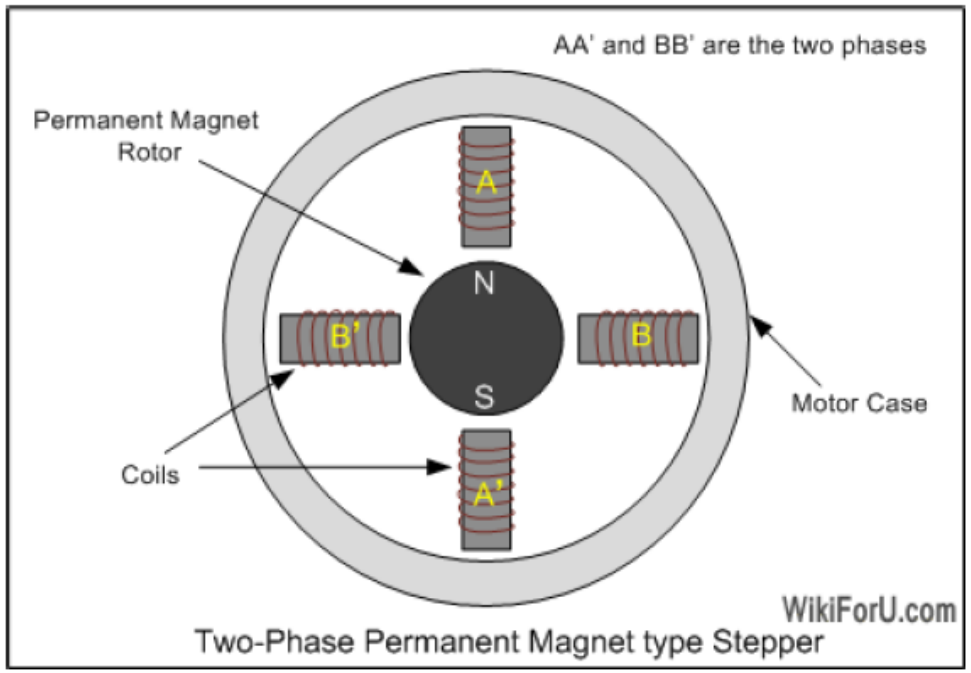
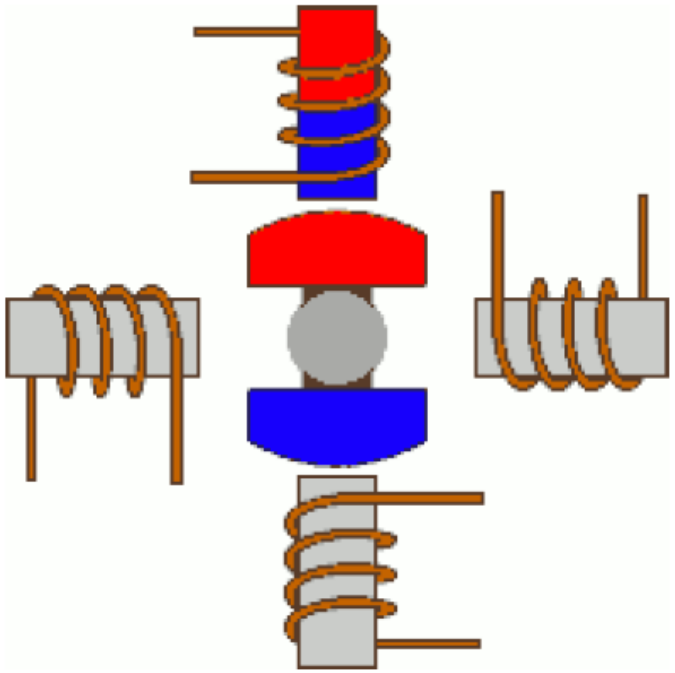
Motors

- Options for motors are:
- Stepper motor
- DC motor
- Synchronous linear motor

Stepper Motor

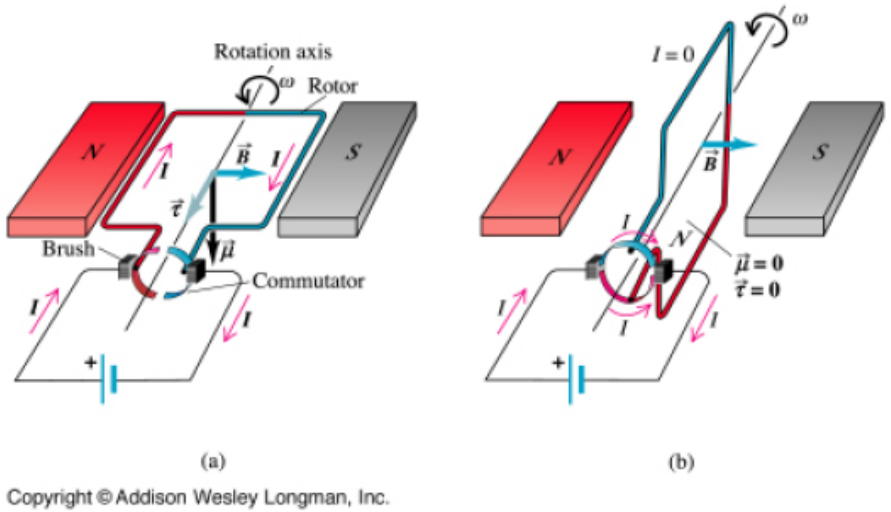


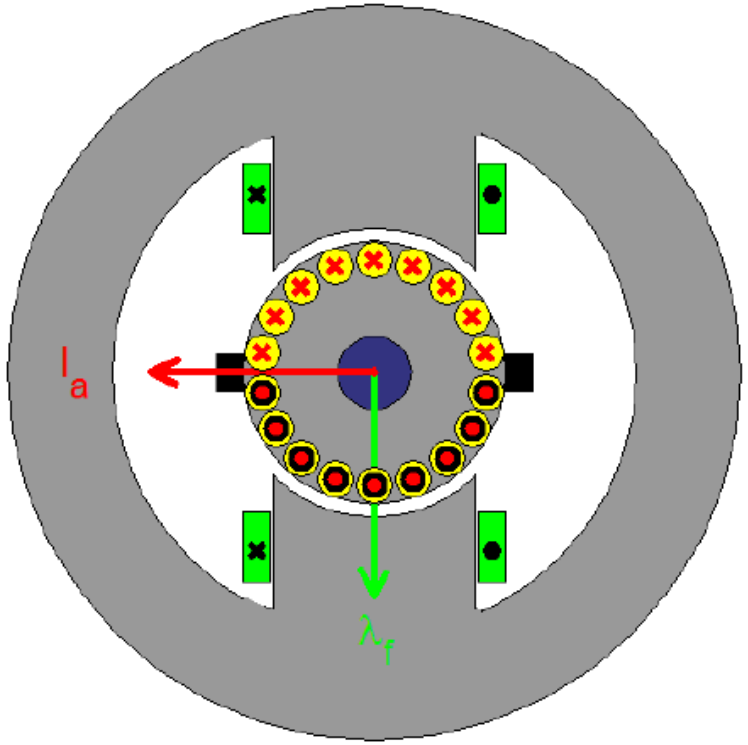
Two-Phase Permanent Magnet type Stepper



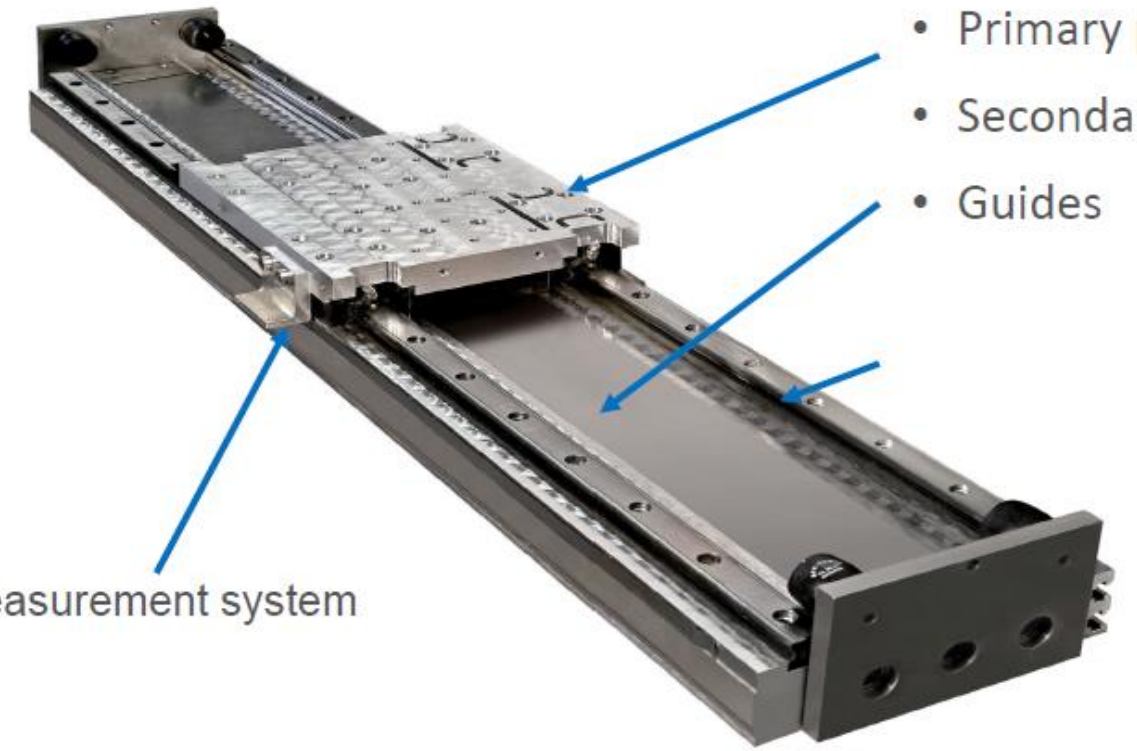
http://pcbheaven.com/wikipages/How_Stepper_Motors_Work/

DC Motor





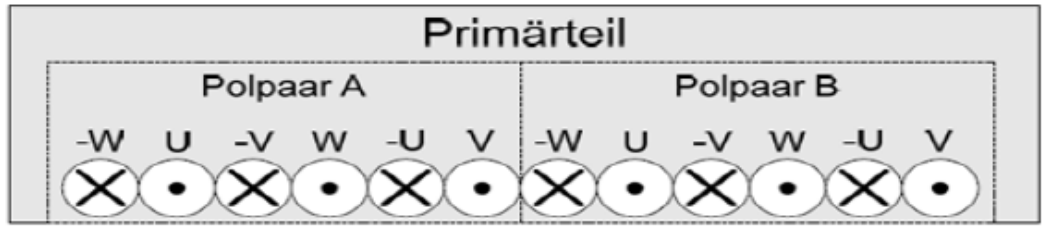
Composition of a Linear Motor



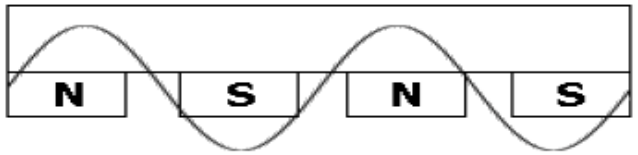
- Primary part (coil)
- Secondary part (magnet)
- Guides

Synchronous Linear Motor

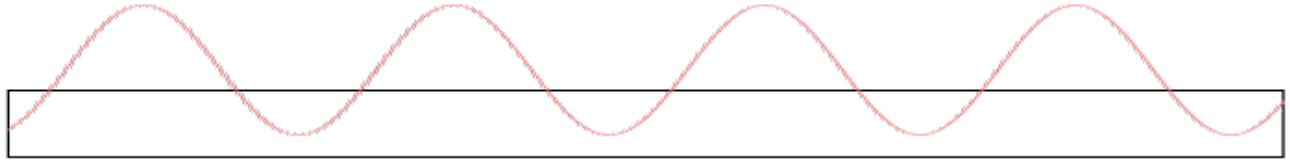
Primary part:



Secondary part:



Primary part:



Application Example

- Digital printer VIRTU RS35
- 2 axis in gantry configuration
- Moved mass print head: ~100kg
- Moved mass of gantry bridge: ~1000kg
- Print width: 3.5m, width over all: 5m
- Maximal print speed 2.5 m/s (5 m/s possible)