TRINAMIC MOTION CONTROL

MOTOR & MOTION CONTROL BASICS

PART1: STEPPER

JUL-2009

WEBINAR GG

TRINAMIC
MOTION CONTROL

MOTOR TYPE: STEPPER

TRINAMIC
MOTION CONTROL

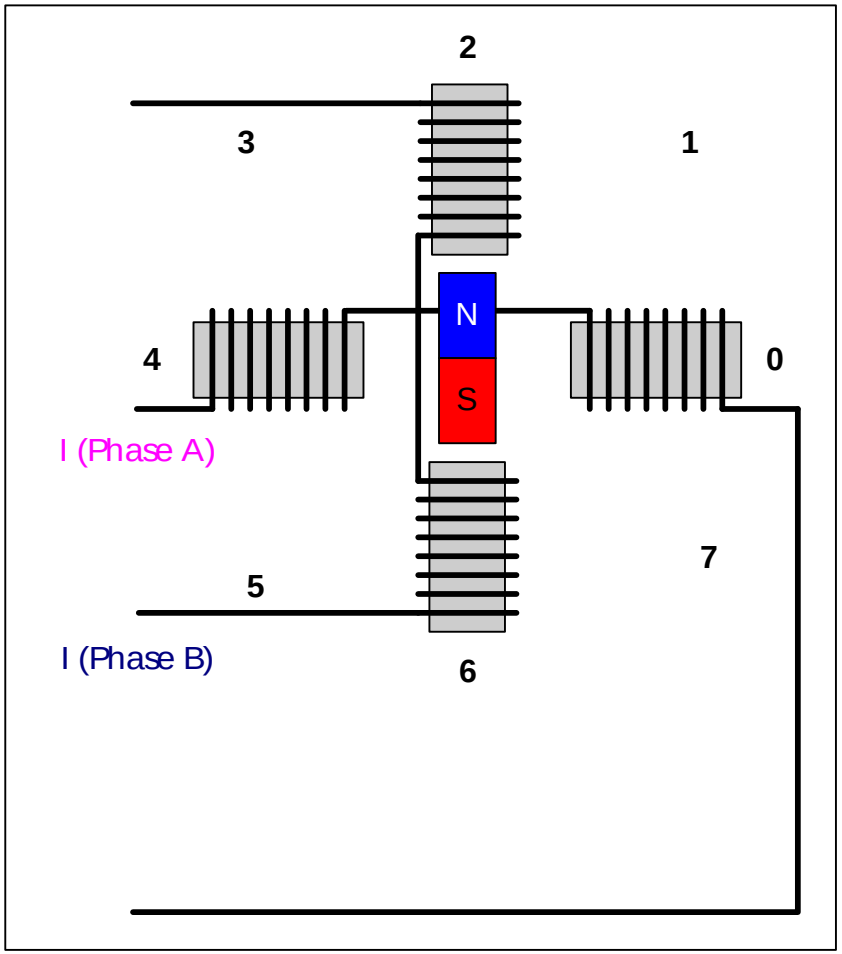
SLOW MOVEMENT AND POSITIONING APPLICATIONS

- standard size from 6mm to 86mm (0.24 to 34 inch)
- resolution from 4 to 800 fullstep positions per revolution
- easy positioning
- cost effective
- high torque at low speed

MOTOR TYPE: STEPPER

TRINAMIC
MOTION CONTROL

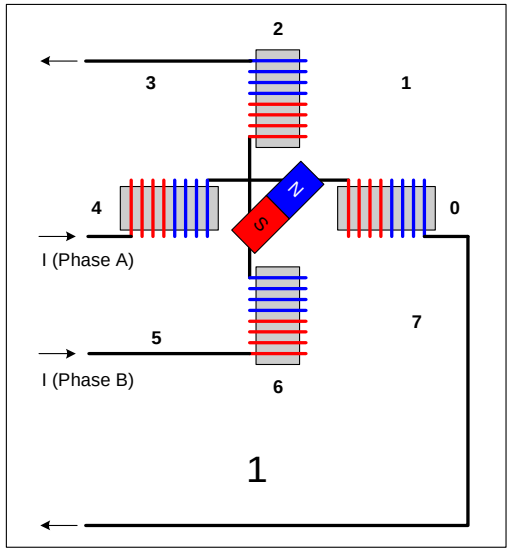
THE EASIEST STEPPER MOTOR

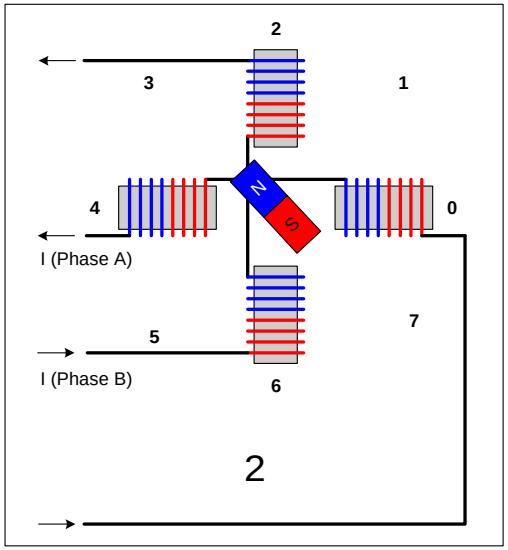


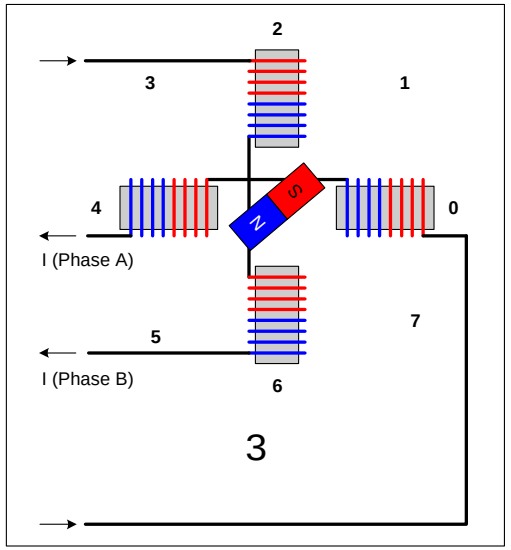
4 coils,
2 in series connection = 1 phase
1 magnet (compass needle)

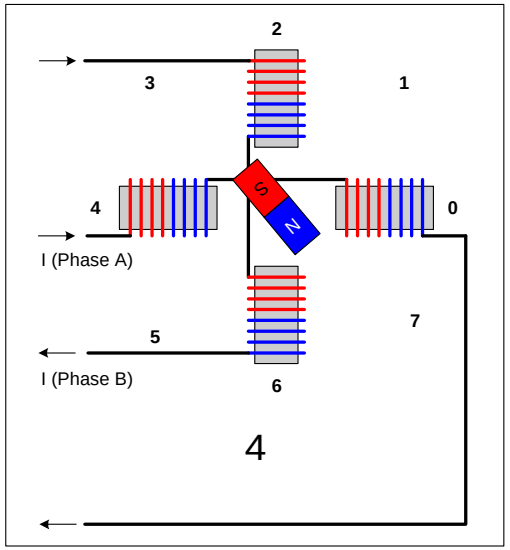
MOTOR TYPE: STEPPER

FULLSTEP OPERATION









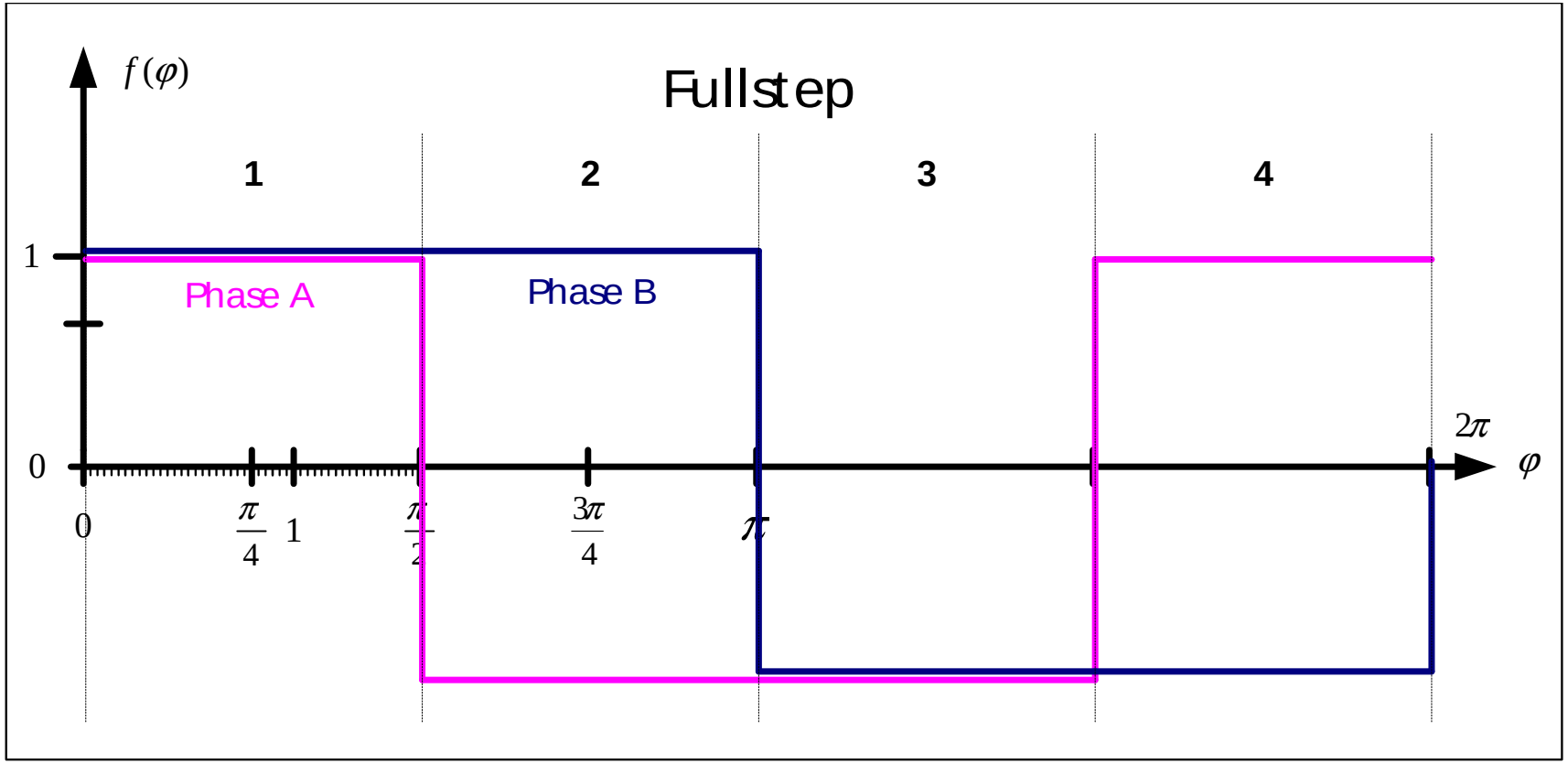
Fullstep operation: always current on both phases

1 electrical period = 4 fullsteps

MOTOR TYPE: STEPPER

TRINAMIC
MOTION CONTROL

FULLSTEP OPERATION



always current on both phases
4 fullsteps = 1 electrical period

MOTOR TYPE: STEPPER

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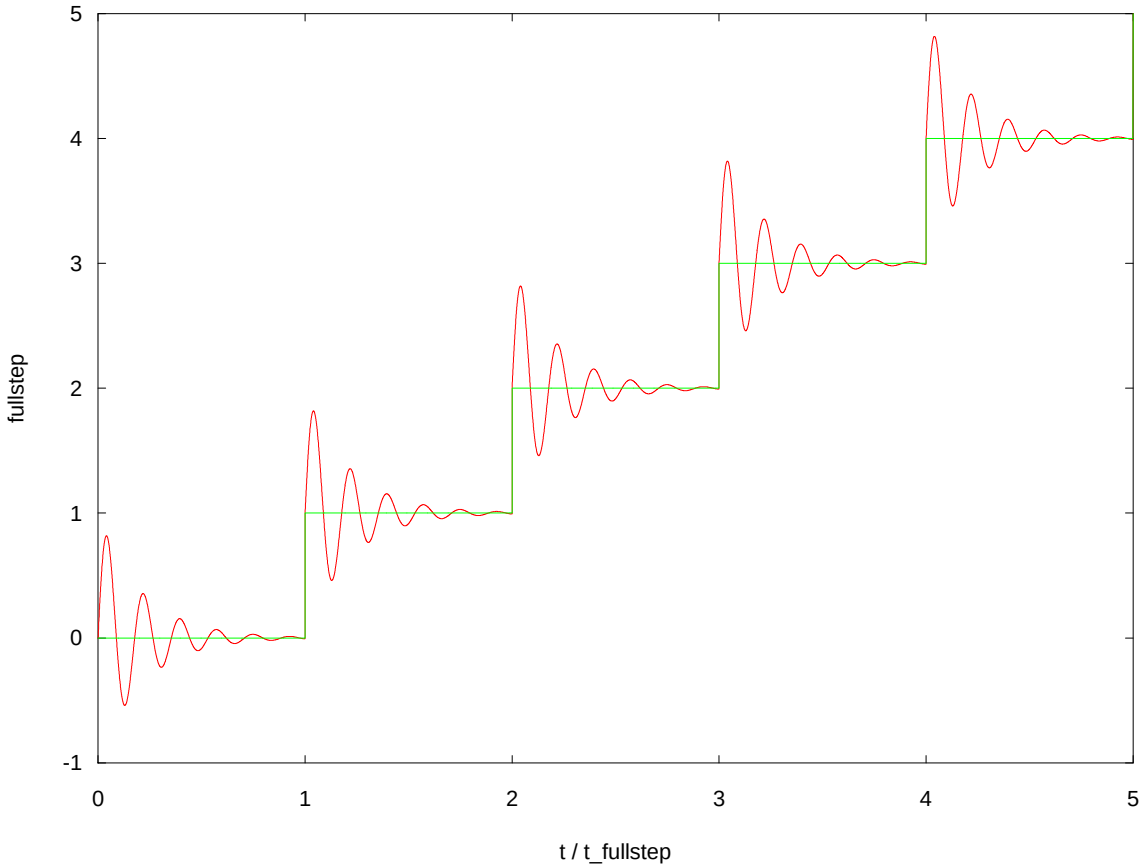
FULLSTEP OPERATION

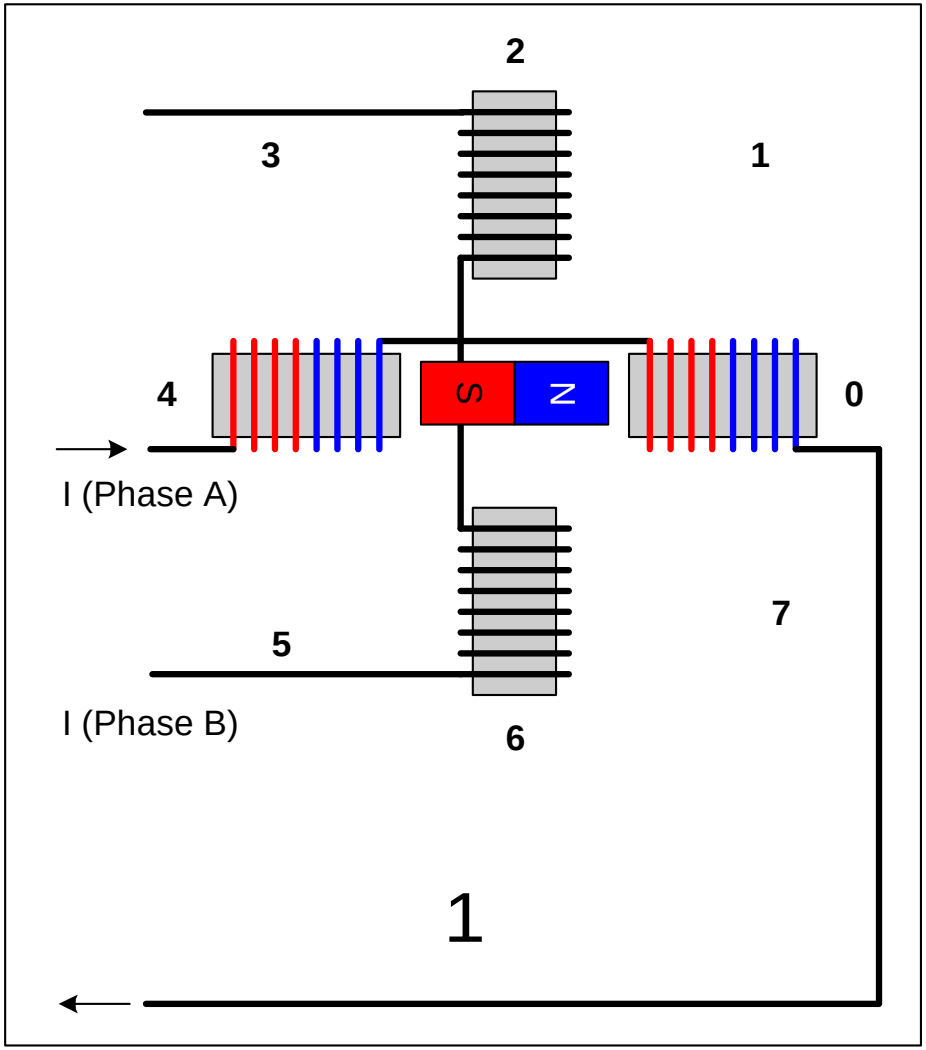


simulation:
path – time diagram

disadvantage of fullstep operation:
high transient oscillation of the rotor position

MOTOR TYPE: STEPPER

HALFSTEP OPERATION

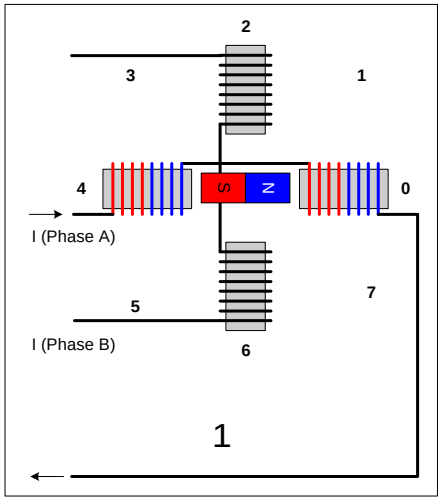


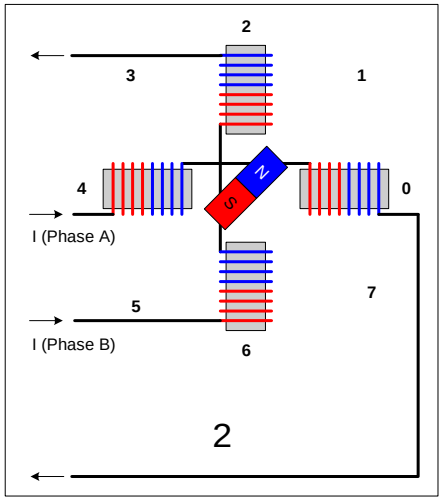
halfstep operation: current on one phase and current on both phases alternating

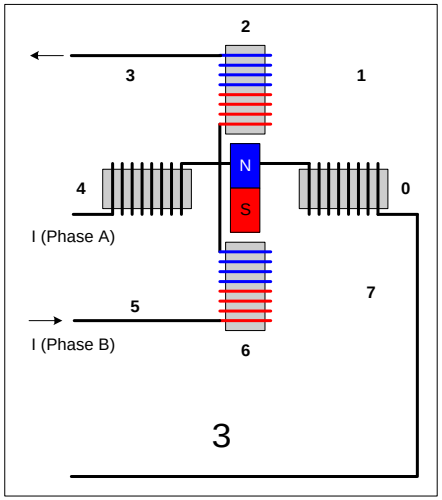
1 electrical period = 8 halfsteps

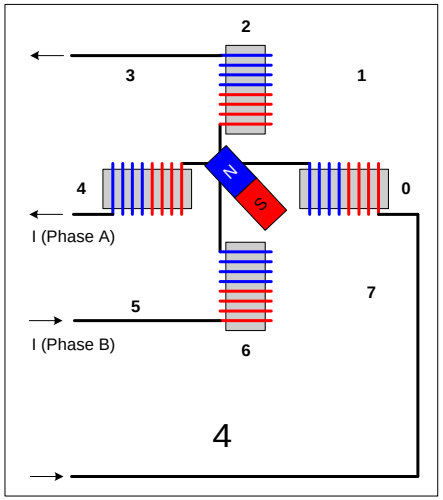
MOTOR TYPE: STEPPER

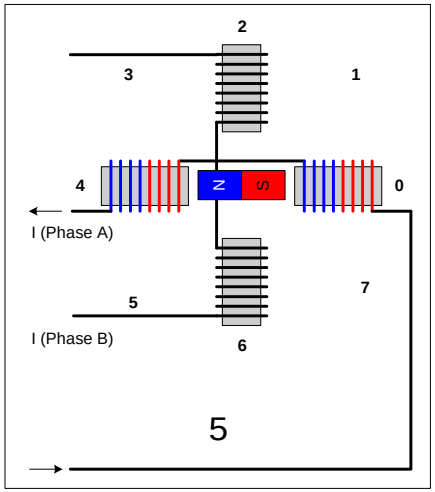
HALFSTEP OPERATION

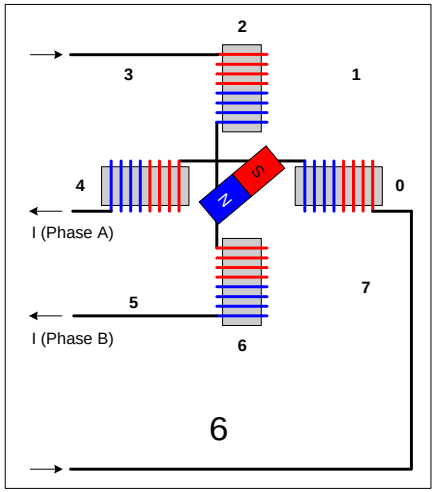


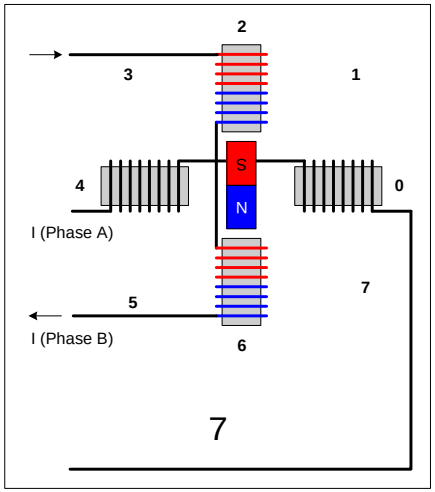


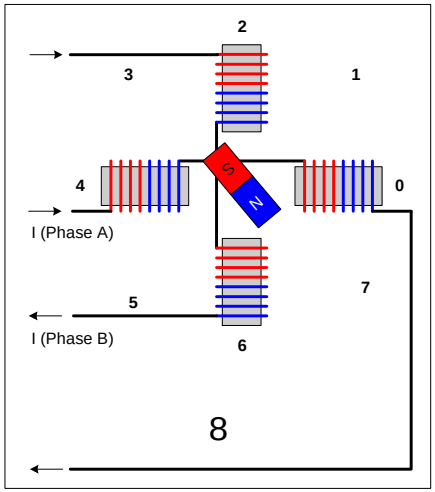












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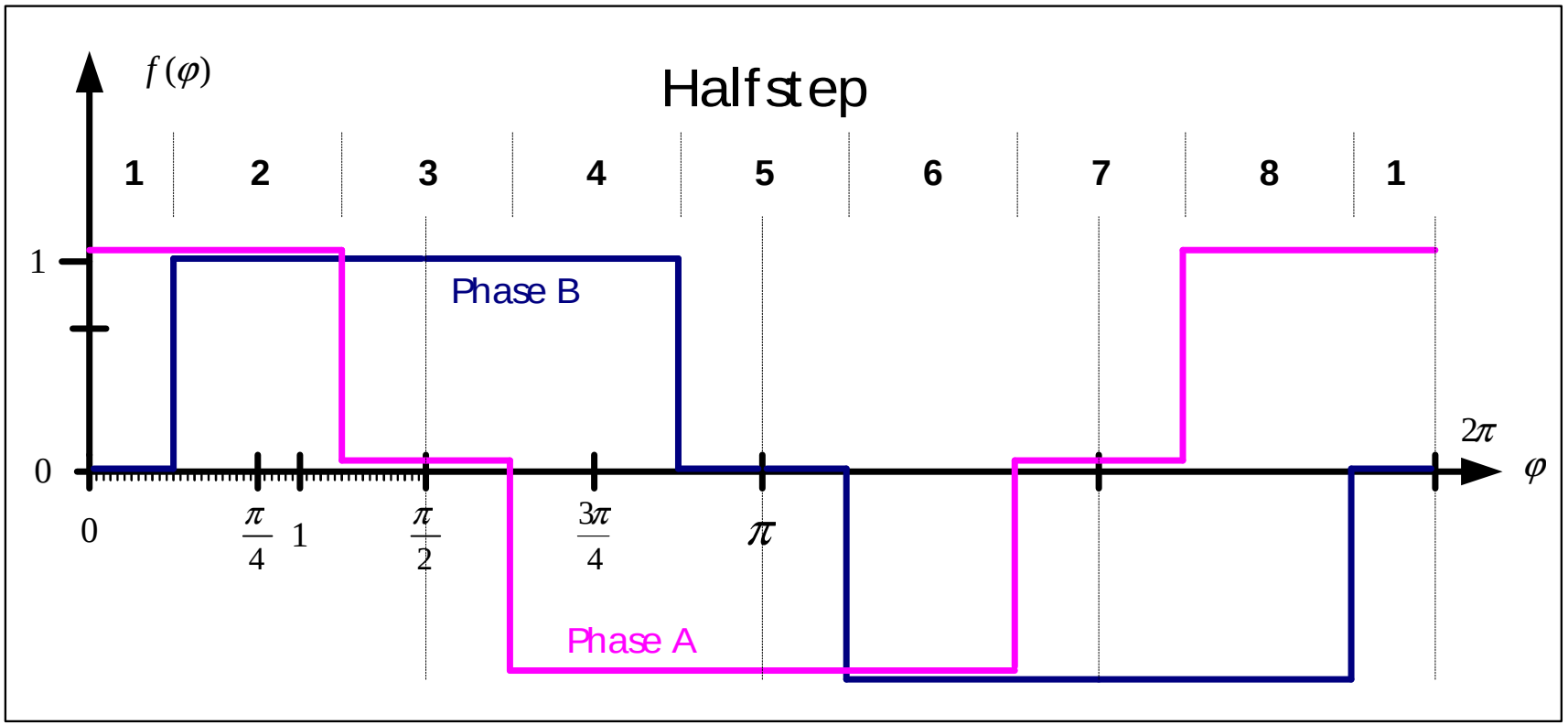
HALFSTEP OPERATION



current on one phase and current on both phases alternating
8 halfsteps = 1 electrical period

MOTOR TYPE: STEPPER

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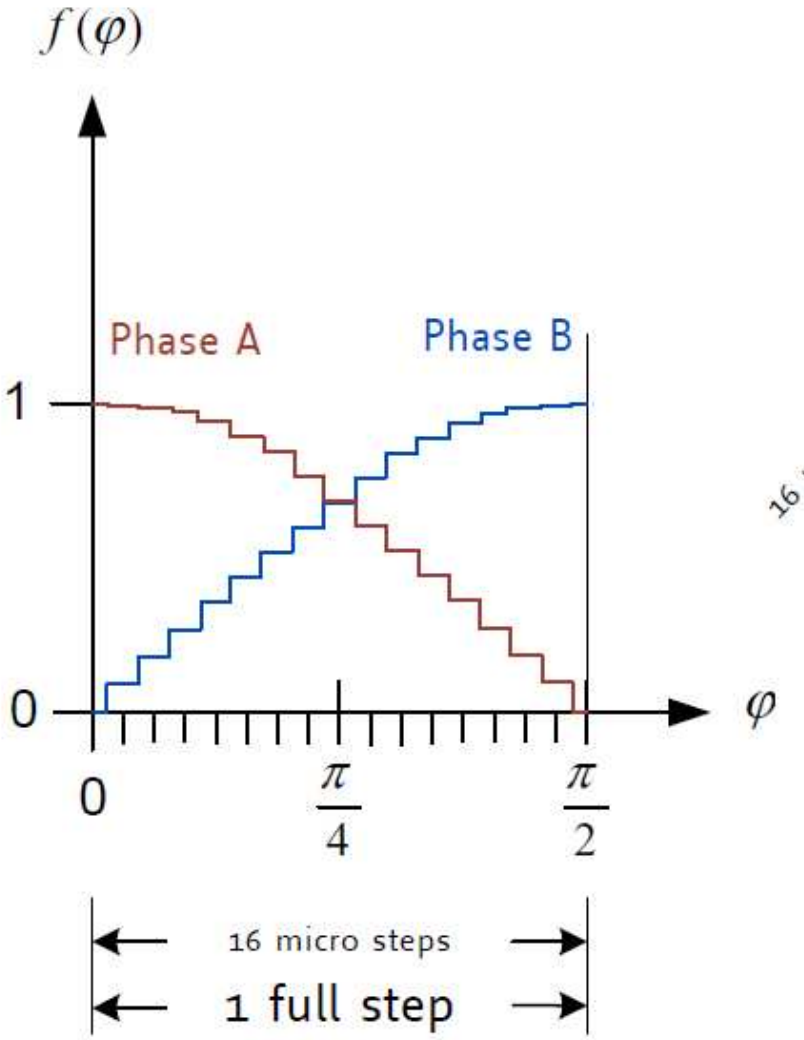
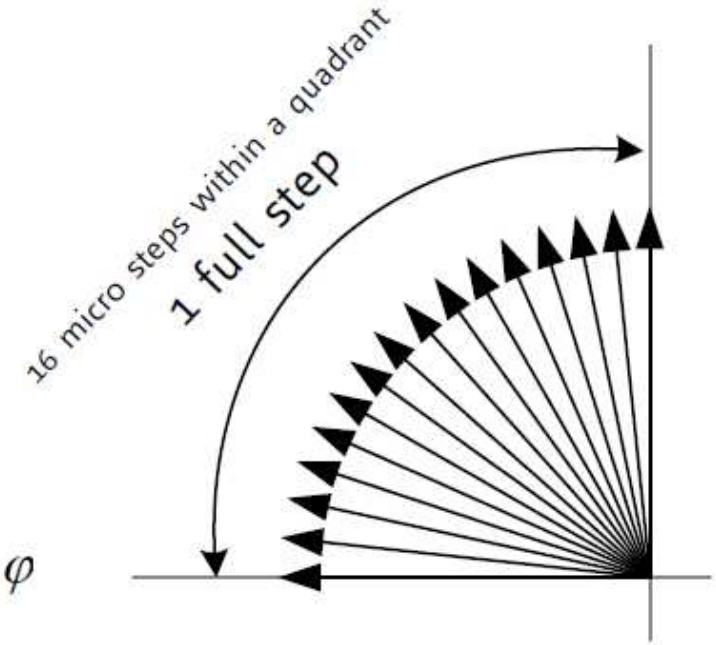
MOTION CONTROL

MICROSTEP OPERATION





sinewave and cosinewave
with 16 analog values

MOTOR TYPE: STEPPER

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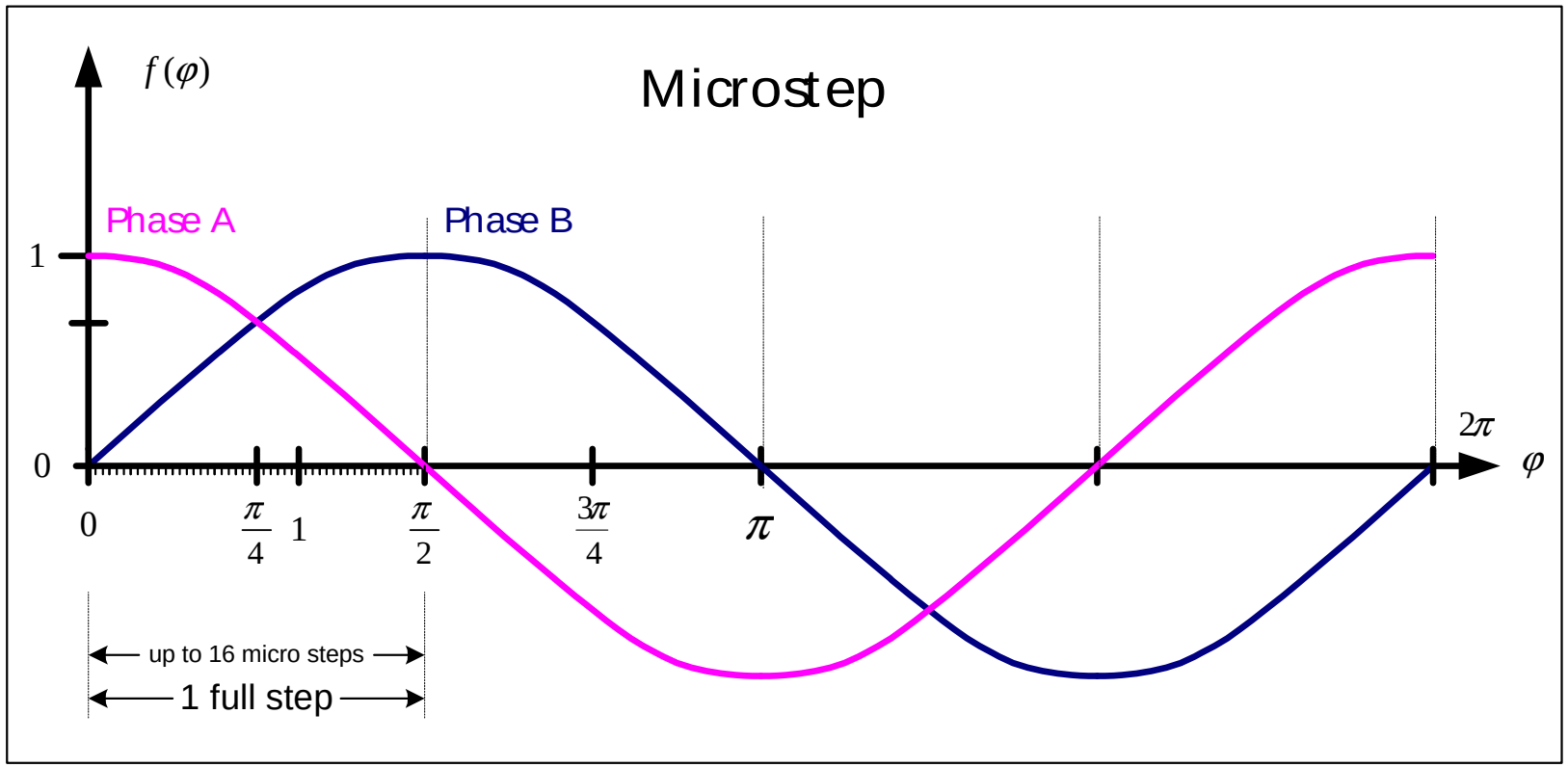
MOTION CONTROL

THE EASIEST STEPPER MOTOR WITH 16 MICROSTEPS



16 microsteps = 1 fullstep
4 fullsteps = 1 rotation
64 microsteps = 1 rotation

sinewave and cosinewave
with 16 analog values

MOTOR TYPE: STEPPER

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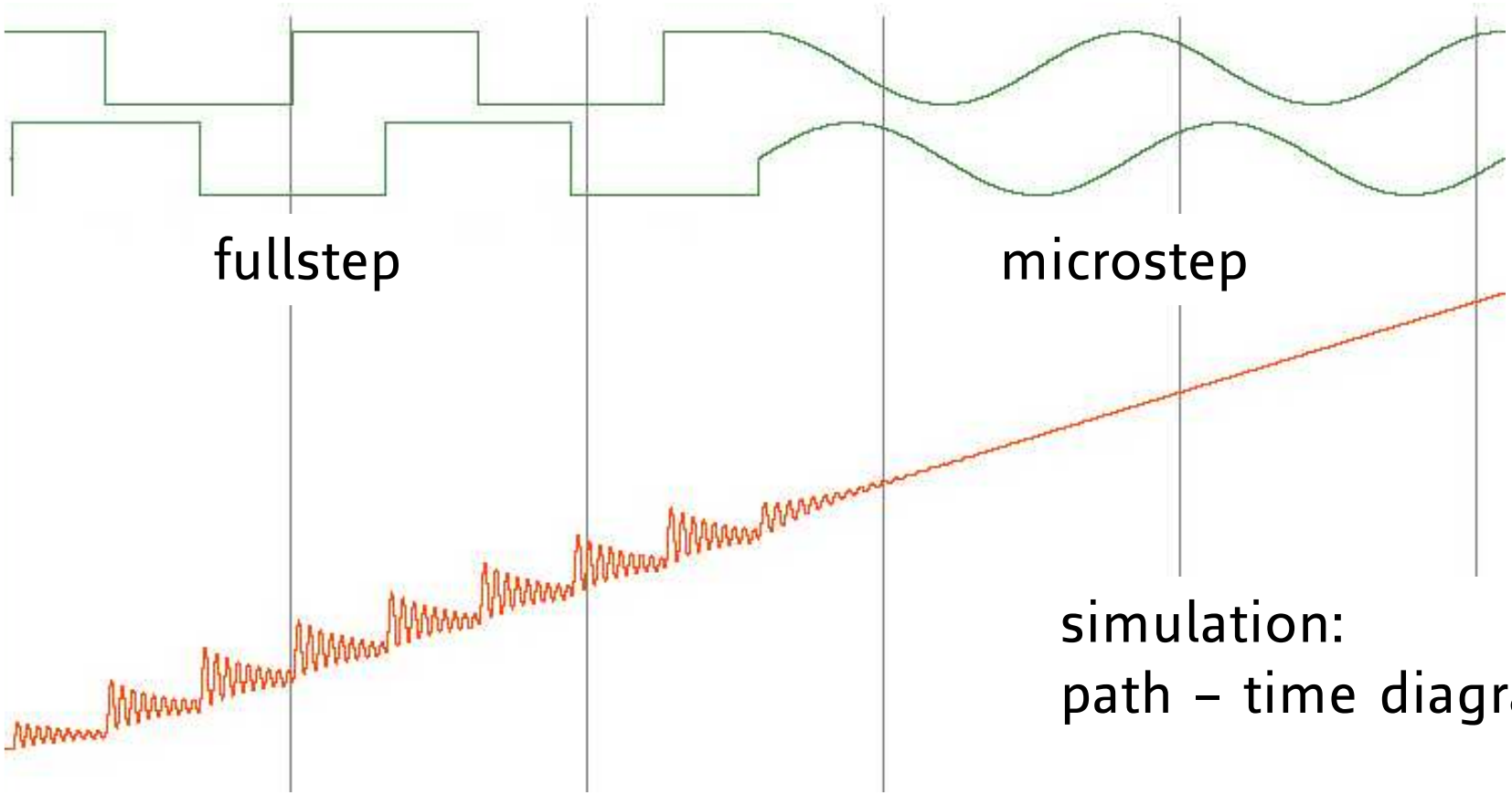
FULLSTEP VS. MICROSTEP OPERATION



microstep operation:
less transient oscillation of the rotor position -> smooth movement

MOTOR TYPE: STEPPER

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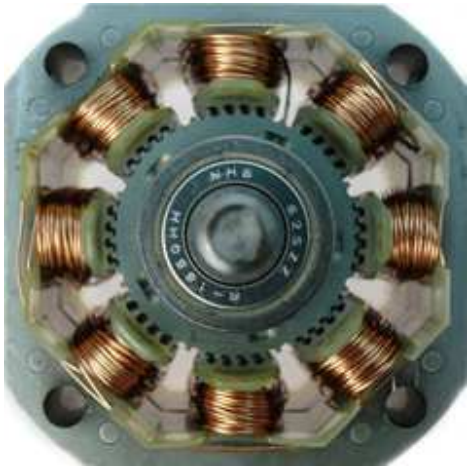
HYBRID STEPPER MOTORS



- high torque
- high resolution (e.g. 200 steps / rev)
- flange with NEMA standard:
  e.g.
  NEMA 11 (1.1 in / 28 mm)
  NEMA 17 (1.7 in / 42 mm)
  NEMA 23 (2.3 in / 57 mm)
  NEMA 32 (3.2 in / 86 mm)

MOTOR TYPE: STEPPER

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PM/PERMANENT MAGNET/CAN STACK-STEPPER MOTORS

- low torque
- low resolution (e.g. 25 steps / rev)
- very cost effective

MOTOR TYPE: STEPPER

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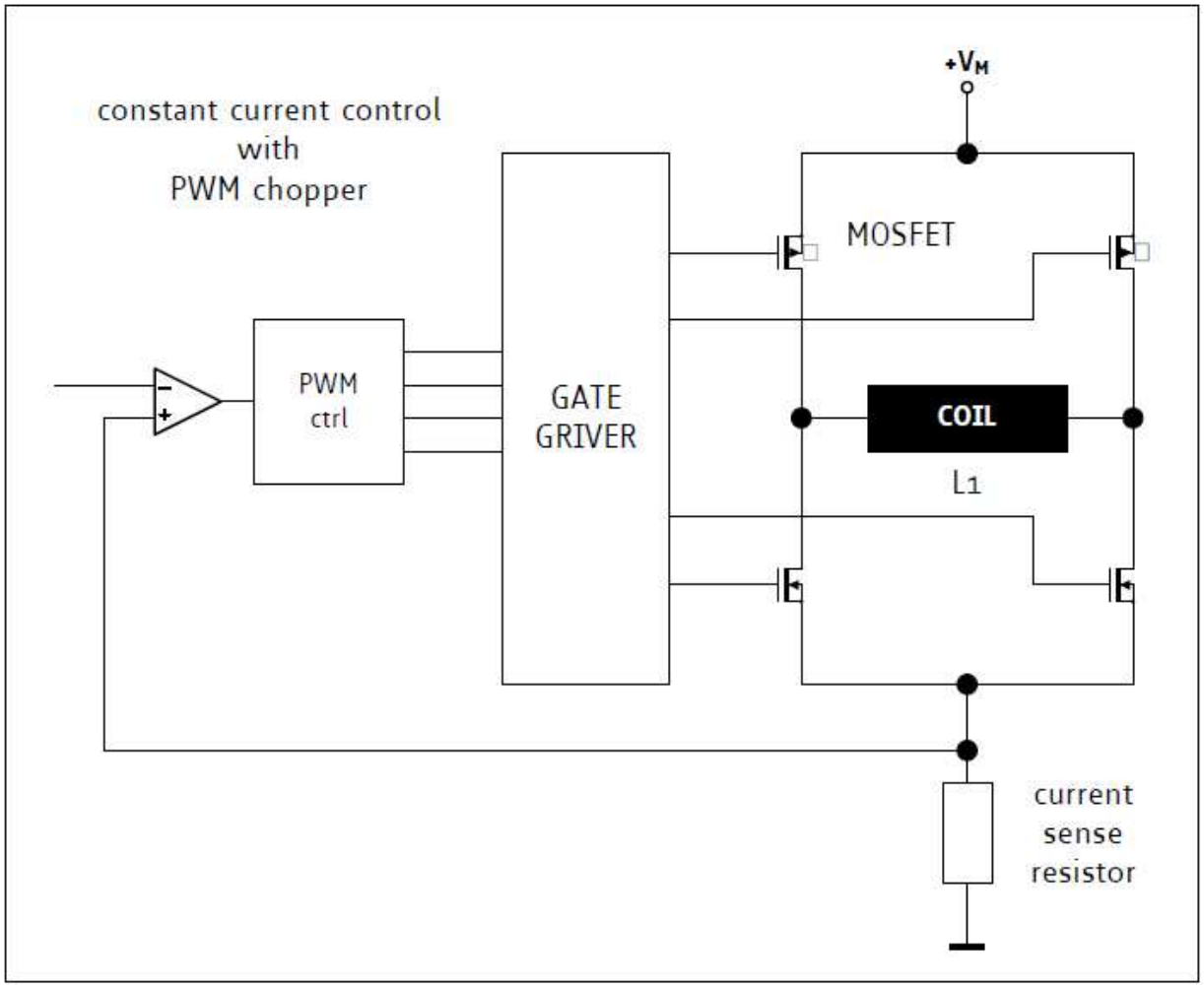
CONSTANT CURRENT CONTROL WITH PWM CHOPPER



one H-bridge per motor coil

MOSFETS are switched on and off very fast in order go get the required current in the coil

chopper frequency e.g. 20kHz

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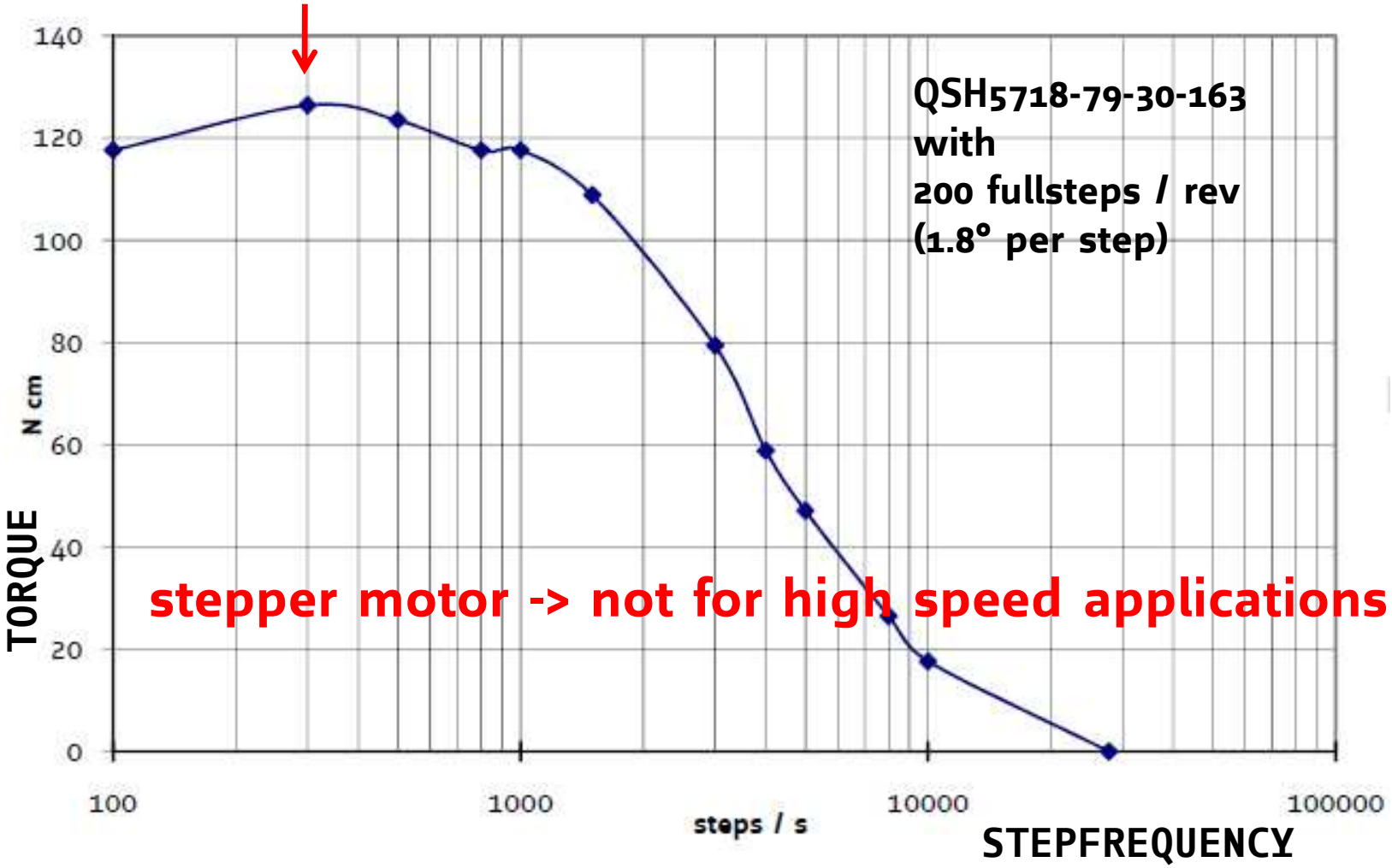
TORQUE OVER STEPFREQUENCY

highest torque at 300 steps/s = 1,5 rps = 90 rpm



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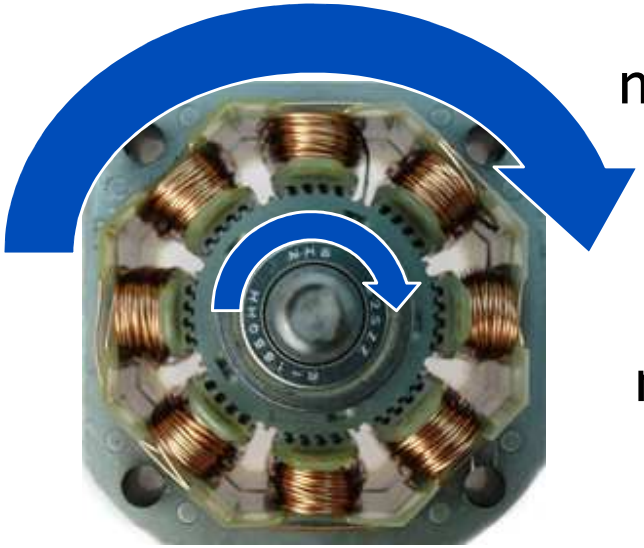
ROTOR VS. MAGNETIC FIELD ROTATION



magnetic rotation field

rotor rotation

because of the rotor inertia the motor needs a acceleration phase up to the desired velocity

motor stalls, when the rotor cannot follow the magnetic rotation field

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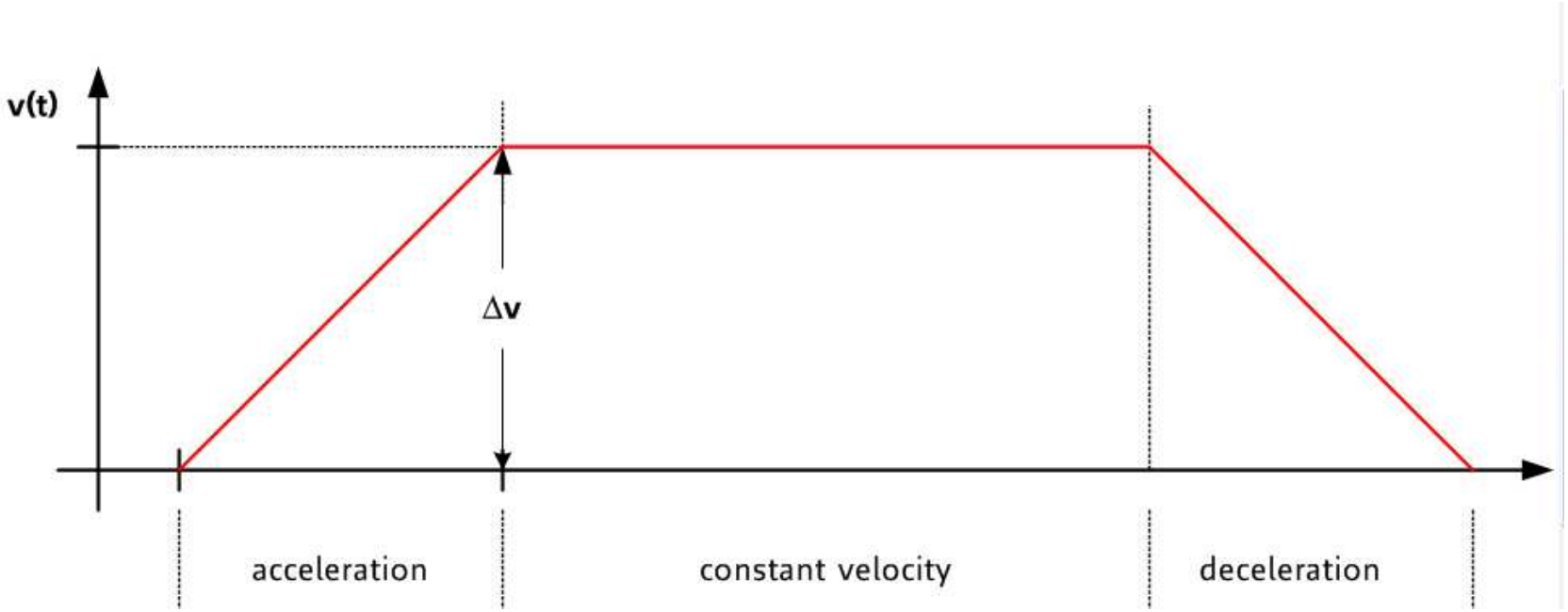
LINEAR ACCELERATION RAMP

for many applications a linear acceleration ramp works

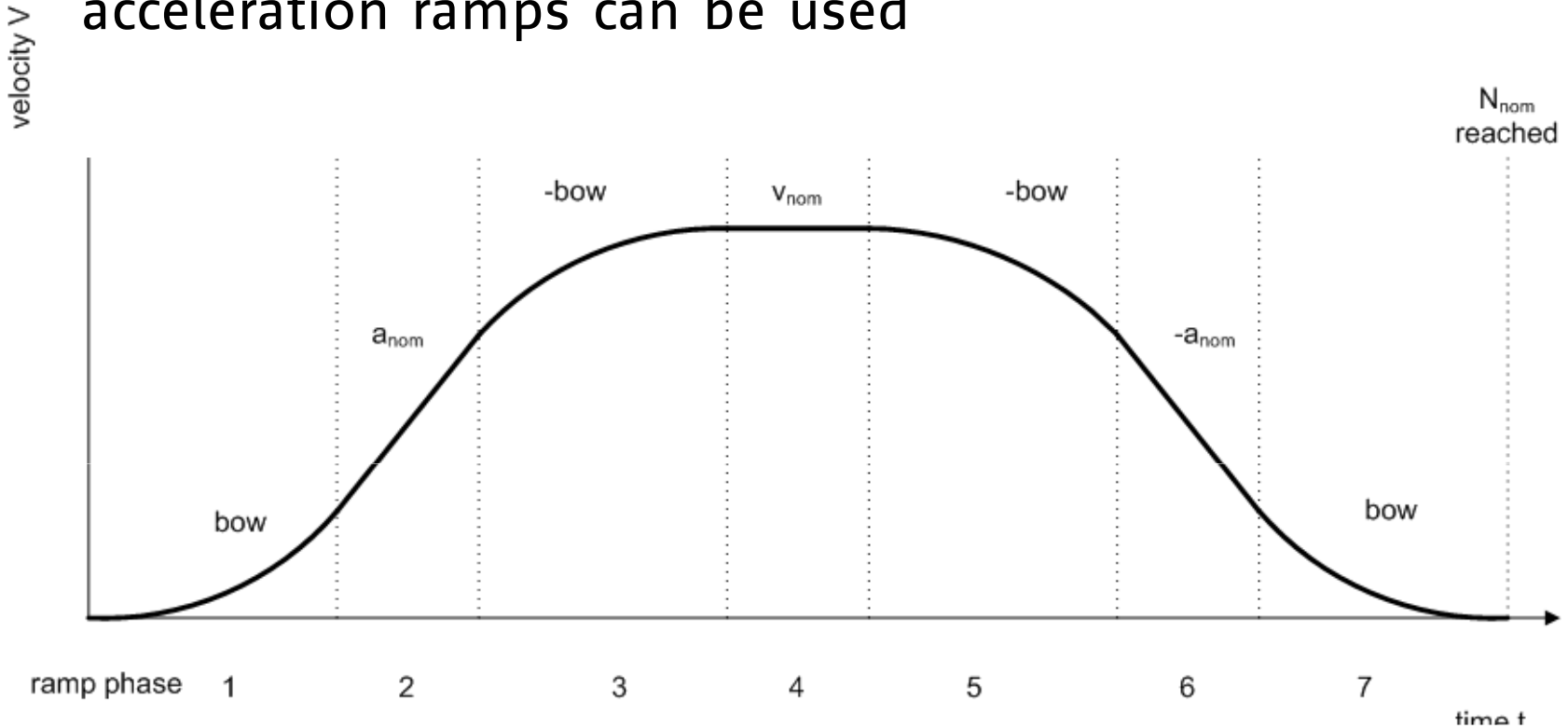


all TRINAMIC stepper motor controller
are able to make linear acceleration ramps

MOTOR TYPE: STEPPER

S-SHAPED ACCELERATION RAMP

when sensitive things have to be moved S-shaped acceleration ramps can be used



following TRINAMIC products can make s-shaped ramps:
TMC454, TMC457, MONOpack 2, TMCM-142

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ADVANTAGE STEPPER MOTOR

- open loop, no feedback necessary for position control
- high torque at rest and low speed
- high torque from a given package size
- no gearing needed
- low cost for positioning applications

MOTOR TYPE: STEPPER

TRINAMIC
MOTION CONTROL

ADVANTAGE MICROSTEPPING

- smooth and noiseless movement
- higher dynamic
- less transient oscillation -> less resonances -> no step loss

all TRINAMIC stepper motor products
are working with microstepping

up to 2048 microsteps per fullstep

MOTOR TYPE: STEPPER

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RESTRICTIONS **TRINAMIC SOLUTIONS**

- can lose steps without feedback
  -> integrated **sensOstep™** encoder
- heating due to constant current flow
  -> dynamic current control
- excessive loads can stall the motor
  -> sensorless stall detection **stallGuard™**
- not for high speed
  -> brush less DC motor solutions (BLDC)

TOOL: Torque Conversion Chart

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MOTION CONTROL

ALL DATA BASED ON SI-UNITS

TORQUE CONVERSION CHART

KNOWN VALUE						
lb-ft x	lb-in x	oz-in x	N-cm x	kg-m x		
1	0.08333	0.005208	0.007376	7.233	= lb-ft	DESIRED VALUE
12	1	0.0625	0.08851	86.796	= lb-in	
192	16	1	1.4161	1.389	= oz-in	
135.6	11.3	0.7062	1	980.66	= N-cm	
0.1383	0.01152	7.201×10^{-4}	0.001097	1	= kg-m	

THANK YOU

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