Secondary Control Technology

DC-IA/SET43

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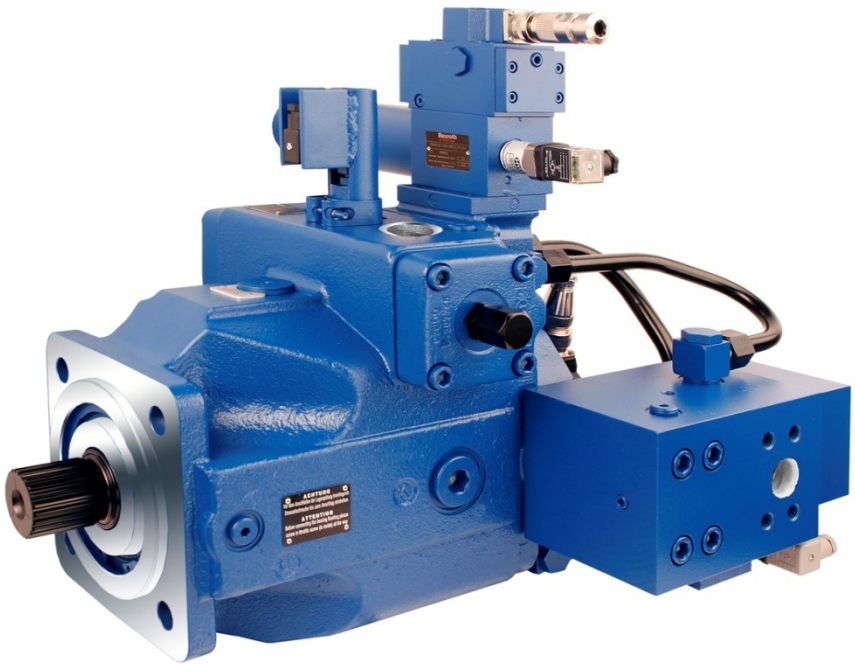
Secondary control technology



- DC-IA/SET43
- Engines and hydrostatic drives

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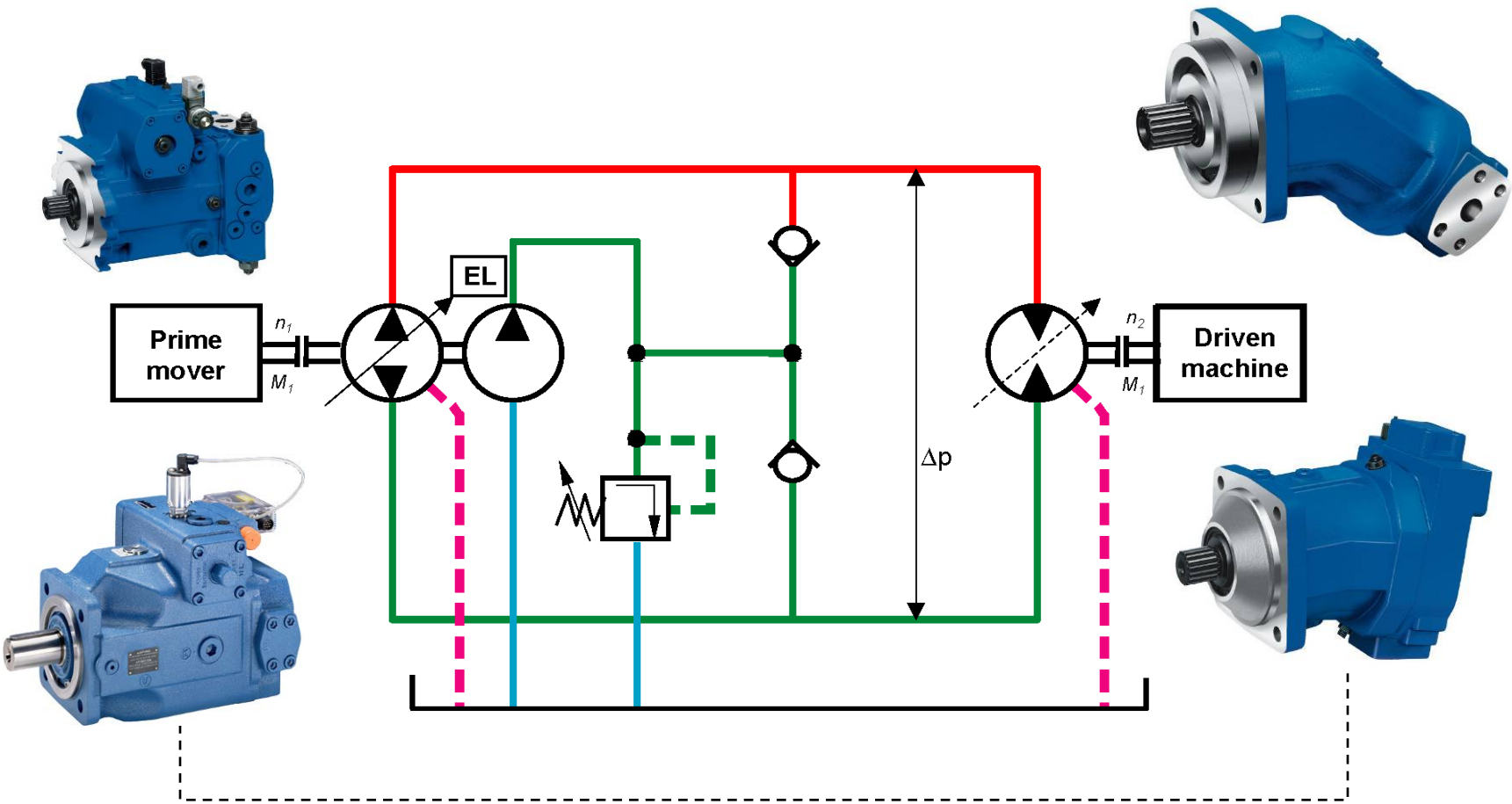
Conventional Hydrostatic Drive With Flow Coupling (Closed Circuit)



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Closed Loop System

Advantages:

- Low installation cost on one axis
- High efficiency
- Few components
- +++

Disadvantages:

- High installation cost on several axes
- Little flexibility
- Low response time
- +++





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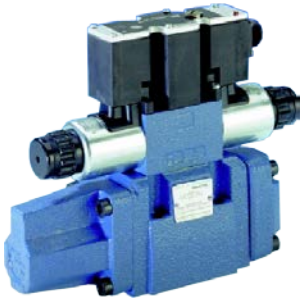
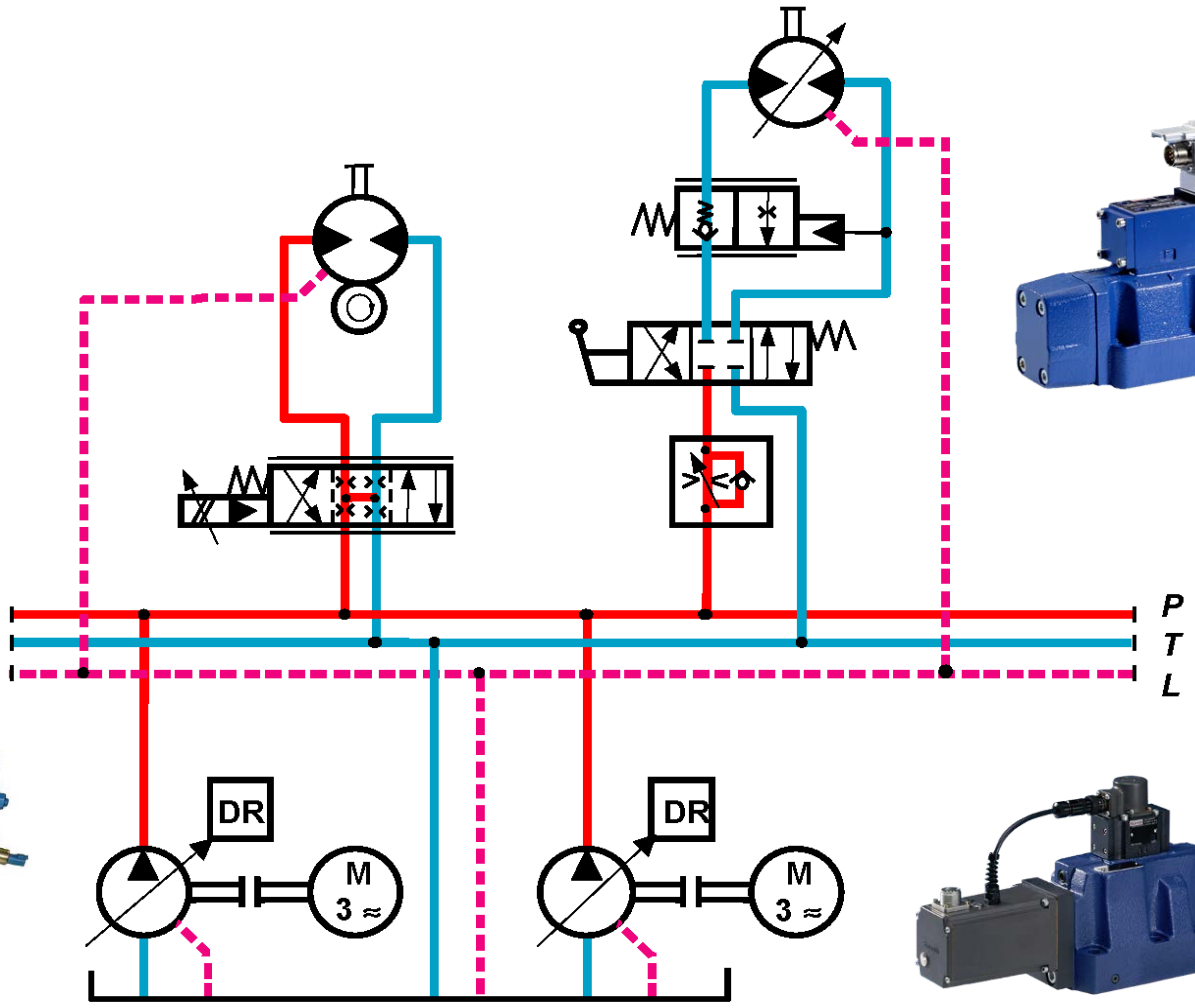
Conventional Hydrostatic Drives In A Constant Pressure Ring Mains Circuit - (Open Circuit)





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Open Loop System

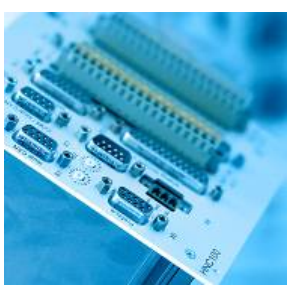
Advantages:

- Low installation cost on several axes
- Wide variety of components
- Fast response time
- High flexibility
- +++

Disadvantages:

- High installation cost on one axis
- Low efficiency
- +++

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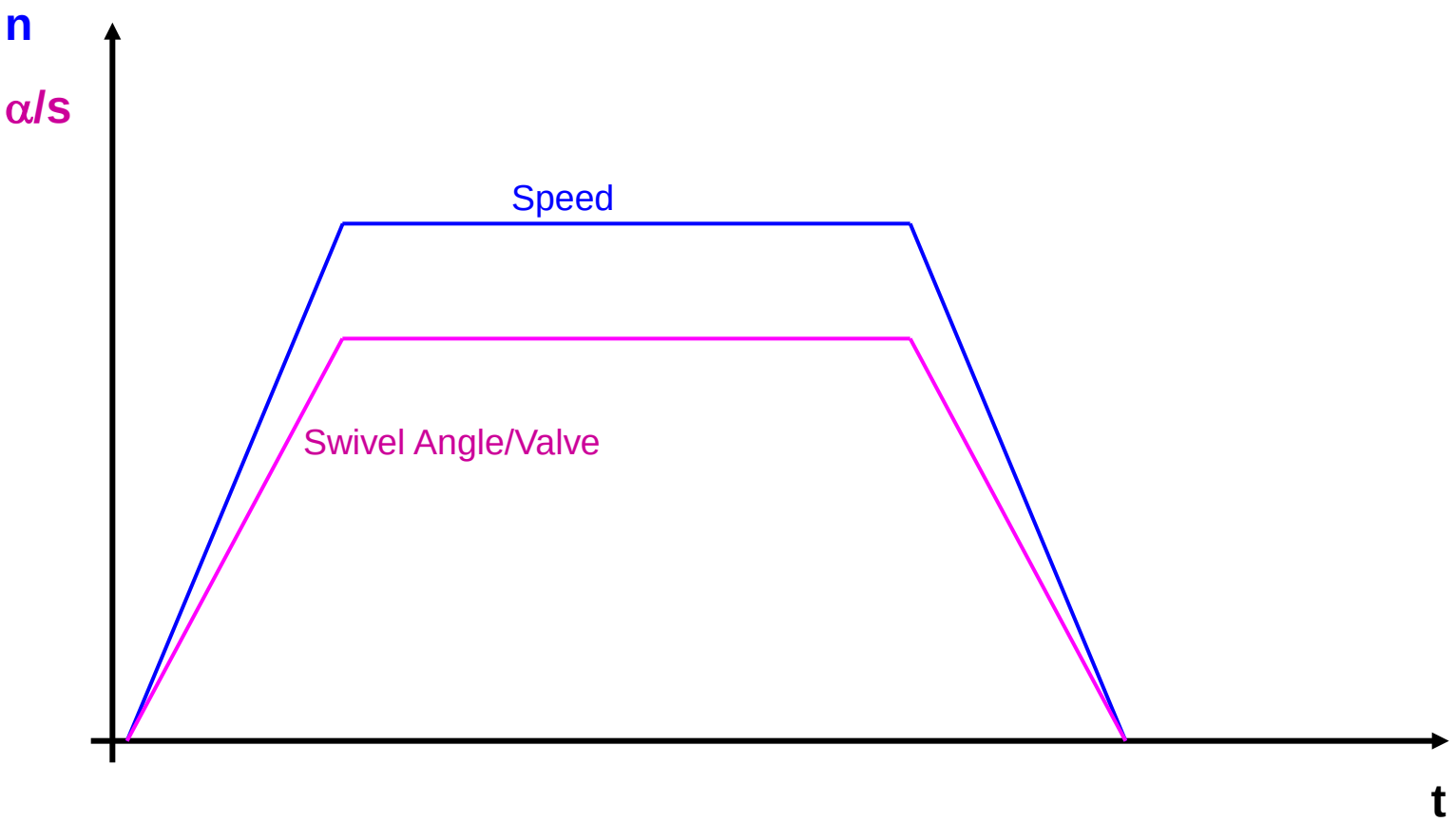
Speed Swivel Angle / Valve Diagram Flow Coupled System



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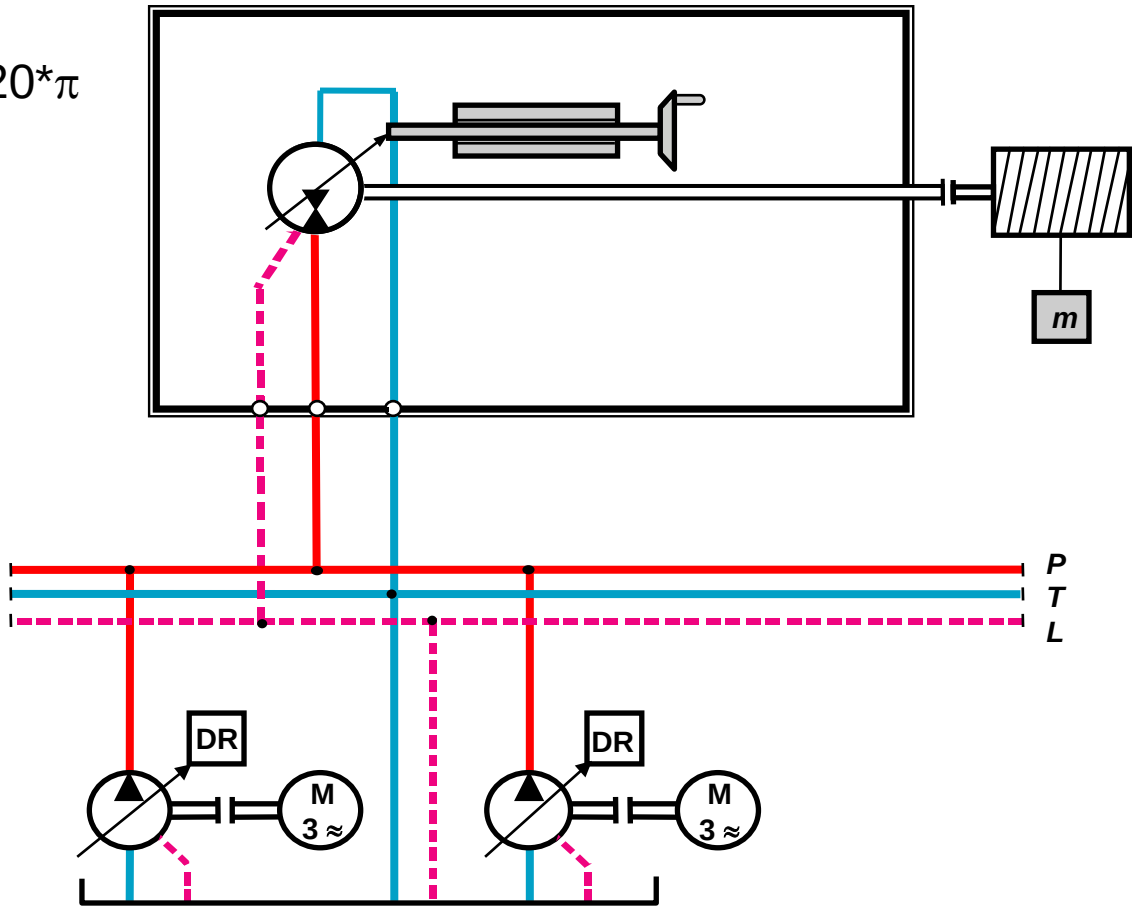
Introduction to secondary control - 1. step

$Md = \alpha * \Delta p / 20 * \pi$



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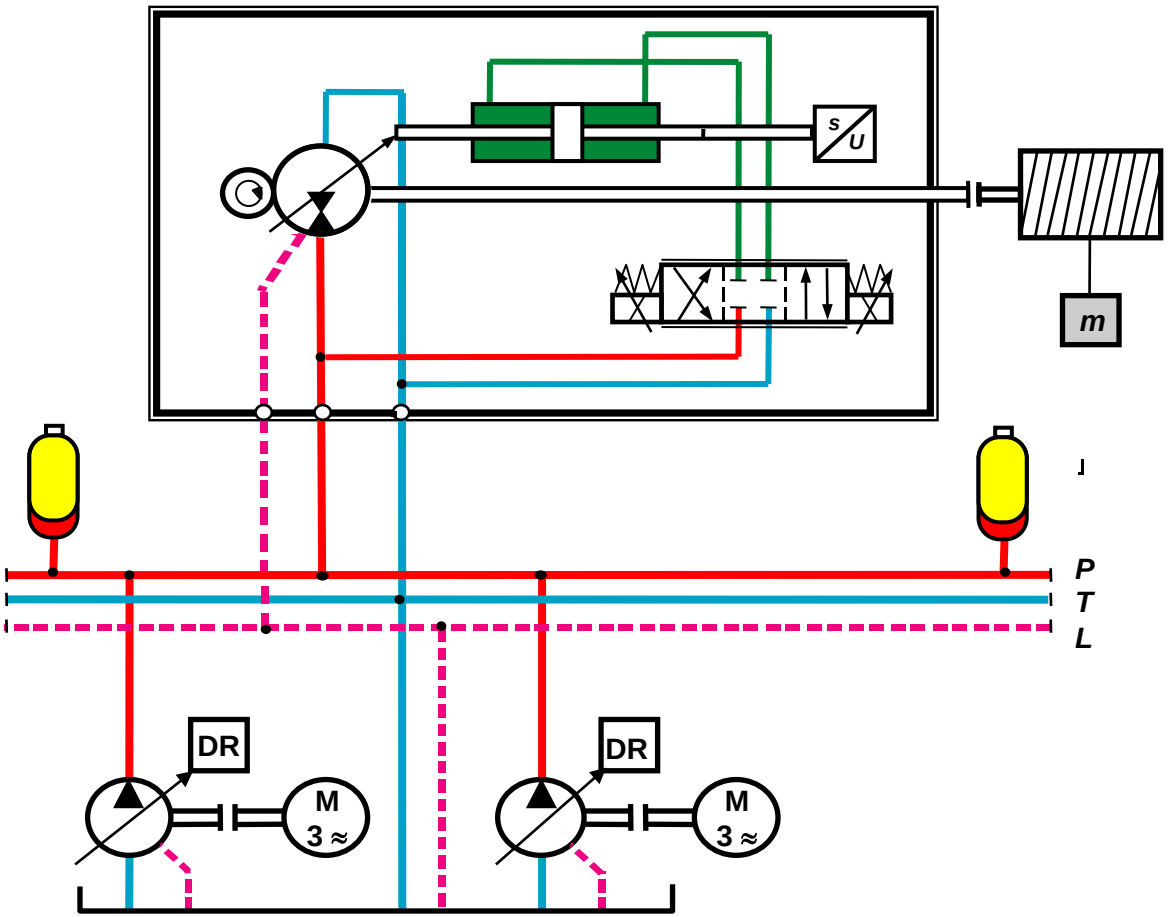
Introduction to secondary control - 2. step



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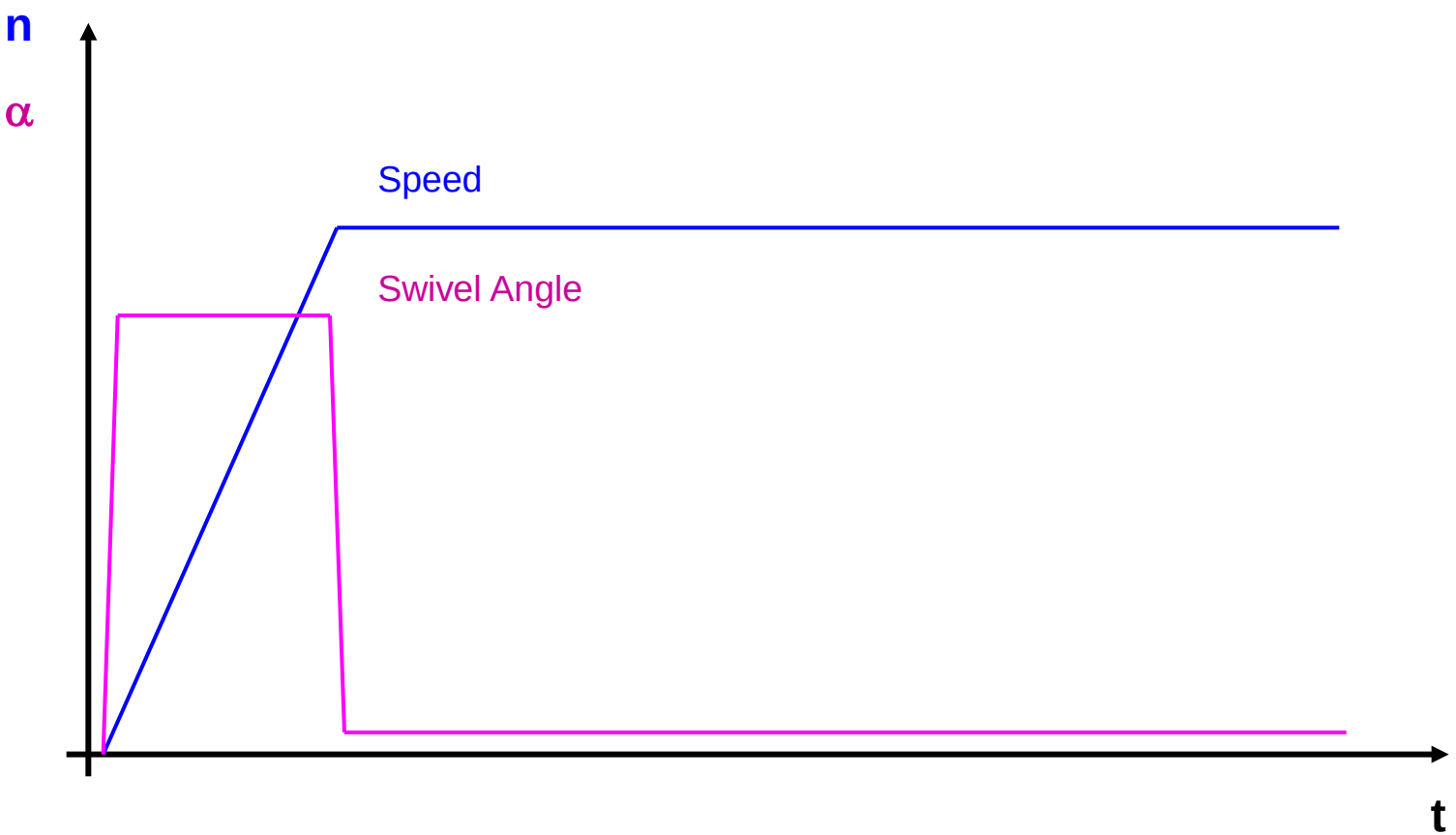
Speed Swivel Angle Diagram Pressure Coupled System Test Bench



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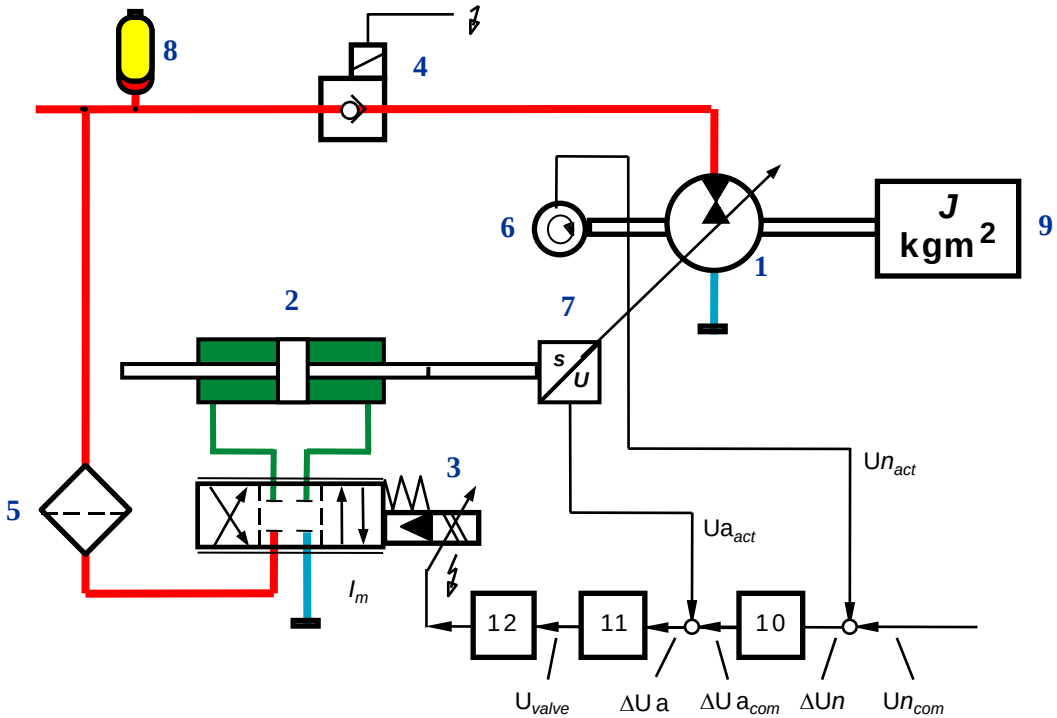
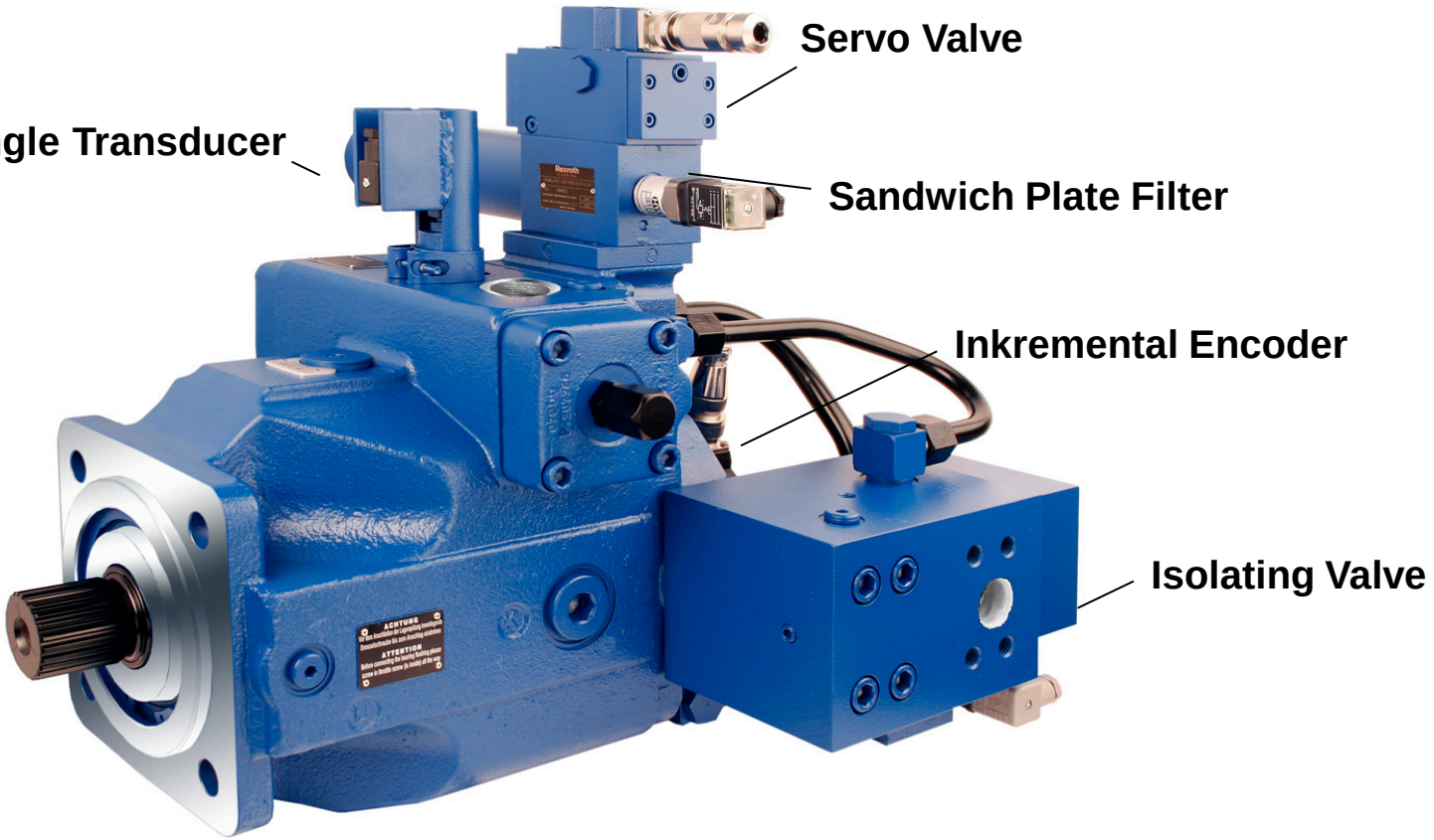
Components for a secondary controlled drive (closed loop velocity control)



1 Secondary unit
2 Control cylinder
3 Servo valve
4 Isolating valve
5 Pressure line filter
6 Incremental encoder
7 Swivel angle transducer
8 Hydraulic accumulator
9 Load
10 Velocity controller
11 Swivel angle controller
12 Control amplifier

Technology of secondary control



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Description of the software functions

- **Available standard software:**
  - Speed control with power limitation
  - Master / slave operation for interconnected use of two or more secondary controlled units
  - Open loop torque control
  - Closed loop torque control

SYHNC100SEK-S3X Two Axis Version

- 4 analogue inputs
- 4 analogue outputs
- Monitoring functions
- Error code transmission
- Up to two axis possible
- Profibus and CAN bus
- Customer specific software possible
- Easy parameter setting with WINPED 6
- Self supported control without PLC
- Top hat rail mounting

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SYHNC100SEK-S3X Four Axis Version

- 8 analogue inputs
- 6 analogue outputs
- Monitoring functions
- Error code transmission
- Up to four axis possible
- Profibus and CAN bus
- Customer specific software possible
- Easy parameter setting with WINPED 6
- Self supported control without PLC
- Top hat rail mounting

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The advantages of using secondary control

- High dynamic of speed and torque
- High accuracy
- Possibility of storage and recovery of energy
- Parallel operation of several consumers without restriction
- Low required space

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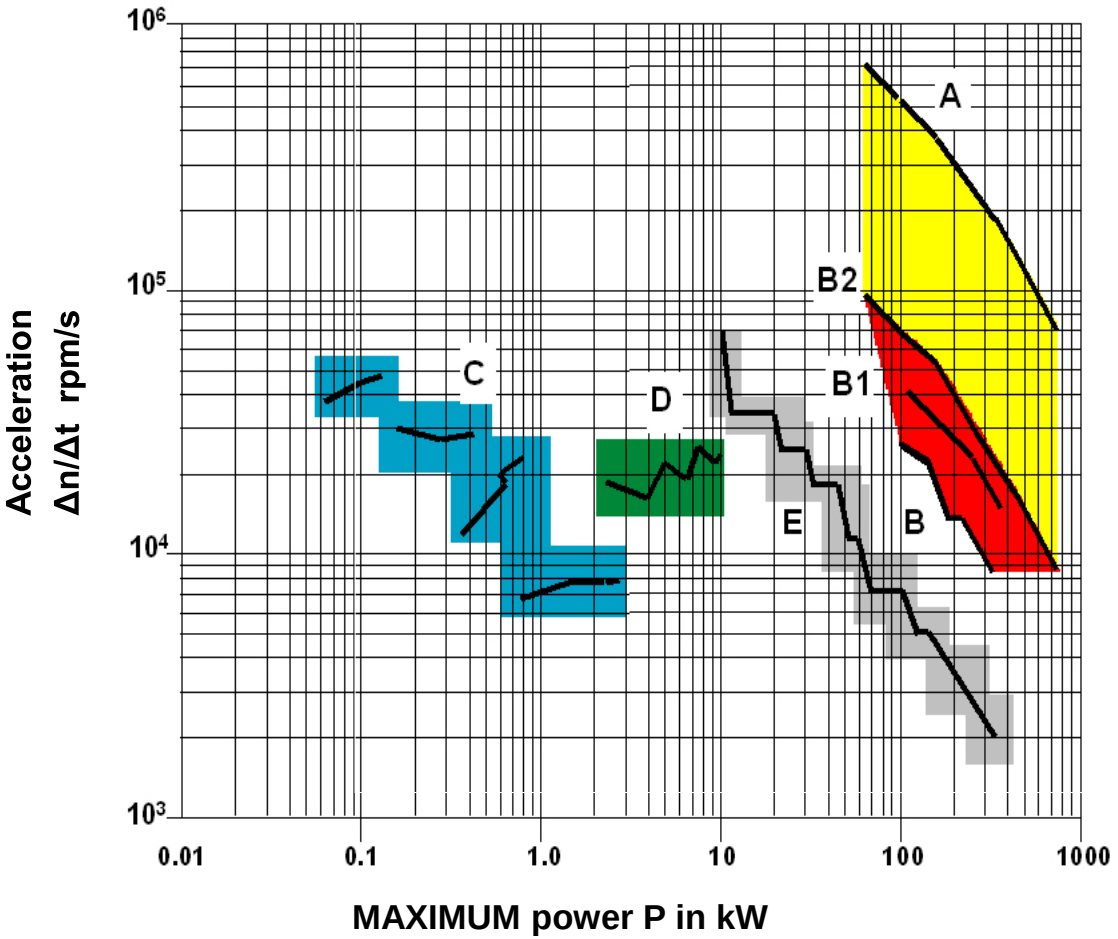
Comparison of the dynamic of the different kinds of motors



A	Hydromotor (theoretical)
B	Hydromotor (A4V...EL - 1984)
B1	Hydromotor (A4VS...DS - 1987)
B2	Hydromotor (A4VS...DS1 - 2002)
C	DC Servomotor
D	AC Servomotor
E	AC Motors (frequency controlled - 2002)

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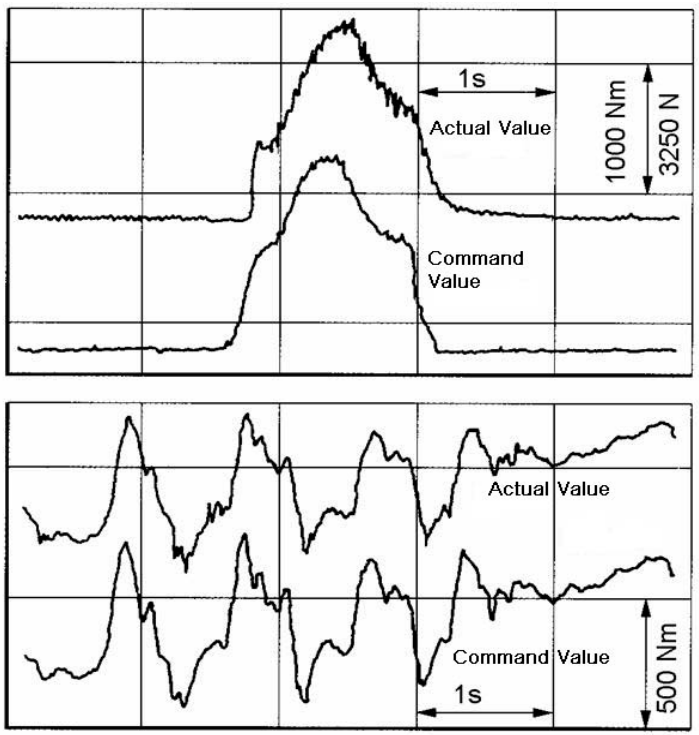
Advantage: high accuracy

- Data acquisition of a tensioning testbench



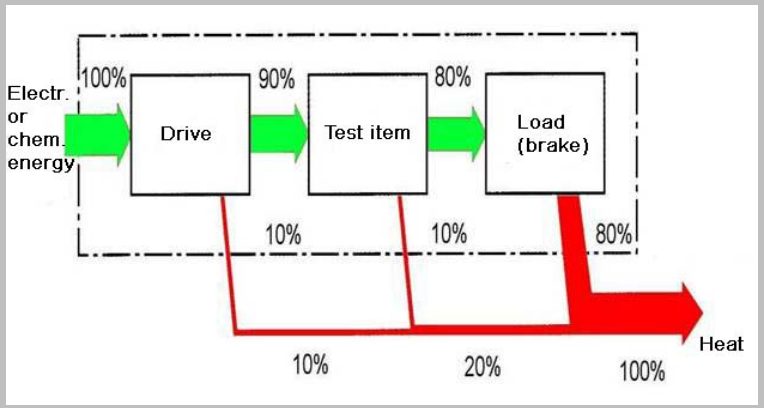
- Achivable Accuracy:

speed control	< 0,1% n_{max}
torque control	< 0,6 % Md_{max}
n_{syn} parallel	< 0,1% n_{max}

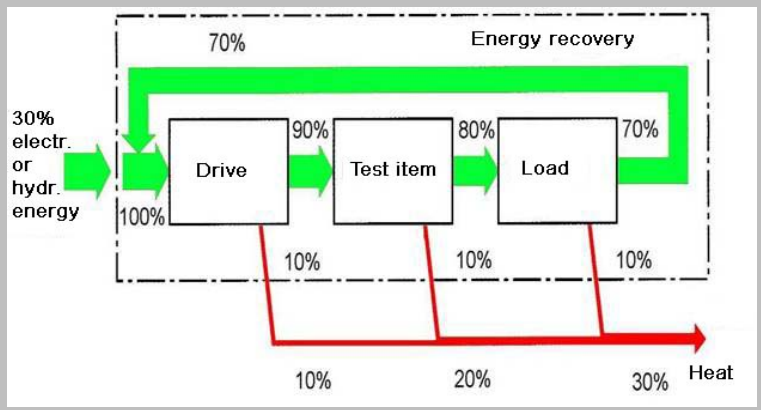
Comparison: Energy balance of the drive systems

- Example: Choice of a suitable test bench concept

- Brake test bench



- Test bench with energy recovery
  - secondary controlled



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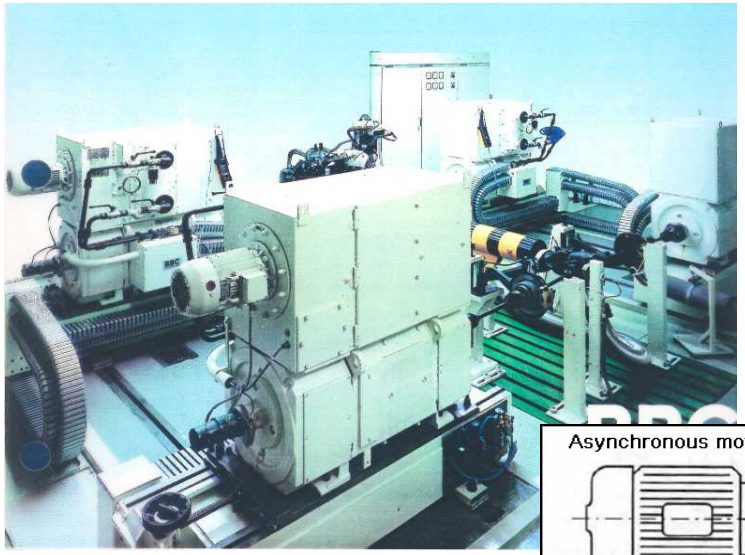
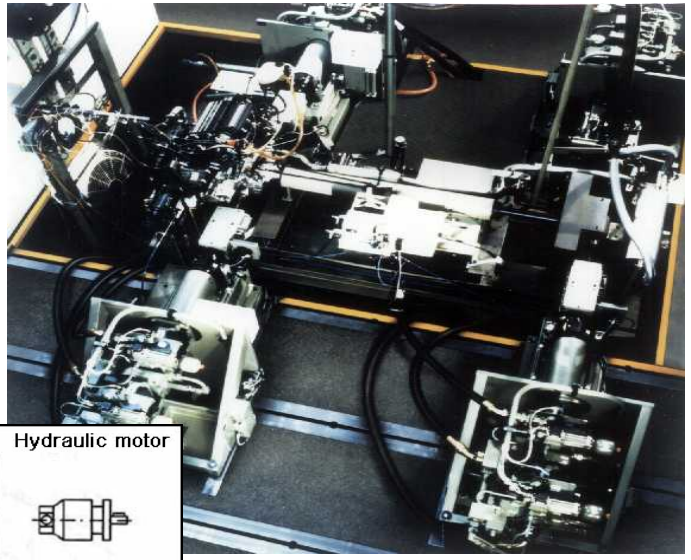
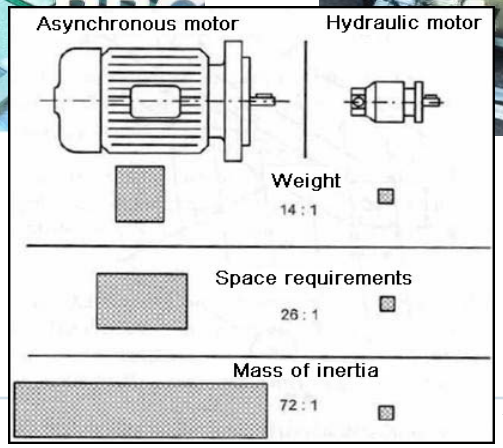
Comparison of the required space/weight for different drives

- 4 - wheel drive test bench:
  - Electric 250 KW
  - Hydraulic 250 KW







+ torque dynamics
- speed dynamics

+ speed dynamics
- torque dynamics

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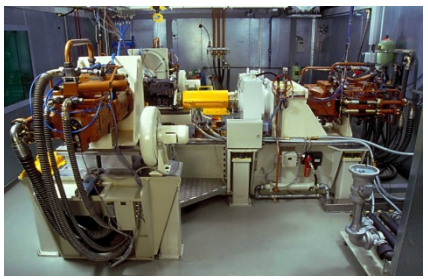
Applications with secondary control

- **More than 3500 secondary controlled axes in different branches in operation:**
  - Ship technology
  - Offshore technology
  - Handling and transport technology
  - Machine tools
  - Test benches
  - Presses
  - Metallurgy



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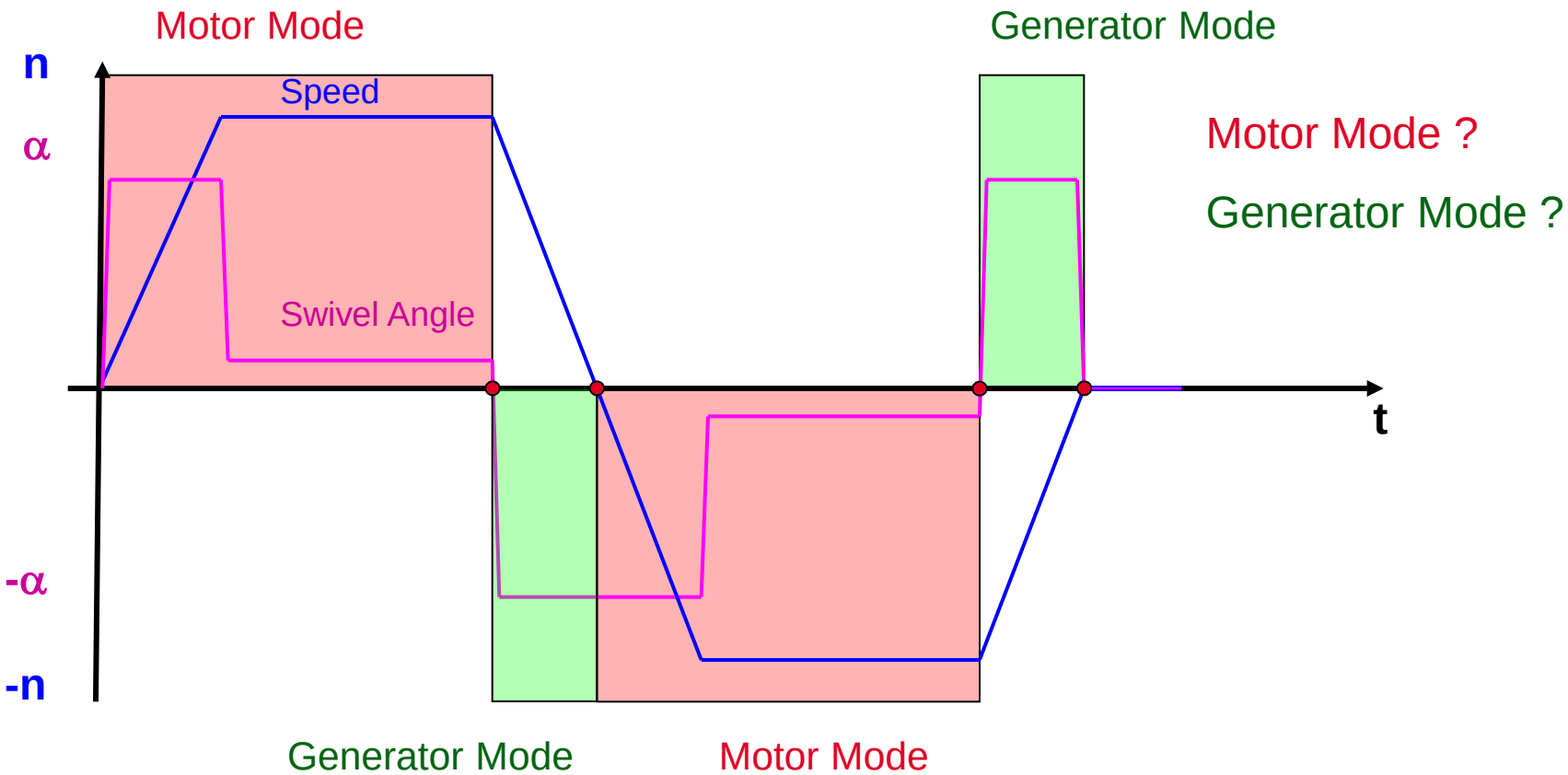
Speed Swivel Angle Diagram Pressure Coupled System Test Bench



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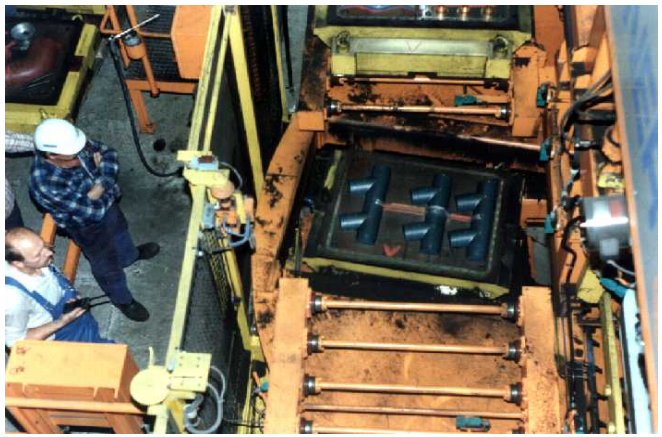
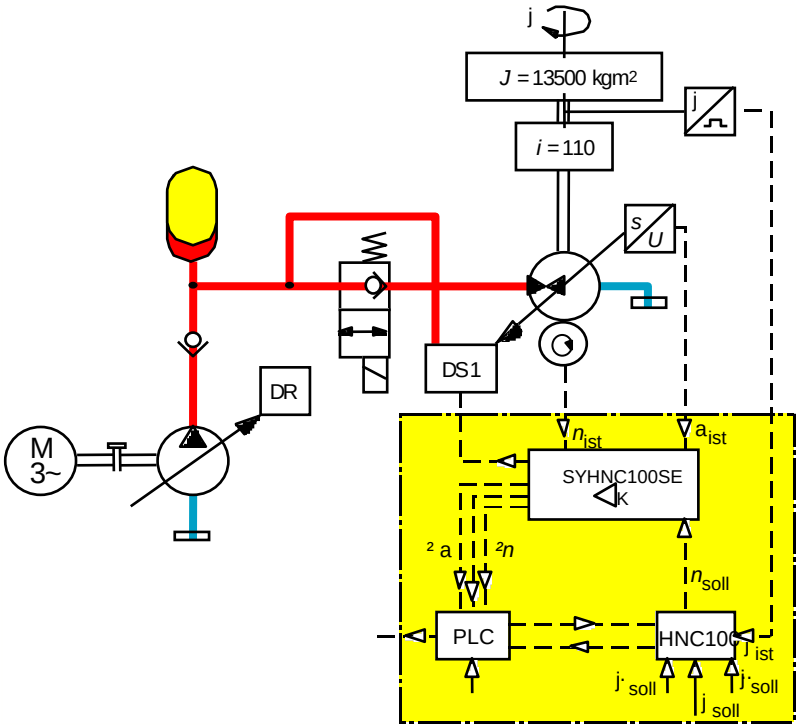
Rotary table for moulding line - drive with energy recovery



- Top view of the rotary table with moulding box



- Installed power: 18,5 kW
- Acceleration power: 80 kW

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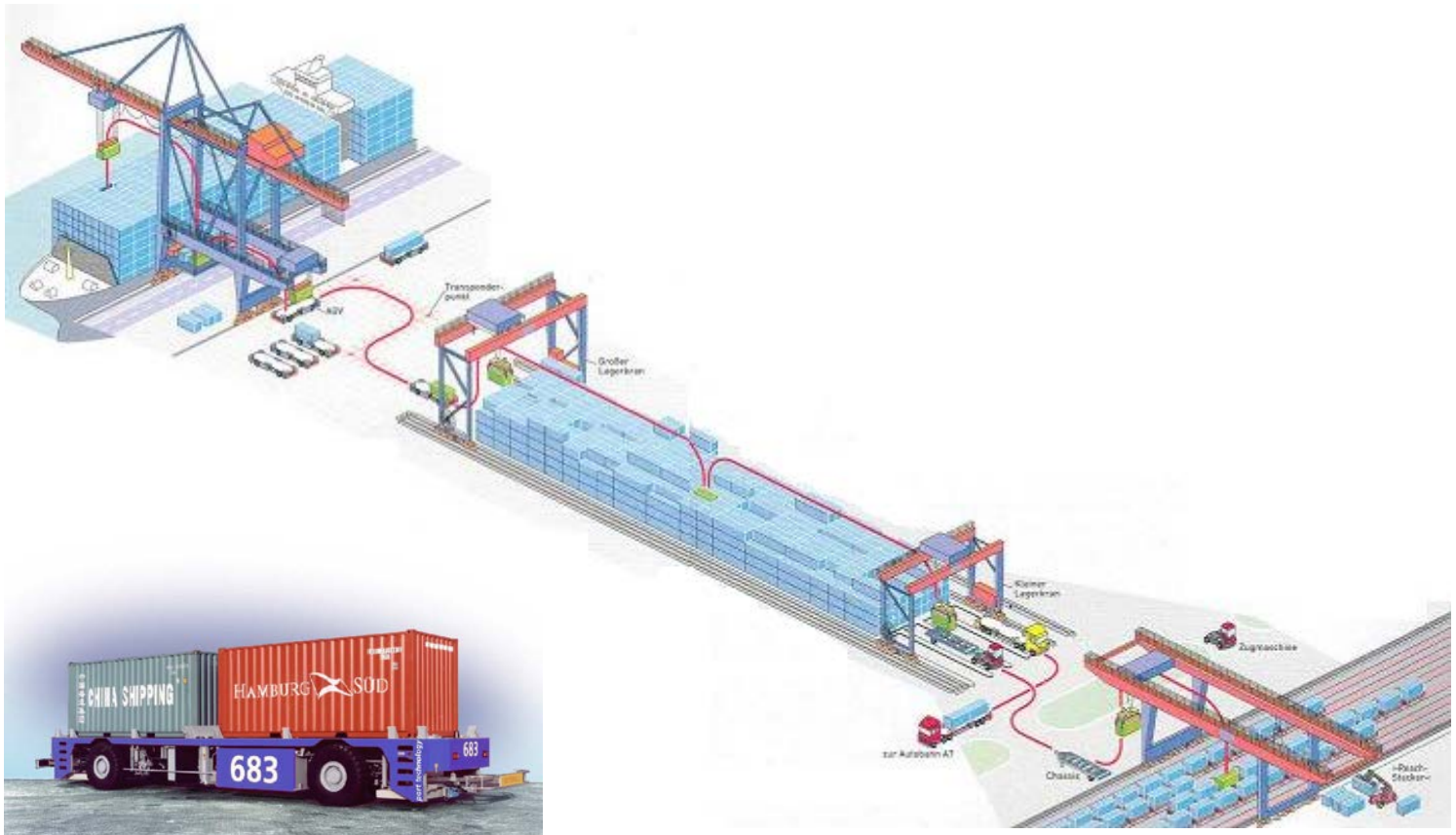
Driverless transport system

- AGV‘s being in operation at the terminals in Rotterdam and Hamburg



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Container terminal Hamburg-Altenwerder

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Pipe laying system

- Pipeline layer „Deep Blue“

- Laying of rigid and flexible pipe from 2” to 16”
- Pipeline length up to 40 km

- Traction capacity : 550 t
- Down to 2500 meter water depth

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Pipe laying system

- Tensioner system
  - Consisting of 2 tensioner units each one with:
    - traction capacity: 275 t
    - 8 pieces of 4VSO500 DS

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Cable laying system for fibre glass communication cable

- Traction force control of underwater plow:

- Operation depth up to 1500 m
- 4 pieces of A4VSO355 DS
- Traction capacity: 130 t
- Prevention against breakaway during the plow is been stuck in the seabed

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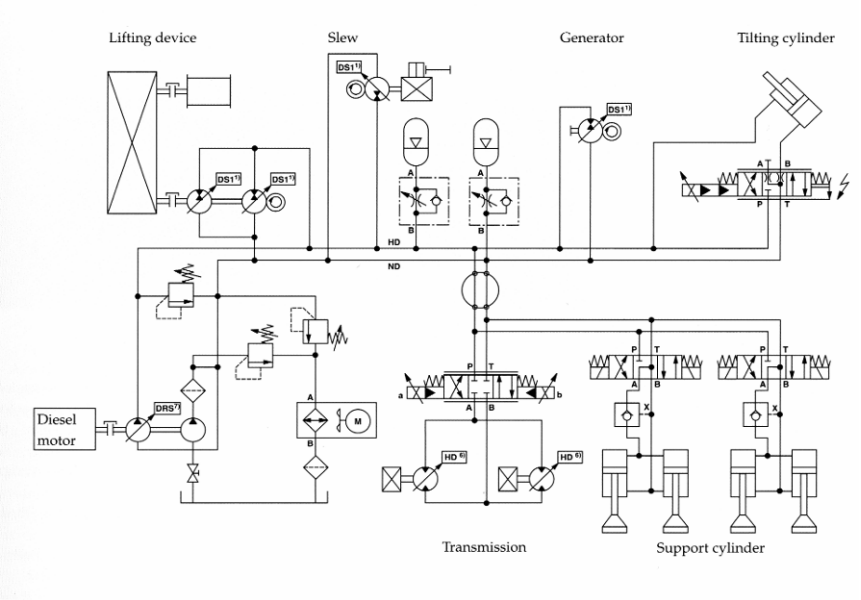
Mobile harbour crane



- Lifting device
- Slew
- Generator
- Tilting cylinder
- Transmission
- Support cylinder

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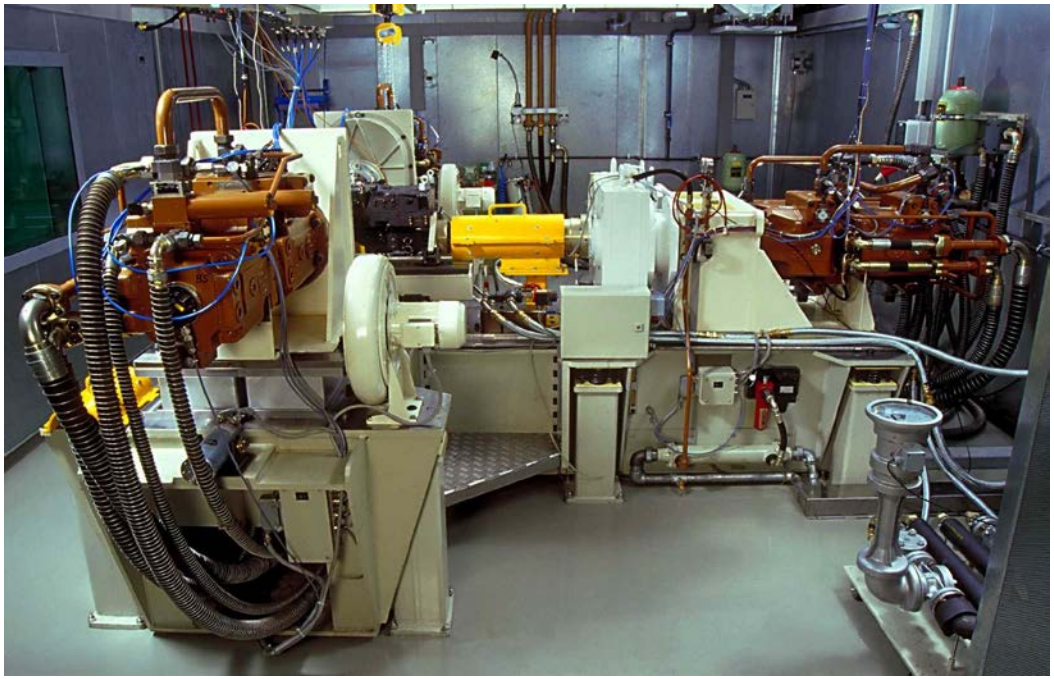
Test bench for rear axle drive

- Four quadrant operation including zero speed and max. torque
- Max. speed gradient of the hydraulic unit 30000 rpm/sec
- Diff. speed between both output drives is capable of changing by approx. 20000 rpm/s
- Torque of both output drives is capable of changing by approx. 50000 Nm/s



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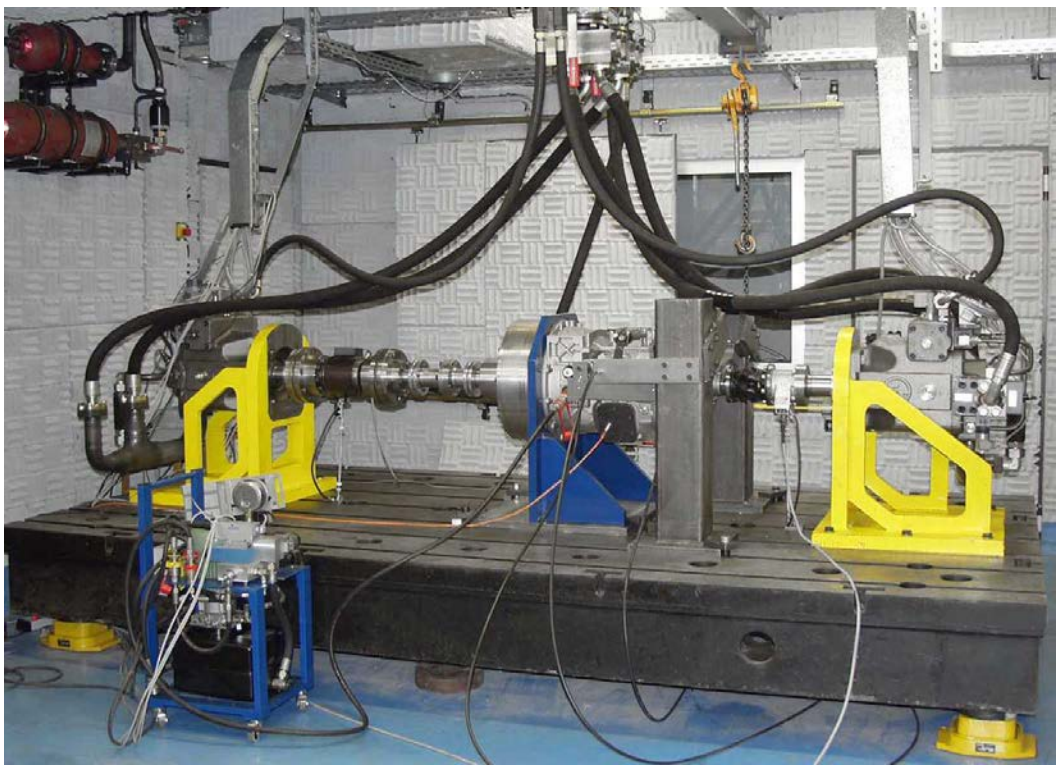
Universal test bench of the IME Aachen

- High dynamic speed control and torque control
- Measurement of the twisting angle
- Feed forward control
- Energy recovery by the load unit



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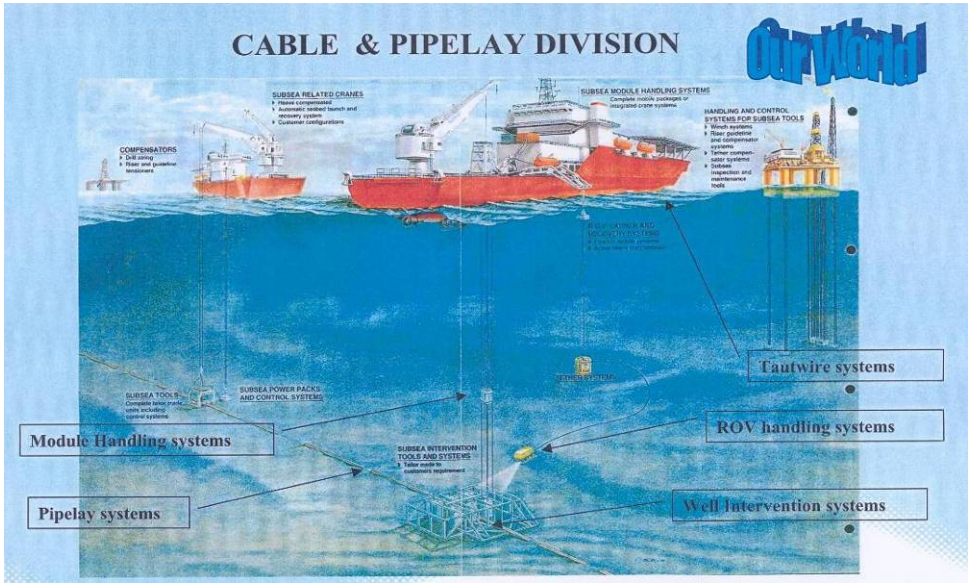
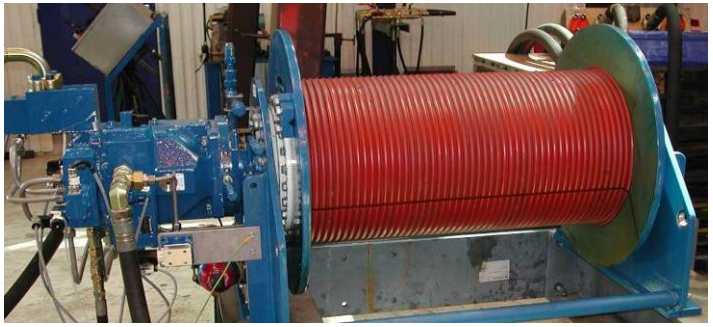
Modul – Handling System

- Moonpool – equipment with four guideway rope winches to deposit modules to the sea bottom.



- Traction force: 5 t
- Speed: 2 m/s

- Closed loop traction force and speed control of 4x A4VSO250DS
- Emergency case: Break away of the rope by controlled overload.



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Universal test bench of the Beijing Institute of Technology

- High dynamic speed control and torque control
- Be in use in Beijing since 1996
- Adaption and configuration of new test conditions by the University themselves
- Energy recovery by the load unit

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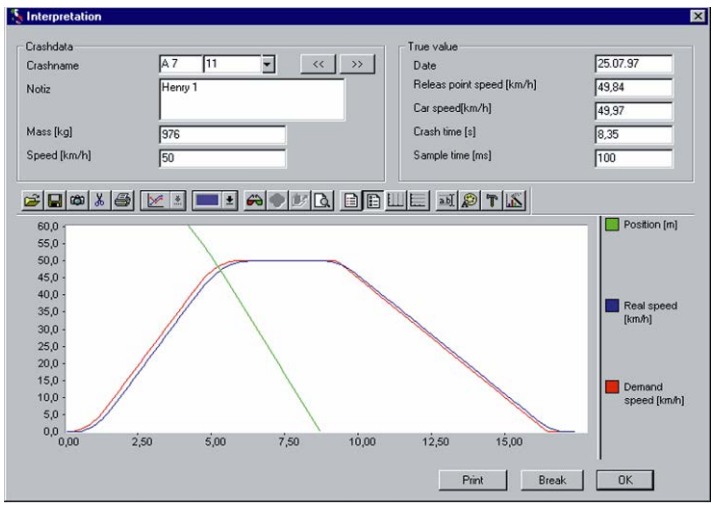
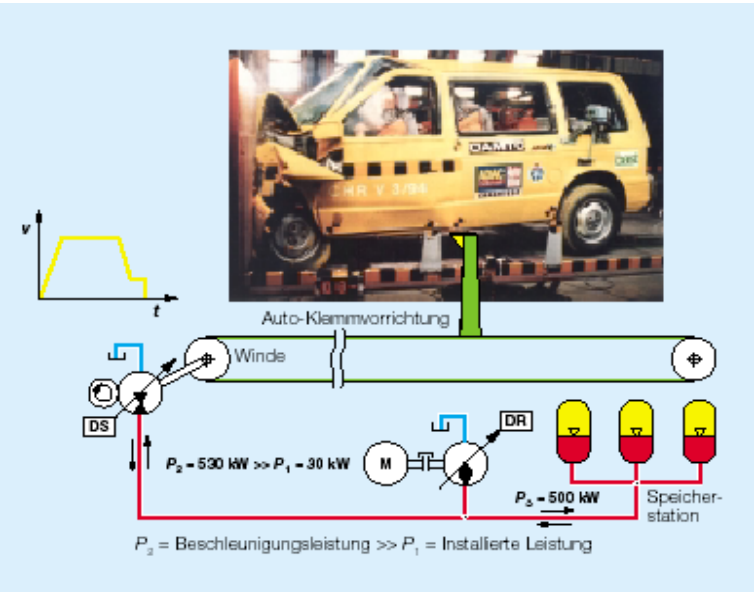
Real crash test bench

- Exact following of the command speed profile
- Speed accuracy < 0,3 Km/h
- Energy recovery
- Limitation of the primary power





- Acceleration power : 530 kW
- Installed power: 30 kW

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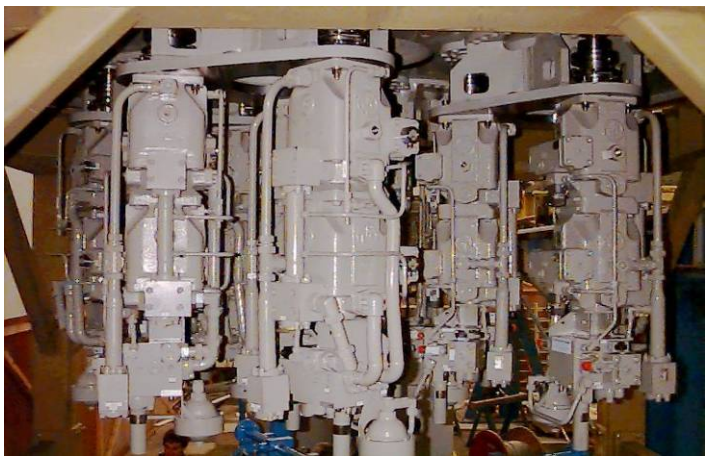
Centrifugal test bench

- Centrifugal force simulation for pilot- and astronaut training
- Tests of space equipment up to 30 g possible
- 60% Energy recovering
- Limitation of the primary power



- Mass of inertia: 350000 kgm^2
- 24 pieces of A4VSO250DS1
- Primary power: 2∗ 400 kW
- Acceleration power: 3000 kW

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Rim spinning machine

- Spinning roll technology:
  - Chipless metal forming of rotationally symmetric hollow items
  - Material compression and homogenous grain structure of the basic material
  - optimum strength values
  - lower weight of the manufactured part

- Reduction of the production line from 4 to 3 machines with the same batch size
- Reduction of the installed power to only 160 kW. Required acceleration power with conventional hydraulic drive: 383 kW
- Energy recovery during the deceleration process

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Tug boat

- Bow Thruster Drive

  - 300 kW installed power
  - Retrofit project with integration in an existing hydraulic system
  - Independend parallel operation with other drive systems
  - Cost efficient solution to conventionell bow thruster drives
  - Maximum utilization of the primary station by the power limitation of the secondary controlled system.

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Test Bench Technology

- Universal Test Bench

  - 160 kW installed power
  - Energy Recovery up to 60%
  - Flexible configuration allows different test possibilities

  - The versitale configuration possibilities allow tests to be carried from component tests up to efficency measurement tests of complete systems

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Centrifugal test bench drive

- Geocentrifuge
  - Acceleration up to 300g
  - n_{max} = 220 rpm (ca. 500km/h)
  - Retrofit Project
  - Lengh of the centrifuge arm 6 m
  - Vacuum centrifugal chamber
  - 2 * 200 KW acceleration power
  - 3,5 t pay load by 2 t container weight

- Due to the acceleration of 300g, the soil sample is compressed. The model test of the soil resistance can be reduced by a factor of 300 times.

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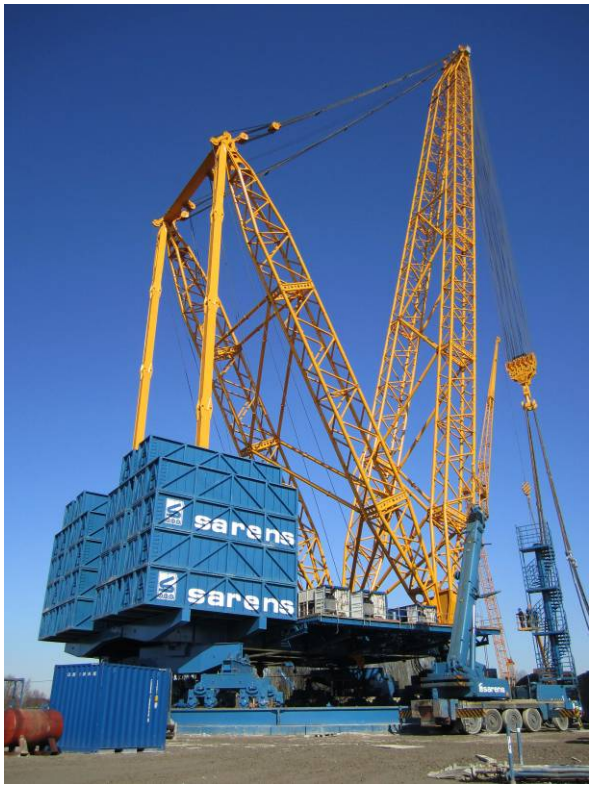
23. Mobilcrane

- Mobilcrane

Movie

  - Secondary controlled lifting and slewing device
  - Boom length up to 220m (up to 180m height)
  - Ring diameter slewing device = 40 m
  - 3200 t payload
  - 20 m/min lifting speed
  - Up to 6 HPU modules a 2 * 280 kW Diesel



- The operation radius can range up to 130 m. At 100 m operation radius loads can be lifted > 600 t.

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Fan of secondary control

Rail Milling Machine

- Drive System
- Secondary controlled drive of two milling wagons
- Synchronisation of 4 chassis with 8 secondary controlled units
- Traction control over 66 m train length with 300 t total weight
- At 0,3 – 2 km/h from 0,3 up to 10 mm milling depth

Milling Wheel Diameter 1,4 m

- Absolute constant speed is neccessary for the planing of the rail profile. According to the rail condition normally 0,3..0,6 mm will be removed by milling. Service life of the 500 milling plates 1..6 km. Change time of the milling plates of the milling wheel 10 min.

Backakter

- Harbour Dredging
  - Slewing device
  - 5 * A4VSO1000DS1
  - Retrofitproject

- Secondary controlled slewing device replace A2F in a closed circuit

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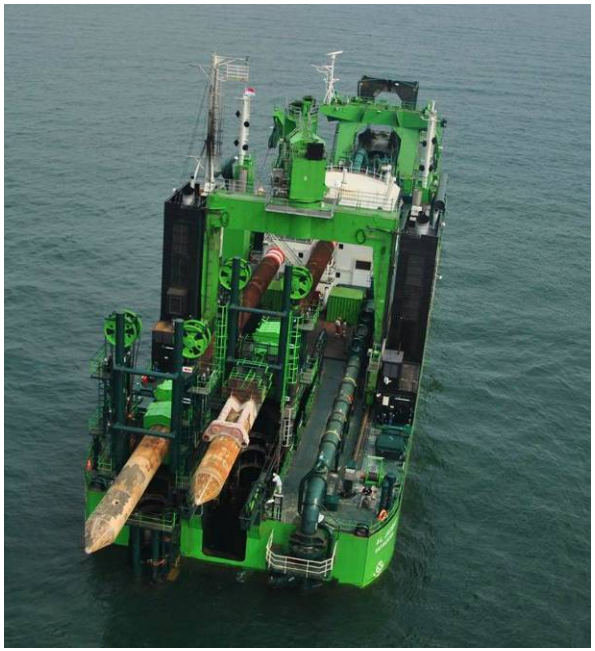
Cutter Dredger

- Milling of waterways
  - Dredging depth 30 m
  - Cutter dredger length 120 m



- 4 Barge mooring winches
- 2 Guy rope winches
- 2 Anchor hoisting winches

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Jack Up Vessel

- Windmill Installation
  - Length legs 92 m
  - 2750t preload / leg
  - 600t crane SWL

- 4 * Positioning winches with secondary controlled drive technology

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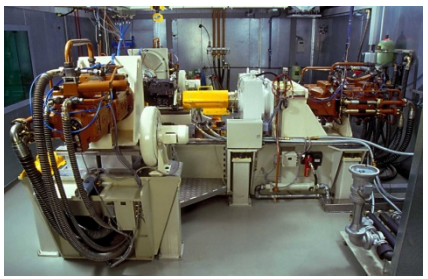
Active Heave Compensation applications with secondary control

- **Secondary controlled axes with AHC functionality in the branches:**
  - Ship technology
  - Offshore technology



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Cranes With Secondary Controlled Drive Systems

- Bosch Rexroth: More than 70 secondary controlled AHC cranes of TTS, Odim, Kenz and DMC in the market.
- Operation fields e.g.:
  - Laying of pipelines
  - Milling of trenches on the seabed
  - Installation of underwater manifolds assemblies
  - Support of submersible vehicles and divers
- Huisman and SMST use also RAHC systems with secondary control in their cranes. Up to now are ca. 250 secondary controlled units in use (2010).

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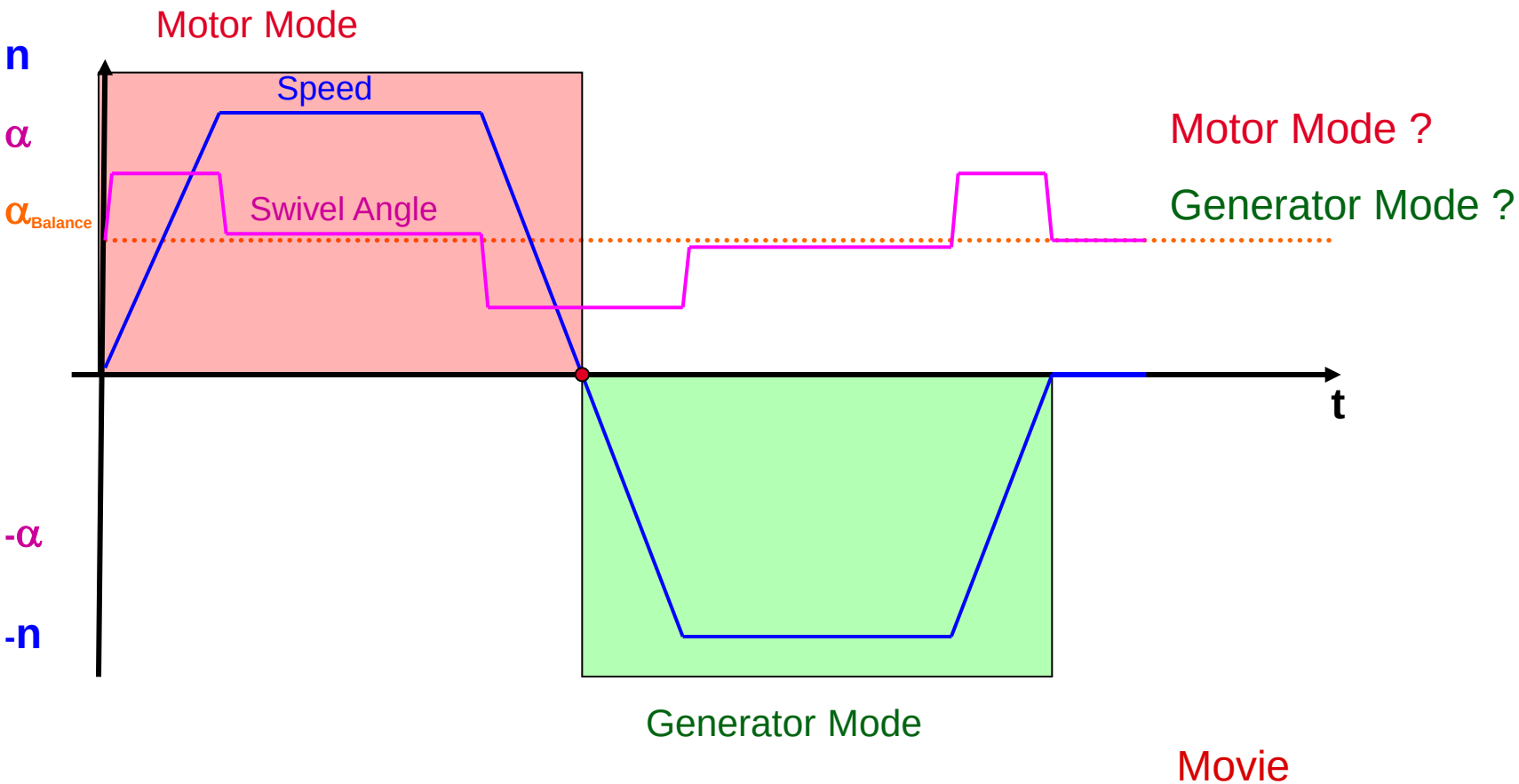
Speed Swivel Angle Diagram Pressure Coupled System Winch



Movie

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AHC Support Crane Oil Drilling Ship

- AHC Offshore Crane
  - Load Capacity 100 t
  - 8*A4VSG 355 Tandem Units

- 1.200 KW installed power
- Integrated MOPS and AOPS function
- Integrated Automatic Slack Protection

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Active heave compensation

- Crane with dynamic heave compensation:

- Compensation values > 90 %
- Traction capacity: 160 t
- Operation depth up to 2100 m
- Combination of conventional hydrostatic drives with 16 motors A6VM200 for lifting function and 2 secondary controlled drives A4VSO500+500DS for the dynamic heave compensation

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CTCU deep water winch

- Use of light and maintenance-free fibre ropes
- Load capacity 50 T in a operation depth > 2500 m
- Compensation of the stretch of the rope via six secondary controlled A4VSO355

Cable Traction Control Unit

Movie

- Installed power 600 kW
- Achievable reduction of the rope weight factor 10 (steel rope) to 1 (fibre rope)

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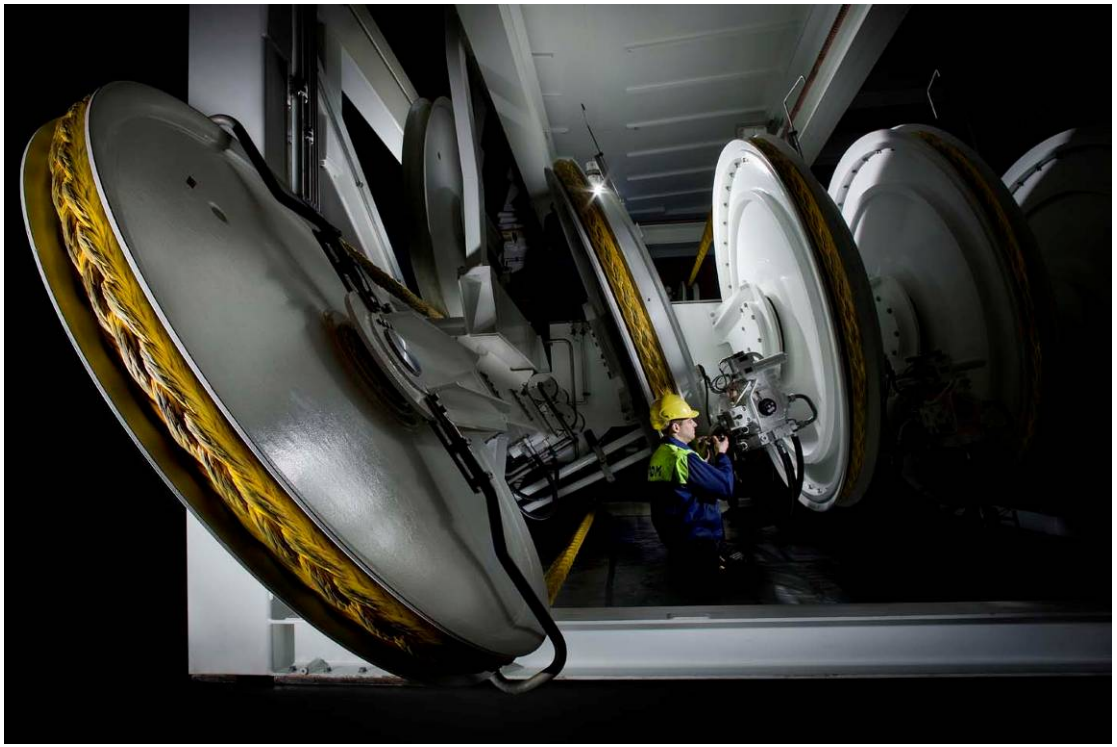
Ship AHC CTCU deep water winch

- Deep Water Winch
  - Use of light and maintenance free fibre ropes
  - Load capacity 125t in a operation depth > 4000 m
  - Compensation of the stretch of the rope via nine A4VSO355DS1 secondary units



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AHC with secondary control

- Rolls Royce Marine deep water crane
  - 3* 125 t cranes

Traditional steel wire vs. Rolls Royce Marine fiber rope crane:

125 t at 3000 m water depth	Fiber	Steel
Hook load at deck:	125 t	125 t
Power consumption	1,4 MW	4,3 MW
Rope weight at 3000m:	2,4 t	142 t
Weight of crane installation:	350 t	590 t

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Stabilized Oil Platform

- Oil Storage Platform

- Heave compensation with integrated overload protection
- Lifting device by secondary controlled drive systems.
- Slewing device combination of conventional A6VM motors with secondary controlled A4VSO units

- Hoisting speed 100m/min
- Load capacity 5t
- Integration of special crane protection software functions in cooperation with the customer

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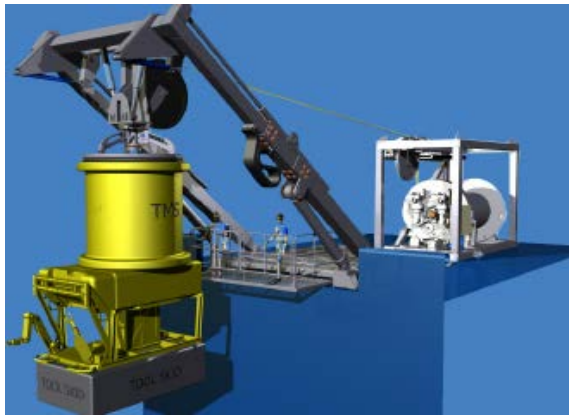
Underwater Robot Winch Drive

- Launch and recovery System

  - Heave compensation with energy recovery
  - Load capacity 20 t
  - Hoisting speed 140 m/min



  - Automatic synchronisation of the support unit with the ROV

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Knuckel Boom Crane

- Heave Compensated Offshore Crane
  - 60 ton on the top layer of the winch
  - +- 3 m wave height with 8 sec wave period
  - Peak power: 2600kW
  - Installed power: 720kW
  - Integrated MOPS and AOPS function

Movie

- 8 cranes with 4 pcs. A4VSO355DS1 and 4 pcs. A2FM355, accumulator, rack and HPU.

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Power classes of RAHC Chapter title

- Standard examples

Winch capacity (t)	5	50	100	250	500
Installed power (kW)	55	480	950	2,350	4,700
Maximum power of winch (kW)	200	1,800	3,600	8,800	17,600
No. of drive units	2	6	12	14	28
Capacity of drive units (cm^3)	71	355	355	1,000	1,000

Wave amplitude: ±3m; Wave period: 9 sec; Hoisting speed: 30 m/min;
Maximum power of winch: AHC mode without additional hoisting movements

AHC Movie 1 AHC Movie 2

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The advantages of using secondary control

- High dynamic of speed and torque
- High accuracy
- Possibility of storage and recovery of energy
- Parallel operation of several consumers without restriction
- Low required space

System solutions of today for your applications of tomorrow