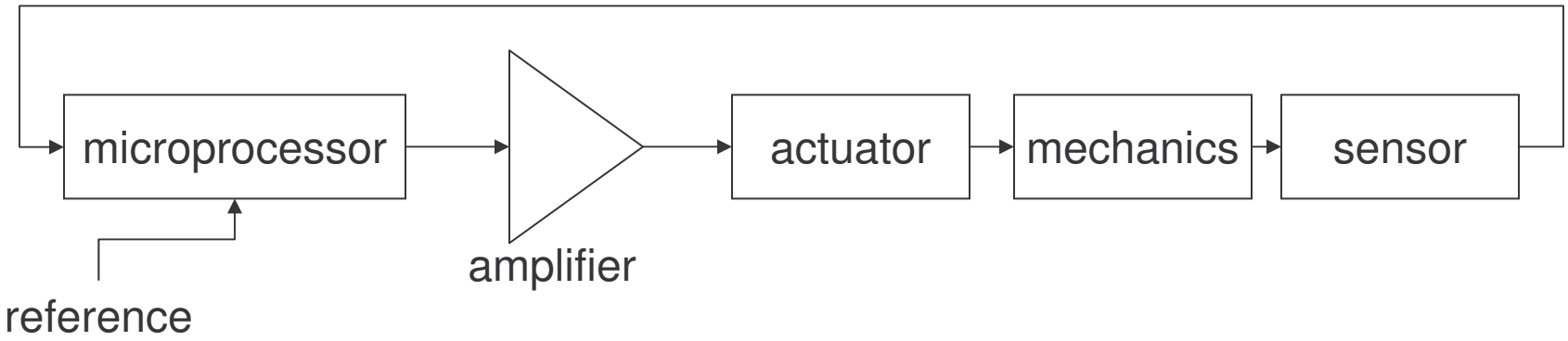
Motor control

A short presentation

Global view

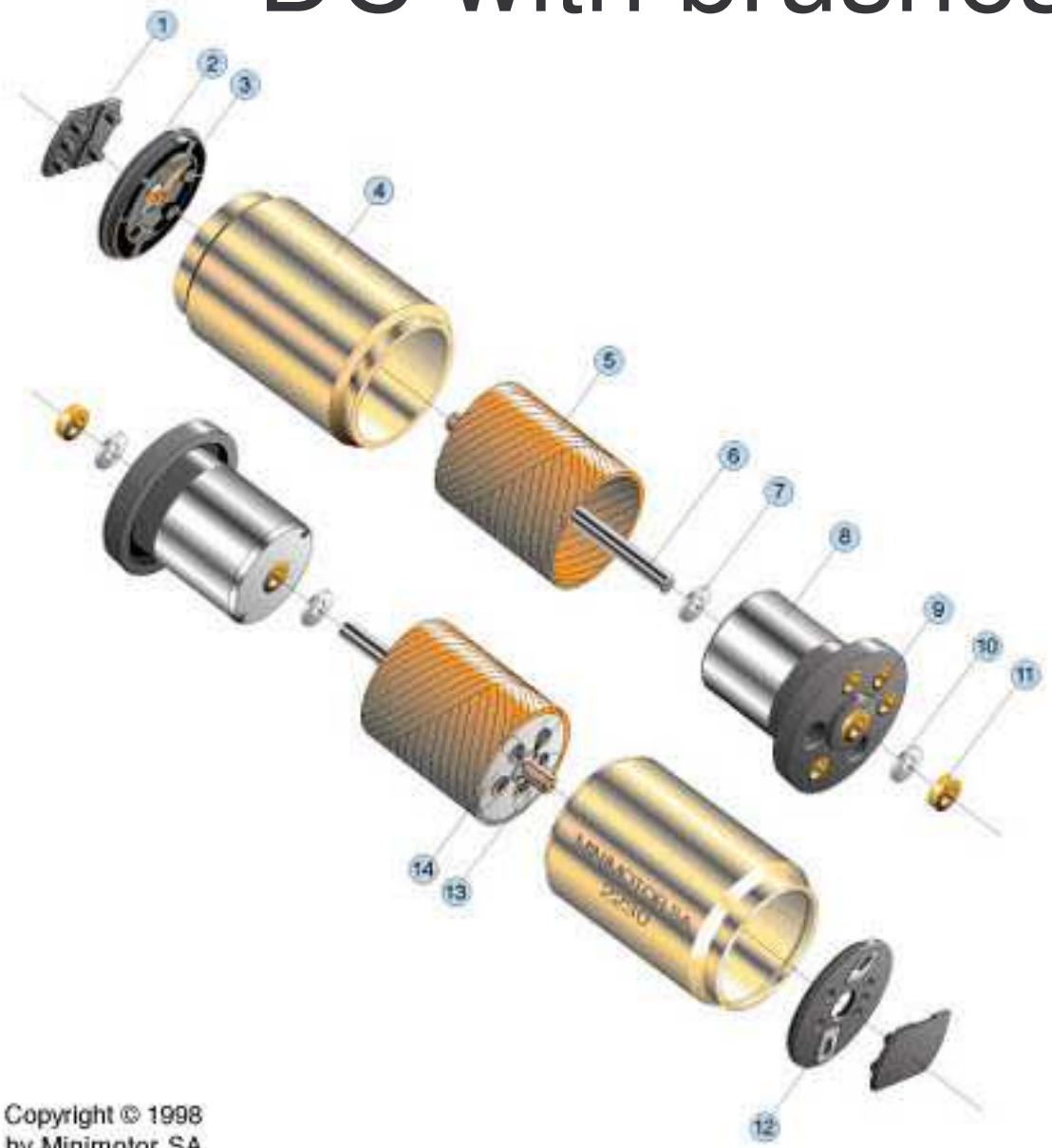

microprocessor
amplifier
actuator
mechanics
sensor
reference

Components

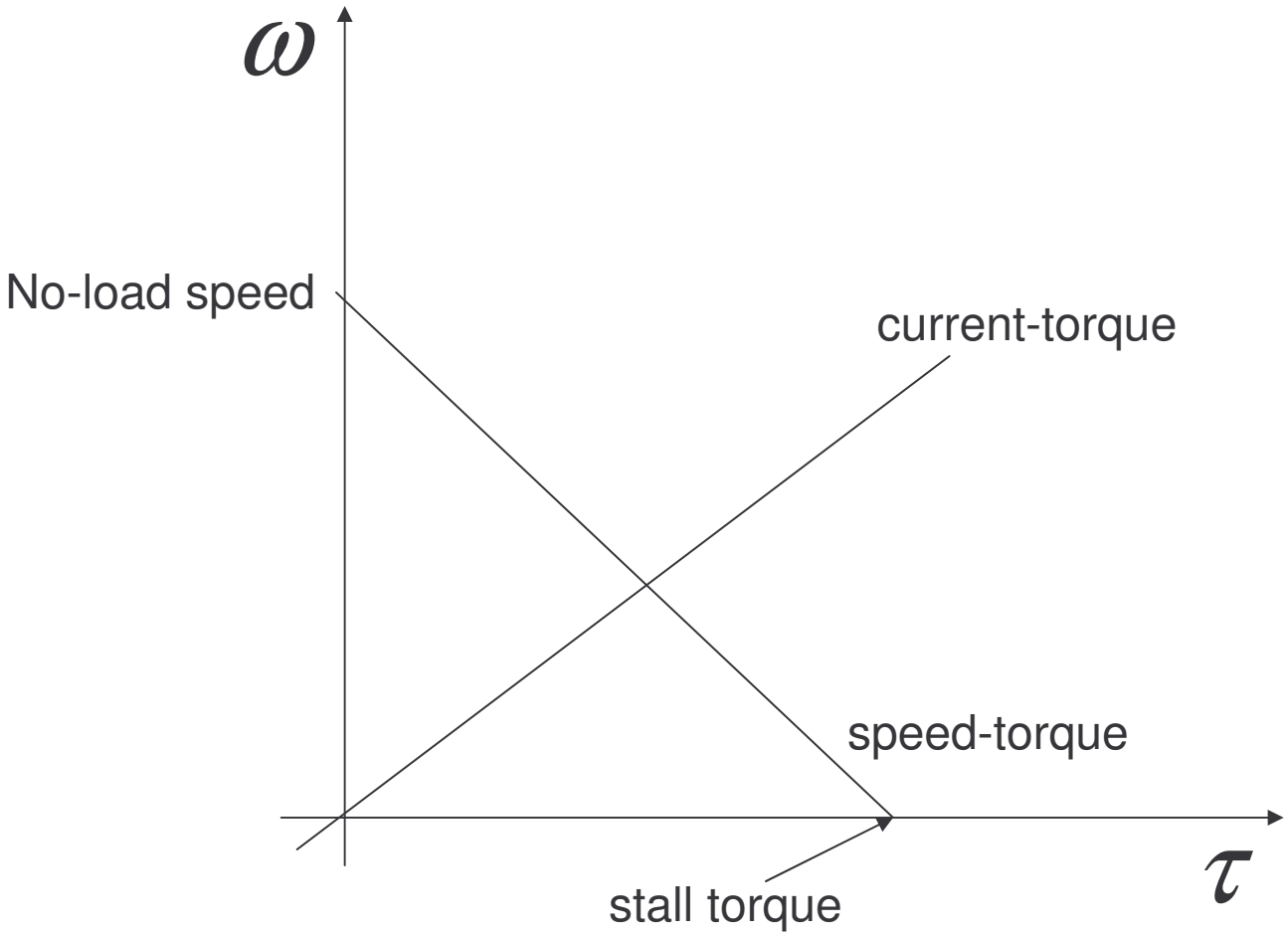
- Digital microprocessor:
  - Microcontroller, processor + special interfaces
- Amplifier (drives the motor)
  - Turns control signals into power signals
- Actuator
  - E.g. electric motor
- Mechanics/load
  - The robot!
- Sensors
  - For intelligence

Actuator

DC with brushes



In particular



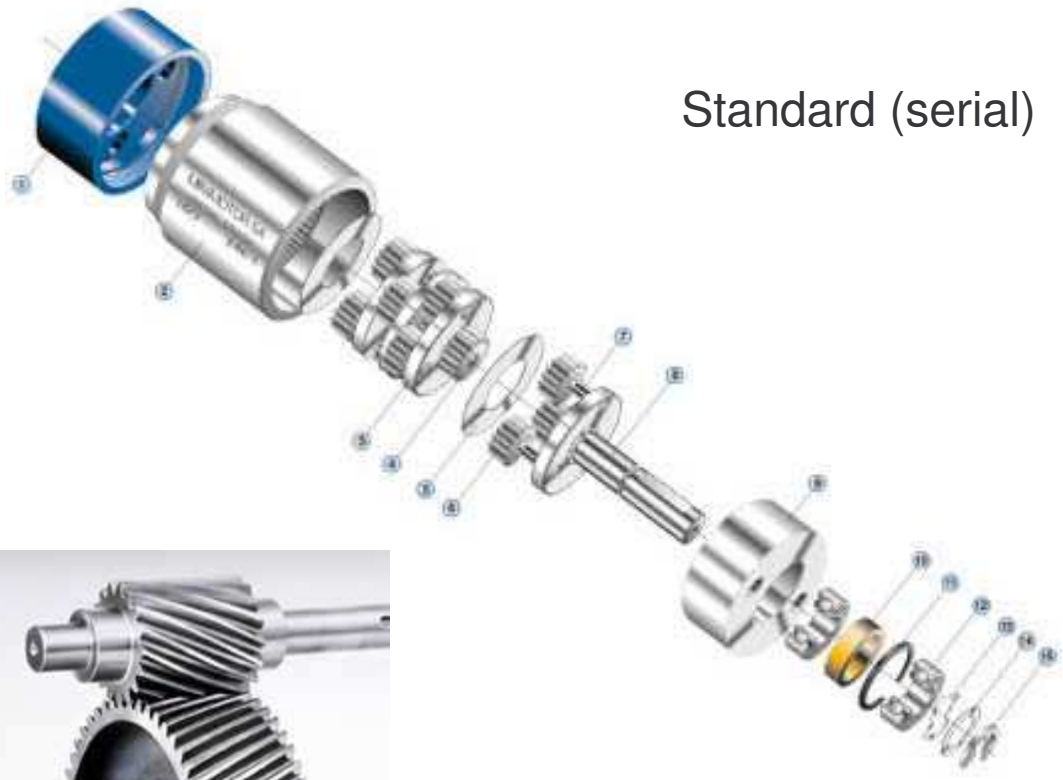
Real numbers!

http://www.minimotor.ch

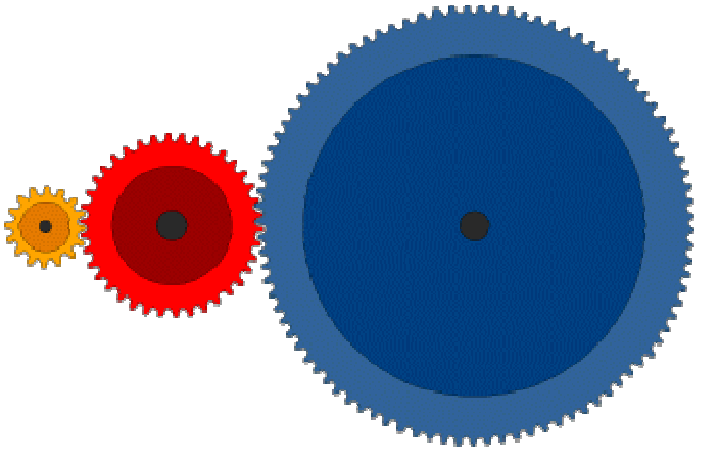
Series 1331 ... SR

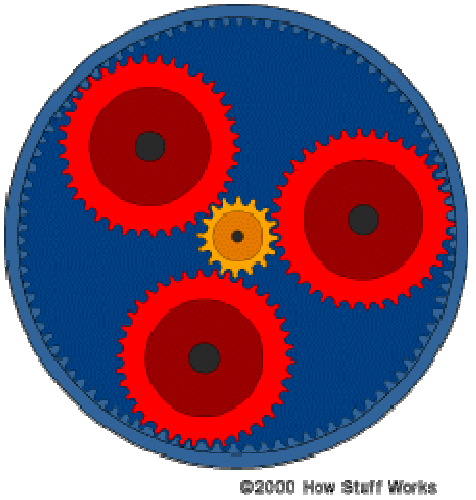
		1331 T		006 SR	012 SR	024 SR	
1	Nominal voltage	U_N		6	12	24	Volt
2	Terminal resistance	R		2,83	13,7	52,9	Ω
3	Output power	$P_{2\,max.}$		3,11	2,57	2,66	W
4	Efficiency	$\eta_{max.}$		81	80	80	%
5	No-load speed	n_o		10 600	9 900	10 400	rpm
6	No-load current (with shaft ø 1,5 mm)	I_o		0,0220	0,0105	0,0055	A
7	Stall torque	M_H		11,20	9,90	9,76	mNm
8	Friction torque	M_R		0,12	0,12	0,12	mNm
9	Speed constant	k_n		1 790	835	439	rpm/V
10	Back-EMF constant	k_E		0,56	1,20	2,28	mV/rpm
11	Torque constant	k_M		5,35	11,4	21,8	mNm/A
12	Current constant	k_I		0,187	0,087	0,046	A/mNm
13	Slope of n-M curve	$\Delta n/\Delta M$		946	1 000	1 070	rpm/mNm
14	Rotor inductance	L		70	310	1 100	µH
15	Mechanical time constant	τ_m		7	7	7	ms
16	Rotor inertia	J		0,71	0,67	0,63	gcm²
17	Angular acceleration	$\alpha_{max.}$		160	150	160	$\cdot 10^3$rad/s²
18	Thermal resistance	$R_{th\,1}$ / $R_{th\,2}$	6 / 25				K/W
19	Thermal time constant	τ_{w1} / τ_{w2}	5 / 190				s
20	Operating temperature range:						
	– motor		– 30 ... + 85 (optional – 55 ... + 125)				°C
	– rotor, max. permissible		+ 125				°C

Gearhead (for real)



Standard (serial)

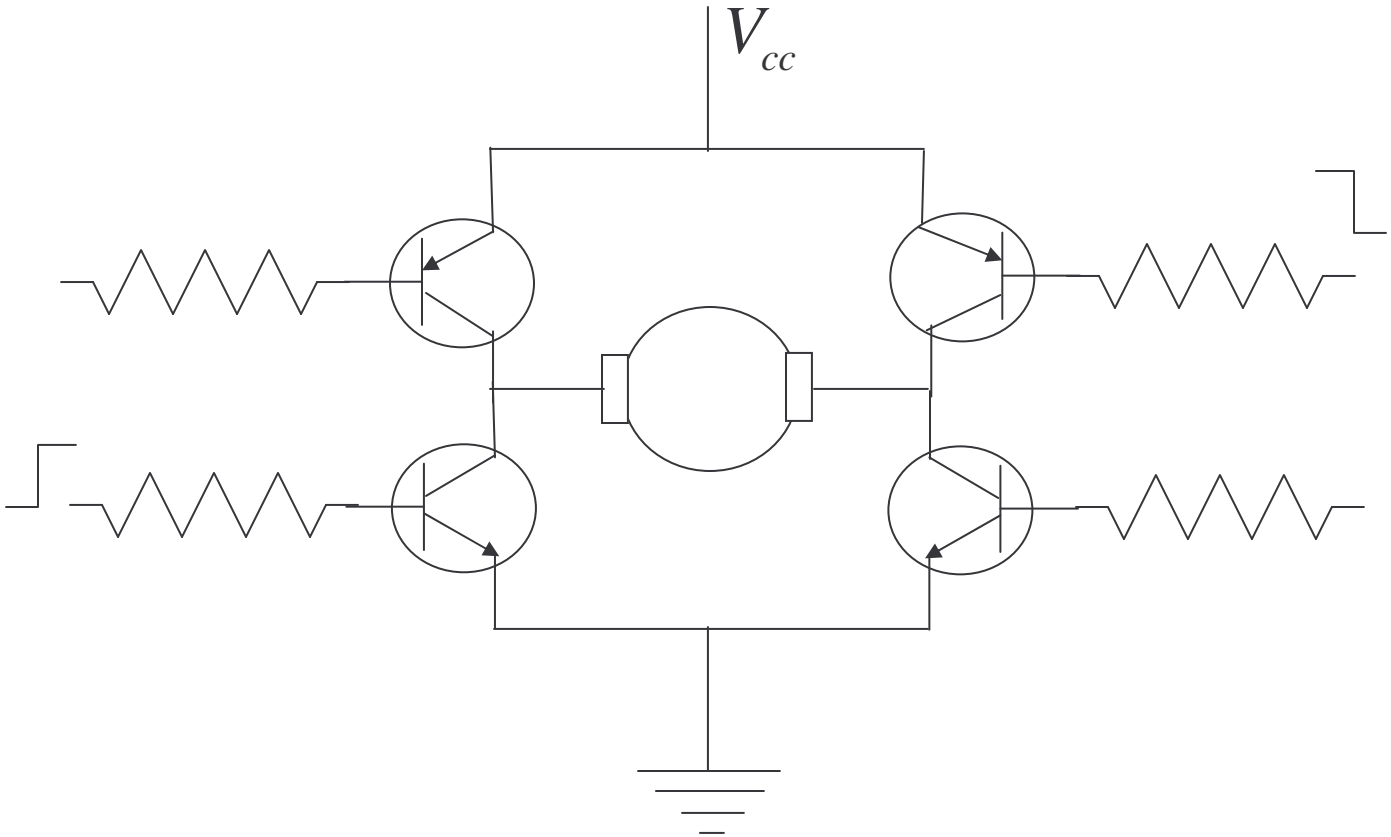




Planetary

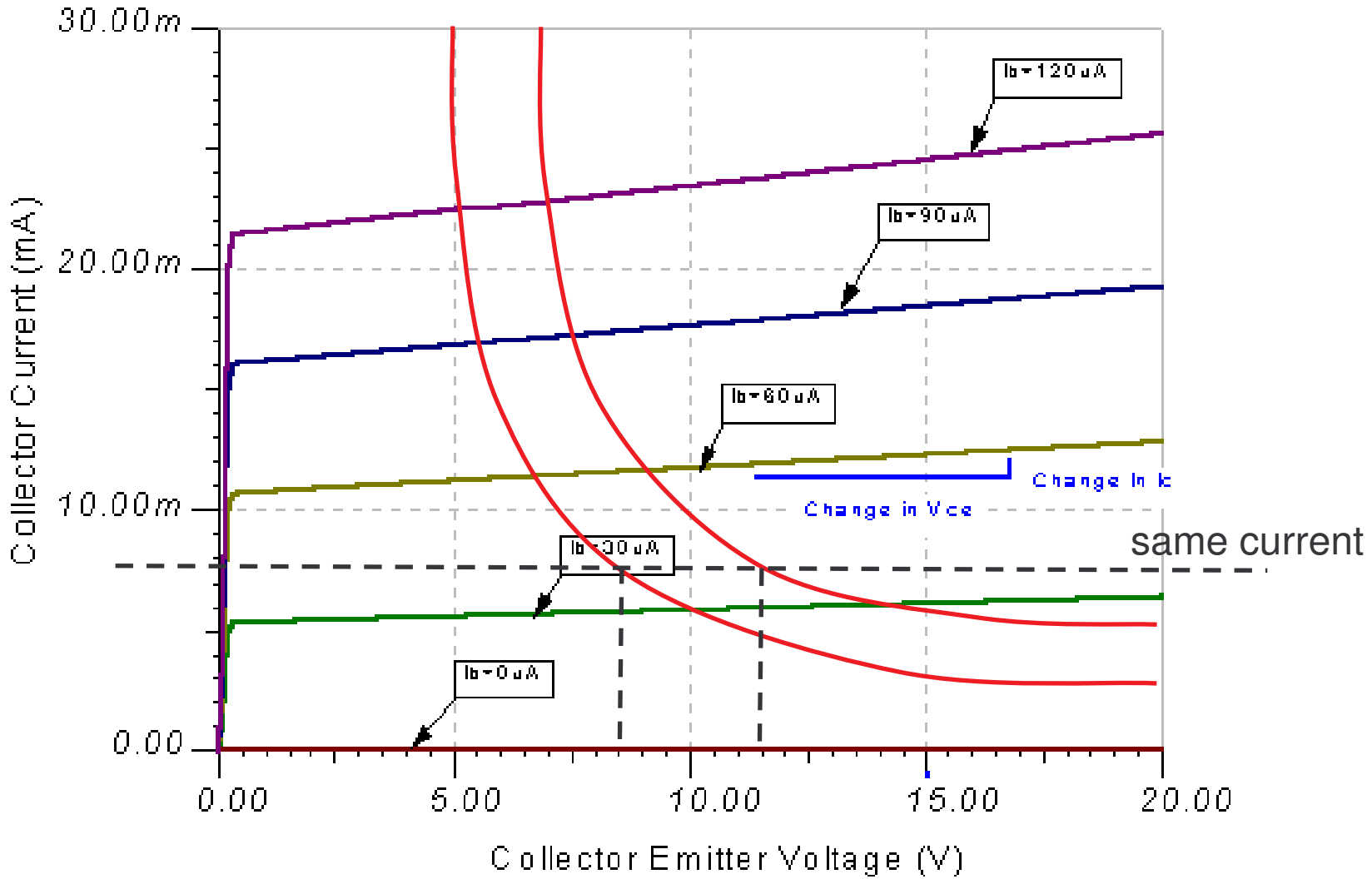
Amplifier

Let's consider the linear as a starting point



PWM amplifiers

$$P = V_{ce} I_c$$

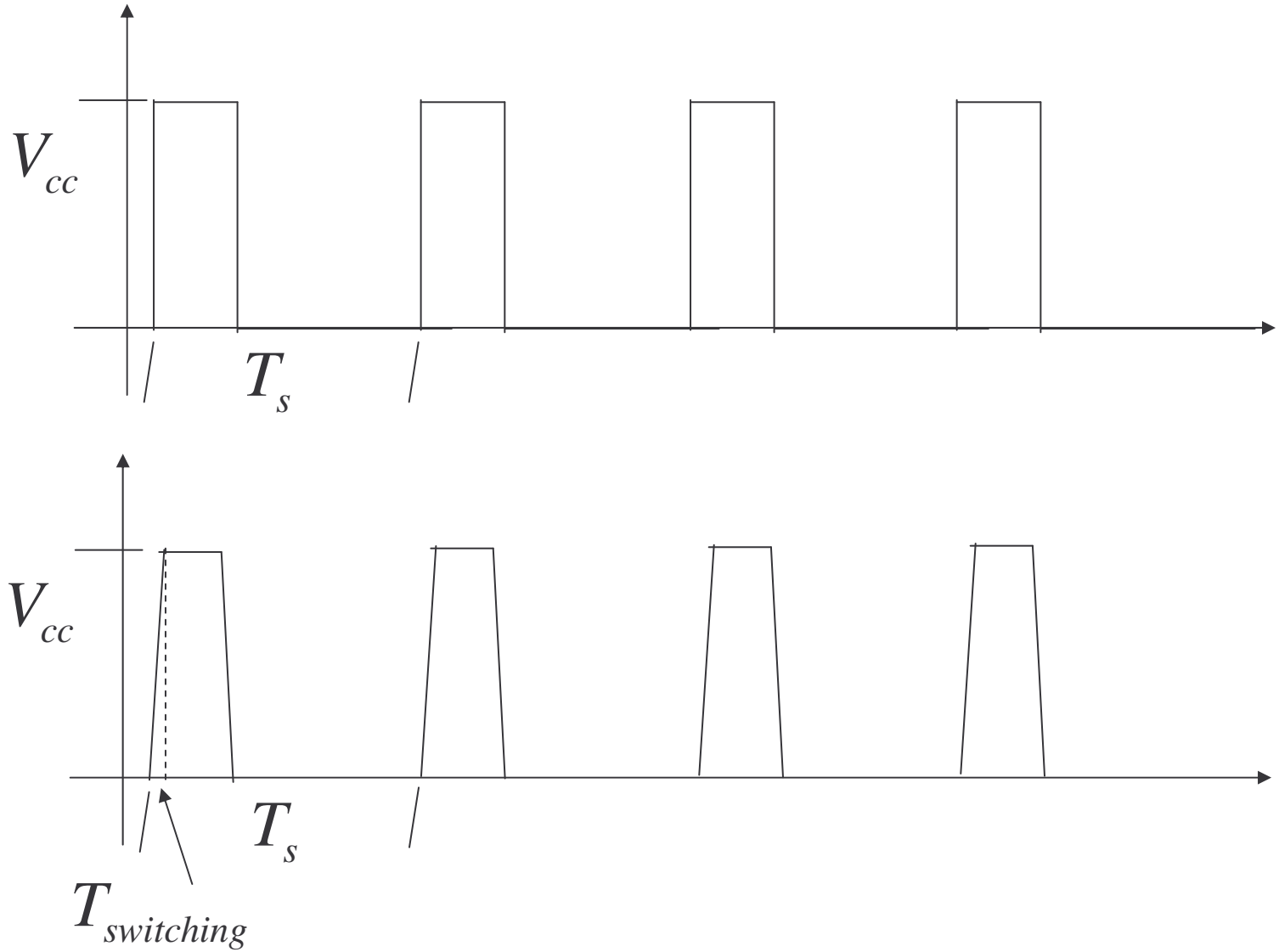


PWM signal

$$P = V_{ce} I_c$$

- Transistors either “on” or “off”
  - When off, current is very low, little power too
  - When on, *V* is low, working point close to (or in) saturation, power dissipation is low

PWM signal



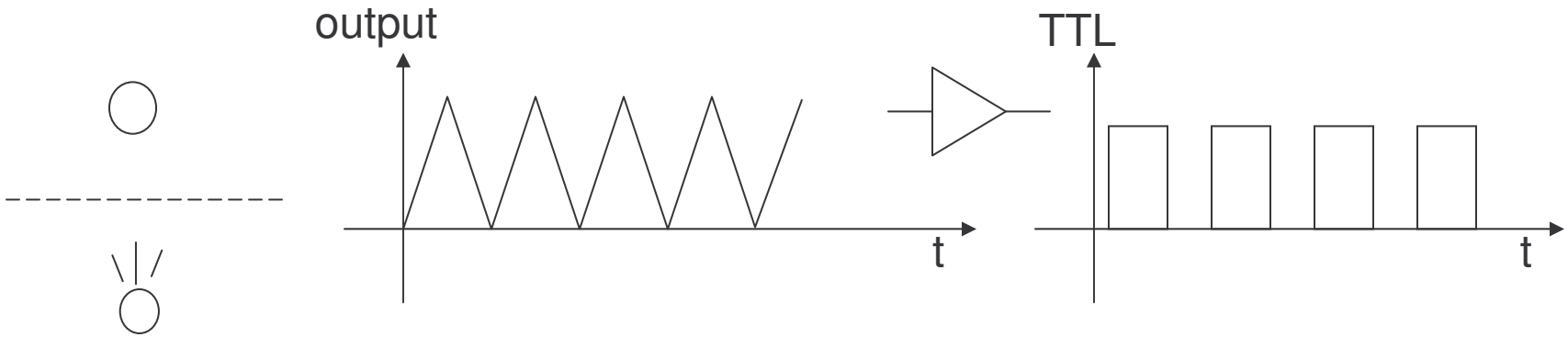
Sensors

- Potentiometers
- Encoders
- Tachometers
- Inertial sensors
- Strain gauges
- Hall-effect sensors
- and many more…

Incremental encoder

- A single-track disk
- No absolute position
- Usually an index marks the beginning of a turn

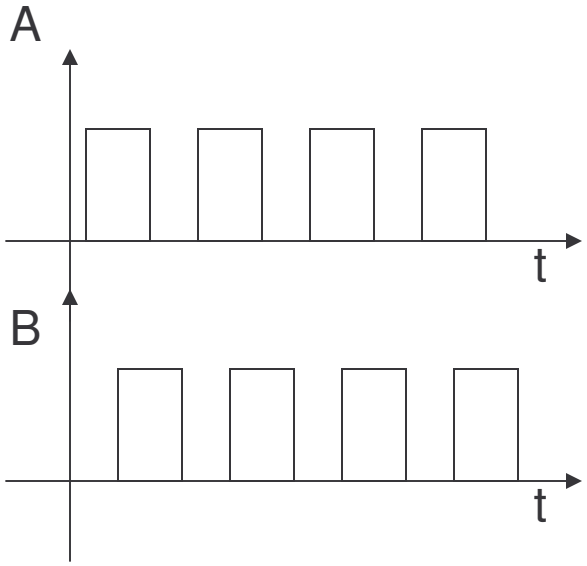
Incremental encoder

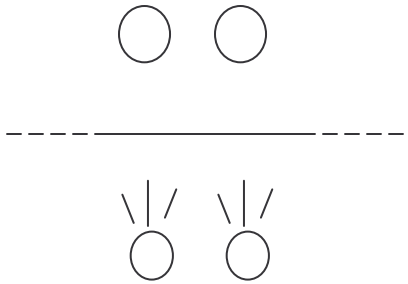


- Sensitive to the amount of light collected
- The direction of motion is not measured

Two-channel encoder

- 2 channels 90 degrees apart (quadrature signals) allow measuring the direction of motion





Controller

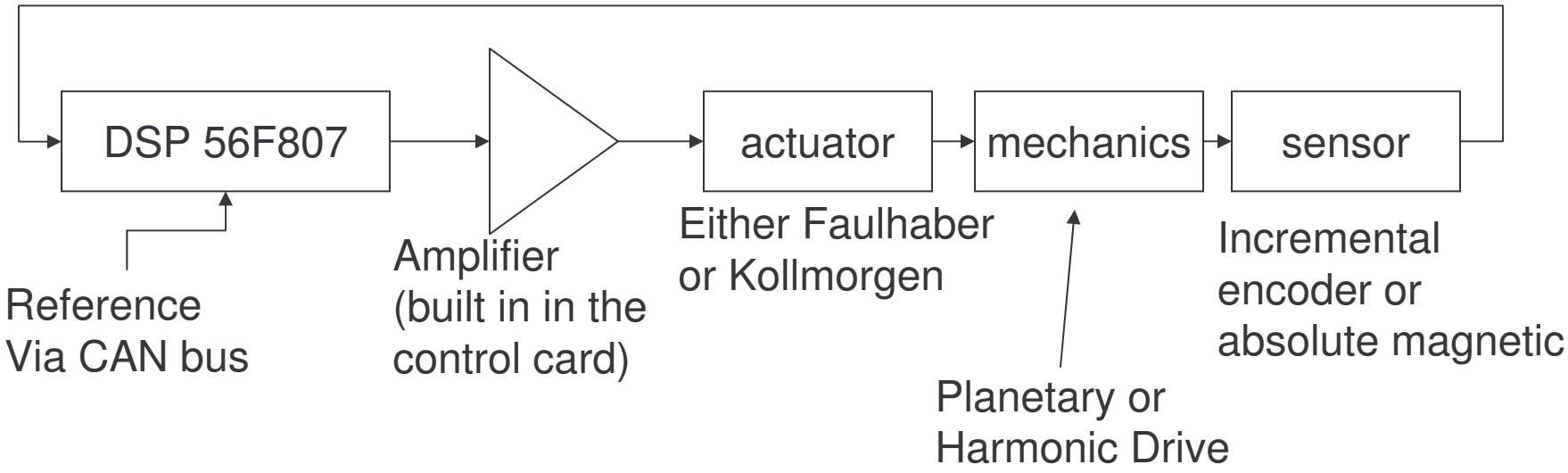
Microprocessors

- Special DSPs for motion control
  - Some are barely programmable (the control law is fixed)
  - Others are general purpose. They are called mixed-mode chips (analog and digital in a single chip)

Example

- DSP 16 bit ALU and instruction set
- PWM generator (simply attach this to either T or H amplifier)
- A/D conversion
- CAN bus, Serial ports, digital I/O
- Encoder counters
- Flash memory and RAM on-board
- Enough of all these to control two motors (either brush- or brushless)

RobotCub


DSP 56F807
actuator
mechanics
sensor
Reference
Via CAN bus
Amplifier
(built in the
control card)
Either Faulhaber
or Kollmorgen
Planetary or
Harmonic Drive
Incremental
encoder or
absolute magnetic