Workshop

TORQUE CONTROL DEMO

Contents

The torque control demo

It is composed of 3 ATV71 drives and 3 motors.
The three motor shafts are mechanically linked by a pulley/notched gear assembly.

The drive V3 (1.5kW) controls the motor M3 (1.5kW)
It serves to test the functions "torque limit" and "torque control"
This also serves as a load for motors M1 and M2, the load level being set by the torque reference.
The energy is dissipated in a braking resistor (which can be disconnected by a contactor).

Drive V1 (1.5kW) controls the speed:
- **either of motor M1 (0.75kW) alone**
- **or M1 and M2 (0.75kW) in parallel**

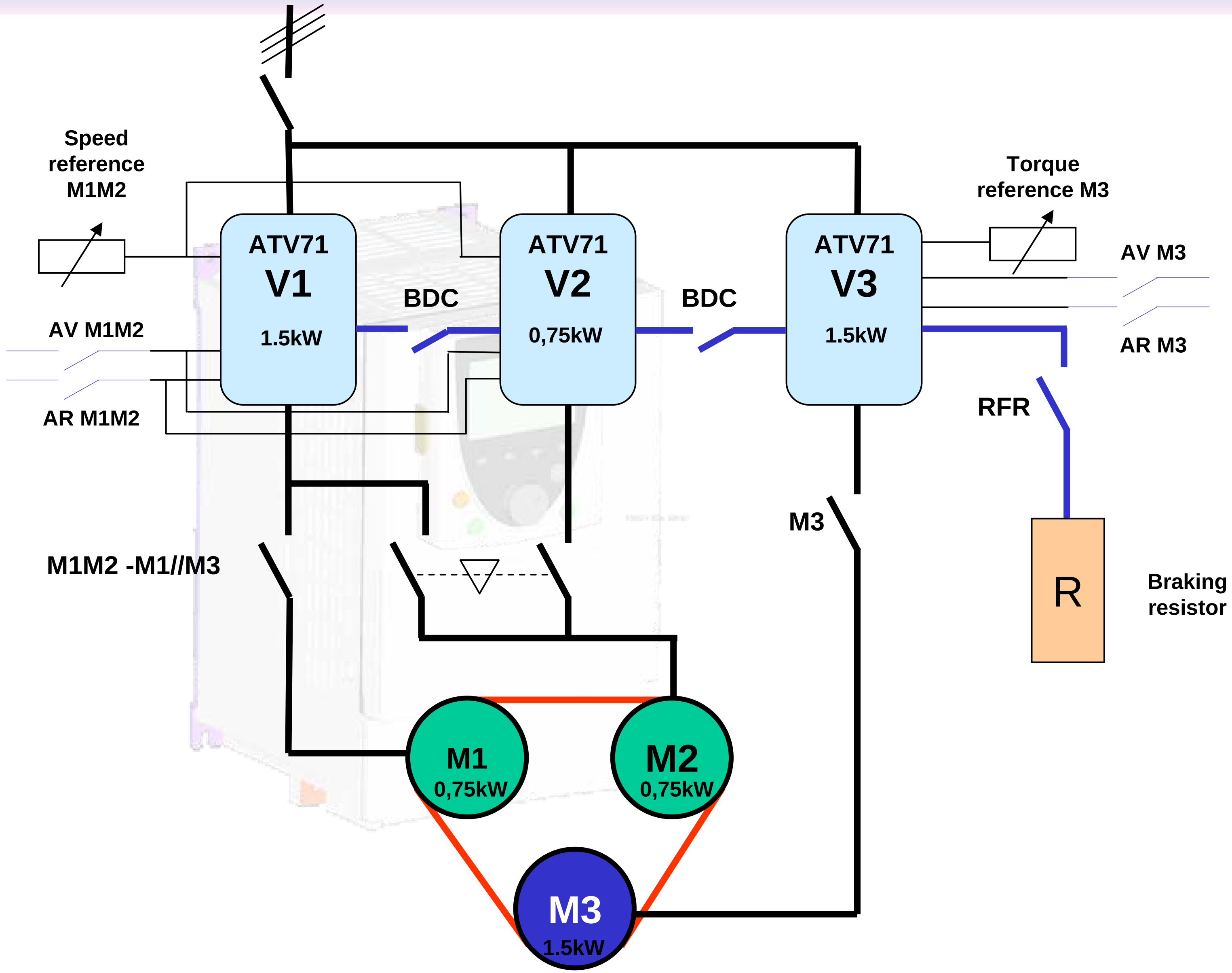
Drive V2 (0.75kW) controls the speed of motor M2 when it is not connected in parallel with M1, or as a torque slave in the master/slave mode.

The M1 and M2 configurations are selected by a switch

Drives V1 and V2 have run commands AV/AR and a common speed reference.

The DC bus can be made common by some contactors.

Presentation



Object

V3 tests torque limit and torque control.

- **Influence of controls**
- **Open or closed loop**
- **Reaction to a torque impulse**
- **Use of the dead band**

V1 and V2 tests the balancing of load :

- **2 motors in parallel on one drive**
- **One drive controls each motor with the following methods :**
  - **suppression of slip compensation**
  - **load balancing function**
  - **master/slave function**

With the entire apparatus, show energy recuperation by establishing a common DC bus.

Preparation of the demo :

1 : Configuration of drive V3 in torque limit

Motor M3 serves as a load for motors M1 and M2
Thus it will work in torque limitation mode in the generating quadrant and the energy will at first be dissipated by a braking resistor.

2 : Configuration of drive V1 in multi-configuration

2 configurations are to be established :
Control of motors M1 and M2 by V1 alone, thus 1.5 kW
Control of motor M1 alone, thus 0.75 kW

3 : Configuration of drive V2

Factory settings for a 0.75 kW motor

Configuration of drive V3

1- Return to factory settings in the Start/stop macro-configuration (Simply start)

2- Enter the motor nameplate data and peform and auto-tuning (Simply start)
- **Motor : 1.5kW, 400V, 50Hz, 3.2A, 1420 rpm**

3- Set the thermal current (ITH) (Set-up)
4- Activate the SVCI motor control law (Motor control)
5- Activate the encoder (Motor Control)
- **Enter the encoder configuration (1024 pt, AABB, monitoring)**
- **Launch the encoder test**

6- Assignment of the inputs/outputs
- **LI1= Forward (Inputs/outputs)**
- **LI2 = Reverse (Inputs/outputs)**
- **AI2 is assigned as speed reference channel 1 as 0-10V (Control)**

7- Activate the torque limit function (Application functions)

- **Activate the function as always active**
- **AI1 is assigned as the torque reference**

8- Deactivate the ramp auto-adaptation function (Ramp function)

Configuration of drive V3

8 – Configure the monitoring screen (Monitoring Screen)

- **Display the speed reference and output frequency on top**
- **In the middle of the screen display the motor torque and the mains voltage**

9 – Activate the switch M3 and the braking resistor switch

10- Start the motor for a test

- **Set the torque reference to maximum (AI1 = M3 torque reference)**
- **Apply a speed reference (AI2 = M3 speed reference)**
- **Activate the M3 forward run command, then the reverse run command**
- **Verify the operation of the torque reference (reduce it until the motor stops)**

11- Create a user menu named V3 (config display)
With the following parameters :

12- Save the configuration in file 1 of the graphic terminal

Configuration of drive V1

1- Return to factory settings in the Start/stop macro-configuration (Simply start)

2- Activate the Multi-motor/conf function (Application functions)
- Assign LI6 (switch M1M2 - M1//M2) to the switching of 2 motors

3- Position the switch to M1 M2 (1 drive for each motor)

M1M2 - M1//M2

3- Enter the motor nameplate data and perform and auto-tuning (Simply start)
- Motor : 0.75kW, 400V, 50Hz, 1.6A, 1410 rpm

4- Set current limit to 2In (Set-up)

5- Set the thermal current (ITH) (Set-up)
6- Activate the SVCI motor control law (Motor control)
7- Activate the encoder (Motor control)
- Enter the encoder configuration (1024 pt, AABB, monitoring)
- Launch the encoder test

8- Assign the inputs/outputs
- LI1= Forward (Inputs/outputs)
- LI2 = Reverse (Inputs/outputs)
- AI1 is assigned as Channel 1 0-10V speed reference (Control)

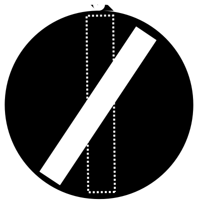
9- Deactivate the ramp auto-adaptation function (Application function – ramp)

Configuration of drive V1

10 – Configure the monitoring screen (Monitoring screen)
- Display the active configuration and the speed reference on top
- Display the motor torque and the mains voltage in the center of the screen

11- Position the switch to M1//M2 (1 drive for 2 motors)
(conf 1 must be displayed at the top of the display to the left)

M1M2 - M1//M2



12 – Enter the nameplate information for 2 0.75kW motors and perform an auto-tuning(Simply start)
- Motor : 1.5kW (2x0.75), 400V, 50Hz, 3.2A (2x1.6A), 1410 rpm

13- Set current limit to 2In (Set-up)

14- Set the thermal current (Set-up)

15- Start the motors for a test
- apply a speed reference (Speed reference M1 M2)
- activate the run forward M1 M2 then the run reverse

16- Create a user menu named V1 (Config display) with the following parameters :
- *Slip compensation,*
- *IR compensation*
- *Acceleration, Deceleration*
- *Type of motor control*
- *Load balancing, load correction*

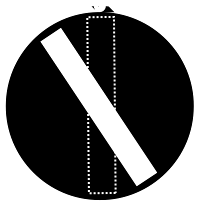
17- Save the configuration as file 1 of the graphic terminal

Configuration of drive V2

1- Return to factory settings in the Start/stop macro-configuration (Simply start)

2- Position the switch to M1 M2 (1 drive for each motor)

M1M2 - M1//M2



3- Enter the motor nameplate data and perform an auto-tuning (Simply start)
- Motor : 0.75kW, 400V, 50Hz, 1.6A, 1410 rpm

4- Set current limit to 2In (Set-up)

5- Set the thermal current (ITH) (Set-up)
6- Activate the SVCI motor control law (Motor control)
7- Activate the encoder (Motor control)
- Enter the encoder configuration (1024 pt, AABB, monitoring)
- Launch the encoder test

8- Assign the inputs/outputs
- LI1= Forward (Inputs/outputs)
- LI2 = Reverse (Inputs/outputs)
- LI3 = Free wheel stop (Application functions)
- AI1 is assigned as a 0-10V Channel 1 speed reference (Control)

9- Deactivate the ramp autoadaptation function (Application function - ramp)

Configuration of drive V2

10 - Configure the monitoring screen (Monitor - screen)

- **Dispaly the speed reference and active configuration on top**
- **Display motor torque and mains voltage in the center of the screen**

11- Create a user menu named V2 (Display configuration) with the following parameters :

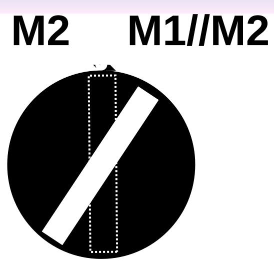
- ***Slip compensation,***
- ***IR compensation***
- ***Acceleration, Deceleration***
- ***Type of motor control***
- ***Load balancing***
- ***Load correction***

17- Save the configuration in file 1 of the graphic terminal

18- Test the configurations

- **Apply a reference to AI1**
- **Test the motors independently with V1-V2 -> Switch at M1M2**
- **Run Forward and Run Reverse**
- **Test the motors in // with V1 -> Switch at M1//M2**
- **Run Forward and Run Reverse**

Test M1//M2 controlled by V1



Switch in position M1//M2

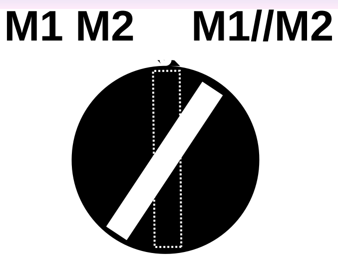
Give a Forward Run command and a speed reference of 20 Hz to M1/M2

Give a Reverse Run command and a speed reference of 10 Hz to M3

Progressively increase the torque reference of M3 and observe the increase of current in drive V1.

Rapidly change the torque and observe the reaction of the motor M1/M2.

Test without load balancing



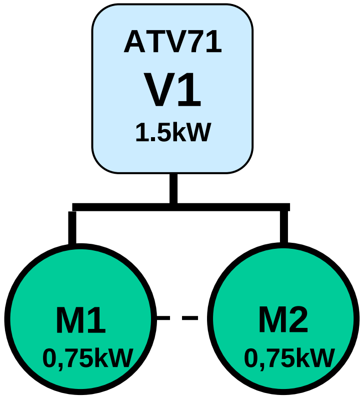
Switch in position M1//M2

Give a Forward Run command and a speed reference of 20 Hz to M1/M2

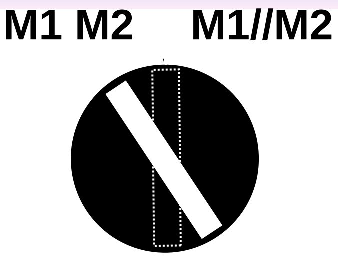
Give a Reverse Run command and a speed reference of 10 Hz to M3 and a torque reference (around 3 A)

Observe the current in the motors M1 and M2 with a clamp-on current probe

Conclusion:
Unbalanced currents, thus unbalanced torques



Test without load balancing

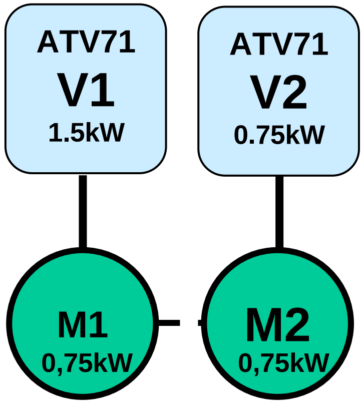


Switch in position M1M2

Give a Run Forward command an a speed reference of 20 Hz to M1/M2

Give a Run Reverse command and a speed reference of 10 Hz to M3 and a torque reference (around 3 A)

Observe the Bus voltages through the line voltage view of the DC bus and the torque on drives V1-V2.



Conclusion:
Strong imbalance of torques and bus voltages
One of the motors operates in the generating quadrant
Solution not usable

Balancing by slip compensation

Switch in position M1M2

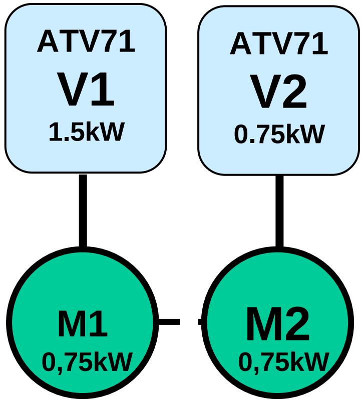
On drives V1 and V2

Menu **MOTOR CONTROL**
Slip compensation = 0

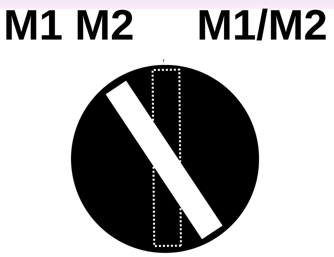
Forward Run command and speed reference (20 Hz) on M1/M2

Reverse Run command and speed reference (10 Hz) on M3

Observe the torque and mains voltage of drives V1 and V2.
Observe the motor speed compared to the reference.



Conclusion:
Good balance of torque and bus voltages
The speed precision is mediocre
The reaction of the speed loop is weak (lethargic)

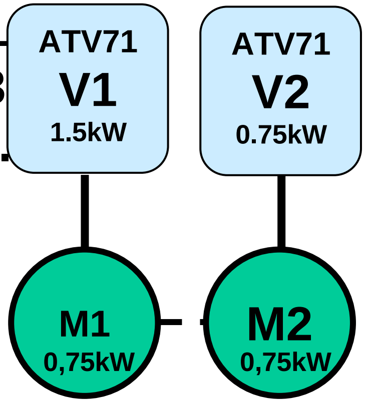


Switch in position M1M2

Menu MOTOR CONTROL
Slip Compensation = 100%
Load balancing function (LbA = Yes)

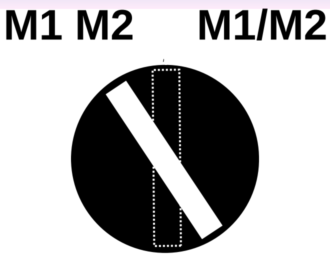
Menu ACCESS LEVEL
Selection EXPERT
Menu MOTOR CONTROL,
Function Load balancing
Low Correction limit (LbC1 = 0)
High Correction limit (LbC2 = 50)

Forward Run command and speed reference (20 Hz) on M1
Reverse Run command and speed reference (10 Hz) on M3
Observe the torque and mains voltage of drives V1 and V2.
Balance the torques of drives V1 - V2 with LbC
optimize if needed with the expert parameters.



Conclusion:
Good balance of torques and bus voltages
Correct speed precision and response

Balancing by Master-Slave function

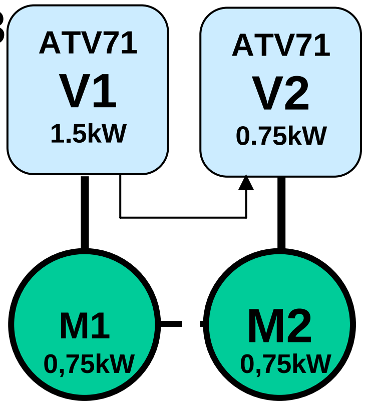


Switch in position M1M2

Link AO1 V1 to AI2 V1
Configure AO1 V1 as motor torque (Inputs/outputs)
Configure AI2 V2 as torque control (Applicaton functions)

Menu **MOTOR CONTROL**
Slip Compensation = 100%
Load balancing function (LbA = no)

Forward Run command and speed reference (20 Hz) on M1/M2
Reverse Run command and speed reference (10 Hz) on M3
Observe the torque and mains voltage of V1 and V2.
Verify the torque balance between V1 - V2



Conclusion:
Good torque balance and bus voltages
The speed precision and response are good

Link the DC bus in common

Switch in position M1M2

Keep the same configuration as previously
Disconnect the braking resistor
Set the M3 torque reference to 0
Start-up, progressively increase the torque
Observe the V3 mains voltage

Now link the DC buses together
Repeat the same operation

Conclusion:
Since V3 is operating in the generator quadrant and without a braking resistor the drive trips on OBF
By connecting the buses together, the drives V1 V2 recover the energy generated by V3

Descriptions of functions

I Balancing by slip

II Load balancing function

II Master-slave function

III Torque control

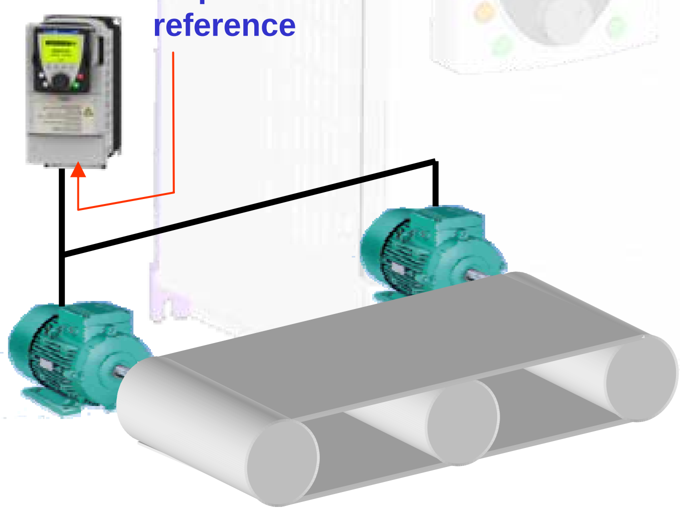
Balancing by slip compensation

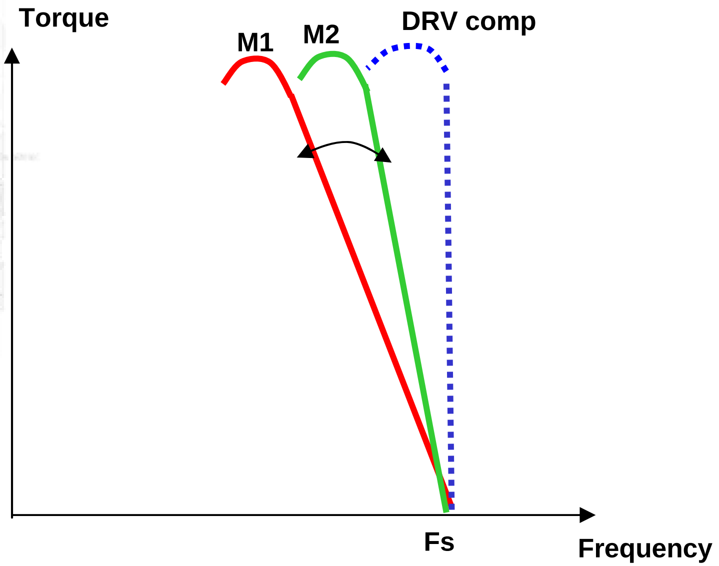
We suppress the slip compensation of the drive

Thus the load balancing is done naturally

The more heavily loaded motor slips more thus it's torque decreases, the torque seen by the other motor increases and so the torques finish by being equal (steady state).

Typically used for the translation of carriers and conveyors.



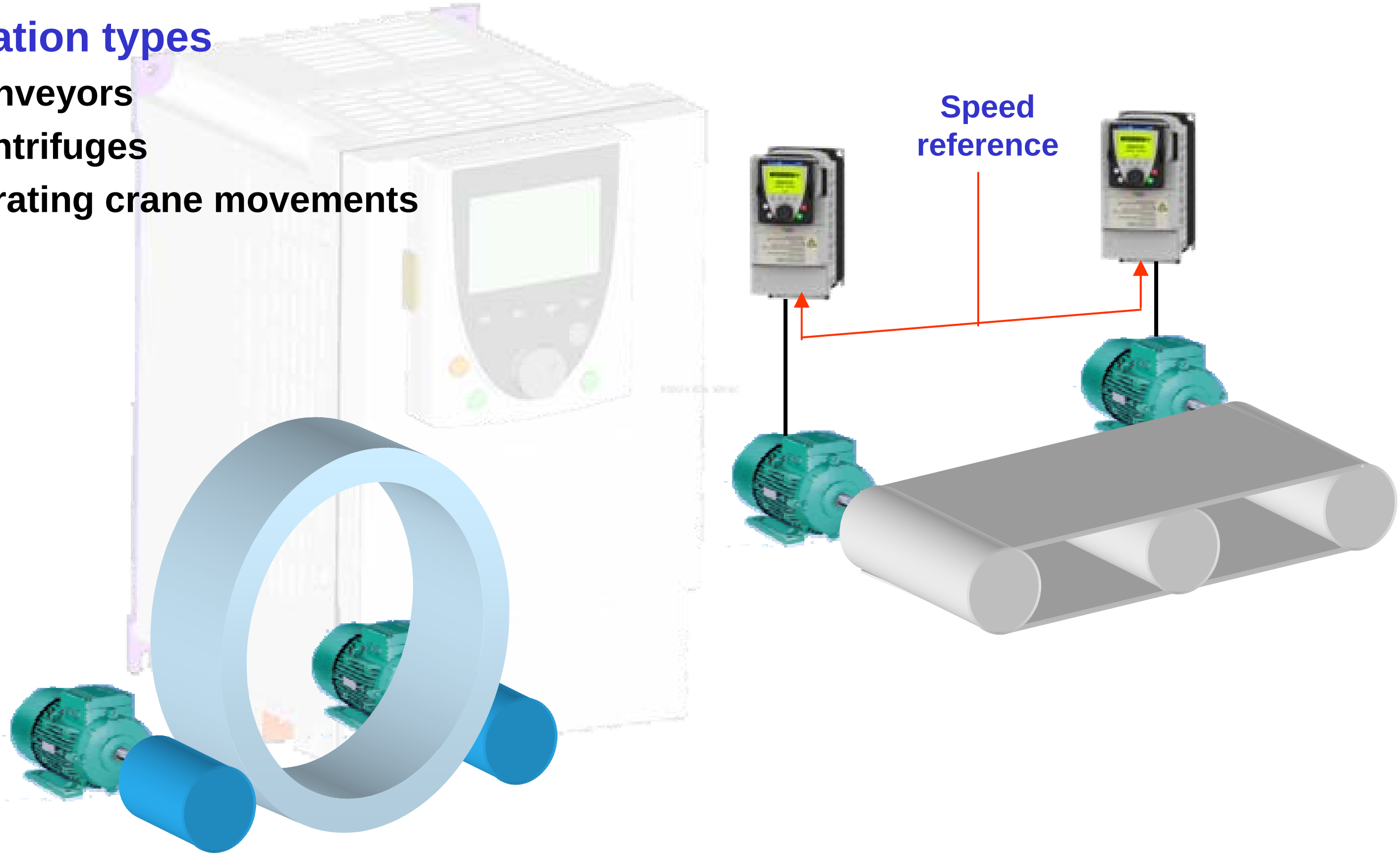


Load balancing function

- **Whenever 2 motors have their shafts mechanically linked with a flexible link permits a better sharing of torque.**

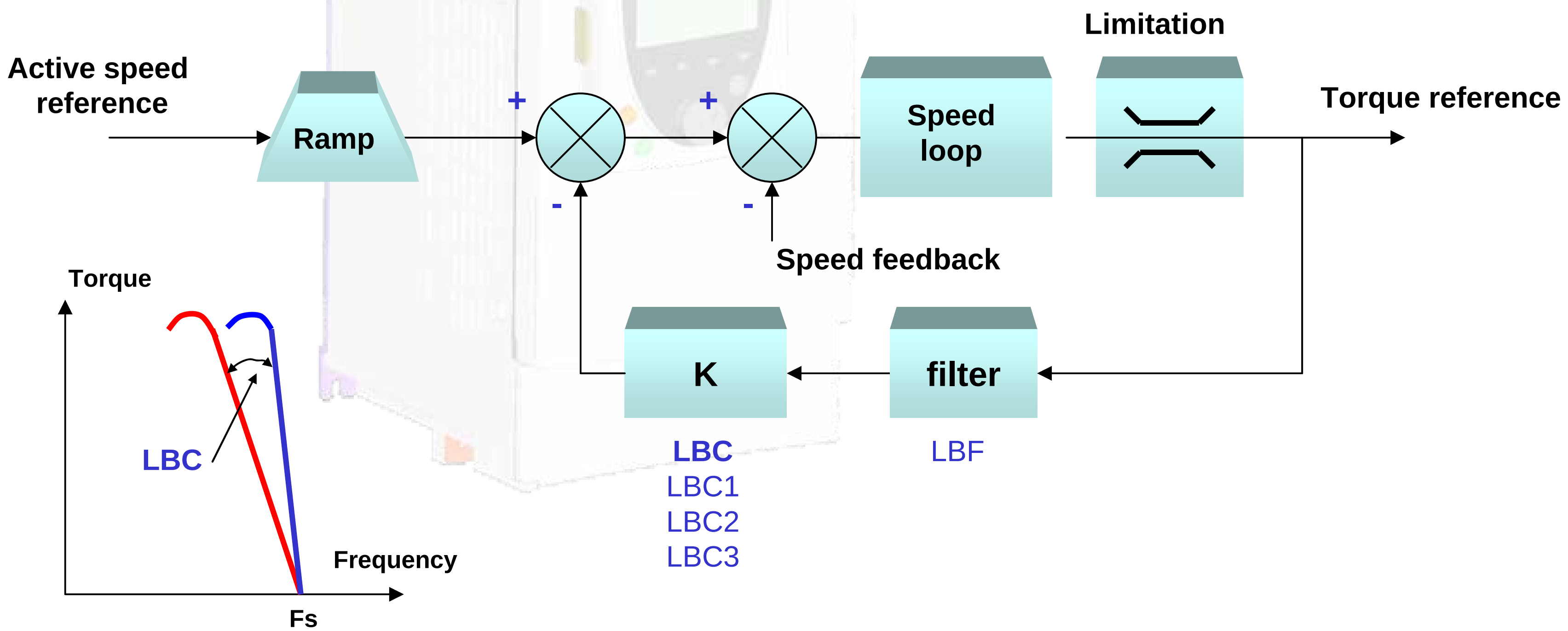
Application types

- Conveyors
- Centrifuges
- Gyrating crane movements



Load balancing function

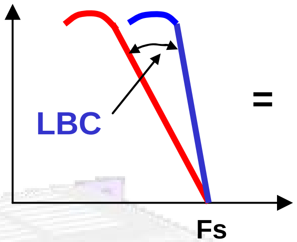
- The funtions allows the correction of the speed of one or many motors linked mechanically to balance the torque between them.
- The correction is a function of the load (artificial slip)
- The drives must be operating in open loop (CTT=SVCI).
- The function is active in both the motoring and generating quadrants



Load balancing function

1 parameter for correction:

- **LBC** (Hz) = speed correction



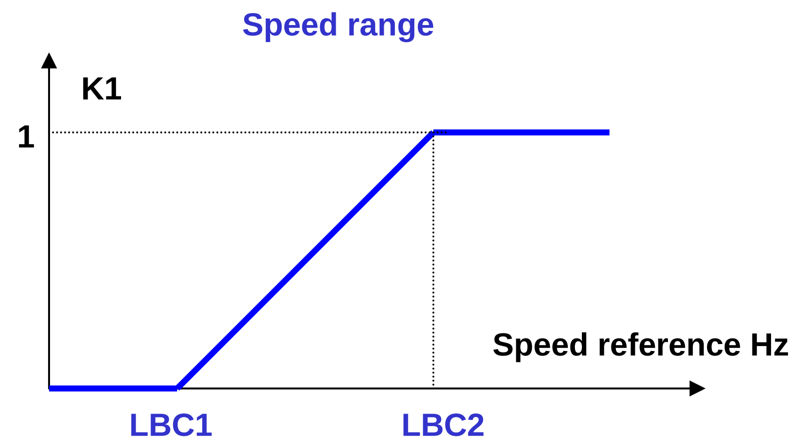
3 expert parameters for optimization :

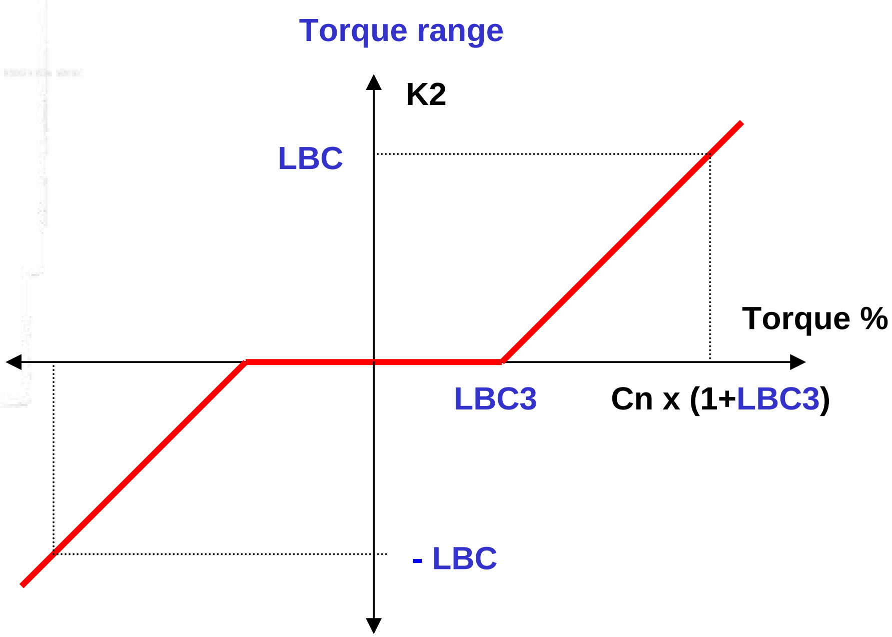
- The correction factor depends upon the speed and the torque.
- **K= K1 f(F) x K2 f(C)**
- Correction = **K*LBC**

- **LBC1** (Hz) = minimal speed for corrective action
- **LBC2** (Hz) = maximum speed for corrective action

- **LBC3** (%) = torque offset to the range of the corrective action

- The correction can be filtered by **LBF**





Master-Slave function

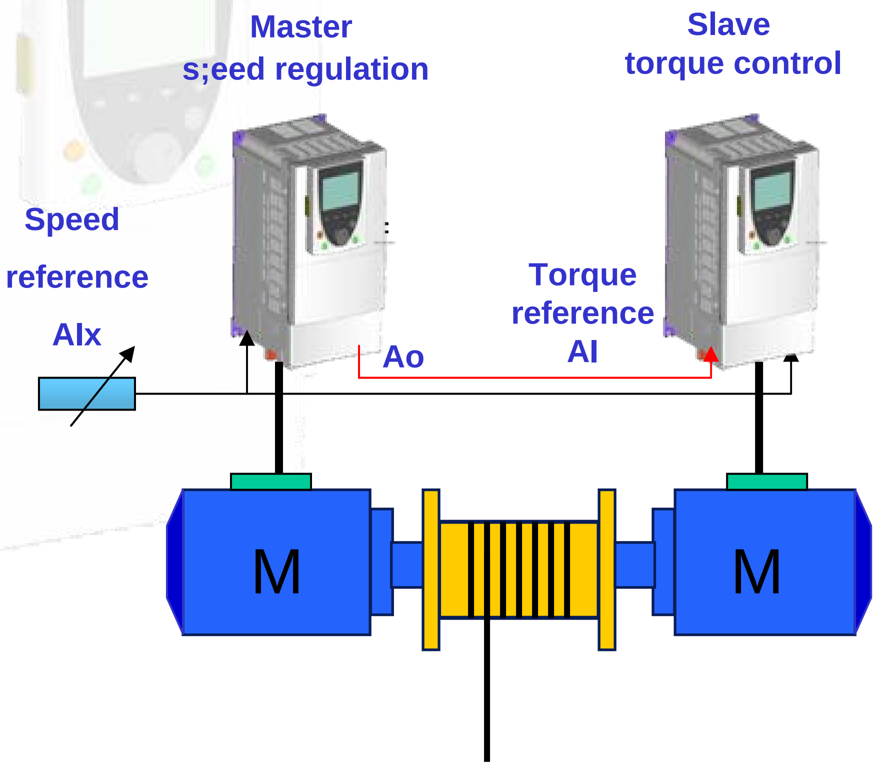
- Allows for a better sharing of torque when 2 motors have their shafts rigidly linked together.

- An AO of the master drive is configured in torque and controls the analog input of a slave drive configured as a torque limit or torque command reference.

- The response time is limited by the response time of the A0 and the AI

Application types

- Hoisting
- Winches

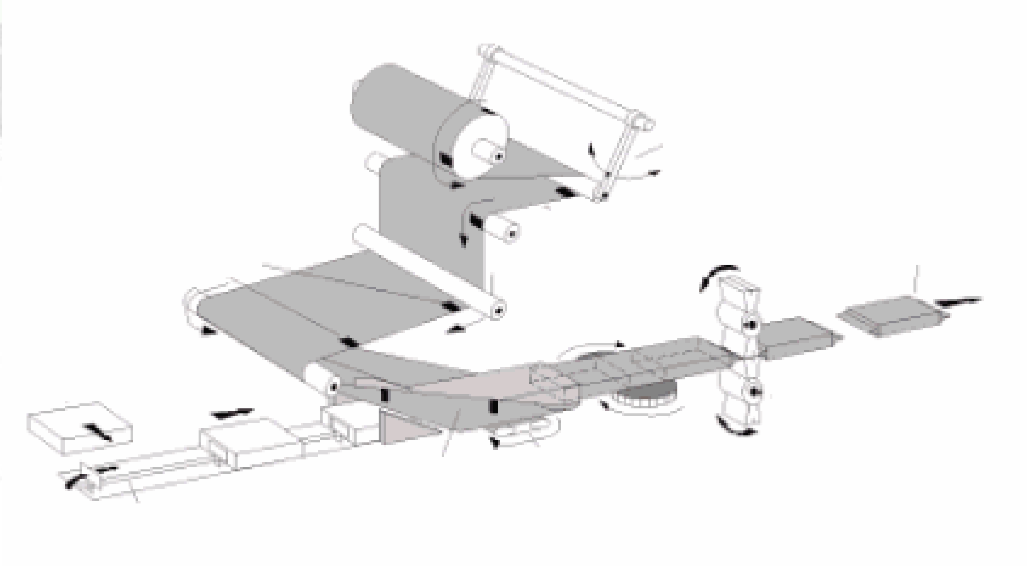


Torque control

- This function allows the control of motor torque instead of speed.
- Torque command is possible in current vector control (SVCI) in either open or closed loop.
- The precision is 15% in open loop and 5% in closed loop of nominal torque
- Regulation range +/-300% of Cn

Application types

- Traction control by sensor
- Winders/Unwinders
- Master/slave in torque ...



Torque control - Description

- **Torque control is activated in the application function menu (TSS = yes , Lix , bus)**

- **The torque reference must be assigned (TR1 =Aix, bus ..)**

- **The torque ramp is settable 0-99s (TRP)**

- **It is possible to switch between torque or speed by LI or by frequency level (dead band).**

- **The sign of the torque can be inverted by a logic input or by a +/- 10V analog input (TSD)**

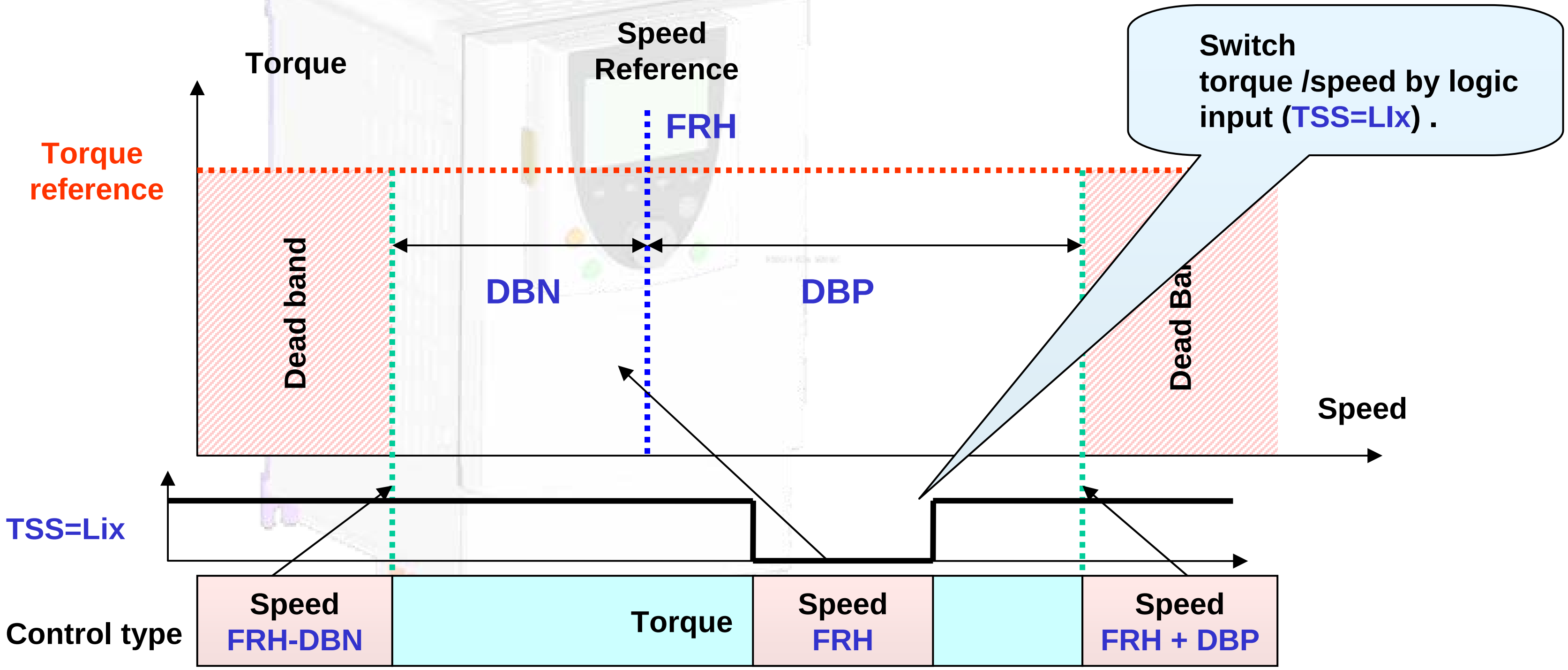
- **3 stop modes are possible with torque control**
  - with a speed ramp TST=SPD
  - free wheel TST=NST
  - with a torque ramp TST=SPN
    - The time for flux maintenance at stop is settable SPT=xs

- **The drive can signal when it is in torque control (terminal, output)**

- **An alarm or a fault can be set if the drive does not pass into torque control after time STO.**

Torque control - Description

- A speed range around the reference is adjustable (DBP, DBN).
- Between these limits, the drive is in torque control
- If a level is attained, the drive limits the speed



➢ Diagram of torque control