



Manual Transmissions for Intercity Buses and Coaches

Commercial Vehicle Technology



Agenda

1. Product and Sales, Benefit
2. Technology and Operation
3. EcoShift with Intarder
4. Competition Topics

01

Product and Sales, Benefit



Development of Manual Bus Transmissions

	1925	1938	1970	1990	2013
Number of gears	3 (4)	4 / 5	5	5 / 6	6 EcoShift
Gear changes	Sliding gear	Dog clutch	Synchro	Synchro	Synchro + servo
Gearing	Straight	Helical	Helical, quiet running	Helical, optimized	Helical, high-performance
Housing material	Gray casting	Gray casting (aluminum casting)	Aluminum casting (gray casting)	Aluminum casting die casting	Aluminum die casting, optimized
Transmission weight	~ 130 %	125 %	100 %	70 %	< 50 %
Example vehicle					

ZF Manual Bus Transmissions

Ecolite

6 S 710 BO up to 700 Nm

6 S 1010 BO up to 1,050 Nm

6 S 1110 BO up to 1,100 Nm

EcoShift

up to 2,100 Nm

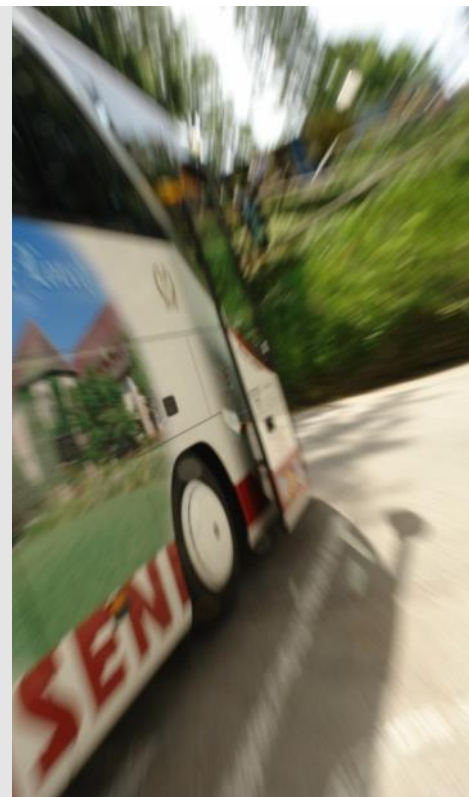
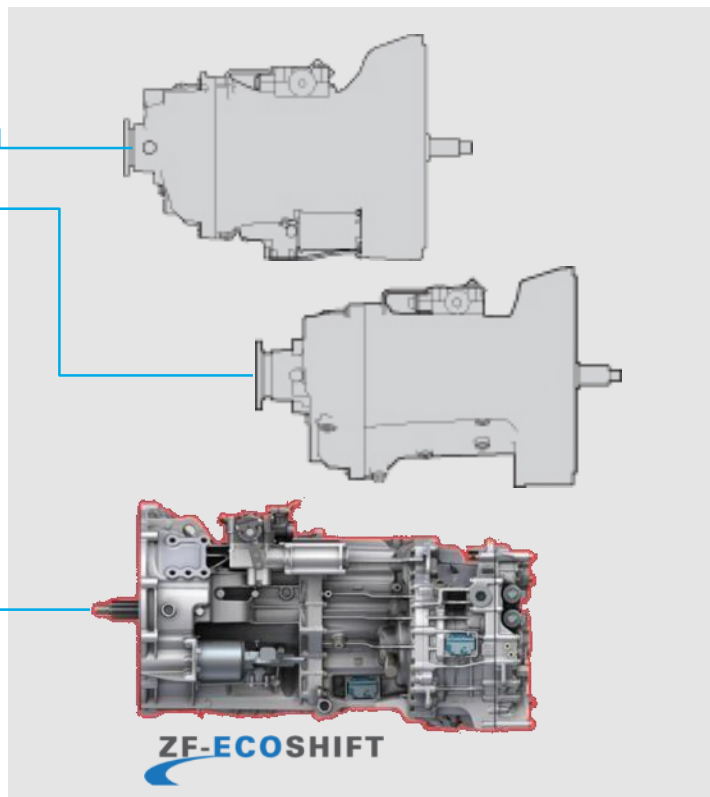
6 S 1310 / 1311* BD / BO

6 S 1610 / 1611* BD / BO

6 S 1910 / 1911* BO

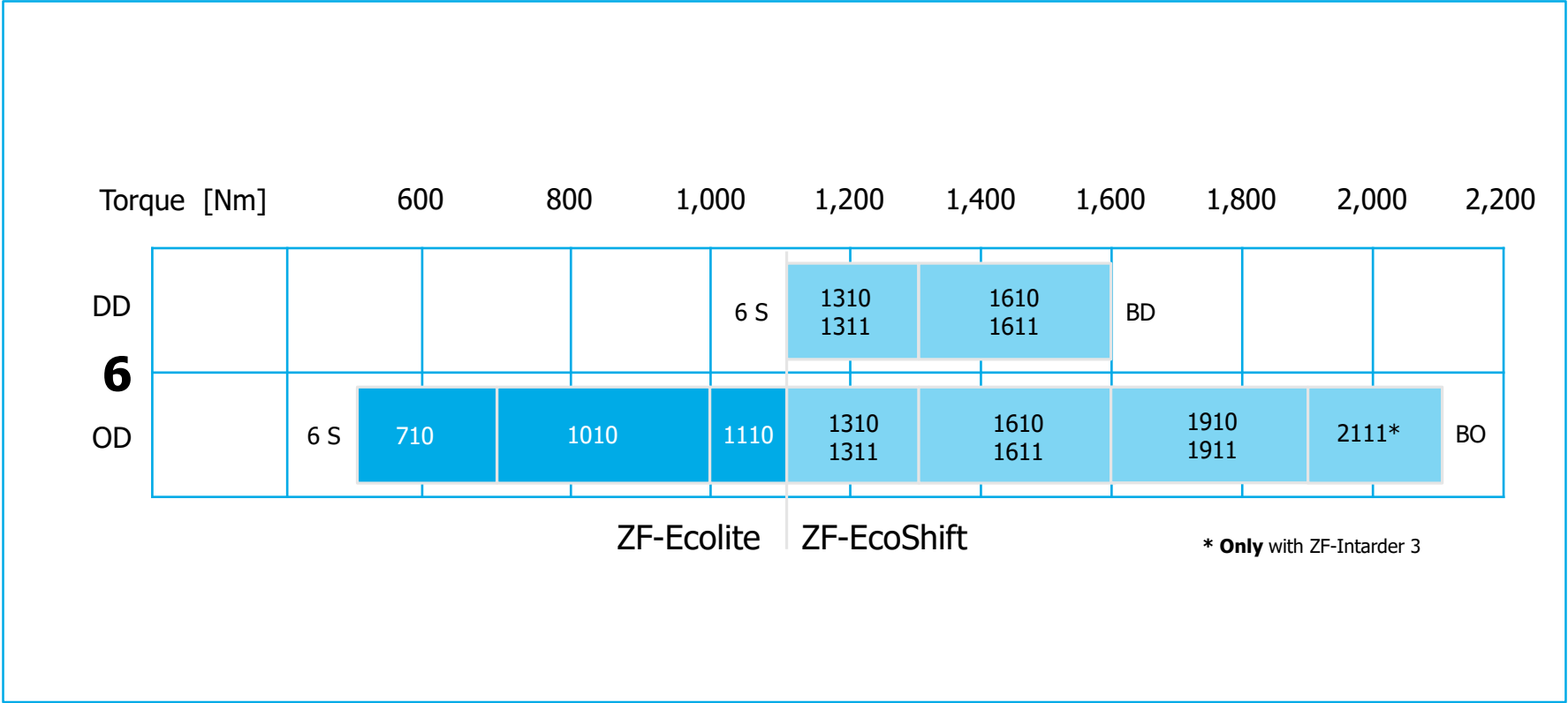
6 S 2111* BO

* Transmission system with Intarder

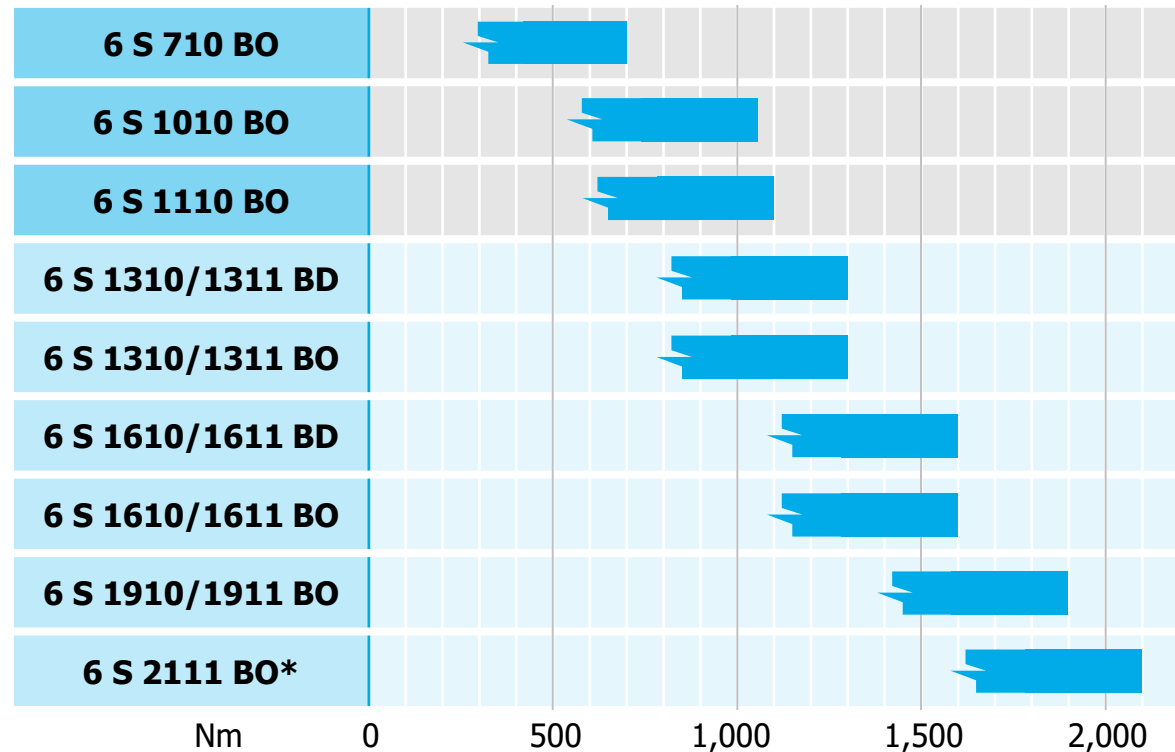


ZF Manual Bus Transmissions

Product Platforms



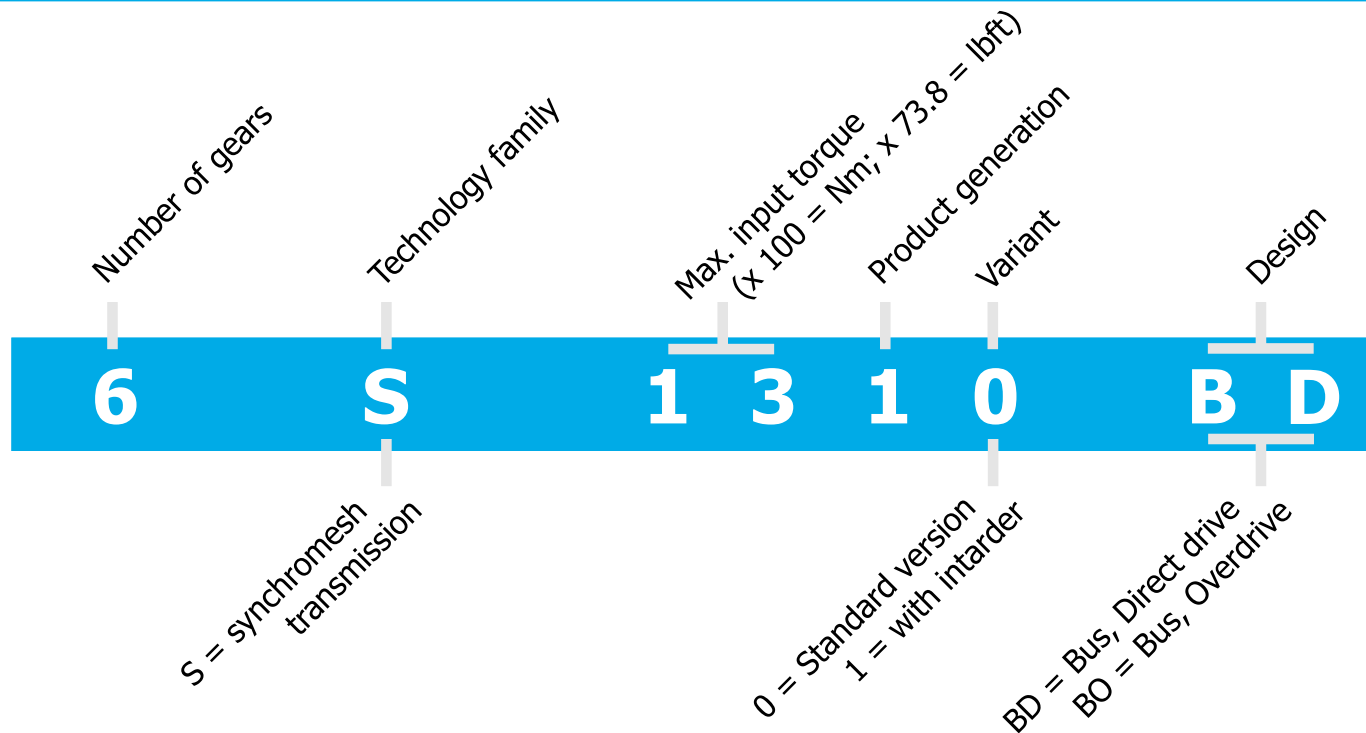
The Product Portfolio of ZF Manual Transmissions



* Only with ZF-Intarder 3



Designation



Technical data

Ecolite

	6-speed $\leq 1,000$ Nm	6-speed $> 1,000$ Nm	
	6 S 710 BO	6 S 1010 BO	6 S 1110 BO
	6.02 – 0.79 R 5.58	6.75 – 0.78 R 6.06	6.42 – 0.74 R 5.76
	700	1,050	1,100
	103	136	136
	6.0	9.3	9.3
	648.5	709	709
	2	2	2

Technical data

EcoShift

	EcoShift: 6-speed $\geq 1,300$ Nm					
	6 S 1310 BD	6 S 1310 BO	6 S 1610 BD	6 S 1610 BO	6 S 1910 BO	6 S 2111 BO ¹⁾
	8.00 – 1.00 R 7.32	6.44 – 0.81 R 5.89	8.00 – 1.00 R 7.32	6.44 – 0.81 R 5.89	6.44 – 0.81 R 5.89	6.44 – 0.81 R 5.89
	1,300	1,300	1,600	1,600	1,900	2,100
	230*	230*	230*	230*	230*	320
	7.9**	7.9**	7.9**	7.9**	7.9**	20.3
	762	762	762	762	762	762
	1	1	1	1	1	1

* The version with Intarder is heavier by 90 kg, weighing 230 kg.

** The oil quantity for the version with Intarder is 12.4 liters more, or 20.3 liters.

¹⁾ **Only** with ZF-Intarder

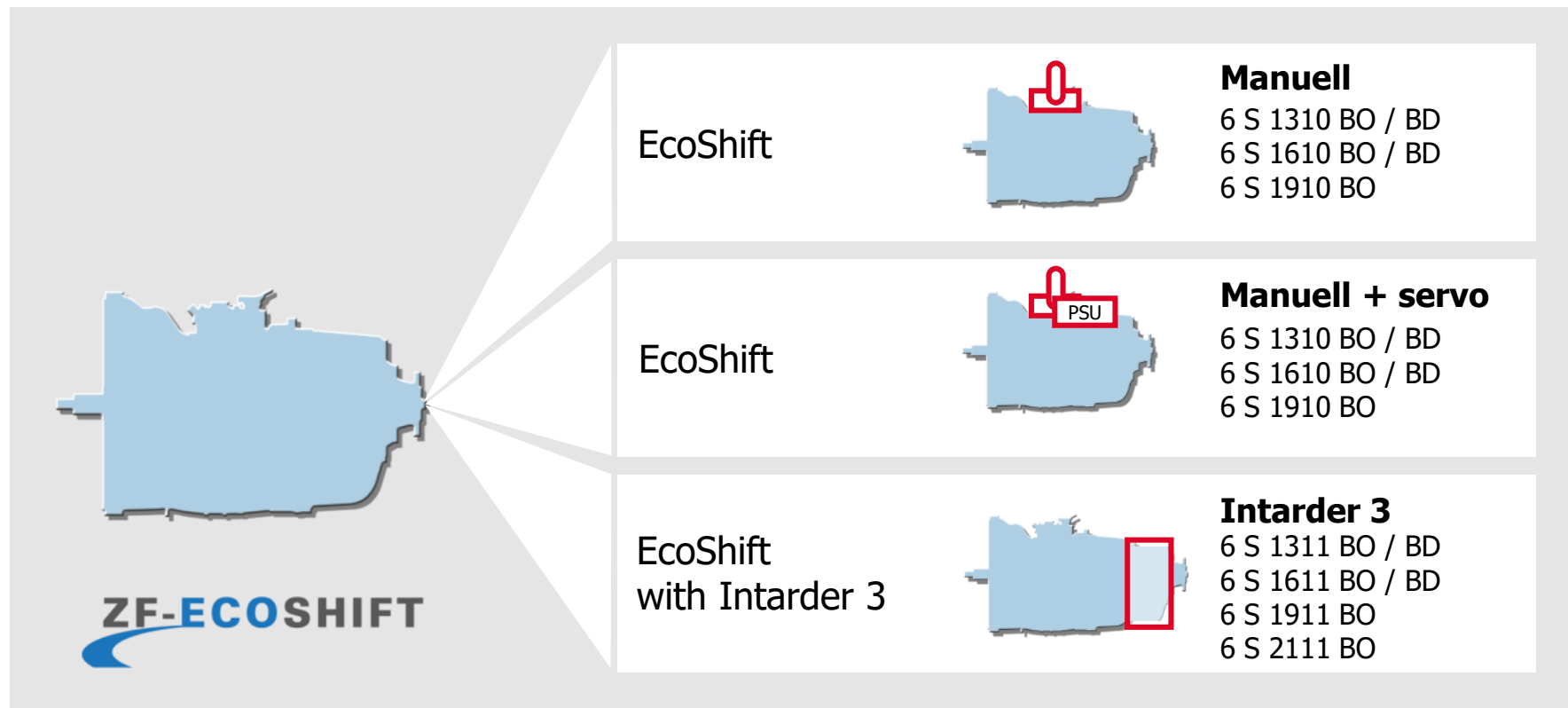
Transmission System

	Installation		Clutch bell housing		Shift system			Retarder		Cooler set	AS variant
	L	St	integr.	attached	Linkage	Cable	Servo	ZF-Intarder	Third party		
6 S 710 BO	●	-	●	-	○	●	○	-	-	○	-
6 S 1010 BO	●	-	●	-	○	●	○	-	○	○	○
6 S 1110 BO	●	-	●	-	○	●	○	-	○	○	○
6 S 1310 BD	●	-	●	-	○	●	○	●	○	○	-
6 S 1310 BO	●	-	●	-	○	●	○	●	○	○	-
6 S 1610 BD	●	-	●	-	○	●	○	●	○	○	-
6 S 1610 BO	●	-	●	-	○	●	○	●	○	○	-
6 S 1910 BO	●	-	●	-	○	●	○	●	○	○	-
6 S 2111 BO	●	-	●	-	○	●	○	●	-	○	-

● Standard ○ Option - not available

EcoShift

One Basic Transmission - Three Variants



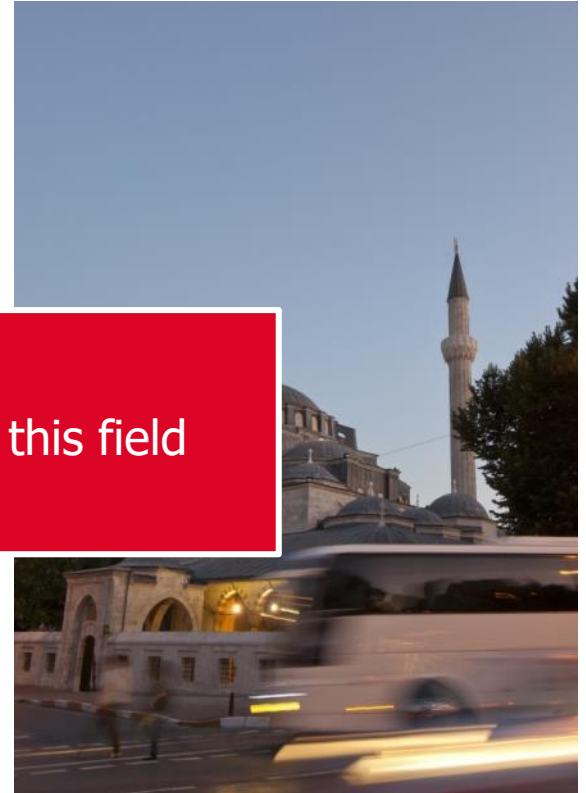
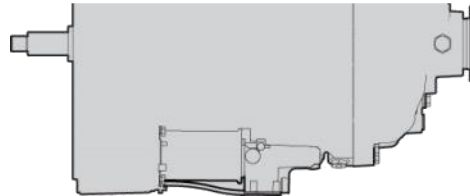
Technical Characteristics

6 S 710 BO

- Installation:
horizontal, on the left
- Clutch bell housing:
SAE 2, integrated
- Housing:
Aluminum die casting
- Cable controlled shift system with
Servoshift or mechanical shift system
- Ratio:
overdrive version

SUPPLEMENTARY SLIDE

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Technical Characteristics

6 S 1010 BO / 6 S 1110 BO

- Installation:
horizontal, on the left
- Clutch bell housing:
SAE 2, integrated
- Housing:
Aluminum die casting
- Cable controlled shift system with
Servoshift or mechanical shift system
- Ratio:
overdrive version
- Attachment of

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EcoShift

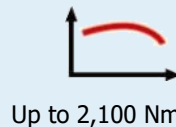
Product Features at a Glance

Types 6 S 1310 / 1311 BD / BO
6 S 1610 / 1611 BD / BO
6 S 1910 / 1911 BO
6 S 2111 BO

Layout

Manual
transmission

Torque



Technical data

Optional

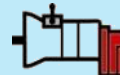
Number of gears



Oil quantity



ZF-Intarder 3



er available for electric sec.
er)

voshift



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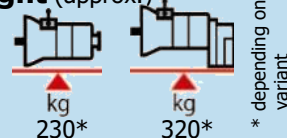
DD: 8.00 - 1.00, R 7.52

762 mm

Usage

Intercity bus,
coach

Weight (approx.)



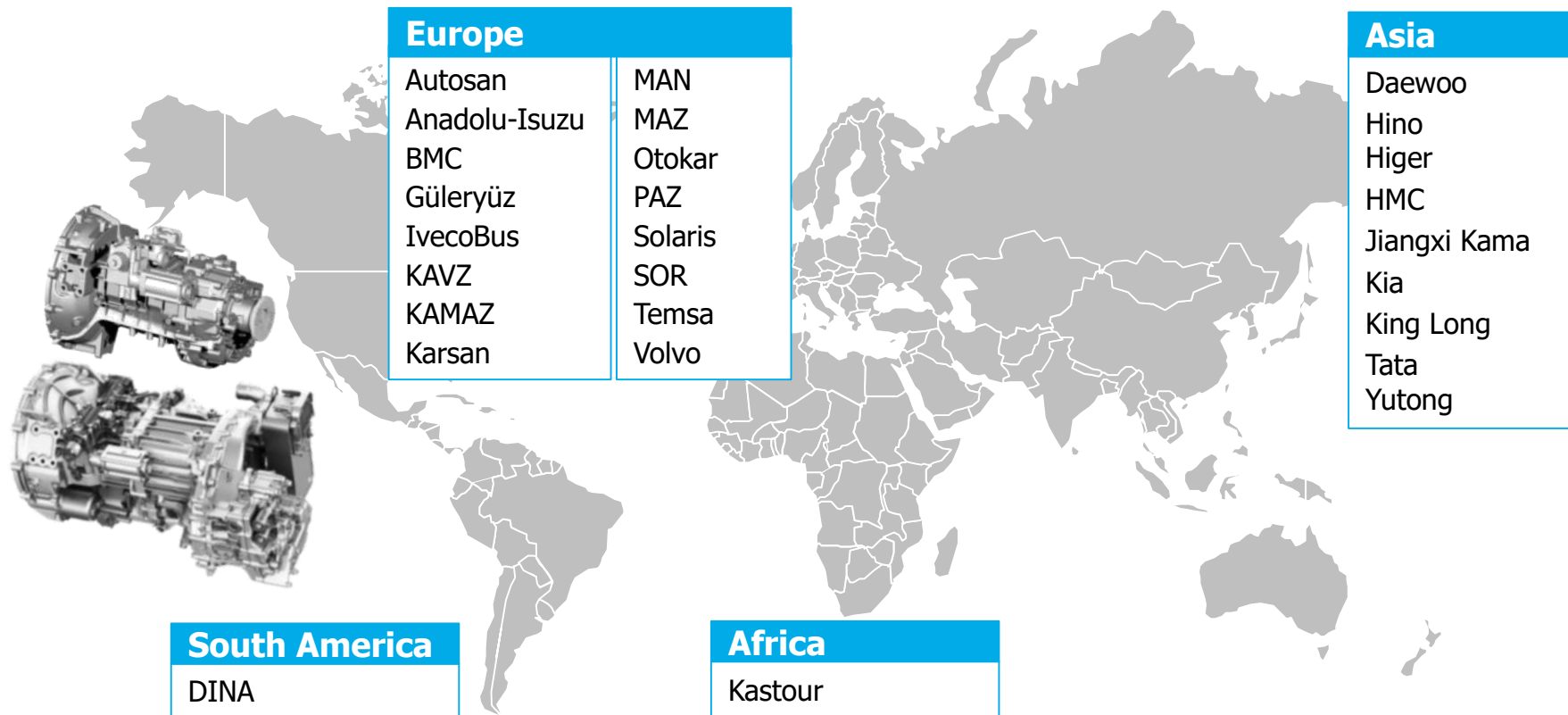
Fields of Application



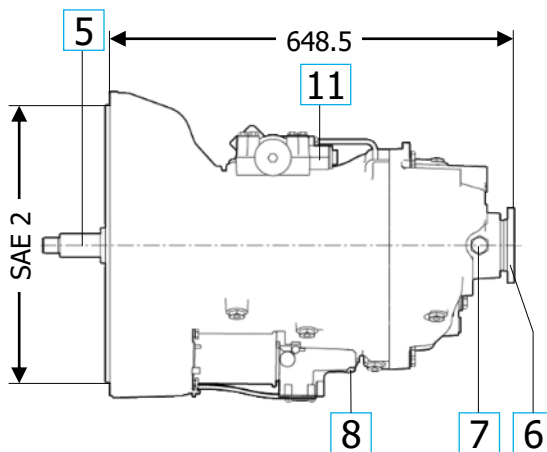
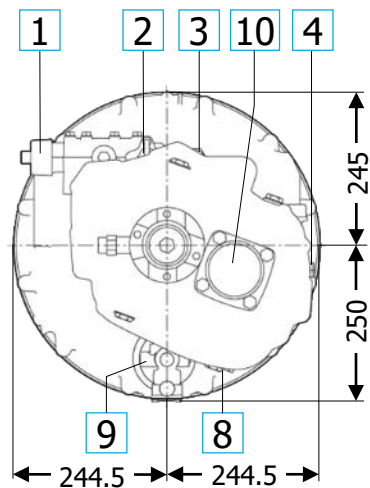
Major Customers Worldwide



Customers Worldwide



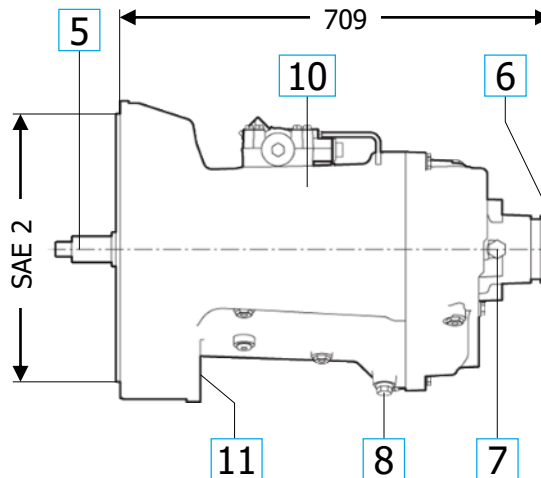
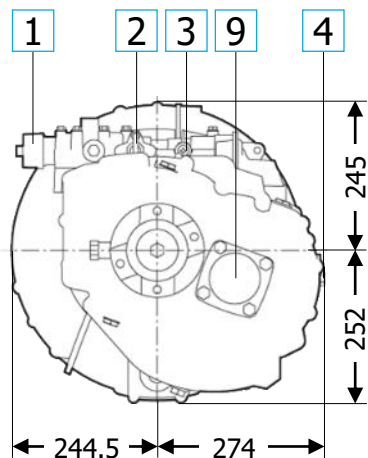
Outline Drawing of Ecolite 6 S 710 BO



- 1 Selector output (shown for linkage shift system)
- 2 "Neutral" sensor
- 3 "R gear" sensor
- 4 Oil filler hole and oil overflow check
- 5 Input
- 6 Output

- 7 Speedo connection
- 8 Oil drain
- 9 Connecting face for clutch cylinder
- 10 Connecting face for cooler set
- 11 Breather

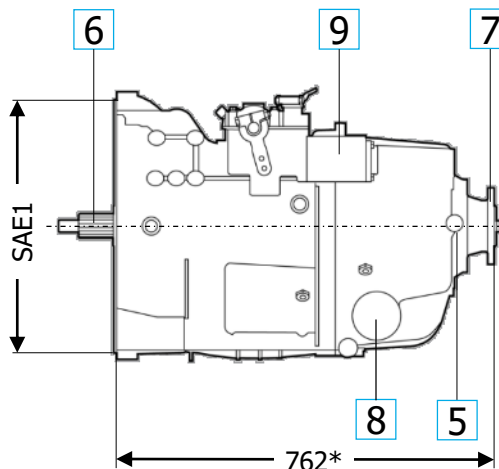
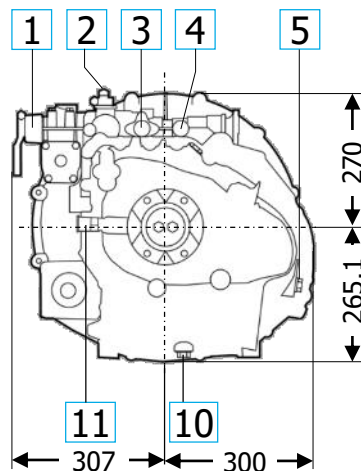
Outline drawing of Ecolite 6 S 1010 BO / 6 S 1110 BO



- 1 Selector output (shown for linkage shift system)
- 2 "Neutral" sensor
- 3 "R gear" sensor
- 4 Oil filler hole and oil overflow check
- 5 Input
- 6 Output

- 7 Speedo connection
- 8 Oil drain
- 9 Connecting face for cooler set pump
- 10 Breather
- 11 Connection for clutch cylinder

Outline Drawing of EcoShift



For the
installation
drawing with
Intarder, see
Module 06!

- 1 Selector output
- 2 "1st gear" sensor
- 3 "Neutral" sensor
- 4 "R gear" sensor
- 5 Oil filler hole and oil overflow check
- 6 Input

- 7 Output
- 8 Heat exchanger (optional, application-specific)
- 9 Servoshift cylinder
- 10 Oil drain
- 11 Speed sensor

* Applies to standard output flange XS155. Other flanges on request

Manual ZF Transmissions

Special Features

Manual transmissions for line service buses and coaches

- High level of power transmission
- Easy to shift
- Large ratio range



Highlights – Technology

Manual transmissions for line service buses and coaches

- State-of-the-art transmission technology in modular design
- Powerful
- 6 gears
- Precise, comfortable gear changes
- Low noise
- For every kind of application
- Lower operating costs (fuel, clutch, oil quantity)
- Flexible installation

EcoShift: standard version with ZF-Intarder



Highlights – Customer Value

Manual transmissions by ZF stand for:

- Experience
- Payload advantages
- Cost-effectiveness
- Safety
- Versatility
- Environmental friendliness



Advantages for the Vehicle Manufacturer

2 transmission platforms for a large number of variants:

- For each platform, one basic transmission with the same connections and installation dimensions for all variants.
 - Manual
 - Manual with Servoshift
 - EcoShift with Intarder
- Minimum installation space
- New design options
- Universally applicable
- Option: automatic transmission



Advantages for Vehicle Owners

Manual transmissions stand for:

- Minimum operating costs
- Optimized payload
- Increased safety
- Reliable operation



Advantages for the Driver

- Top driving comfort
- More safety
- Suitable gears
- Reliable service



Benefits for the Environment

Manual transmissions stand for:

- Lower emissions
- Resource saving
- Eco-friendly driving



Lower Operating Costs

Optionally available: sensor "1st gear engaged"

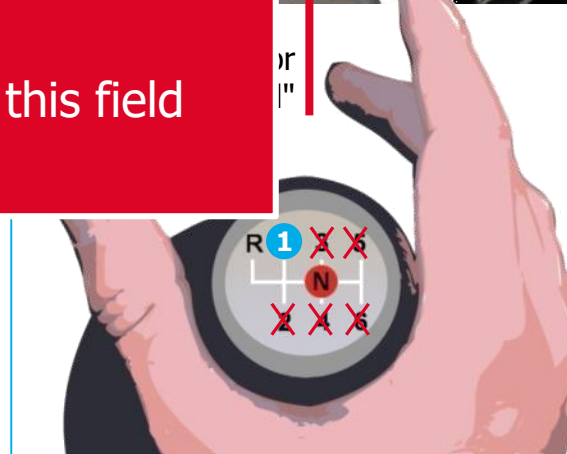
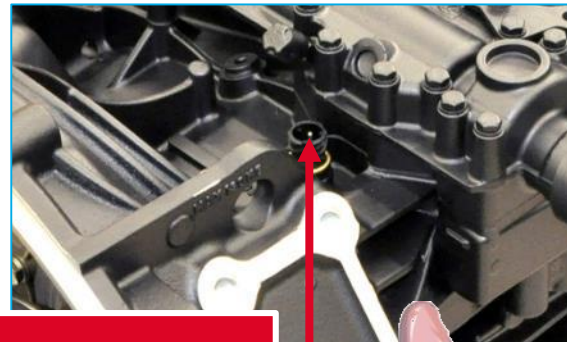
- This means the vehicle manufacturer can easily implement the "setting off only in 1st gear" function.

Advantage: c

- Setting off in
is no longer p

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Precise Shift Systems

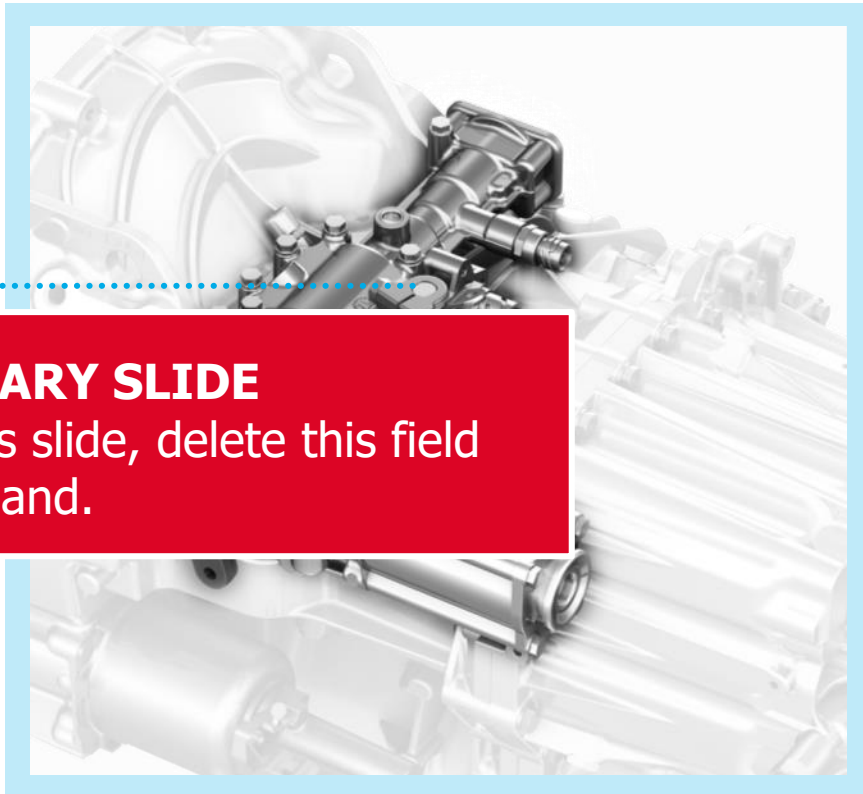
Optimized connection of cable controlled shift system with separate selection and shifting mechanism

- For clear and precise shift sequences in the transmission

Select

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Powerful - EcoShift

EcoShift – optimal power-to-weight ratio for optimized payload

- High input torques of up to 2,100 Nm
- Low weight:
the transmission without Intarder weighs 230 kg
- Universally applicable:
For any engine power from 1,000 to 2,100 Nm input torque
- Integrated clutch
Weight-optimized

SUPPLEMENTARY SLIDE

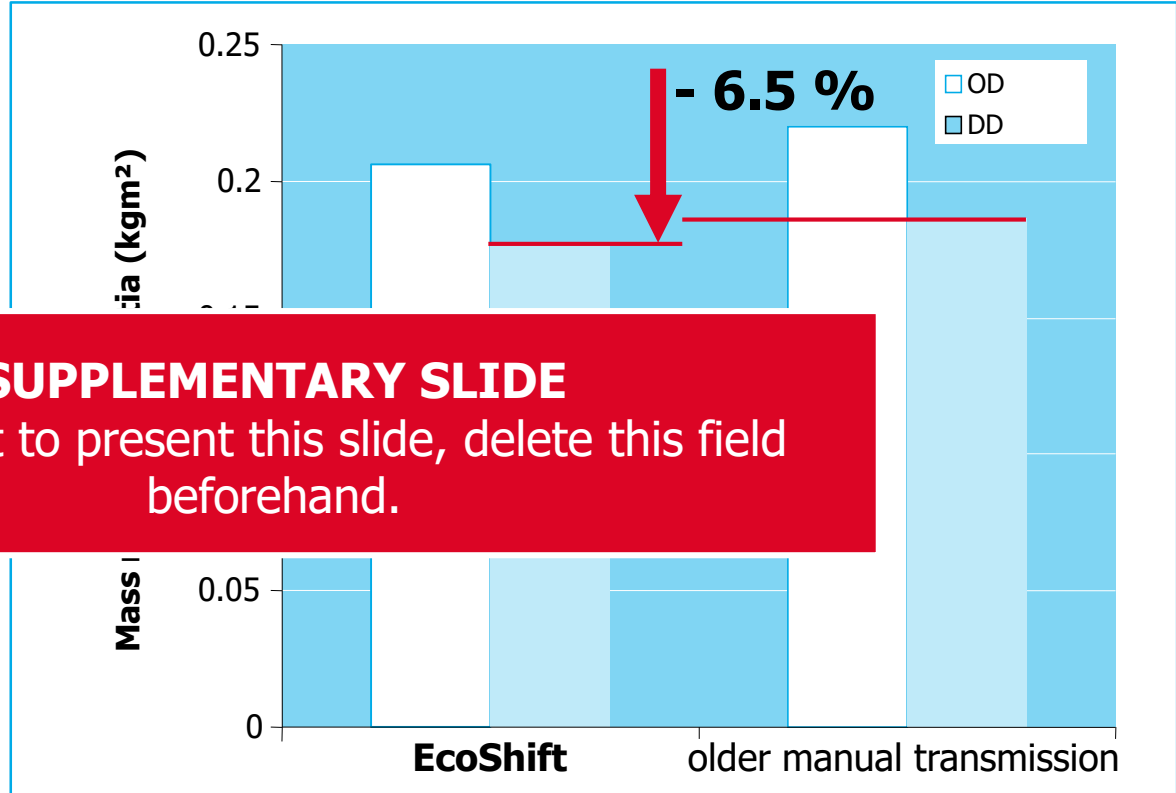
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Shift Comfort EcoShift

Easy to shift thanks to reduced mass moment of inertia

- Because: rotating masses have been reduced (incl. clutch disk)
- Synchronizer on countershaft



Benefits / Technical Characteristics of EcoShift

Summary (I)

Benefits

- Latest transmission technology
- Optimal power-to-weight ratio
- Highly efficient
- Extended clutch life
- Low-noise (meets future noise requirements)

Technical features

- 6-speed transmission platform (from 1,000 Nm) for manual shifting
- High torque of up to 2,100 Nm, low transmission weight
- Available as an option
- New gear set design
- Integrated clutch bell housing for high housing rigidity

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Benefits / Technical Characteristics of EcoShift

Summary (II)

Benefits

- Flexible installation: dashboard-suitable shift system with short shift travel
- Easy to shift (reduced shift force)
- High shift precision
- Wear-free braking with high brake force

Technical features

- Servoshift, cable controlled shift system
 - Low mass inertia of the gear set
 - ZF-Intarder 3 (optional)

Optional: adapter for electric third-party retarder available
- mechanism controlled shift

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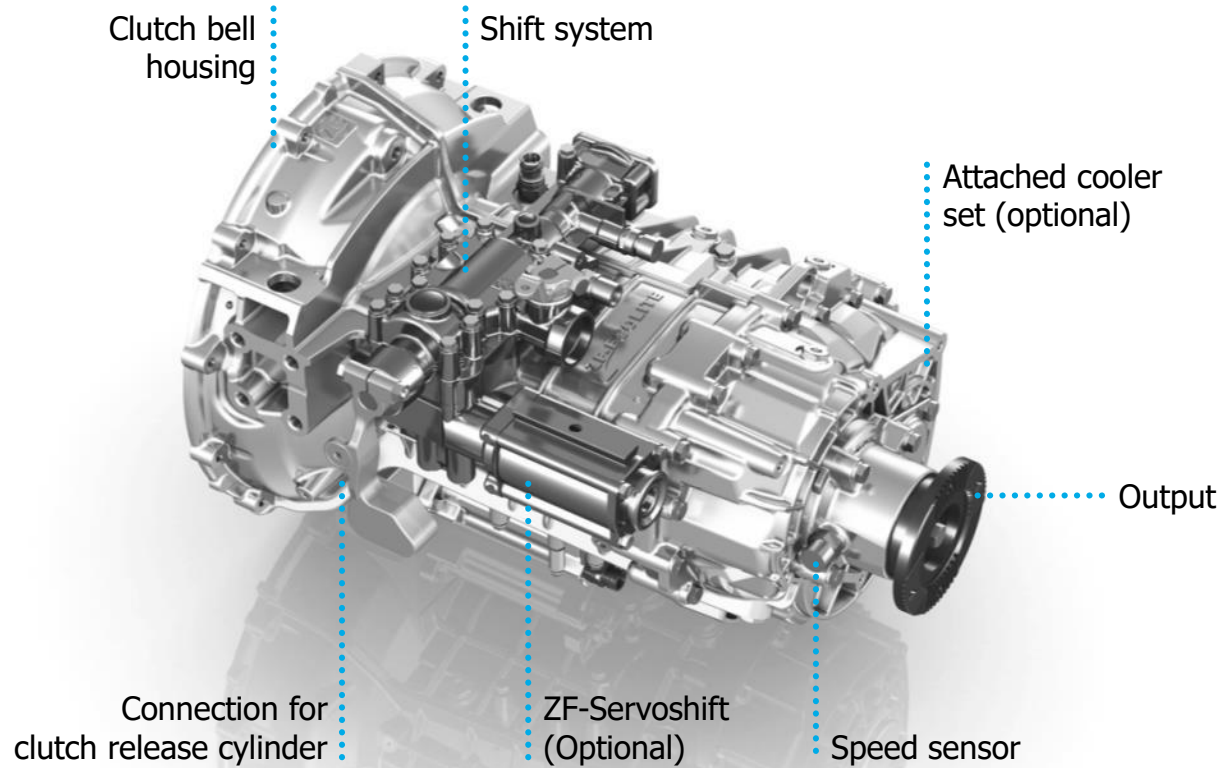
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02

Technology and Operation

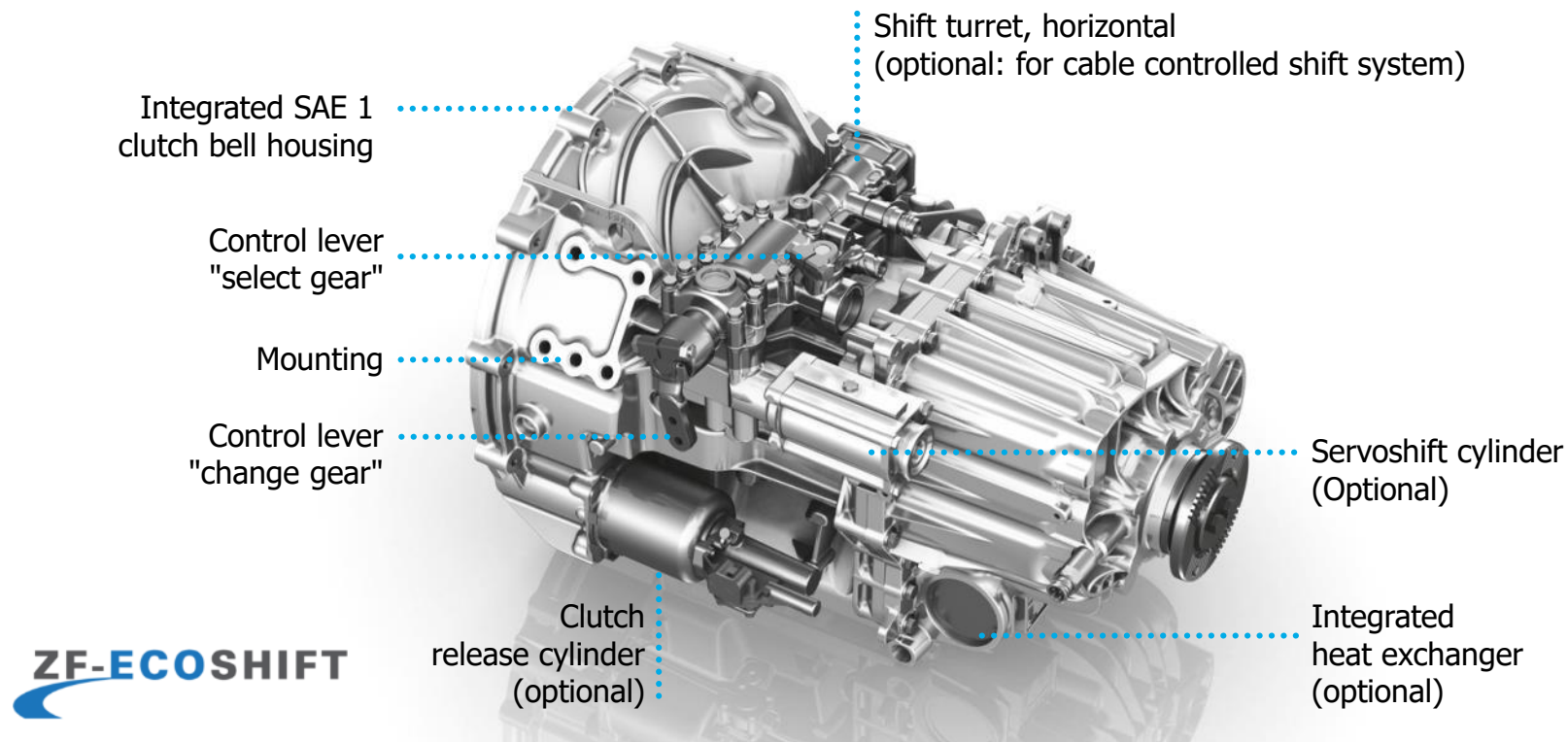
Ecolite

The Transmission System



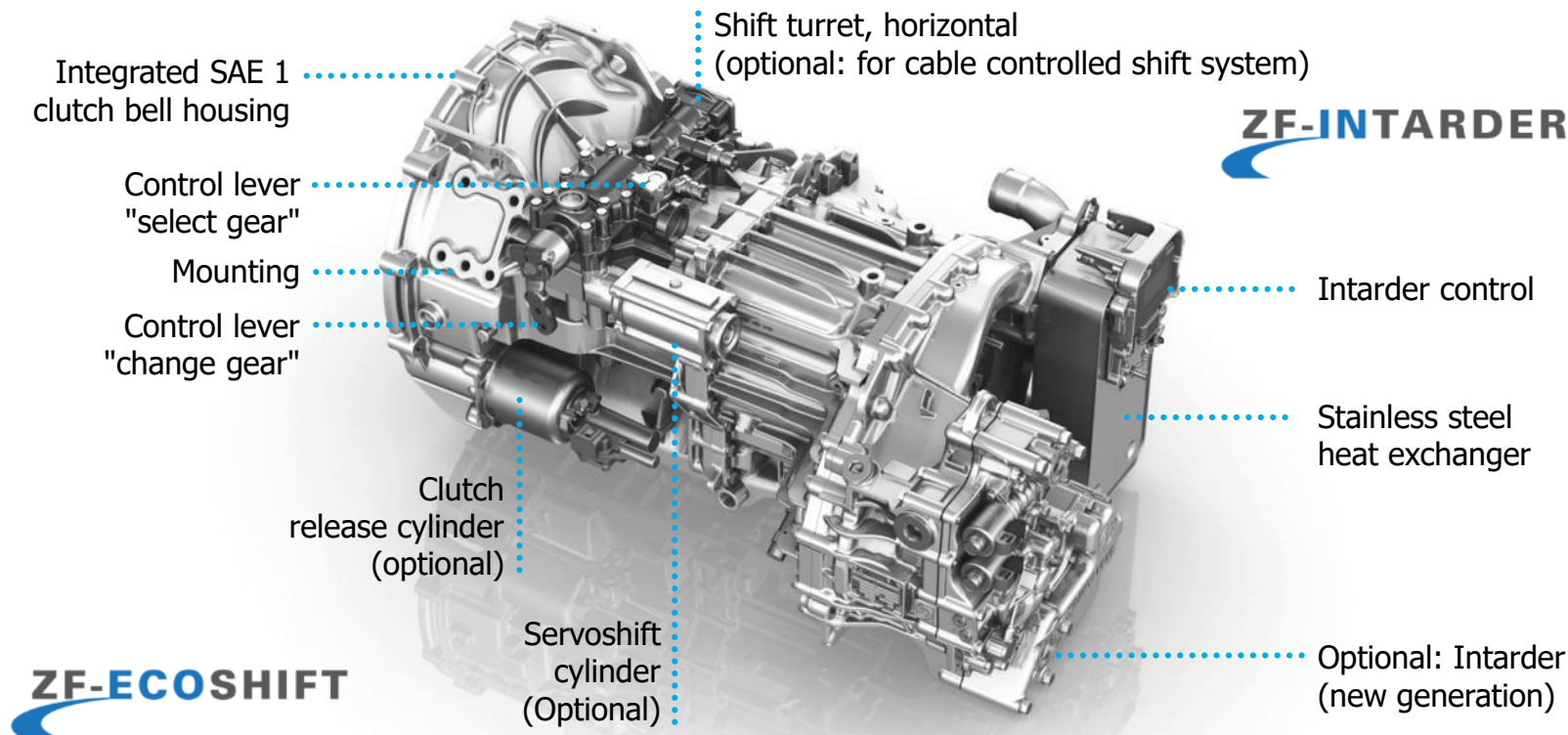
EcoShift

The Transmission System



EcoShift with Intarder

The Transmission System

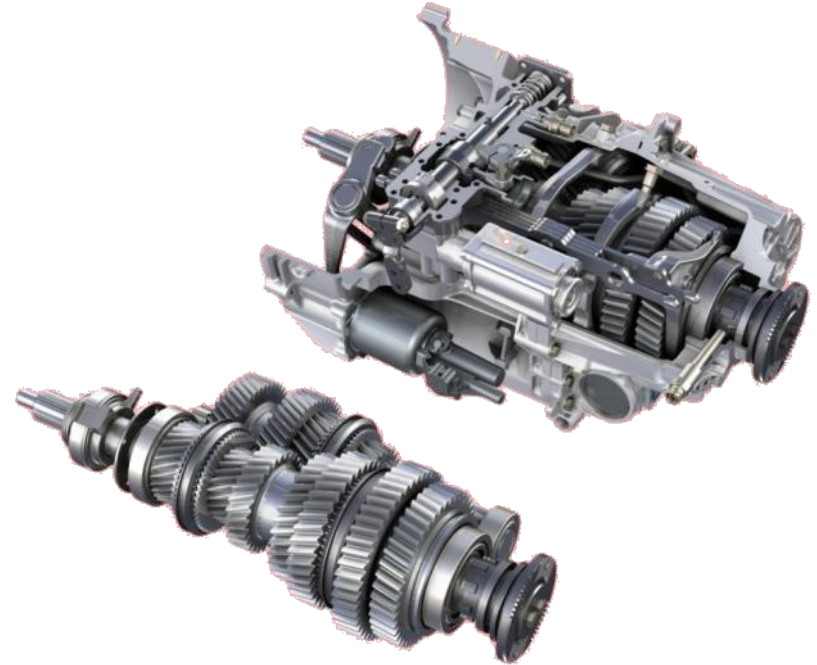


Transmission Design (Example: 6-Speed)

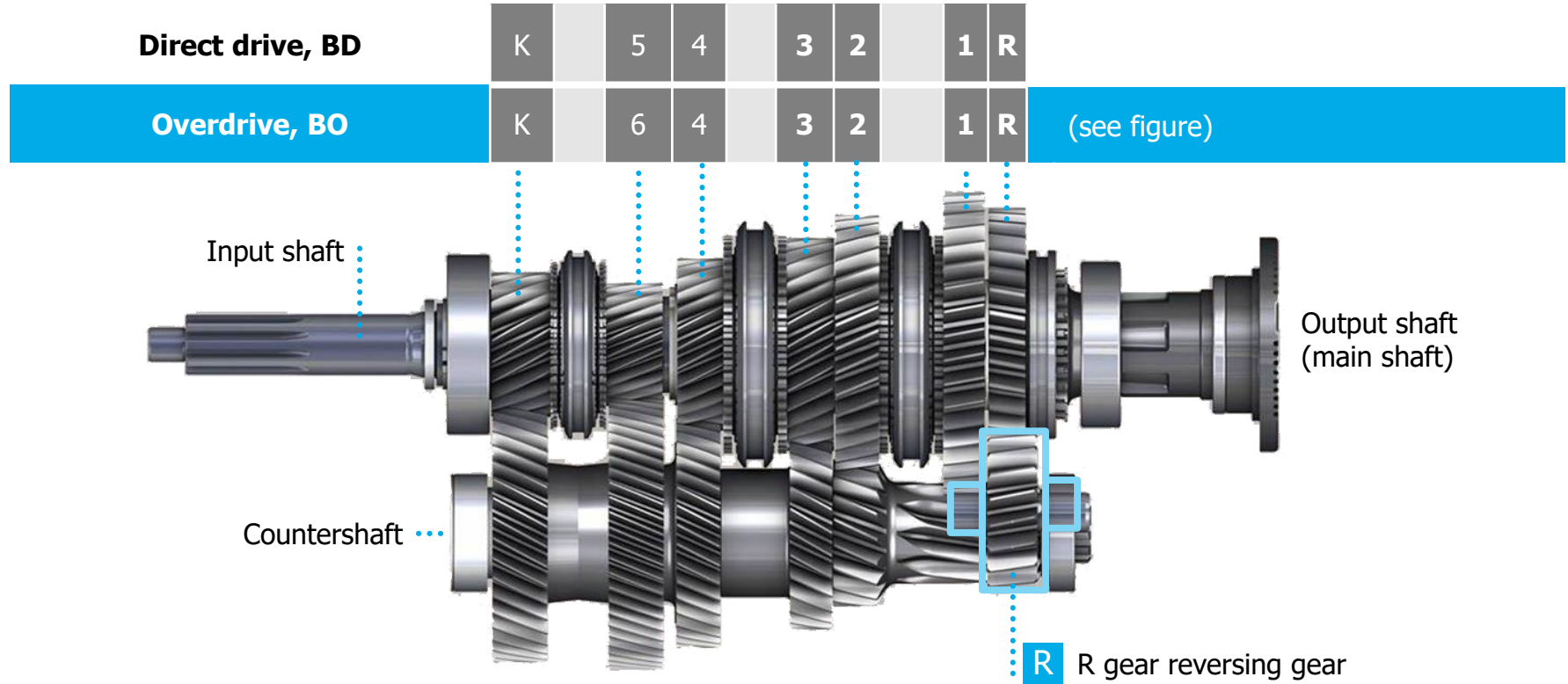
Ecolite



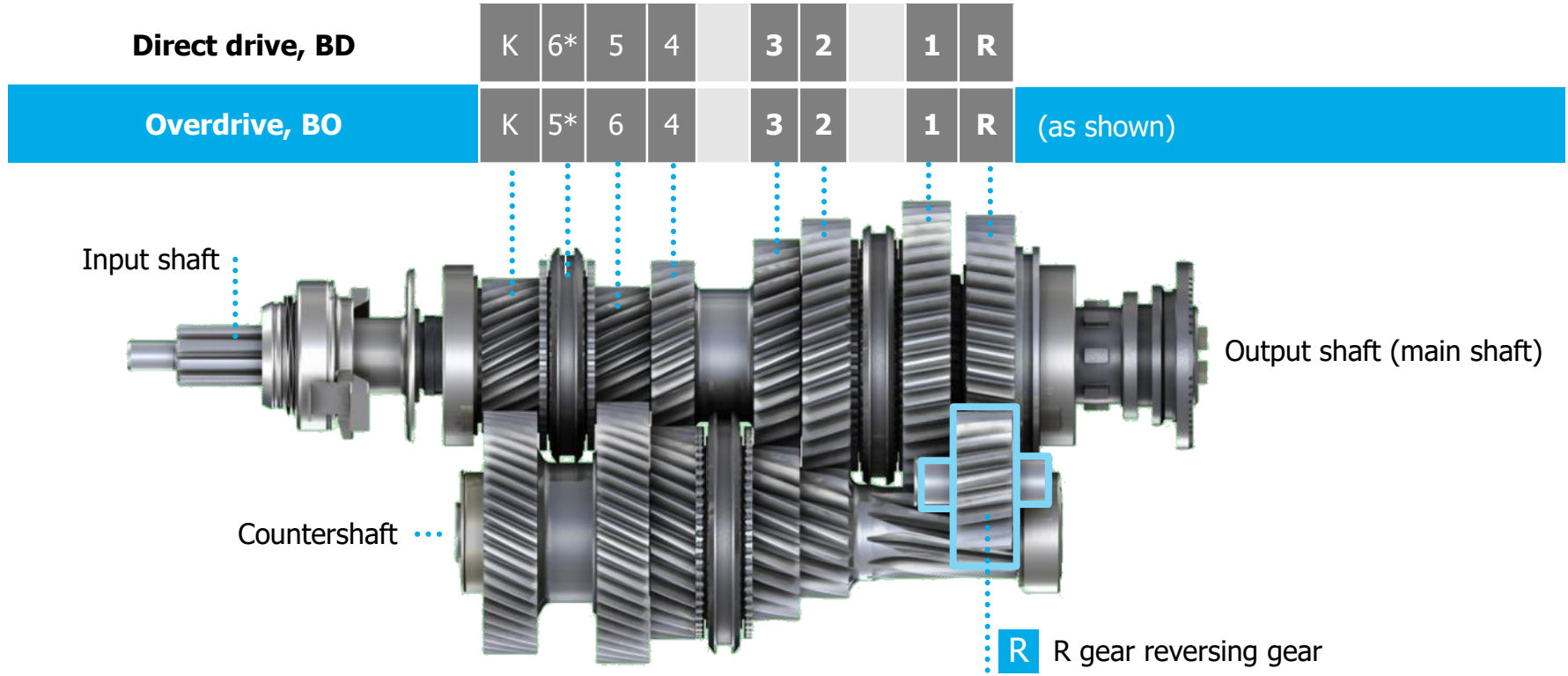
EcoShift



Ecolite Shift System (Example: 6-Speed)

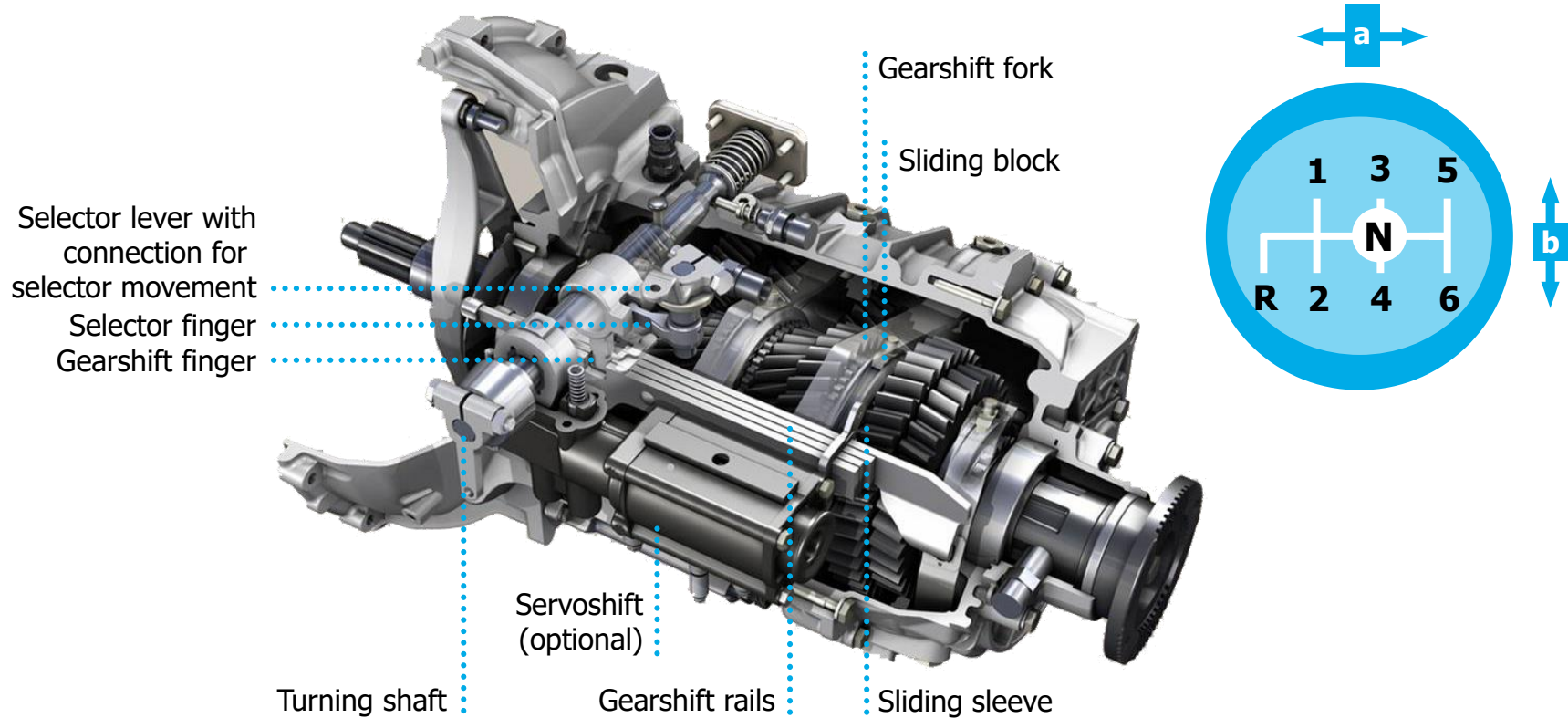


EcoShift Shift System

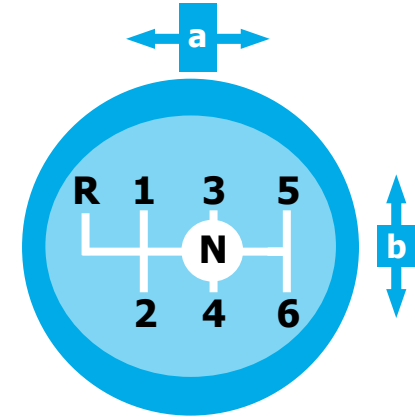
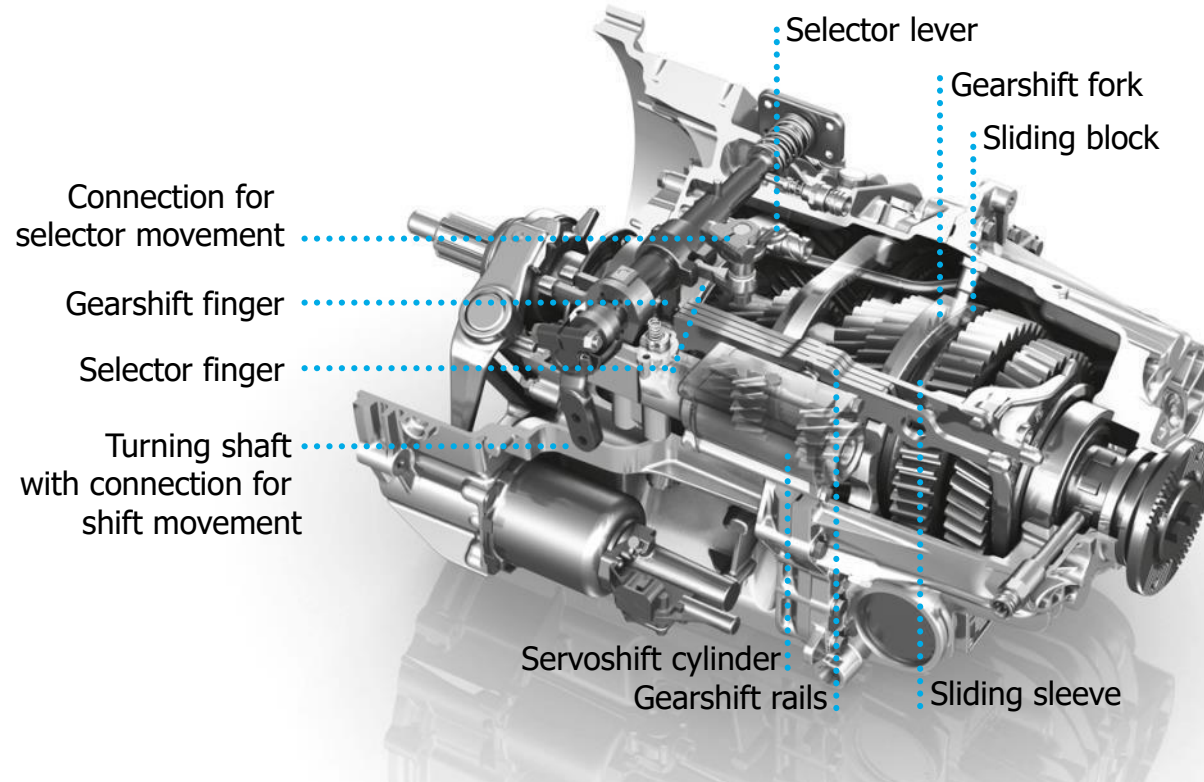


* Direct gear (direct connection of input shaft and main shaft)

Ecolite Gear-Change Mechanism, (Example: 6-Speed, Cable Controlled Shift System)



EcoShift Gear-Change Mechanism, (Example: 6-Speed, Cable Controlled Shift System)

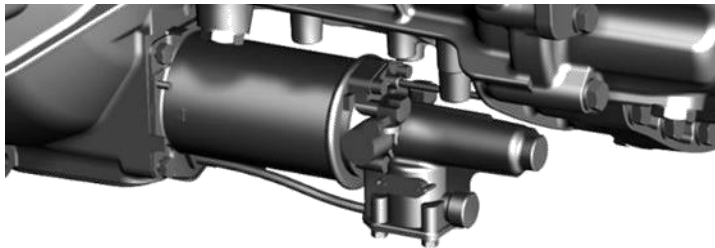
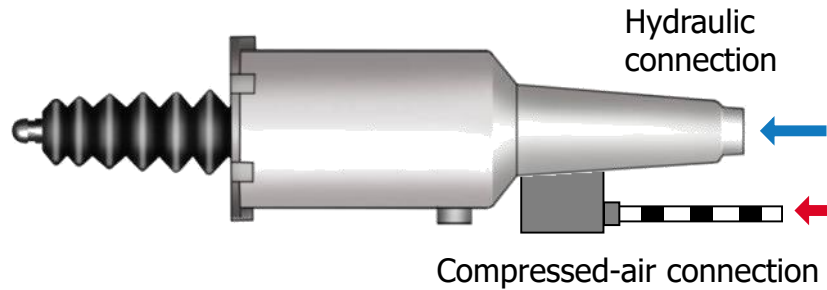


Clutch Release Cylinder (Optional)

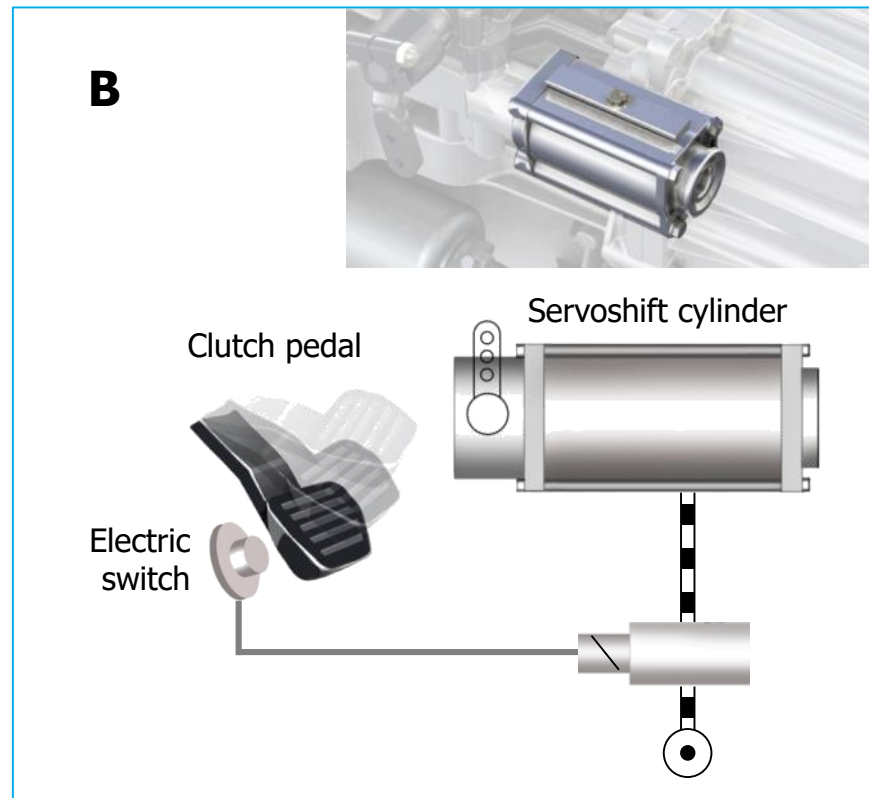
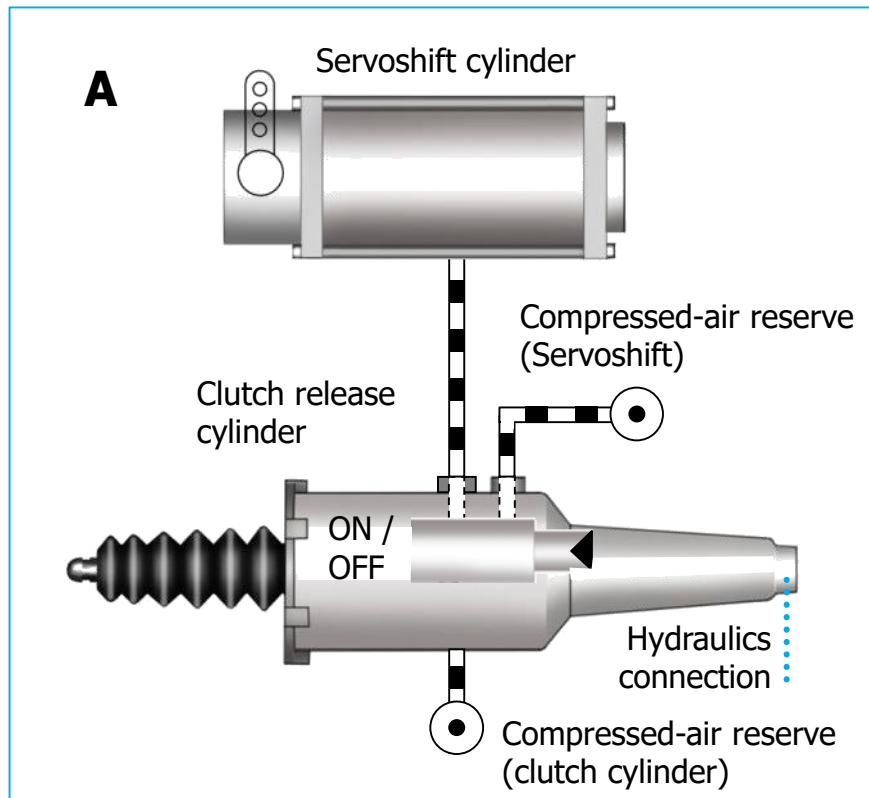
Clutch release cylinder with compressed-air assistance

Ecolite

EcoShift

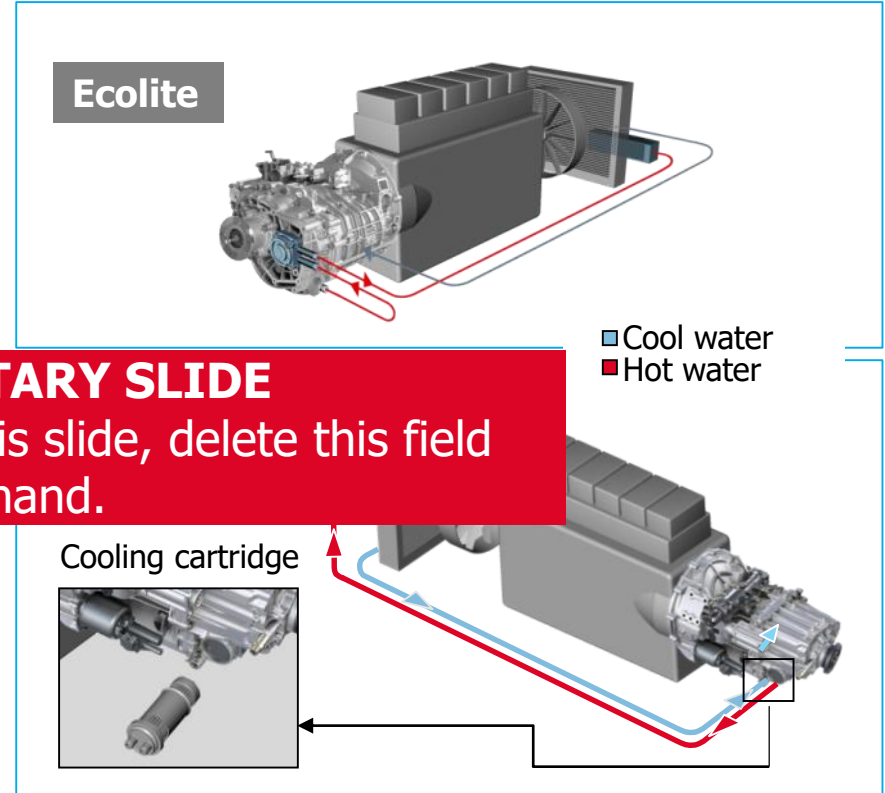


Servoshift (Option)



Cooler Set (Optional)

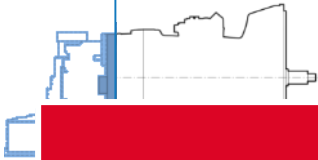
- For extreme and tough applications without Intarder
- Additional cooling system connected with the vehicle cooling system.
 - **Ecolite:** connection of an oil pump to the PTO connector
 - **EcoShift:** inserted cooling cartridge
- reduces the transmission operating temperature so that the oil change intervals of the ZF List of Lubricants TE-M
- No additional ext



Retarder – Installation of Additional Brake

- **The ZF-Intarder is available for EcoShift transmissions (see Module 06).**
- Retarders from other manufacturers can be attached to Ecolite transmissions using an adapter; this option is also available for EcoShift.

Hydraulic
retarder

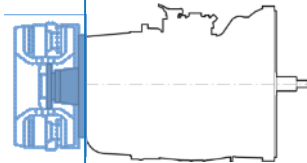


Electric
retarder

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Electric
retarder



EcoShift



Clutch Bell Housings

Ecolite

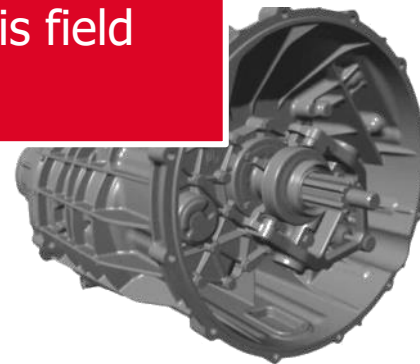
- **Size 2**
according to SAE Standard J 617 c and ISO Standard 7649
for servo-assisted flange couplings.
- **Push-type clutch actuation system:**
6 S 710 BO, 6 S 1010 BO, 6 S 1110 BO
- **Option:**
With servo-assi

EcoShift

- **Size 1**
according to SAE Standard J 617 c
for flange couplings.
- **Pull-type clutch actuation system.**
- Components available for clutch release mechanism.

SUPPLEMENTARY SLIDE

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beforehand.



Manual Transmissions

Operating Concept

The contents at the following pages provide information on the essential functions required to operate the transmission.

The information is not complete and does not replace the applicable operating instructions!

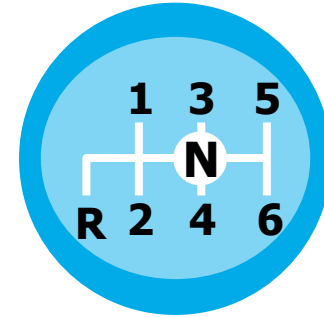
Starting Engine and Driving Off

Operation

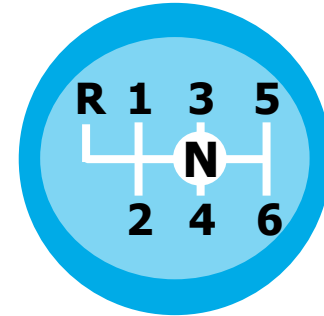
- Apply parking brake
- Move shift lever to neutral position
- Start the engine
- Fully depress clutch pedal
- Engage 1st gear
- Release parking brake and engage the clutch

Shift pattern

Ecolite



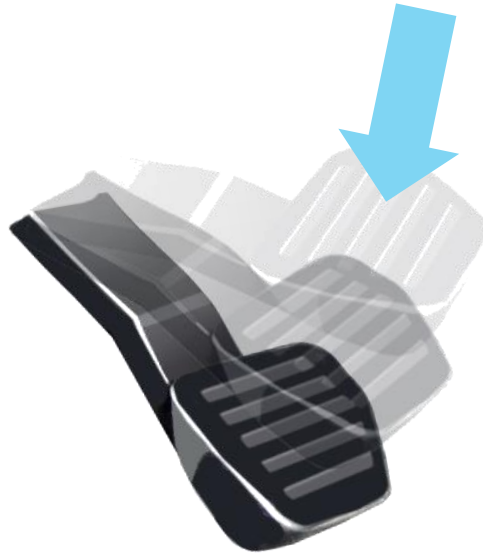
EcoShift



Shifting the Transmission

Operation

- Fully depress clutch pedal
- Select shift gate
- Engage gear

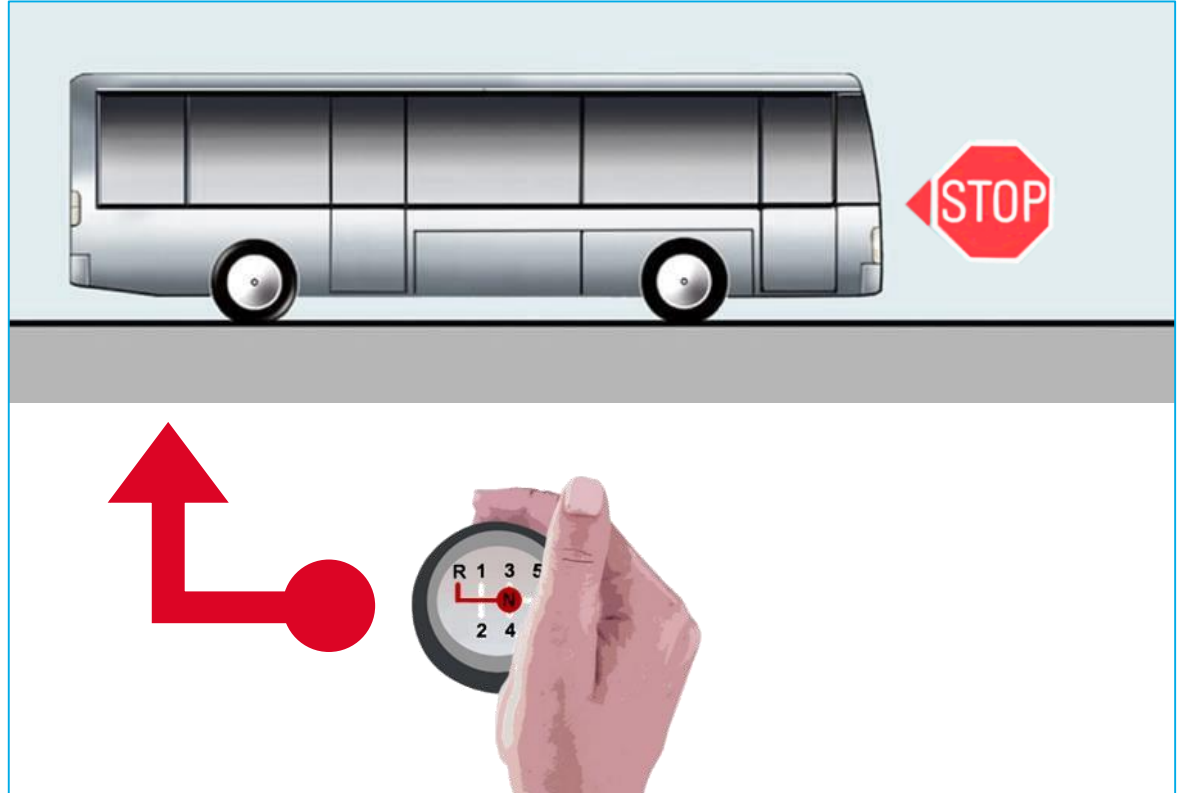


N = neutral position

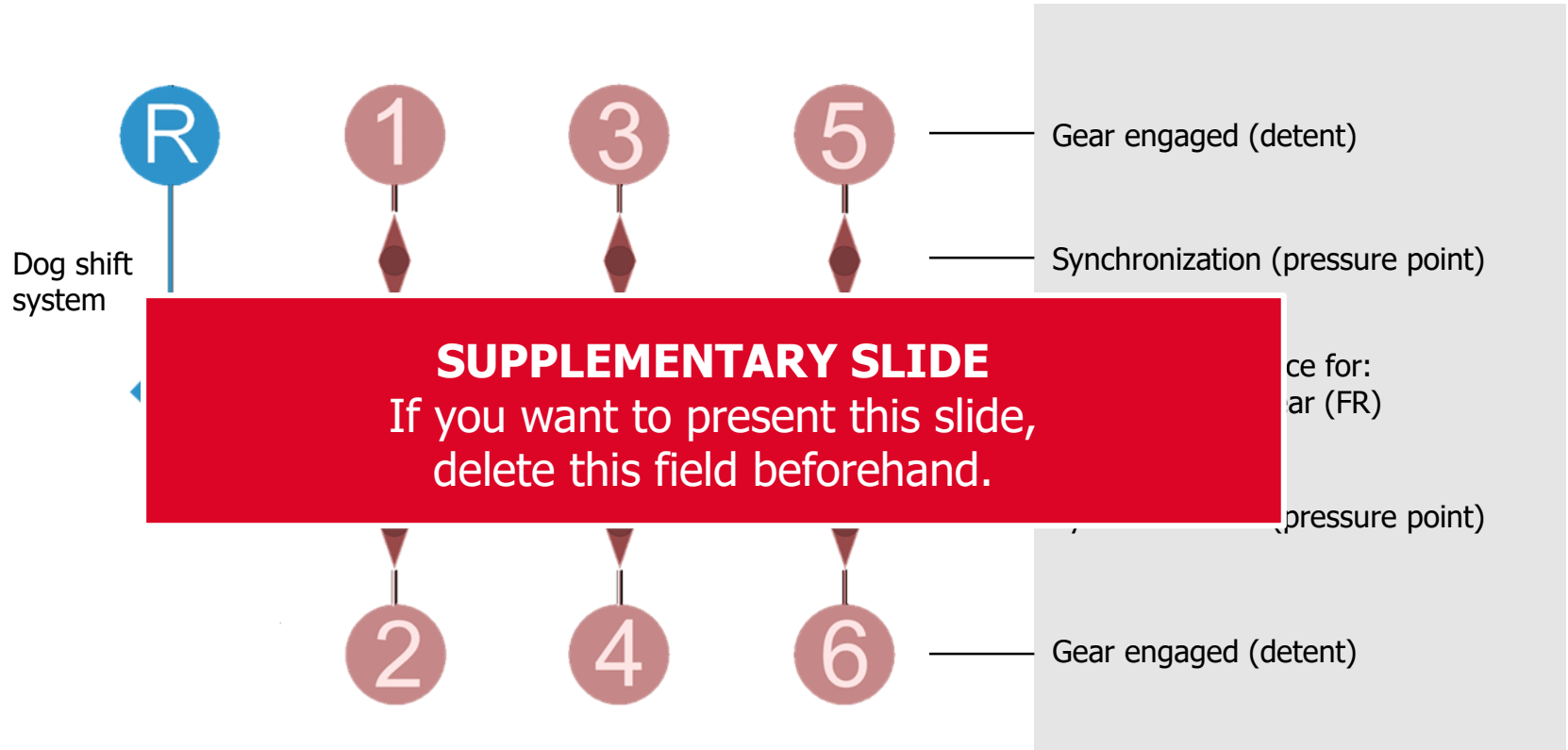
Engaging Reverse Gear

Operation

- Stop the vehicle
- Fully depress clutch pedal
- Wait for engine idling
- Select shift gate for R gear
- Engage gear

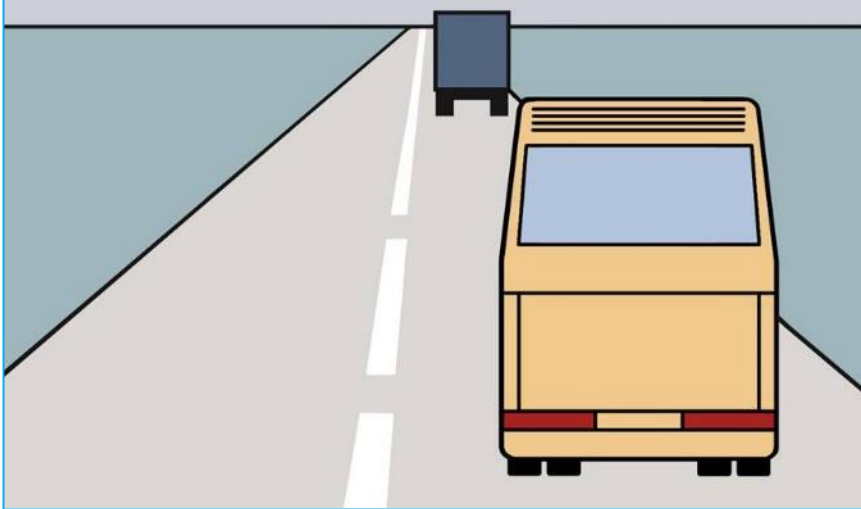


Shift pattern (example EcoShift)



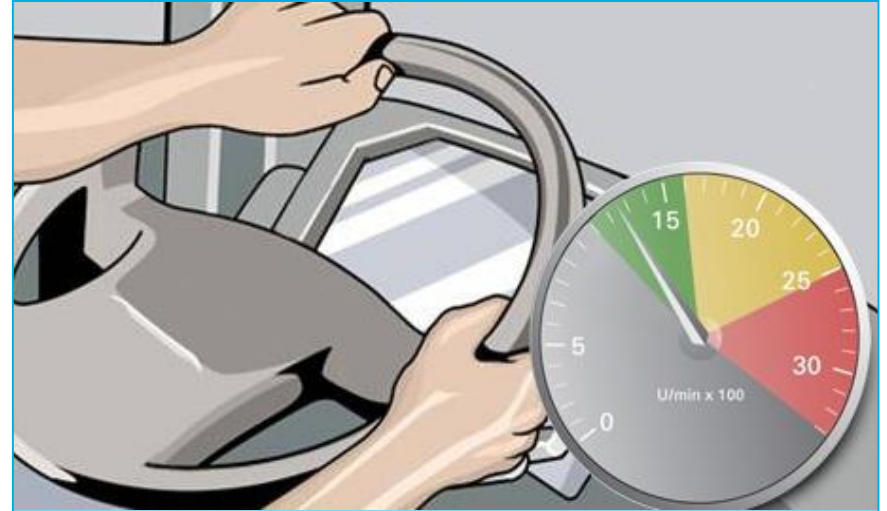
Driving Tips 1 and 2

Tip 1: Drive with foresight!



A consistent driving style saves fuel, avoids stress and improves safety.

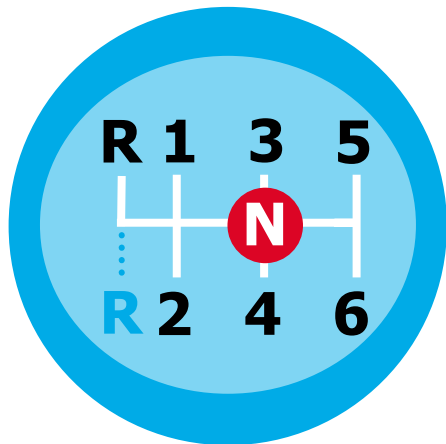
Tip 2: Drive within the green speed range!



Green range: fuel-efficient engine speeds!

Driving Tips 3 and 4

Tip 3: In case of longer stops, switch to neutral!



Reduces strain on the clutch mechanism!

Tip 4: Stop before changing direction of travel!



Changes in direction of travel only when the vehicle is stationary.

Driving Tips 5 and 6

Tip 5: Apply the parking brake!



Apply the parking brake before you leave the driver's seat!

Tip 6: Gentle driving prevents wear



Fully depress the clutch pedal. Do not jump gears. Set off in 1st gear!

03

EcoShift with Intarder



EcoShift with ZF-Intarder

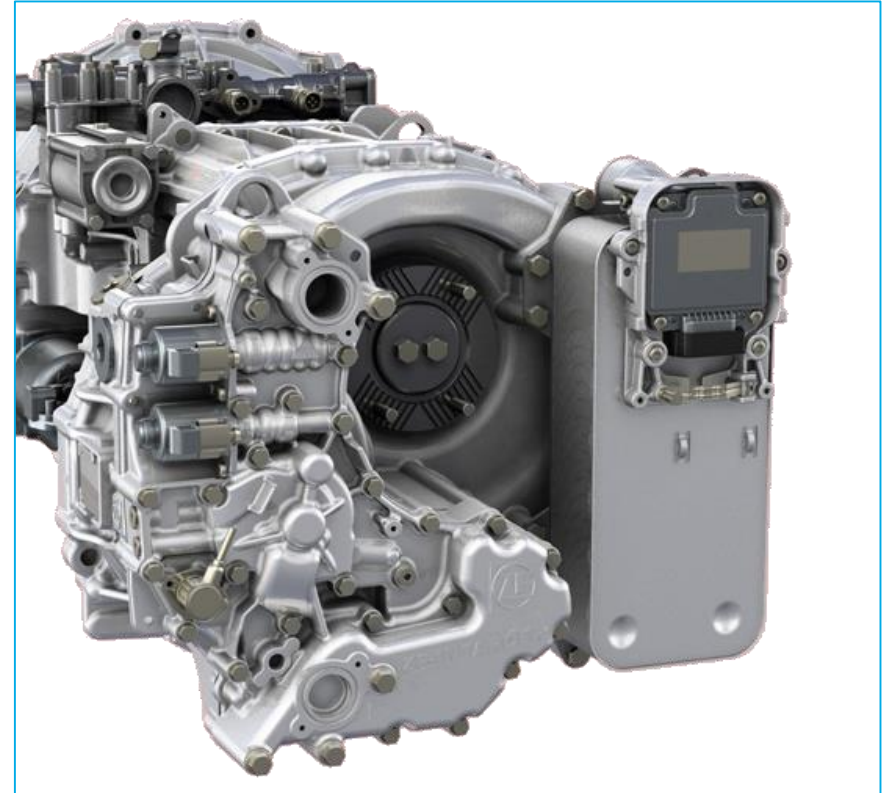
The Complete System

The ZF-Intarder is available for EcoShift transmissions.

Highlights:

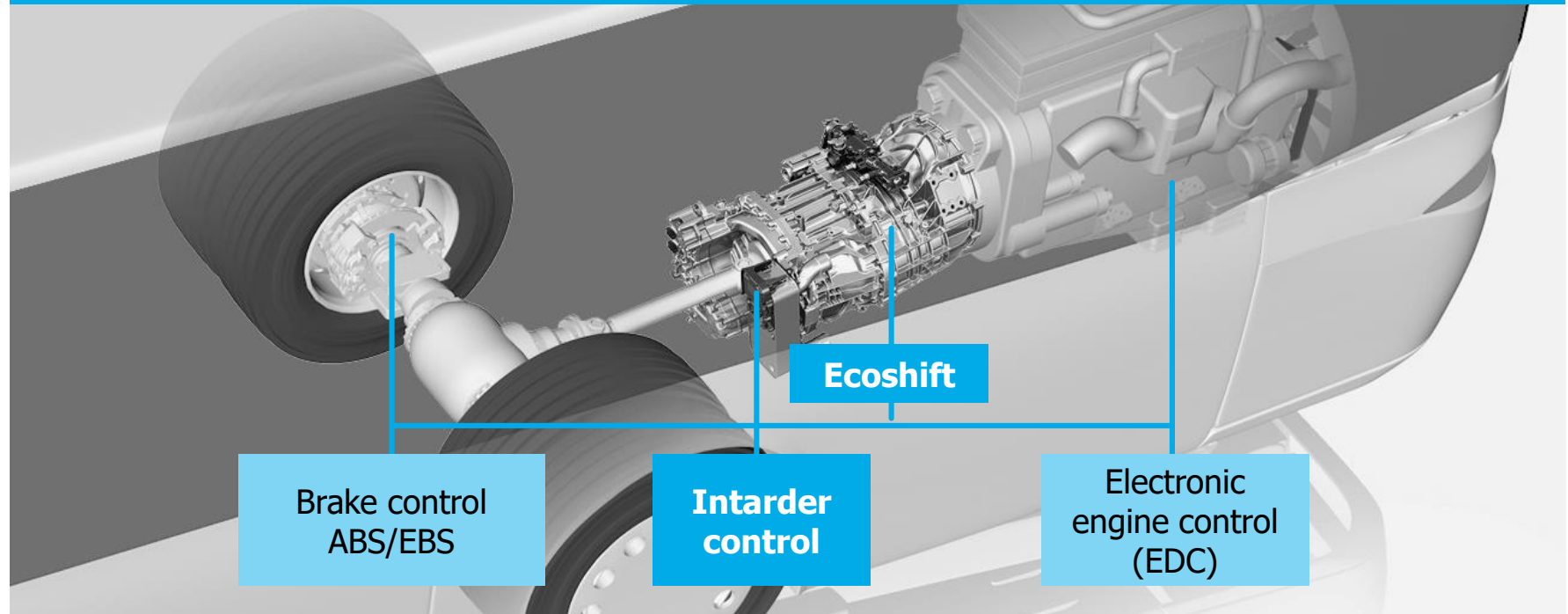
- Braking power of up to 600 kW
- Short response times
- 2 versions: Eco, Power
- On-site electronics

ZF-INTARDER



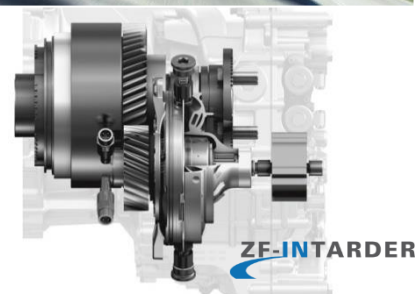
EcoShift with ZF-Intarder Communication in the Driveline

Connection to the bus's CAN system with conventional setup

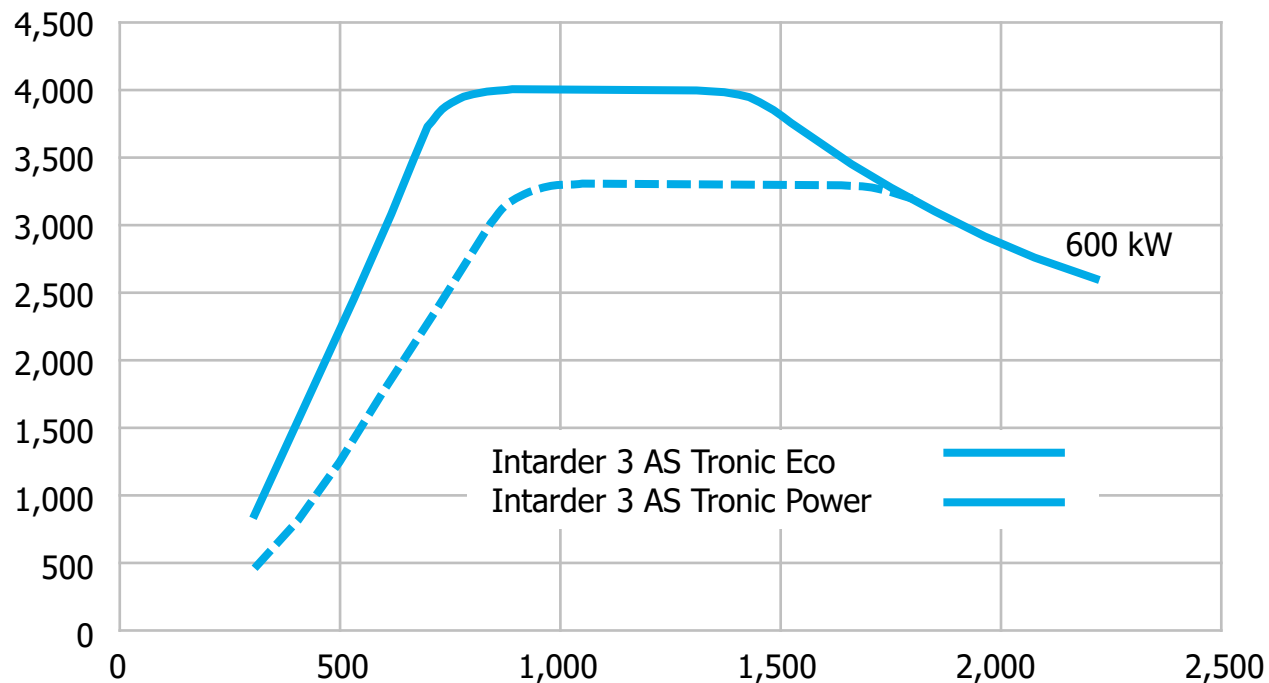


Product data for EcoShift

Operating modes	Bremsomat • Bremsomatic • Bremsomatic + cruise control
Braking steps	5
Brake torque [Nm]	AS Tronic • EcoShift: 4,000 (Power) or 3,300 (Eco)
Braking power [kW]	Max. 600 (short-time)
Idle speed performance (1,500 rpm)	1.4 kW (Power); 1.1 kW (Eco)
Noise [db(A)]	80
Weight of ZF-Intarder unit [kg]	Approx. 65 (depending on version)
Operating principle	Hydrodynamic hydraulic brake
Control unit	Electronic (CAN communication)
Oil supply	Together with the transmission
Cooling and heating function	Via the vehicle radiator for the transmission and the Intarder
Compatibility	With ABS systems, EBS
Release	According to Directive on the Transportation of Hazardous Goods (GGV)

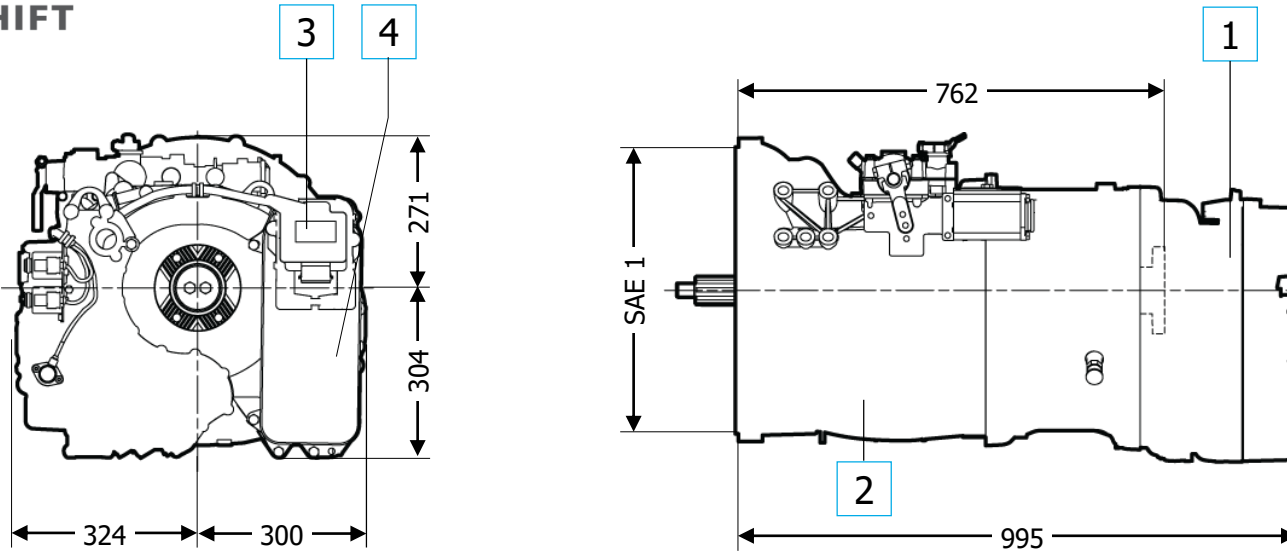


Intarder 3 EcoShift Brake Torque Chart



Installation Dimensions EcoShift with Intarder 3

ZF-ECOSHIFT



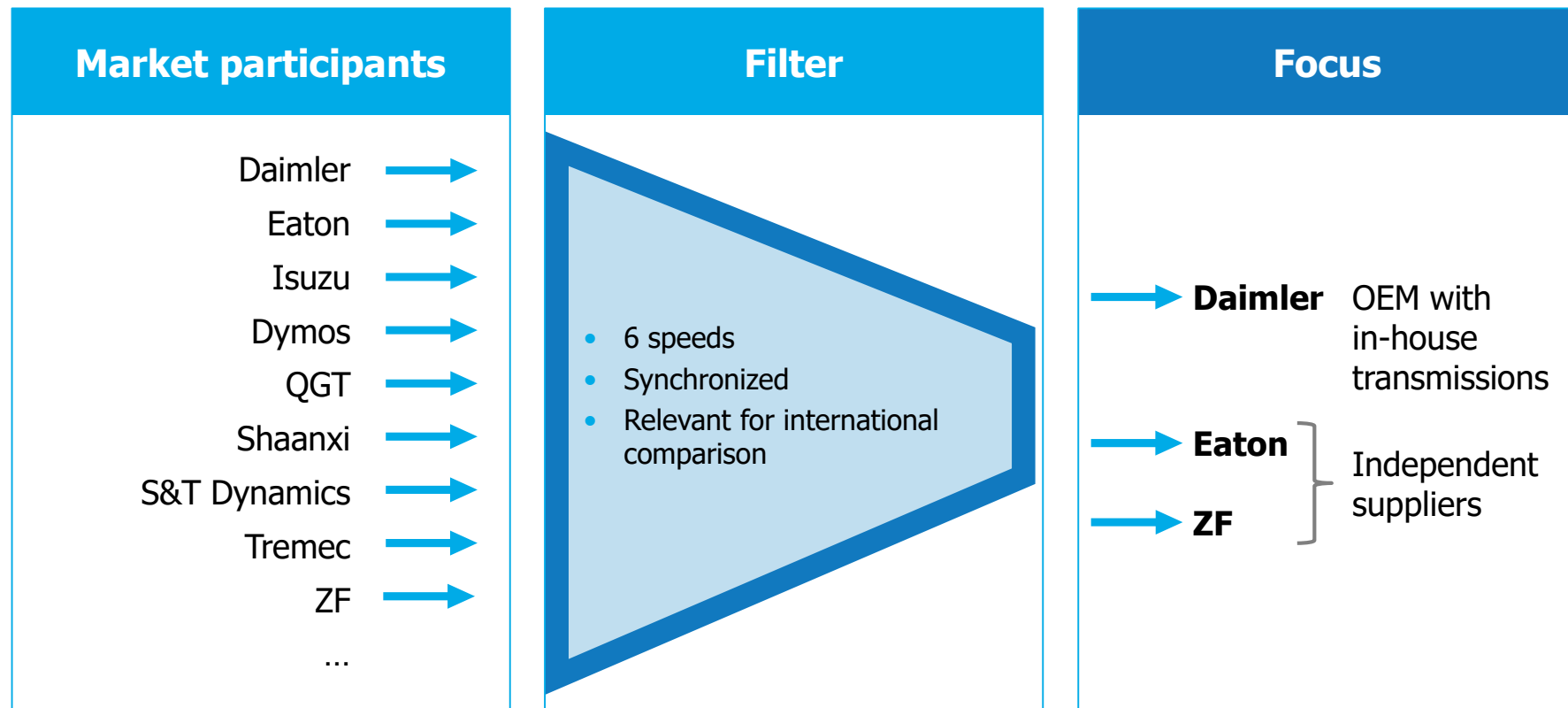
- 1 ZF-Intarder
- 2 EcoShift transmission
- 3 Intarder control unit
- 4 Oil/water heat exchanger

04

Competition Topics

ZF Manual Transmissions in Buses

Focus on Market Participants



ZF Manual Transmissions in Buses

Overview Over Main Competitors



EcoShift, up to 2,100 Nm

6 S 1310 / 1311 BD / BO
6 S 1610 / 1611 BD / BO
6 S 1910 / 1911 BO
6 S 2111 BO



Ecolite, up to 1,100 Nm

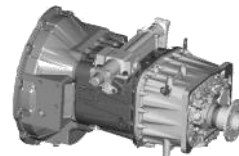
6 S 710 BO
6 S 1010 BO
6 S 1110 BO



FSB 5406 B
FSB 6406 B
FSBO 6406 A
FSBO 8406 A
FSBO 9406 A



FS 5206 A/B
FSO 5206 B



DAIMLER

(OEM with in-house transmissions)

GO 190-6 CPS
GO 210-6 CPS
GO 230-6 CPS



G 70-6S (OD)
G 71-6S
G 90-6S



Application Examples

ZF, Eaton and Daimler



Hyundai



MAN



Temsa



VDL



Daewoo



Iveco Bus



Further examples: BMC, Higer, Hino, Kamaz, Kia, King Long, MAZ, Solaris, SOR, Temsa, Volvo, VW, Xiaman Golden Dragon, Yutong and many more

Used by more than 50 bus manufacturers on four continents



Examples of OEM:

Otokar, VW Volksbus Chassis

Otokar



Only available from a few bus manufacturers



Examples of own brands:

Mercedes-Benz, Setra

Examples of other manufacturers:

Van Hool

Mercedes-Benz



Used only in buses of their own brands as well as with some individual applications at other manufacturers

ZF vs. Eaton

Overview



EcoShift, up to 2,100 Nm

6 S 1310 / 1311 BD / BO
6 S 1610 / 1611 BD / BO
6 S 1910 / 1911 BO
6 S 2111 BO



Ecolite, up to 1,100 Nm

6 S 710 BO
6 S 1010 BO
6 S 1110 BO



Up to 1,290 Nm

FSB 5406 B
FSB 6406 B
FSBO 6406 A
FSBO 8406 A
FSBO 9406 A



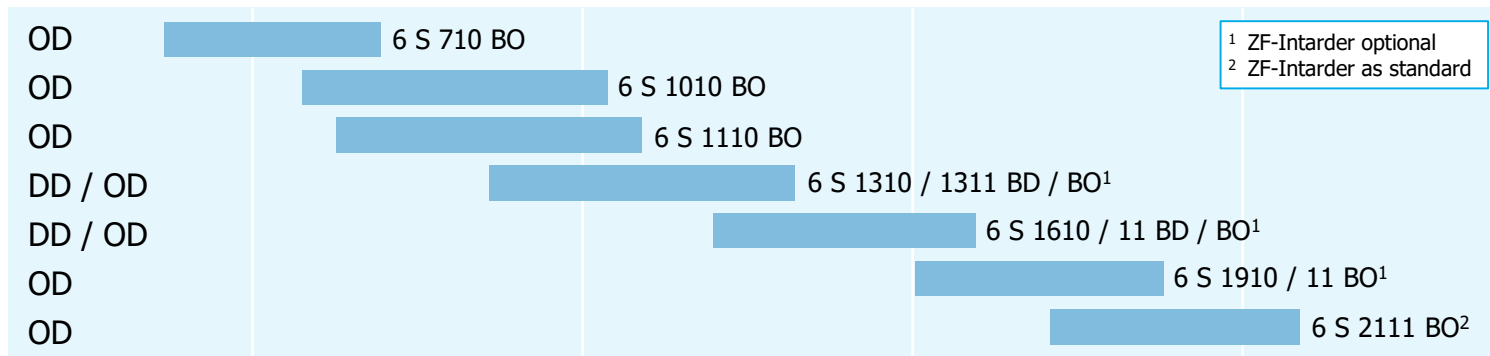
Up to 825 Nm

FS 5206 A/B
FSO 5206 B

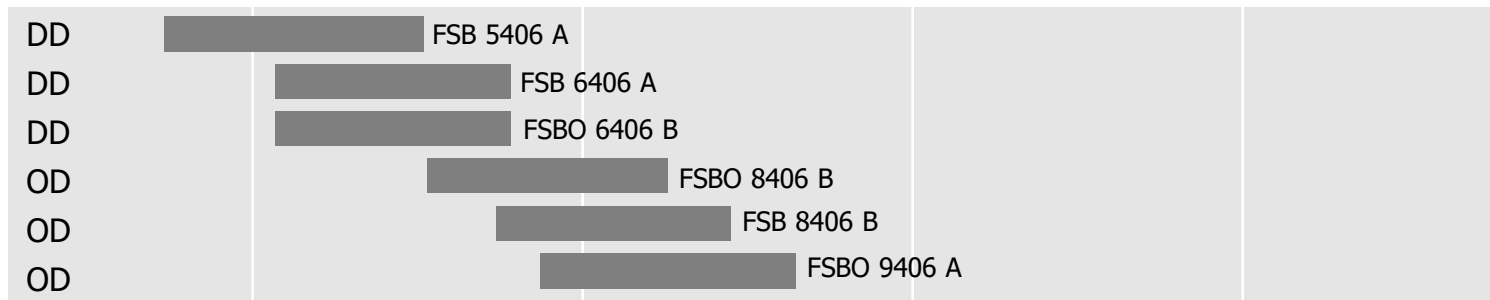


FS	Fuller Synchronized
B	Bus
O	Overdrive
9	x 100 = approx. admissible input torque [Lbs-Ft]
4	Development stage
06	Number of forward gears
A/B	Gear ratio series

ZF vs. Eaton Torques



¹ ZF-Intarder optional
² ZF-Intarder as standard



Torque [Nm]

500

1,000

1,500

2,000

Compared to Eaton, ZF offers a more extensive product portfolio for all bus classes!

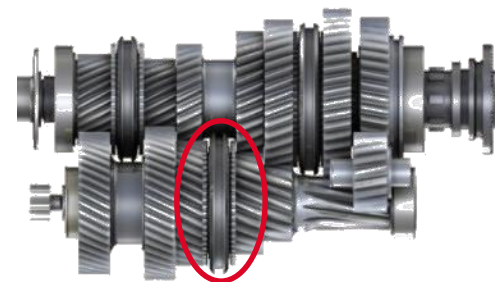
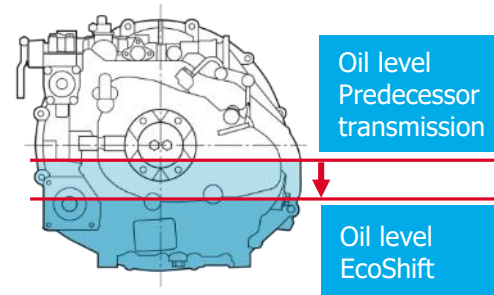


EcoShift vs. Eaton

Advantages (1)

EcoShift – State of the art for manual bus transmissions

- **High efficiency = less fuel consumption**
Fewer churning losses due to pressure oil lubrication with low oil level:
17 % less oil at approx. 40 % higher torque than Eaton
- **Higher performance**
 - 800 Nm more than Eaton
 - Integrated clutch bell housing instead of separate one
 - Weight-optimized aluminum housing instead of gray casting
- **Easier gear shifting**
 - Fewer inert masses due to relocation of **synchronizer unit 3rd/4th gear to countershaft – a novelty in this bus class**
 - Optional pneumatic Servoshift shifting support
 - Less resistance when downshifting due to low oil level



Synchronizer unit 3rd/4th gear on countershaft

EcoShift vs. Eaton

Advantages (2)

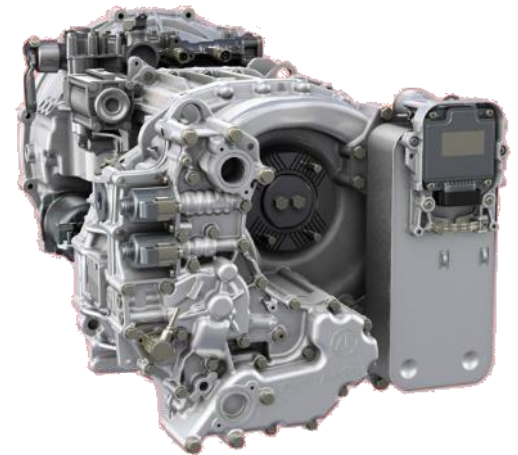
EcoShift – State of the art for manual bus transmissions

- **Optional ZF-Intarder of the latest generation**

Fully integrated system consisting of transmission and retarder with common oil circuit instead of retarder from another supplier

- Protection of transmission against overheating thanks to retarder cooling unit
- Transmission quickly at operating temperature with short retarder braking processes
- In case of transmission encapsulation, no additional cooling system required
- One contact

Adapter for electric third-party retarder available as option



ZF vs. Daimler Overview



EcoShift, up to 2,100 Nm

6 S 1310 / 1311 BD / BO
6 S 1610 / 1611 BD / BO
6 S 1910 / 1911 BO
6 S 2111 BO



Ecolite, up to 1,100 Nm

6 S 710 BO
6 S 1010 BO
6 S 1110 BO



DAIMLER (OEM with in-house transmissions)

Up to 2,300 Nm

GO 190-6 CPS
GO 210-6 CPS
GO 230-6 CPS



Up to 1,000 Nm

G 70-6S (OD)
G 71-6S
G 90-6S



GO

Transmissions for buses

G

Transmissions from truck program

210

x 10 = approx. admissible input torque [Nm]

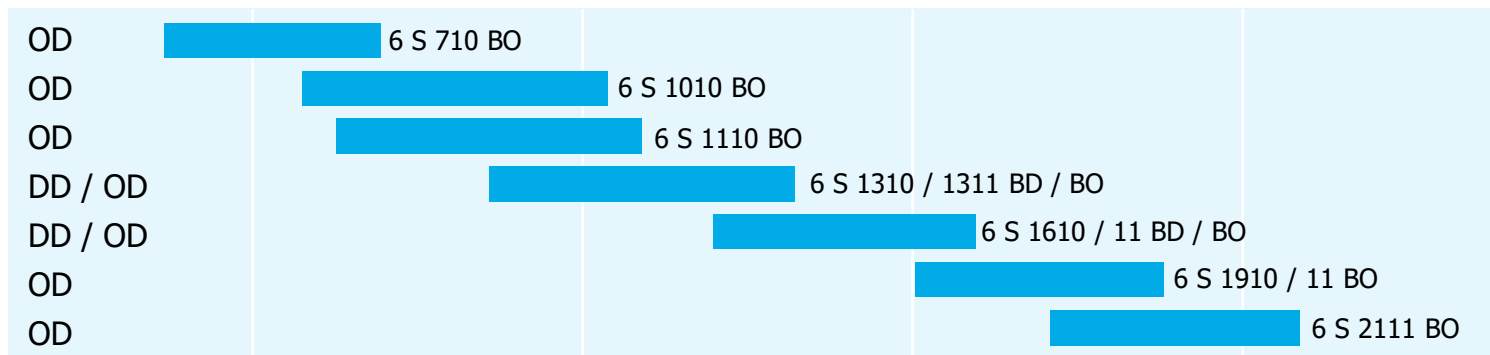
- 6

Number of forward gears

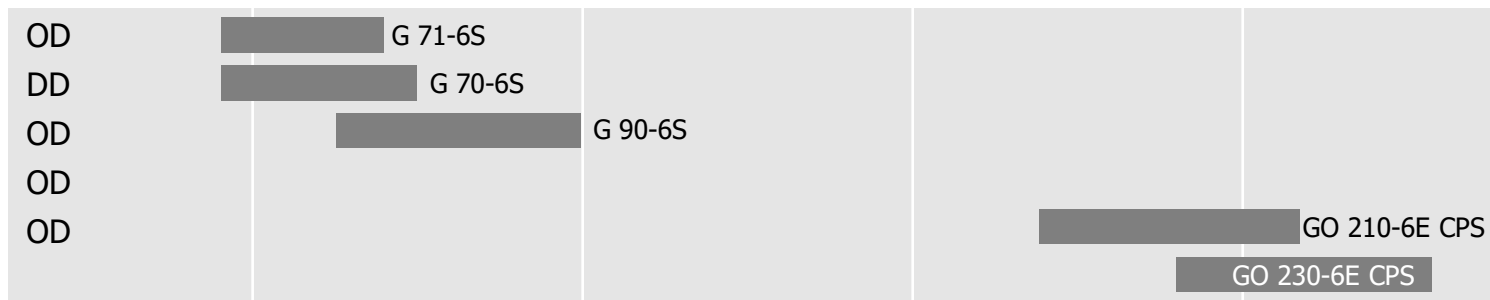
E

Modified ratio for the 6th gear

ZF vs. Daimler Torques



DAIMLER



Torque [Nm]

500

1,000

1,500

2,000

Compared to Daimler, ZF offers a complete product portfolio for all bus classes!



EcoShift vs. Daimler Advantages (1)

EcoShift – State of the art for manual bus transmissions

- **High efficiency = less fuel consumption**

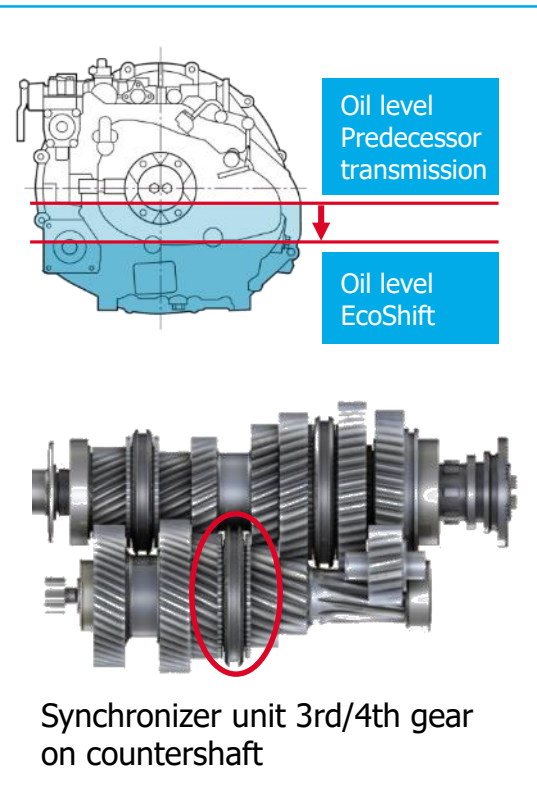
Fewer churning losses due to pressure oil lubrication with low oil level:
Up to 40 % less oil

- **Easier gear shifting**

- Fewer inert masses due to relocation of **synchronizer unit 3rd/4th gear to countershaft – a novelty in this bus class**
- Less resistance when downshifting due to low oil level

- **Highly comprehensive experience with applications**

Successful cooperation with more than 50 OEMs on 4 continents.



EcoShift vs. Daimler Advantages (2)

EcoShift – State of the art for manual bus transmissions

- **Optional ZF-Intarder of the latest generation**

Fully integrated system consisting of transmission and retarder with common oil circuit instead of retarder from another supplier

- Protection of transmission against overheating thanks to retarder cooling unit
- Transmission quickly at operating temperature with short retarder braking processes
- In case of transmission encapsulation, no additional cooling system required
- One contact

