MESYS AG
Technoparkstrasse 1
CH–8005 Zürich
info@mesys.ch
T: +41 44 455 68 00

Tutorial: Shift gear transmission

This tutorial is intended to provide the user with some guidelines on modelling of gear shifting in gearboxes with parallel shafts by using MESYS Shafts System. Specifically, we will design a 3-speed gearbox consisting of spur gear stages. For a successful completion of this tutorial, it is assumed that the user has first completed both the shaft and shaft systems tutorials in order to learn how to define the geometry, supports and loading, as well as the connections, positioning and load spectrum.

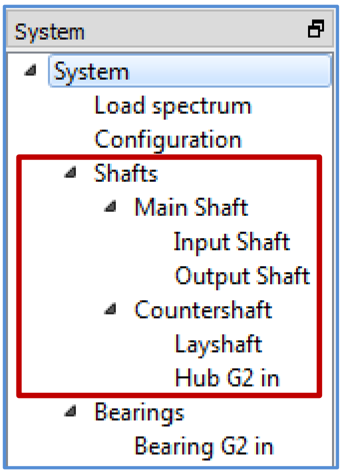
System settings

It is commonly known that the actual operating times of the different speeds in a gearbox can differ noticeably from each other. This fact will be taken into account by means of a load spectrum analysis, since each gear speed will be handled as load case; so please set the flag for the load spectrum option on the 'Settings' page. For this tutorial a new software feature, called 'Consider configurations', will be introduced in order to simulate the gear engagement and disengagement. We will just activate it for now on the 'Settings' page, and it will be discussed later on.

Groups of shafts

The gearbox will have two groups of shafts, which in turn will contain two shafts each. Please proceed to create their geometry from the following table data:

Names		Outer Geometry		Inner Geometry		Position	Speed
Groups	**Shafts**	**Length**	**Diameter 1**	**Length**	**Diameter 1**		
'Main Shaft'							
	'Input Shaft'	50	20	-	-	0	2000
	'Output Shaft'	60	25	-	-	50	-
'Countershaft'							
	'Layshaft'	100	30	-		0	-
	'G2 in Hub'	20	40	20	35	70	-

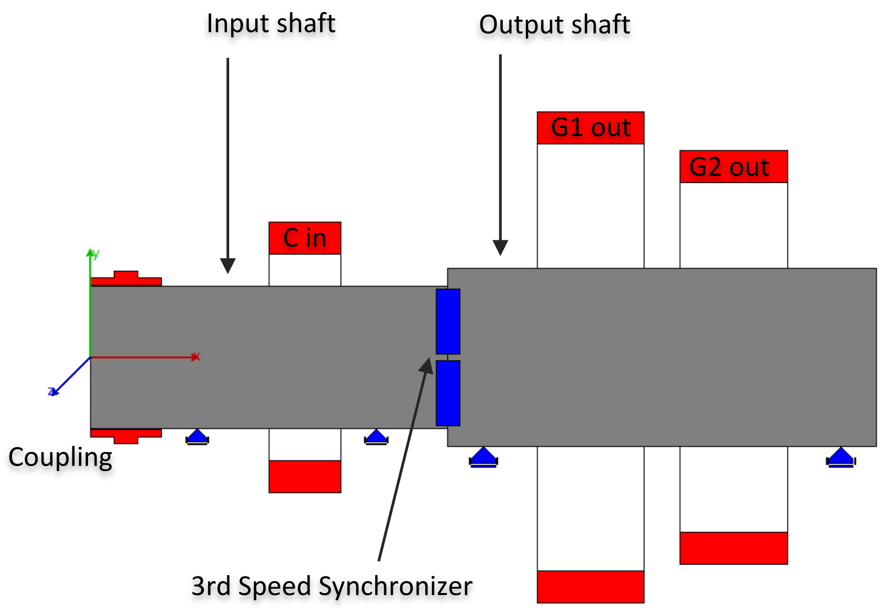


Loading and Supports

Now we will begin to create all the elements that are needed on the shafts:

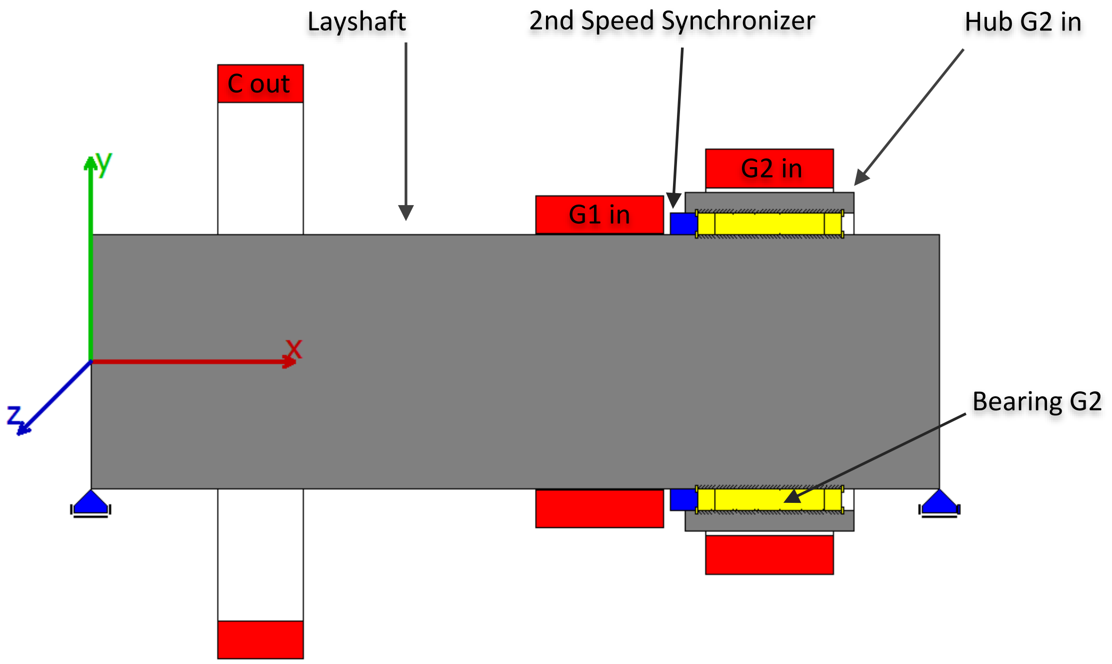
	Element	Name	Position	Parameters (in addition to default values)
Main Shaft				
Input Shaft	Coupling	Coupling	5	b = 10, T = 50
	Cylindrical Gear	C in	30	b=10, z=17, mn=2, α=20
	Support	Support1	15	Leave default values
	Support	Support2	40	Leave default values
Output Shaft	Cylindrical Gear	G1 out	20	b=15, z=33, mn=2, α=20
	Cylindrical Gear	G2 out	40	b=15, z=27, mn=2, α=20
	Support	Support3	5	Default values
	Support	Support4	55	Set also the flag for ‘Shaft is supported against torsion’
	General constraint	3rd Speed Synchronizer	0	Rotation around x-axis: Type->Fixed
Counter Shaft				
Layshaft	Cylindrical Gear	C out	20	b=10, z=33, mn=2, α=20
	Cylindrical Gear	G1 in	60	b=15, z=17, mn=2, α=20
	Support	Support5	0	Leave default values
	Support	Support6	100	Leave default values
Hub G2 in	Cylindrical Gear	G2 in	10	b=15, z=23, mn=2, α=20
	General constraint	2nd Speed Synchronizer	1	Translation in x-axis: Type->Fixed Rotation around x-axis: Type->Fixed
	Roller bearing	Bearing G2 in	10	Type -> Needle bearing ‘K 30x35x17’. -> Shaft connected to outer ring. -> Connect inner ring to shaft ‘Layshaft’. -> Set all flags for the support conditions.

Main Shaft



mesys
Engineering Consulting Software AG
MESYS AG
Technoparkstrasse 1
CH–8005 Zürich
info@mesys.ch
T: +41 44 455 68 00

Countershaft

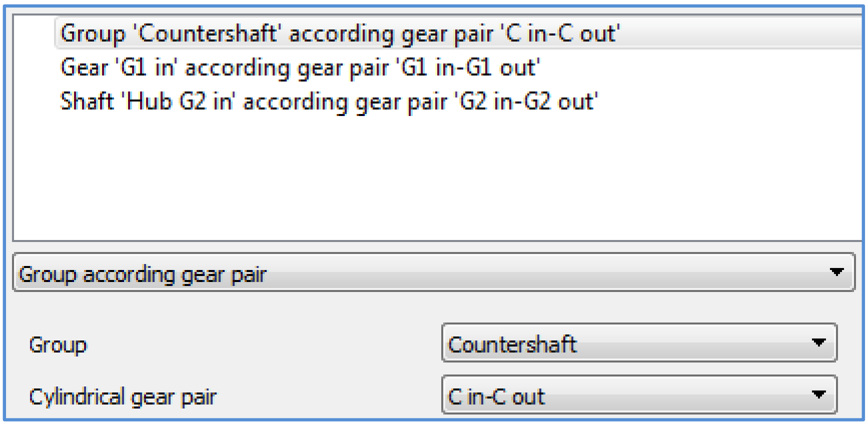


Gear connections

Cylindrical gear pairs	T1 [Nm]	T2 [Nm]		SF1	SF2	SH1	SH2		
C in-C out	-	-							
G1 in-G1 out	-	-							
G2 in-G2 out	-	-							
Planetary gear sets	T1 [Nm]	T2 [Nm]	T3 [Nm]	SF1	SF2	SF3	SH1	SH2	SH3
Bevel gear pairs	T1 [Nm]	T2 [Nm]		SF1	SF2	SH1	SH2		
Worm gears	T1 [Nm]	T2 [Nm]		SF	SH	SW	ST	SB	

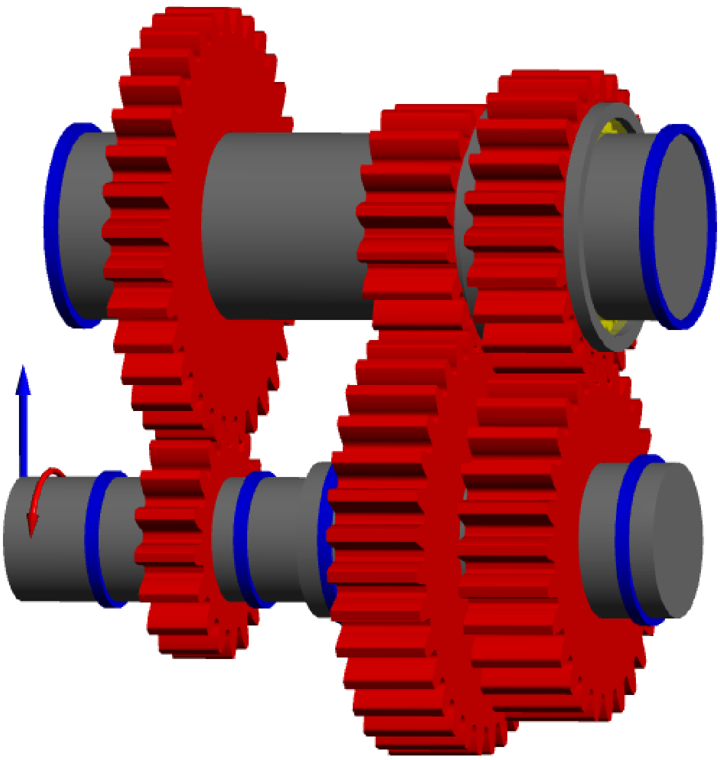
Positioning

Please proceed to define the following positioning conditions:



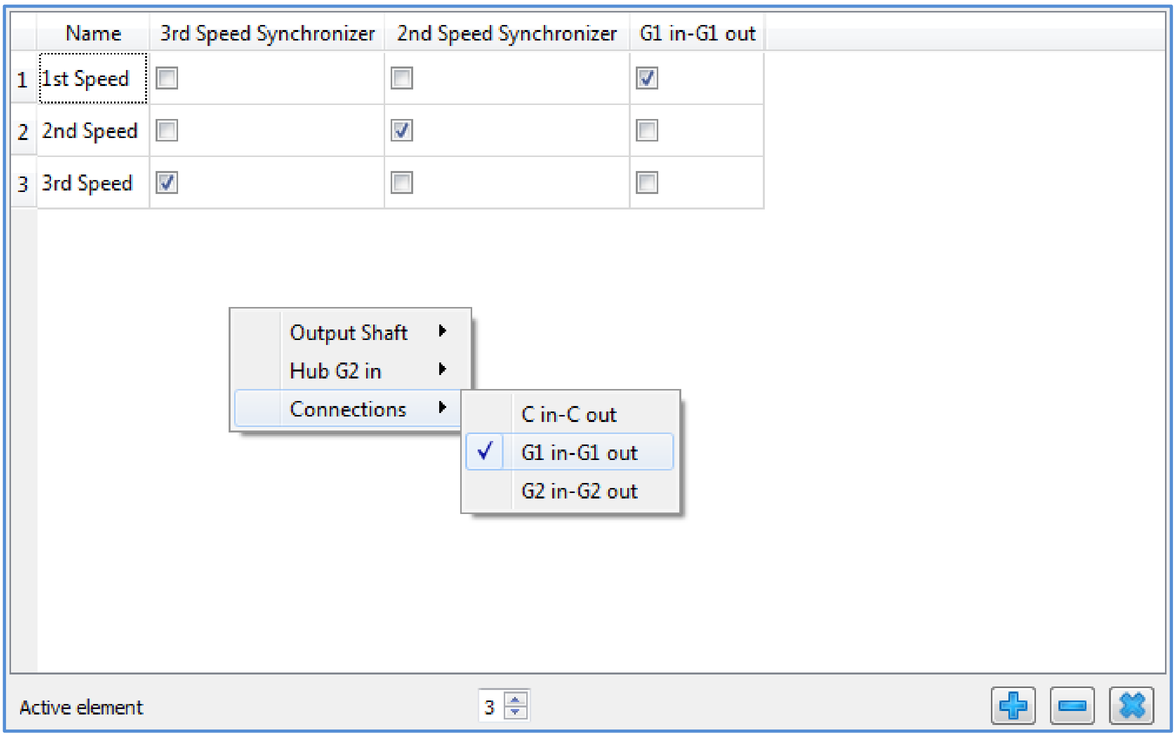
The first positioning will locate the Countershaft group according to the gear pair ‘C in-C out’ providing the center distance between the groups and the axial position so that the gear ‘C out’ is centered to ‘C in’. The second positioning will axially locate the gear ‘G1 in’ so that it always matches its mating gear ‘G1 out’. The third positioning will axially locate the hollow shaft ‘Hub G2 in’ so that the gear ‘G2 in’ always matches its mating gear ‘G2 out’, i.e. the centers of the gears will be aligned. Note that the ‘Bearing G2 in’ and the ‘2nd Speed Synchronizer’ were created in the hollow shaft ‘Hub G2 in’ so that they move all together with the gear ‘G2 in’.

The system model should look as follows:



Configurations

Click now on the header 'Configuration' at the system tree. The so-called configurations will be defined in a table and arranged in rows. Each configuration is used to simulate each of the three gear shifts:

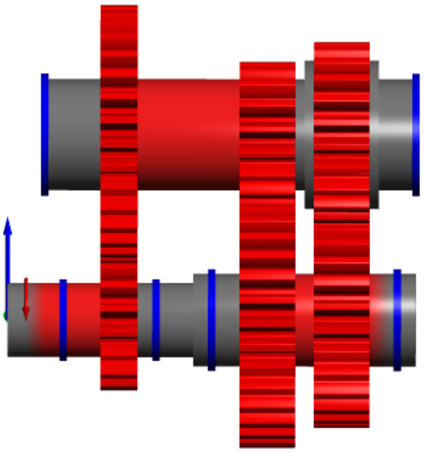


The columns will be used to consider those gear connections, reaction couplings or general constraints which must be taken into consideration for the corresponding configuration. By ticking/clearing the check boxes, the elements of the colummns will be activated/deactivated as appropiate. Note that the check box of general constraints only applies for its torsional constraint, so the constraints in all the other directions are not affected.

Use the ✚-button to add three rows and enter the corresponding names which will correspond to our three configurations as shown in the picture above. Then add the '3rd Speed Synchronizer', '2nd Speed Synchronizer' and 'G1 in-G1 out' in the columns; they can be selected from the context menu when doing a right-mouse click in the window. Note that the 'Rotation around x-axis' of the general constraints, must be always first set to 'Fixed', so that they can be selected afterwards from the context menu in the page 'Configuration'.

Once all the data has been entered, we will discuss the interpretation and implementation of the created configurations.

1st Speed



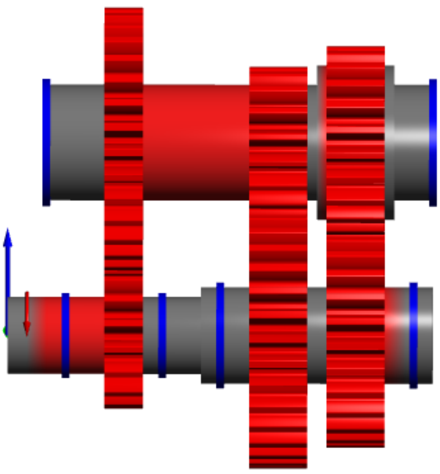
The power will first flow through the gear pair 'C in-C out', whose gears are constantly engaged, and will be eventually transmitted through the gear pair 'G1 in-G1 out', so we will set the flag of the corresponding check box.

In order to allow this to happen, the general constraint '3rd Speed Synchronizer' must remain deactivated as if the selector fork of a manual gearbox was not shifted and thus letting the input and output shafts turn at different velocities. That means that the rotation around x-axis of this general constraint, which was previously set to 'Fixed', will be unconstrained. Moreover, the so-called '2nd Speed Synchronizer' will be also deactivated.

At this point it is noteworthy to mention that we have created two different ways to engage or disengage the gear pairs by using the configurations. On one hand, for the gear pair 'G1 in-G1 out', a simply omission of the gear engagement itself has been implemented. On the other hand, for the gear pair 'G2 in-G2 out', a more complex and close to reality simulation has been implemented. It can be observed how the gear 'G2 in' is placed on the hollow shaft 'Hub G2 in' which in turn is mounted on a needle bearing. Therefore, unless the general constraint '2nd Speed Synchronizer' is activated, the gear 'G2 in' will behave as an idler gear.

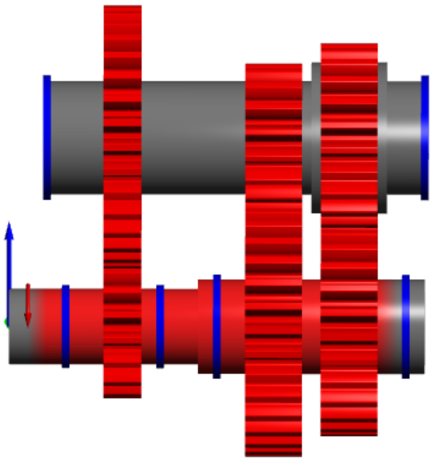
2nd Speed

The power flow coming from the gear pair 'C in-C out', will be transmitted through 'G2 in-G2 out':



3rd Speed

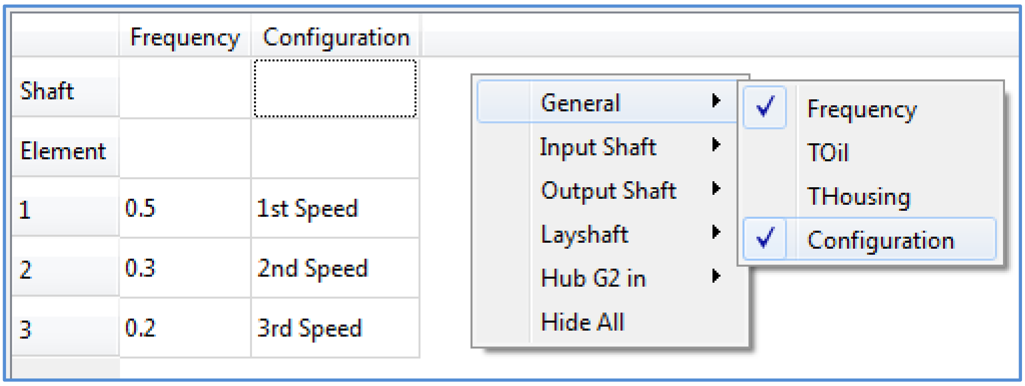
The 3rd speed emulates the direct drive, so the rotation of the first shaft is directly transmitted the output shaft without any reductions upon activation of the '3rd Speed Synchronizer', omission (deactivation) of the gear pair 'G1 in-G1 out' and deactivation of '2nd Speed Synchronizer':



Each of these three cases can be analyzed independently by entering the desired reference configuration number in the box at the bottom of the window. This number indicates the 'Active element' (configuration) that will be considered.

Configurations within a load spectrum

Nevertheless, the software also offers the possibility to consider these configurations within a load spectrum as if they were load cases, and thus allowing us to assign any operating time (frequency) to each of them:



In this way, a proper analysis of the gear shifting process can be performed.