APPLICATION NOTE

AC30 Master-Slave in Torque Sharing Control

Contents

1. Abstract

This document explains how to synchronise 2 drives in torque sharing control. It provides key data and the architecture needed to achieve the outlined performance.

2. Introduction

This application note is for skilled personnel who can start a frequency drive, set basic parameters and ensure proper tuning. It does not cover protections or basic settings of the configuration.

3. Application Description

This application aims to explain how to control two mechanically linked motors in speed control mode. In this example, each motor is independently controlled by its own closed-loop drive. Closed-loop control is essential for mastering both speed and torque. We will see that torque control is crucial to ensure balance between the two motors.

Some drives feature a position loop, and it may seem like a good idea to synchronize by position—like an electronic shaft, for example. However, it is usually more beneficial to choose a torque master-slave control. The advantage is ensuring that the effort provided by both motors is equal. Synchronizing by position could create torque imbalances due to mechanical imperfections or uneven reactions on either side of the applied effort. The torque “synchronization” proposed here ensures balanced torque and forces. The master drive receives the speed command—which may or may not be ramped internally. In fact, we can imagine the master having a position loop to follow a specific profile. The master’s torque reference is sent to the slave drive, which will be controlled purely in torque. The speed loop must be disabled, and only the torque command applied. The key point is not the precision of the torque transmitted from master to slave but rather the speed of the exchange.

To illustrate the difference: consider a high precision of 16 bits (1/65536) and a 10ms exchange time: in this case, with rapid torque changes, master and slave torque may differ of nearly 100% every 10 ms.

Now consider a 12-bit resolution (1/4096) and a 125 µs cycle—matching a 4 kHz PWM on the AC30: in rapid torque changes, the error will be at most 1/4096 every 250 µs (since master and slave PWMs are not synchronized, so let’s consider worse case: 2 times).

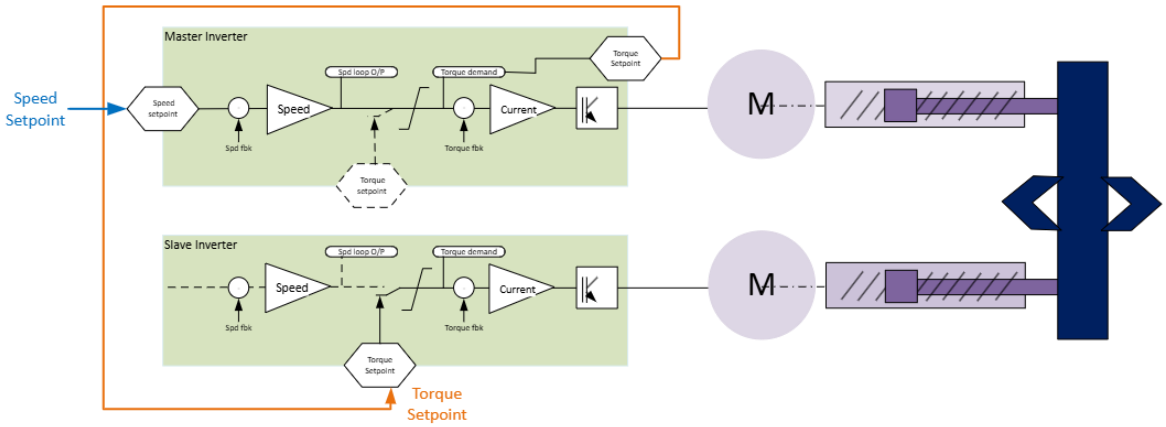
With current (torque) bandwidths of roughly 100 to 500 Hz, at 300 Hz, during an extreme torque change, the master-slave torque difference could be:

- 63% at 0.5 ms
- 99.9% at 10 ms
- 21% at 125 µs

The application described in this note has been proven over decades with Parker AC drives. The AC30 is the result of many years of field experience and incorporates functions that have been successfully conceived and implemented in real applications, enhanced with new features such as speed limiting in torque control mode.

4. Operating Principles

This diagram represents the internal loops of the drives—speed loops and torque loops—as well as the mechanical linkage between the motors and the shared mechanics that force them to move strictly in sync (e.g. actuator ETH)



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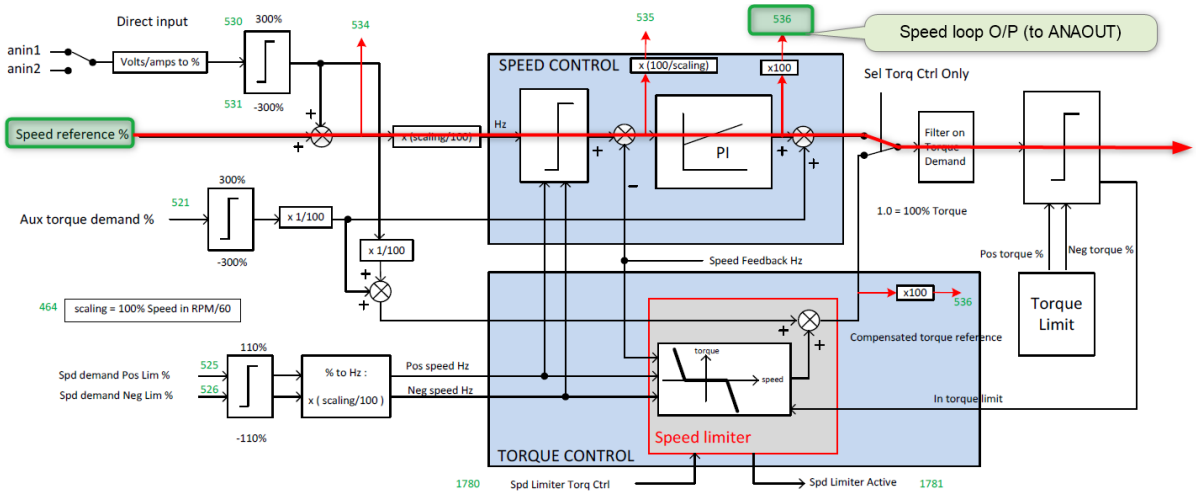
In this example, we use ±10 volt analog signals to operate in all four quadrants. The AC30's analog inputs and outputs are fast and directly synchronized with the drive's switching frequency.

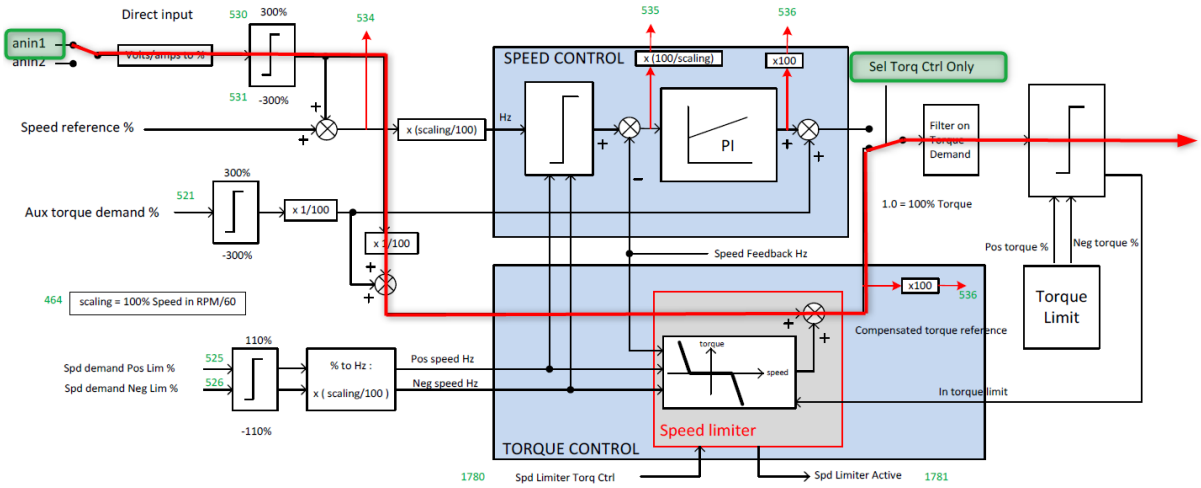
5. AC30 configurations

Below is the representation of the Speed loop SVC function block. It shows all the internal parameters and, for each configuration (master and slave), the signal paths that must be implemented to achieve the described function.

Master Speed loop FB configuration:



Slave Speed loop FB configuration:

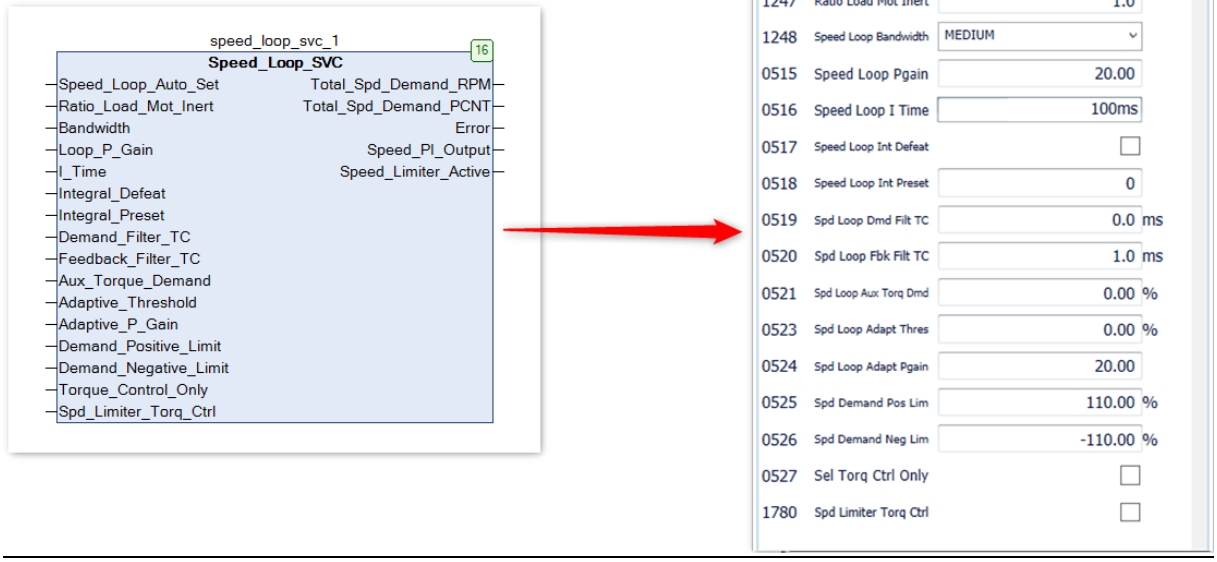


Corresponding Codesys Application configurations:

Master drive settings:

1/ Speed loop

⇨ Remember that the speed loop is, by default, connected to the REFERENCE2 function block, which receives the speed setpoint, ramped or not. Therefore, no additional connection is required.



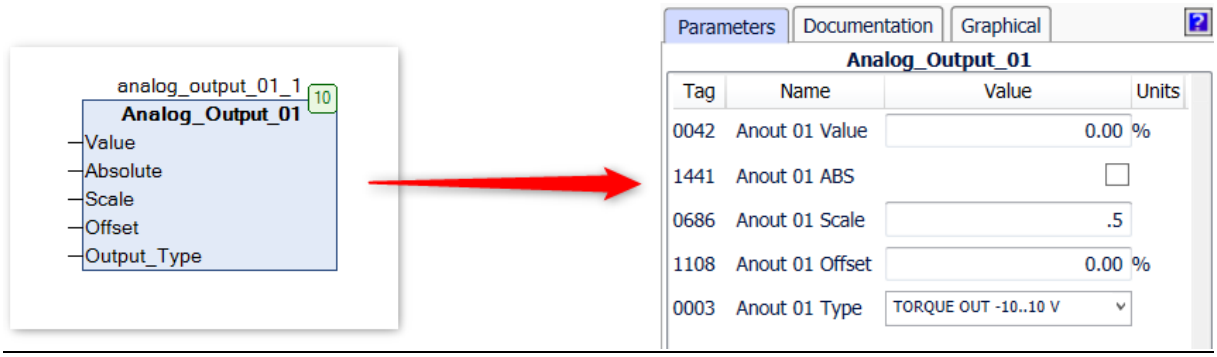
Speed_Loop_SVC

Tag	Name	Value	Units
1246	Speed Loop Auto Set	☐	
1247	Ratio Load Mot Inert	1.0	
1248	Speed Loop Bandwidth	MEDIUM	
0515	Speed Loop Pgain	20.00	
0516	Speed Loop I Time	100ms	
0517	Speed Loop Int Defeat	☐	
0518	Speed Loop Int Preset	0	
0519	Spd Loop Dmd Filt TC	0.0	ms
0520	Spd Loop Fbk Filt TC	1.0	ms
0521	Spd Loop Aux Torq Dmd	0.00	%
0523	Spd Loop Adapt Thres	0.00	%
0524	Spd Loop Adapt Pgain	20.00	
0525	Spd Demand Pos Lim	110.00	%
0526	Spd Demand Neg Lim	-110.00	%
0527	Sel Torq Ctrl Only	☐	
1780	Spd Limiter Torq Ctrl	☐	

Nothing special is required on the master side; standard speed loop settings are used. Keep in mind that the speed loop is directly connected to the load, which in this application consists of two motors driving a common load. The master's speed loop is therefore effectively the speed loop of the entire system.

Parameters::Motor Control::Spd Loop Settings		
Speed loop Auto Set	If enabled, P&I are set accordingly to the ratio load motor inertia and Bandwidth selected.	False
Speed Loop Bandwidth	Low / Medium / High,	Medium
Speed Loop P gain	Speed error x proportional gain = torque percent.	20
Speed Loop I time	Integral time constant of the sped loop	100ms
Sel Torq Ctrl Only	Disconnection speed loop O/P -> Torque loop	False
Spd Limiter Trq Ctrl	Allows speed limit in torque control	False

2/ Speed loop O/P to analogue O/P



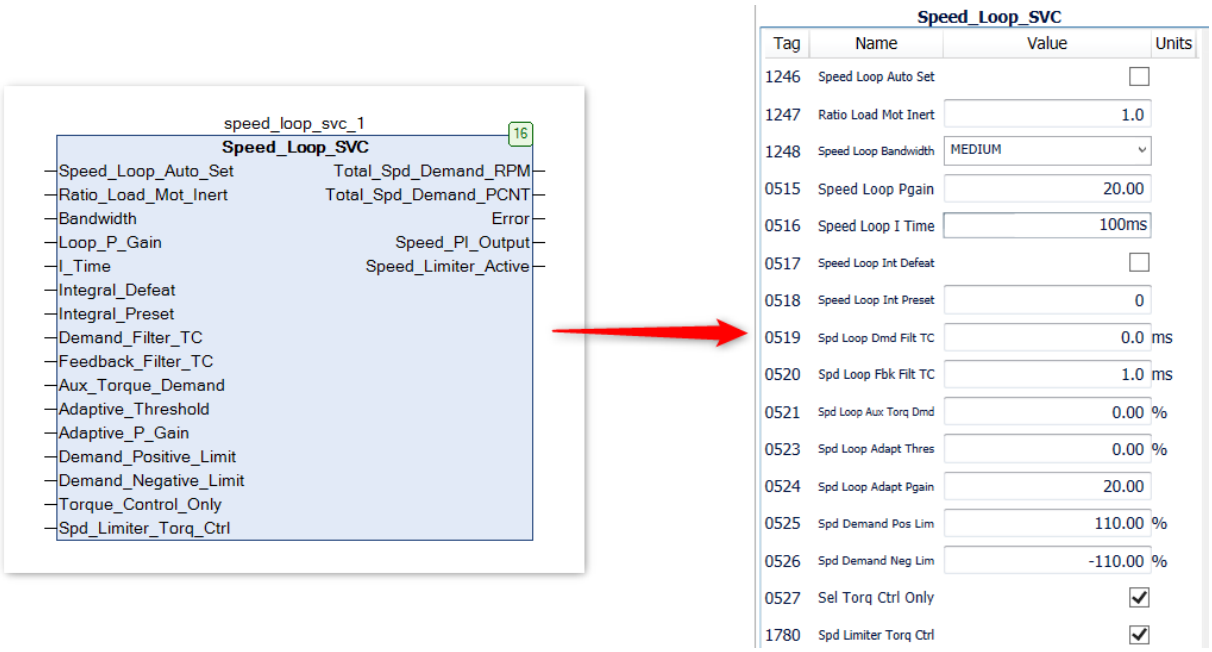
Parameters::Inputs And Outputs::IO Configure		
Anout 01 Type	Can be 0-10V, +/-10V or TORQUE OUT +/-10V	TORQUE OUT +/-10V
Anout 01 ABS	Allows signed or unsigned value	False
Anout 01 Scale	Raw signal multiplier. Value 1 means 100% ⇔ 10V	0.5

Input_Select pin of the Analogue Output FB must not be connected when type selected is *Torque Out +/-10V*. the internal connection from the sped loop O/P is on the loop level, not an the application layer.
It allows the sample time to be half the PWM period i.e. 125µs for PWM freq (PNO412) = 4kHz.

The Anout 01 Scale is set to 0.5 allowing the full electrical signal range (10V) to transmit 200% of the torque demand (overload capability). This scaling must be adapted on the Anin Scaling on slave side to get the correct balancing Master-Slave.

Slave drive settings:

1/ Speed loop



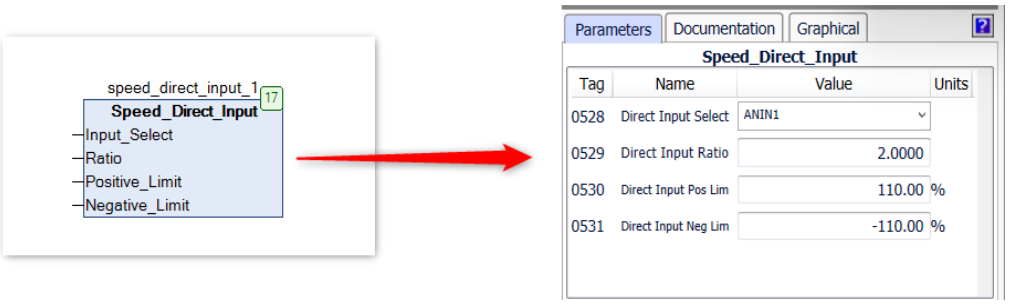
The slave's speed loop is effectively decoupled from the current loop by setting *Sel Torq Ctrl Only* to True.

Spd Limiter Torq Ctrl can be set to True to prevent the motor from running away if the resistive torque drops below the applied torque.

Parameters::Motor Control::Spd Loop Settings		
Speed loop Auto Set	If enabled, P&I are set accordingly to the ratio load motor inertia and Bandwidth selected.	-
Speed Loop Bandwidth	Low / Medium / High,	-
Speed Loop P gain	Speed error x proportional gain = torque percent.	-
Speed Loop I time	Integral time constant of the sped loop	-
Sel Torq Ctrl Only	Disconnection speed loop O/P -> Torque loop	True
Spd Limiter Trq Ctrl	Allows speed limit in torque control	True

2/ Analogue I/P to Current loop

As with the master's analogue output, the selected analogue input of the slave is internally connected to the current loop by choosing it in Direct Input Select. Continuing the example above, the scaling (Direct Input Ratio) is set to 2.0, corresponding to 200% ⇔ 10 V.
The *Input_Select* pin of the function block must not be connected.



Parameters::Motor Control::Spd Direct Input		
Input Select	Select analogue I/P 1 or 2	ANIN1
Direct Input Ratio	Allows scaling master / slave ratio	2.00

6. Tips and Recommendations

If the mechanical arrangement and sizing allow it, it is recommended to start commissioning with only one of the two motors under a reduced load. Once the first drive has been tuned, its configuration can easily be copied to the second drive to ensure that both systems operate identically. For example, verify that their speed/torque performance is the same. From this point, setting up the master–slave configuration is straightforward and safe**.**
If the installation uses asynchronous motors, the autotuning should be carried out with the motor uncoupled. Since the two motors are assumed to be identical, you can avoid running auto-tuning twice and simply copy the results from one drive to the other.

7. Technical Support Contact Information

Refer to the complete AC30 software manual for more information on these parameters:
HA503711U003 Issue 4 – Software Reference.

For further technical assistance, please contact the **EMPD Application Engineering Team**.

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