A METHOD AND A CONTROL SYSTEM FOR GEAR SHIFTING IN A MOTOR VEHICLE AND A COMPUTER PROGRAM

Abstract: A method for gear shifting in a motor vehicle with an automatic mechanical transmission (AMT), in which the gear shifting involves a shifting of gear in a range gearbox or a split gearbox of the transmission, involves the step of starting a gear shifting for obtaining gear engagement in the basic gearbox before a synchronous rotational speed has been obtained by synchronization means (22, 24) of said split or range gearbox by utilizing synchronization means (23) of the basic gearbox to assist the synchronization means of said split or range gearbox for obtaining synchronous rotational speed, so that the gear shifting operation may be completed.
A method and a control system for gear shifting in a motor vehicle and a computer program.

TECHNICAL FIELD

The present invention relates to a system for controlling gear shifting in a motor vehicle provided with an engine, an automatic mechanical transmission (AMT) having a basic gearbox with a main shaft and at least one secondary gearbox, such as a range gearbox or a split gearbox, said main shaft being through an input shaft of the transmission connectible to a shaft of said engine and through an output shaft of the transmission to a driven axle of the vehicle, first synchronization means of said secondary gearbox adapted to be activated upon gear shifting in the secondary gearbox for acting to obtain a synchronous rotational speed of said input shaft, main shaft and output shaft, means for calculating the rotational speed of said engine shaft at the gear of the transmission to be selected by a gear shifting operation for the present rotational speed of said driven axle and by that of said output shaft, and means for controlling, in a gear shifting operation, said engine towards a rotational speed of said shaft thereof corresponding to said rotational speed calculated. The invention also relates to a method for gear shifting in a motor vehicle with an automatic mechanical transmission. Furthermore, the invention relates to a computer program comprising computer program code for implementing such a method, a computer program product comprising a data storage medium readable by an electronic unit and having said computer program stored thereon, and an electronic control unit.

BACKGROUND ART

The present invention is applicable to motor vehicles provided with an automatic mechanical transmission having a basic gearbox and at least one secondary gearbox, such as a range gearbox or a split gearbox, especially heavy motor vehicles such as
lorries, towing vehicles and busses. Such motor vehicles have mostly both a split gearbox and a range gearbox. It is pointed out that "gearbox" is here to be interpreted broadly and the split part, the basic or main part and the range part of the transmission may be enclosed in the same gearbox housing. The invention is directed to gear shifting involving shifting of gear in a said secondary gearbox, but this gear shifting may at the same time involve a shifting of gear in the basic gearbox. The invention is particularly directed to gear shifting involving a shifting of gear in a range gearbox, but it is also concerned with such gear shifting involving a shifting of gear in a split gearbox.

A gear shifting involving a shifting of gear in a said range gearbox in known systems and through known methods of this type will now be discussed for illuminating but not in any way restricting the invention thereto. In this type of manual motor controlled gear shifting the basic gearbox is brought into neutral position with the gears thereof disengaged from said main shaft and said range gearbox is also brought to disengaged position. The engine is then controlled to obtain a rotational speed of the output shaft of the engine corresponding to a rotational speed of the input shaft of said gearbox being synchronous with respect to the rotational speed of the output shaft of the transmission determined by the present rotational speed of the driven axel of the vehicle for the gear to be selected by said shifting action. The synchronization means of the range gearbox is then controlled to act upon the main shaft until the rotational speed of the main shaft is synchronous with respect to the rotational speed of the input shaft and the output shaft of the transmission, so that the gear shifting may be completed in the range gearbox and in the basic gearbox without any substantial torque existing between the engaging parts in the moment of engagement. However, the period of time needed for said synchronization means of the range gearbox to accelerate or retard (brake) said main shaft for obtaining synchronous rotational speed thereof may be comparatively long, since the
high transmission ratio of the range gearbox requires a large amount of energy for synchronizing the main shaft. This problem also exists for a gear shifting action involving a shifting of gear in a said split gearbox, although not that accentuated, since the transmission ratio is lower there.

Systems and methods of this type are already known through for example WO200502591 1 and US2001 0029221.

DISCLOSURE OF THE INVENTION

The object of the present invention is to provide a system for controlling a gear shifting involving a shifting of gear in a secondary gearbox in a motor vehicle with an automatic mechanical transmission of the type defined in the introduction, which makes it possible to shorten the period of time needed for completing the gear shifting operation.

This object is according to the invention obtained by providing such a system, which further comprises a second synchronization means associated with said basic gearbox for acting to obtain a synchronous rotational speed of said input shaft, main shaft and output shaft, and a device for controlling a said gear shifting involving a shifting of gear in said secondary gearbox after the basic gearbox has been brought into a neutral position with the gears thereof disengaged from said main shaft and said secondary gearbox has been brought to disengaged position, said device being adapted to control gear shifting members to start gear shifting for obtaining gear engagement in said secondary gearbox by controlling said first synchronization means to be activated, to control gear shifting members to start gear shifting for obtaining gear engagement in said basic gearbox before said synchronous rotational speed has been obtained by the action of said first synchronization means by controlling said second synchronization means of the basic gearbox to be activated for assisting said first synchronization means in acting for
obtaining said synchronous rotational speed and to control said
gear shifting members to complete gear shifting in the secon-
dary gearbox and in the basic gearbox when said synchronous
rotational speed has been reached. This means that the time
needed for completing the gear shifting action may be consid-
erably shortened, especially in the case of carrying out a gear
shifting action involving a shifting of gear in a range gearbox.
This is obtained by influencing the part of the gearbox to be
synchronized from two directions, namely both by utilizing the
output shaft of the gearbox having a rotational speed deter-
mined by the rotational speed of the driven axle of the vehicle,
and the input shaft of the gearbox having a rotational speed
determined by the engine for the gear to be selected by the gear
shifting. This means in the case of changing gear in said range
gearbox that the synchronization means of the basic gearbox is
controlled to assist the synchronization means of the range
gearbox in said synchronization action, so that the synchronous
rotational speed needed for completing the gear shifting opera-
tion may be reached earlier than if only the range gearbox syn-
chronization means were used.

According to an embodiment of the invention the system is
adapted for controlling gear shifting in a motor vehicle with a
transmission having a secondary gearbox in the form of a range
gearbox, and said device is adapted to control a said gear
shifting involving a shifting of gear in said range gearbox. The
present invention is particularly interesting when carrying out
such a gear shifting operation, since the transmission ratio in
said range gearbox is high and the period of time normally re-
quired for synchronizing said main shaft is rather long, so that
there is on one hand desirable to reduce this time and on the
other a considerable reduction of said time may be obtained by
"synchronizations from two directions" in accordance with the in-
vention in this case.
According to another embodiment of the invention said device is adapted to control said first synchronization means to act upon said main shaft by establishing an accelerating or retarding connection of said output shaft to said main shaft for influencing the main shaft towards said synchronous rotational speed and to control said synchronization means to act upon said main shaft by establishing an accelerating or retarding connection of said input shaft to said main shaft for influencing the main shaft towards said synchronous rotational speed, which constitutes a preferred way of obtaining synchronization of said main shaft through both the synchronization means of the basic gearbox and those of the range gearbox.

According to another embodiment of the invention the system is adapted for controlling gear shifting in a motor vehicle having a basic gearbox with a lay shaft for connecting said input shaft to said main shaft, said lay shaft having gears engaging a gear each engagable with said main shaft by synchronization means of said basic gearbox, in which the device is adapted to control means to keep said input shaft and said lay shaft rigidly engaged throughout said gear shifting. This means that the rotational speed of the lay shaft will vary with the rotational speed of the output shaft of the engine and reach a synchronous rotational speed when the engine has been controlled to deliver the rotational speed according to said calculation, whereupon the synchronization means of said basic gearbox will establish an accelerating or retarding connection of said lay shaft with said main shaft for influencing the main shaft towards said synchronous rotational speed at the same time as a corresponding influence is achieved by the synchronization means of the range gearbox.

According to another embodiment of the invention the system is adapted to control gear shifting in a motor vehicle with a transmission having a split gearbox for connecting said input shaft to said basic gearbox, in which said device is adapted to control
means to keep one split gear in engaged position throughout said gear shifting, when said gear shifting involves shifting of gear in said range gearbox. Said device will then be adapted to control said split gearbox to keep said input shaft and said lay shaft rigidly engaged throughout said gear shifting.

According to another embodiment of the invention the system is adapted to control gear shifting in a motor vehicle with a transmission having a secondary gearbox in the form of a split gearbox, and said device is adapted to control gear shifting involving a shifting of gear in said split gearbox. This means that the time for completing such gear shifting may be reduced by using the synchronization means of said split gearbox as well as of said basic gearbox for obtaining said synchronous rotational speed for completing said gear shifting operation.

According to another embodiment of the invention the device is adapted to control said first synchronization means to act upon a shaft of said split gearbox by establishing an accelerating or retarding connection of said input shaft to said split gearbox shaft for influencing said split gearbox shaft towards said synchronous rotational speed, the device is adapted to control means to keep the main shaft and the output shaft rigidly engaged throughout said gear shifting, and the device is adapted to control said second synchronization means to act upon said split gearbox shaft by establishing an accelerating or retarding connection of said main shaft to said split gearbox shaft for influencing the split gearbox shaft towards said synchronous rotational speed. Said split gearbox shaft will in this way obtain said synchronous rotational speed in a shorter period of time than when using known systems for controlling gear shifting involving shifting of a gear in a split gearbox, so that the gear shifting operation may be completed earlier.

According to another embodiment of the invention, in which said split gearbox shaft is formed by a part of a lay shaft of the basic
gearbox adapted to connect said input shaft to the main shaft, said lay shaft having gears engaging a gear each engagable with said main shaft by said second synchronization means of the basic gearbox, said device is adapted to control said first synchronization means of the split gearbox to act upon said lay shaft by influencing gears of said split gearbox to form an engagement of said input shaft.

According to another embodiment of the invention the system is adapted to control gear shifting in a motor vehicle having a transmission with a range gearbox for connecting said output shaft to said basic gearbox, and said device is then adapted to control means to keep one range gear in engaged position throughout said gear shifting in said split gearbox, so that the main shaft of the basic gearbox will then have said synchronous rotational speed determined by the rotational speed of the driven axle of the vehicle throughout the gear shifting operation in the split gearbox.

The invention also relates to a method having the features defined in claim 11 for gear shifting in a motor vehicle with an automatic mechanical transmission (AMT) having a basic gearbox with a main shaft and at least one secondary gearbox, such as a range gearbox or split gearbox, said main shaft being through an input shaft of the transmission connectible to a shaft of an engine of the vehicle and through an output shaft of the transmission to a driven axle of the vehicle, in which said gear shifting involves a shifting of gear in said secondary gearbox.

The invention also relates to a computer program having the features defined in claim 21, a computer program product having the features defined in claim 31 and an electronic control unit having the features defined in claim 32.

BRIEF DESCRIPTION OF THE DRAWINGS
The invention will in the following be more closely described by means of embodiment examples, with reference to the appended drawings, where:

Fig 1 is a schematic outline diagram illustrating a system according to the present invention,

Fig 2 is a simplified view illustrating the system according to the present invention more in detail for explaining how a gear shifting operation is carried out according to embodiments of a method according to the invention,

Fig 3 is a graph used to show the degree of engagement of gears in the basic gearbox and in the range gearbox in gear shifting involving shifting of gear in said range gearbox according to the present invention,

Fig 4 is a schematic outline diagram of an electronic unit for implementing the method according to the invention, and

Fig 5 is a flow diagram illustrating a method according to an embodiment of the invention.

EMBODIMENTS OF THE PRESENT INVENTION

Parts of a motor vehicle 1 in the form of a truck for explaining the present invention are very schematically shown in Fig 1. The vehicle has a front wheel axle 2, a first rear wheel axle 3 in the form of two half shafts and a second rear wheel axle 4. Many other wheel configurations than the one shown here are of course within the scope of the invention, and more than one axle may be driven.

The vehicle is further provided with an engine 5 with an output shaft 6 connected through a clutch 7 to an input shaft 8 of an automatic mechanical transmission 9 comprising a gearbox
having a split gearbox 10 for engagement with said input shaft 8, a main or basic gearbox 11 and a range gearbox 12 for engagement with an output shaft 13 of the transmission driving the wheel axle 3 through a differential 17. Said transmission 9 has a gear shift lever 14 for selecting different modes of Neutral, Drive, Reversing, Parking etc and a button for changing between an automatic gear shifting according to a computer program and a manual gear shifting in which the driver selects the gear but a program shifts the gear. This way of gear shifting has in the Fig 1 been symbolized by a gear shift lever 14 provided with a ring 15 for actuating a gear shifting in said range gearbox from low to high range and conversely, as well as a split selector switch 16 for actuating gear shifting in said split gearbox between low and high, although said ring and split selector switch are in fact integrated in said computer program.

12 different gears or gear ratios may in this way be obtained through said transmission if the basic gearbox has three different gears which may be brought to engagement with a main shaft of said basic gearbox. This means more exactly that the gear positions 1, 3 and 5 may be obtained when the split selector is in the position low and the range gearbox in low range, the gear positions 2, 4 and 6 when the split selector is moved into high, whereas when the range gearbox is in high range the gear positions 7-12 may be obtained through correspondingly actuating the lever 14 and the split selector 16. This is conventional technique, and the gearboxes connected in series may have the following optional factors, which are to be multiplied for obtaining the total transmission ratio of the transmission:

the split gearbox: 1 and 1,233
the basic gearbox (shift lever 14): 1, 1,549 and 2,461
the range gearbox: 1 and 3,750,

The lower factor, the higher gear position. Thus, the transmission ratio of the transmission is defined to be 1 for the highest
gear position, namely the gear 12. The twelve gear positions will in this case have the following relationship between the rotational speed of the input shaft 8 and the output shaft 13 of the transmission:

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<td>11</td>
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The system for controlling gear shifting according to the invention comprises means 18 for measuring the rotational speed of the engine shaft and by that of said input shaft 8 and means 19 adapted to measure the rotational speed of the output shaft 13 of the transmission. Signals from the means 18 and 19 are sent to a device 20 also receiving information about a gear to be selected by a gear shifting from a sensor 21.

The three gearboxes connected in series, split gearbox 10, basic gearbox 11 and range gearbox 12, are each provided with synchronisation means 22-24, which are controlled by the device 20 and the function of which will be described below.

How a gear shifting takes place according to a method according to a first embodiment of the invention, in which said gear shifting involves a shifting of gear in the range gearbox, will now be explained while referring also to Figs 2 and 3. It is shown in Fig 2 how a main shaft 25 extends through the basic gearbox. This main shaft may through influence of sleeves 26-28 be brought into engagement with one of three gears 29-31 by influence of said synchronization means 23 upon one of said
sleeves. By moving the shift lever 14 into neutral position the gear 29-31 in question will be disengaged from said main shaft 25. The basic gearbox also comprises a lay shaft 32 arranged in parallel with the main shaft 25 and carrying gears 33-35 rotating therewith and in engagement with a respective of the gears 29-31. The lay shaft 32 has also gears 36, 37 rotating therewith and in engagement with gears 38, 39 of said split gearbox, which may through influence of the synchronization means 22 upon sleeves be brought into engagement with the input shaft 8. The range gearbox is provided with a planetary gearing for connecting said main shaft 25 to the output shaft 13 of the transmission by influencing the synchronization means 24 of the range gearbox to act upon corresponding sleeves for one connection according to low range and one according to high range. A gearbox having this structure is already known, and it is also known to have synchronization means for said basic gearbox in an automatic mechanical transmission of this type.

How a gear shifting involving a shifting of gear in the range gearbox is carried out according to an embodiment of the present invention will now be described while referring to Figs 1-3. It is pointed out that this gear shifting may then also involve a shifting of gear in the basic gearbox and accordingly not only a shifting from high range to low range or conversely. The gear shifting action is started by bringing the basic gearbox into neutral position with the gears 29-31 thereof disengaged from the main shaft 25. The range ring is also brought into the position for the new range gear, low or high, which means a disconnection of the main shaft 25 with respect to the output shaft 13. The rotational speed of the engine shaft and thereby of the input shaft 8 at the gear of the transmission to be selected by said gear shifting operation is calculated by the device 20 for the present rotational speed of said driven axle and thereby of said output shaft through information thereabout received from means 19 and the transmission ratio values stored. The engine is then controlled by the device 20 towards the rotational speed
calculated of the engine shaft and thereby of the input shaft 8 corresponding to the rotational speed calculated. The control device 20 now controls the synchronization means 24 of the range gearbox for acting to obtain a synchronous rotational speed of said input shaft 8, main shaft 25 and output shaft 13 while establishing a connection between the output shaft 13 and the main shaft 25, so that the output shaft 13 will accelerate or retard (brake) the main shaft 25. The lay shaft 32 is throughout the entire gear shifting operation kept rigidly engaged with the input shaft 8 through one of the two split gears. The control device controls the synchronization means 23 of the basic gearbox to act upon the sleeve for the gear selected before said synchronous rotational speed has been obtained by the action of the synchronization means 24 of the range gearbox for assisting the latter synchronization means in acting for obtaining said synchronous rotational speed. Accordingly the main shaft 25 will by this be influenced towards said synchronous rotational speed also by the input shaft with an engine controlled rotational speed through said lay shaft 32. This means that the main shaft will be influenced from both the input side and the output side of the transmission through the input shaft and the output shaft already having said synchronous rotational speed for the gear to be obtained by said gear shifting operation. When the main shaft in this way has reached said synchronous rotational speed the gear shifting in the range gearbox as well as in the basic gearbox will be completed by rigidly engaging the gear in question in the basic gearbox with said main shaft and the output shaft with the main shaft through a said range gear. The time required for carrying out a gear shifting operation involving a shifting of gear in the range gearbox may in this way be considerably shortened, such as reduced by in the order of 50% with respect to such a gear shifting operation already known, in which no synchronization means associated with the basic gearbox is used, but it is waited until the synchronization means of the range gearbox has obtained a synchronous rotational speed of the main shaft be-
fore the gear shifting in the basic gear box and in the range gearbox is completed.

It is shown in Fig 3 how a gear shifting is carried out from low range L to high range H without changing the gear G in the basic gearbox. The line A shows the position of the range gear and the line B of the gear in the basic gearbox. a indicates when the synchronization means 24 starts to accelerate the main shaft 25 and b when the synchronization means 23 is controlled to assist in accelerating the main shaft, whereas the point c indicates when the main shaft has reached a synchronous rotational speed and the range gearbox as well as the basic gearbox are brought into the target position, i.e. where the gear shifting operation is completed.

A method for gear shifting according to another embodiment of the invention relates to a gear shifting operation in which the gear shifting involves a shifting of gear in the split gearbox 10. One of the range gears, low or high, is throughout this gear shifting operation in engagement for keeping the main shaft and the output shaft rigidly engaged. This means that the main shaft has a rotational speed determined by the rotational speed of the output shaft 13 and by that of the driven axle of the vehicle, and the synchronous rotational speed to be obtained for completing the gear shifting operation is that of the lay shaft 32. Thus, the basic gearbox is brought into neutral position, the split gear disengaged and the engine controlled to obtain the rotational speed of the input shaft 8 calculated for the gear to be selected, whereupon the synchronization means 22 of the split gearbox is controlled to start to connect the input shaft 8 with the lay shaft by starting to engage a recently selected gear 38 or 39 with the input shaft. This will result in a retardation or acceleration of the lay shaft 32. The synchronization means 23 of the basic gearbox is at the same time controlled to start to act upon the sleeve 26-28 in question for starting to engage the respective gear with the main shaft 25 and by that assisting the synchronization
means 22 of the split gearbox in bringing the lay shaft 32 to a rotational speed enabling completion of the gear shifting operation.

The flow diagram illustrating a method according to an embodiment of the invention is shown in Fig 5. In a first step S1 a basic gearbox is brought into a neutral position and the engaged gear of the secondary gearbox is moved out of engagement. The rotational speed of the engine shaft at the gear of the transmission to be selected by said gear shifting operation is then calculated for the present rotational speed of the driven axle of the vehicle in step S2. The engine is then in step S3 controlled towards a rotational speed of the shaft thereof corresponding to said rotational speed calculated. Synchronization of the secondary gearbox is then started in a fourth step S4, whereupon synchronization of the basic gearbox is in a fifth step S5 started before the synchronization in step S4 has been completed for assisting the synchronization in step S4 in acting for obtaining synchronous rotational speed needed for completing the gear shifting operation. It is in step S6 checked whether said synchronous rotational speed has been obtained or not, and if the answer to this question is yes gear shifting in the secondary gearbox and in the basic gearbox are completed in step S7. If the answer to this question is no said synchronization action is continued and the checking in step S6 is carried out again, and this loop is carried out until said synchronous rotational speed has been reached.

Computer program code for implementing a method according to the invention is suitably included in a computer program, which is loadable into the internal memory of a computer, such as the internal memory of an engine control unit of the vehicle. Such a computer program is suitably provided via a computer program product comprising a data storage medium readable by an electronic control unit, which data storage medium has the computer program stored thereon. Said data storage medium is
for instance an optical data storage medium in the form of a CD-ROM disc, a DVD disc etc, a magnetic data storage medium in the form of a hard disc, a diskette, a cassette tape etc, or a memory of the type ROM, PROM, EPROM or EEPROM or a Flash memory.

The computer program according to an embodiment of the invention comprises computer program code for causing a computer, e.g. in the form of an electronic unit:

- to sense a control of said basic gearbox to move into neutral position with the gears thereof disengaged from said main shaft and said secondary gearbox to disengaged position,
- to calculate the rotational speed of said engine shaft at the gear of the transmission to be selected by said gear shifting operation for the present rotational speed of said driven axle and by that of said output shaft,
- to control the engine towards a rotational speed of said shaft thereof corresponding to said rotational speed calculated,
- to control gear shifting for obtaining gear engagement in said secondary gearbox to start by controlling synchronization means of said secondary gearbox to be activated for acting to obtain a synchronous rotational speed of said input shaft, main shaft and output shaft,
- to control gear shifting for obtaining gear engagement in the basic gearbox to start before said synchronous rotational speed has been obtained by controlling synchronization means of said basic gearbox to be activated for assisting said synchronization means of the secondary gearbox in acting for obtaining said synchronous rotational speed, and
- to control said gear shifting in the secondary gearbox and in the basic gearbox to be completed when said synchronous rotational speed is reached.

Fig 4 very schematically illustrates an electronic control unit 40 comprising an execution means 41, such as a central processing unit (CPU) for executing computer software. The execution
means 41 communicates with a memory 42, for instance of the type RAM, via a data bus 43. The control unit 40 also comprises data storage medium 44, for instance in the form of a memory of the type ROM, PROM, EPROM or EEPROM or a Flash memory.

The execution means 41 communicates with the data storage medium 44 via the data bus 43, A computer program comprising computer program for implementing a method according to the invention is stored on the data storage medium 44.

The invention is of course not in any way restricted to the embodiments described above. On the contrary, many possibilities to modifications thereof will be apparent to a person with ordinary skill in the art without departing from the basic idea of the invention as defined in the appended claims.

The invention is applicable to automatic mechanical transmissions having other appearances than shown in the Figures.
Claims

1. A system for controlling gear shifting in a motor vehicle (1) provided with:
   - an engine (5),
   - an automatic mechanical transmission (AMT) having a basic gearbox (11) with a main shaft (25) and at least one secondary gearbox, such as a range gearbox (12) or a split gearbox (10), said main shaft being through an input shaft (8) of the transmission connectible to a shaft (6) of said engine and through an output shaft (13) of the transmission to a driven axle (3) of the vehicle,
   - first synchronization means (22, 24) of said secondary gearbox adapted to be activated upon gear shifting in the secondary gearbox for acting to obtain a synchronous rotational speed of said input shaft (8), main shaft (25) and output shaft (13),
   - means for calculating the rotational speed of said engine shaft at the gear of the transmission to be selected by a gear shifting operation for the present rotational speed of said driven axle and by that of said output shaft, and
   - means for controlling, in a said gear shifting operation, said engine towards a rotational speed of said shaft thereof corresponding to said rotational speed calculated,

characterized in that the system also comprises:
   - second synchronization means (23) associated with said basic gearbox (11) for acting to obtain a synchronous rotational speed of said input shaft (8), main shaft (25) and output shaft (13), and
   - a device (20) for controlling a said gear shifting involving a shifting of gear in said secondary gearbox after the basic gearbox has been brought into a neutral position with the gears (29-31) thereof disengaged from said main shaft (25) and said secondary gearbox has been brought to disengaged position, said device being adapted to control gear shifting members to start gear shifting for obtaining gear engagement
in said secondary gearbox by controlling said first synchronization means to be activated, to control gear shifting members to start gear shifting for obtaining gear engagement in said basic gearbox before said synchronous rotational speed has been obtained by the action of said first synchronization means (22, 24) by controlling said second synchronization means (23) of said basic gearbox to be activated for assisting said first synchronization means in acting for obtaining said synchronous rotational speed and to control said gear shifting members to complete gear shifting in the secondary gearbox and in the basic gearbox when said synchronous rotational speed has been reached.

2. A system according to claim 1 for controlling gear shifting in a motor vehicle with a transmission having a secondary gearbox in the form of a range gearbox (12), characterized in that said device (20) is adapted to control a said gear shifting involving a shifting of gear in said range gearbox.

3. A system according to claim 2, characterized in that said device (20) is adapted to control said first synchronization means (24) to act upon said main shaft (25) by establishing an accelerating or retarding connection of said output shaft (13) to said main shaft for influencing the main shaft towards said synchronous rotational speed and to control said second synchronization means (23) to act upon said main shaft by establishing an accelerating or retarding connection of said input shaft (8) to said main shaft (25) for influencing the main shaft towards said synchronous rotational speed.

4. A system according to claim 3 for controlling gear shifting in a motor vehicle having a basic gearbox (11) with a lay shaft (32) for connecting said input shaft (8) to said main shaft (25), said lay shaft having gears (33-35) engaging a gear (29-31) each engagable with said main shaft by synchronization means (23) of said basic gearbox, characterized in that the device (20) is
adapted to control means to keep said input shaft (8) and said lay shaft (32) rigidly engaged throughout said gear shifting.

5. A system according to claim 3 or 4, which is adapted to control gear shifting in a motor vehicle with a transmission having a split gearbox (10) for connecting said input shaft to said basic gearbox, characterized in that said device (20) is adapted to control means to keep one split gear in engaged position throughout said gear shifting.

6. A system according to claims 4 and 5, characterized in that said device is adapted to control said split gearbox (10) to keep said input shaft (8) and said lay shaft (32) rigidly engaged throughout said gear shifting.

7. A system according to any of claims 1-6 for controlling gear shifting in a motor vehicle with a transmission having a secondary gearbox in the form of a split gearbox (10), characterized in that said device (20) is adapted to control gear shifting involving a shifting of gear in said split gearbox.

8. A system according to claim 7, characterized in that device (20) is adapted to control said first synchronization means to act upon a shaft of said split gearbox (10) by establishing an accelerating or retarding connection of said input shaft (8) to said split gearbox shaft for influencing said split gearbox shaft towards said synchronous rotational speed, that said device is adapted to control means to keep the main shaft (25) and the output shaft (8) rigidly engaged throughout said gear shifting, and that said device is adapted to control said second synchronization means (23) to act upon said split gearbox shaft by establishing an accelerating or retarding connection of said main shaft to said split gearbox shaft for influencing the split gearbox shaft towards said synchronous rotational speed.
9. A system according to claim 8, in which said split gearbox shaft is formed by a part of a lay shaft (32) of the basic gearbox adapted to connect said input shaft to the main shaft, said lay shaft having gears engaging a gear each engagable with said main shaft by said second synchronization means (23) of said basic gearbox, characterized in that said device is adapted to control said first synchronization means (22) of said split gearbox to act upon said lay shaft (32) by influencing gears of said split gearbox to form an engagement with said input shaft (8).

10. A system according to claim 8 or 9 for controlling gear shifting in a motor vehicle having a transmission with a range gearbox (12) for connecting said output shaft (13) to said basic gearbox, characterized in that said device is adapted to control means to keep one range gear in engaged position throughout said gear shifting in said split gearbox.

11. A method for gear shifting in a motor vehicle (1) with an automatic mechanical transmission (AMT) having a basic gearbox (11) with a main shaft (25) and at least one secondary gearbox, such as a range gearbox (12) or a split gearbox (10), said main shaft being through an input shaft (8) of the transmission connectible to a shaft (6) of an engine (5) of the vehicle and through an output shaft (13) of the transmission to a driven axle (3) of the vehicle, in which said gear shifting involves a shifting of gear in said secondary gearbox and comprises the following steps:
a) the basic gearbox is brought into neutral position with the gears (29-31) thereof disengaged from said main shaft (25) and the secondary gearbox is brought to a disengaged position,
b) the rotational speed of said engine shaft (6) at the gear of the transmission to be selected by said gear shifting operation is calculated for the present rotational speed of said driven axle (3) and by that of said output shaft (13),
c) the engine is controlled towards a rotational speed of said shaft thereof corresponding to said rotational speed calculated,

d) gear shifting for obtaining gear engagement in the secondary gearbox (10, 12) is started by activating synchronization means (22, 24) of said secondary gearbox for acting to obtain a synchronous rotational speed of said input shaft (8), main shaft (25) and output shaft (13),

e) gear shifting for obtaining gear engagement in the basic gearbox (11) is started before said synchronous rotational speed has been obtained in step d) by activating synchronization means (23) of said basic gearbox for assisting said synchronization means of the secondary gearbox in acting for obtaining said synchronous rotational speed, and

f) said gear shifting in the secondary gearbox and in the basic gearbox are completed when said synchronous rotational speed is reached.

12. A method according to claim 11, characterized in that said gear shifting involves a gear shifting in a range gearbox (12) of said transmission.

13. A method according to claim 12, characterized in that step d) comprises controlling of synchronization means (24) of said range gearbox (12) to act upon said main shaft (25) by establishing an accelerating or retarding connection of said output shaft (13) to said main shaft for influencing the main shaft (25) towards said synchronous rotational speed, and that step e) comprises controlling of said synchronization means (23) of the basic gearbox (11) to act upon said main shaft by establishing an accelerating or retarding connection of said input shaft (8) to said main shaft (25) for influencing the main shaft towards said synchronous rotational speed.

14. A method according to claim 13, characterized in that said gear shifting is carried out for a basic gearbox (11) having a lay
shaft (32) for connecting said input shaft (8) to the main shaft (25), said lay shaft having gears (33-35) engaging a gear (29-31) each engagable with said main shaft by synchronisation means (23) of said basic gearbox, and that said input shaft (8) and said lay shaft (32) are kept rigidly engaged throughout said gear shifting.

15. A method according to claim 13 or 14, characterized in that it is carried out for a transmission having a split gearbox (10) for connecting said input shaft (8) to the basic gearbox (11), and that one split gear is kept in engaged position throughout said gear shifting.

16. A method according to claims 14 and 15, characterized in that said split gearbox (10) is controlled to keep said input shaft (8) and said lay shaft (32) rigidly engaged throughout said gear shifting.

17. A method according to claim 11, characterized in that said gear shifting involves a gear shifting in a split gearbox (10) of said transmission.

18. A method according to claim 17, characterized in that step d) comprises controlling of synchronization means (24) of said split gearbox to act upon a shaft of said split gearbox by establishing an accelerating or retarding connection of said input shaft (8) to said split gearbox shaft for influencing said split gearbox shaft towards said synchronous rotational speed, that the main shaft (25) and the output shaft (13) are kept rigidly engaged throughout said gear shifting, and that step e) comprises controlling of said synchronization means (23) of the basic gearbox (11) to act upon said split gearbox shaft by establishing an accelerating or retarding connection of said main shaft to said split gearbox shaft for influencing the split gearbox shaft towards said synchronous rotational speed.
19. A method according to claim 18, characterized in that said split gearbox shaft is formed by a part of a lay shaft (32) of the basic gearbox (11) adapted for connecting said input shaft (8) to the main shaft (25), said lay shaft having gears engaging a gear each engagable with said main shaft by synchronization means (23) of said basic gearbox, and that said controlling in step e) comprises controlling of said synchronization means (22) of said split gearbox to act upon said lay shaft by influencing gears of said split gearbox to form an engagement with said input shaft.

20. A method according to claim 18 or 19, characterized in that it is carried out for a transmission having a range gearbox (12) for connecting said output shaft (13) to the basic gearbox, and that one range gear is kept in engaged position throughout said gear shifting.

21. A computer program loadable into the internal memory of a computer, which computer program comprises computer program code for causing the computer, for a motor vehicle (1) provided with an automatic mechanical transmission (AMT) having a basic gearbox (11) with a main shaft (25) and at least one secondary gearbox, such as a range gearbox (12) or a split gearbox (10), said main shaft being through an input shaft (8) of the transmission connectible to a shaft (6) of an engine (5) of the vehicle and through an output shaft (13) of the transmission to a driven axle (3) of the vehicle, in which the computer program is adapted to control gear shifting involving a shifting of gear in said secondary gearbox:
- to sense a control of said basic gearbox to move into neutral position with the gears thereof disengaged from said main shaft and said secondary gearbox to be brought to a disengaged position,
- to calculate the rotational speed of said engine shaft (6) at the gear of the transmission to be selected by said gear shifting operation for the present rotational speed of said driven axle (3) and by that of said output shaft (13),
- to control the engine towards a rotational speed of said shaft thereof corresponding to said rotational speed calculated,
- to control gear shifting for obtaining gear engagement in said secondary gearbox to start by controlling synchronization means (22, 24) of said secondary gearbox to be activated for acting to obtain a synchronous rotational speed of said input shaft (8), main shaft (25) and output shaft (13),
- to control gear shifting for obtaining gear engagement in the basic gearbox (11) to start before said synchronous rotational speed has been obtained by controlling synchronization means (23) of said basic gearbox to be activated for assisting said synchronization means of the secondary gearbox in acting for obtaining said synchronous rotational speed, and
- to control said gear shifting in the secondary gearbox and in the basic gearbox to be completed when said synchronous rotational speed is reached.

22. A computer program according to claim 21, characterized in that the computer program comprises computer program code for causing the computer:
- to control gear shifting involving a gear shifting in a range gearbox (12) of said transmission.

23. A computer program according to claim 22, characterized in that the computer program comprises computer program code for causing the computer:
- to control said synchronization means (24) of said range gearbox (12) to act upon said main shaft by establishing an accelerating or retarding connection of said output shaft (13) to said main shaft (25) for influencing the main shaft towards said synchronous rotational speed, and
- to control said synchronization means (23) of the basic gearbox to act upon said main shaft by establishing an accelerating or retarding connection of said input shaft (8) to said
main shaft (25) for influencing the main shaft towards said synchronous rotational speed.

24. A computer program according to claim 23, characterized in that the computer program comprises computer program code for causing the computer:
- to control gear shifting for a basic gearbox having a lay shaft (32) for connecting said input shaft (8) to the main shaft, said lay shaft having gears (33-35) engaging a gear (29-31) each engagable with said main shaft (25) by synchronization means of said basic gearbox, and
- to control said input shaft and said lay shaft to be kept rigidly engaged throughout said gear shifting.

25. A computer program according to claim 23 or 24, characterized in that the computer program comprises computer program code for causing the computer:
- to control gear shifting for a transmission having a split gearbox (10) for connecting said input shaft (8) to the basic gearbox, and
- to control one split gear to be kept in engaged position throughout said gear shifting.

26. A computer program according to claims 24 and 25, characterized in that the computer program comprises computer program code for causing the computer:
- to control said split gearbox (10) to keep said input shaft (8) and said lay shaft (32) rigidly engaged throughout said gear shifting.

27. A computer program according to claim 21, characterized in that the computer program comprises computer program code for causing the computer:
- to control gear shifting involving a gear shifting in a split gearbox (10) of said transmission.
28. A computer program according to claim 27, characterized in that the computer program comprises computer program code for causing the computer:
- to control synchronization means (22) of said split gearbox (10) to act upon a shaft of said split gearbox by establishing an accelerating or retarding connection of said input shaft (8) to said split gearbox shaft for influencing said gearbox shaft towards said synchronous rotational speed,
- to control the main shaft (25) and the input shaft (8) to be kept rigidly engaged throughout said gear shifting, and
- to control said synchronization means (23) of the basic gearbox (11) to act upon said split gearbox shaft by establishing an accelerating or retarding connection of said main shaft to said split gearbox shaft for influencing the split gearbox shaft towards said synchronous rotational speed.

29. A computer program according to claim 28, in which said split gearbox shaft is formed by a part of a lay shaft (32) of the basic gearbox adapted for connecting said input shaft (8) to the main shaft (25), said lay shaft having gears (33-35) engaging a gear (29-31) each engagable with said main shaft (25) by synchronization means (23) of the basic gearbox characterized in that the computer program comprises computer program code for causing the computer:
- to control synchronization means (22) of said split gearbox (10) to act upon said lay shaft (32) by influencing gears of said split gearbox to form an engagement with said input shaft (8) for influencing said lay shaft towards said synchronous rotational speed.

30. A computer program according to claim 28 or 29 for controlling gear shifting for a transmission having a range gearbox (12) for connecting said output shaft (13) to said basic gearbox, characterized in that the computer program comprises computer program code for causing the computer:
- to control one range gear to be kept in engaged position throughout said gear shifting.

31. A computer program product comprising a data storage medium (44) readable by an electronic unit (40), a computer program according to any of claims 21-30 being stored on said data storage medium.

32. An electronic unit comprising an execution means (41), a memory (42) connected to the execution means and a data storage medium (44) connected to the execution means, a computer program according to any of claims 21-30 being stored on said data storage medium.
Basic gearbox into neutral and secondary gearbox disengaged

Calculation of rotational speed of engine shaft for selected gear and for rotational speed of driven axle

Control of engine to obtain engine shaft rotational speed calculated

Synchronization of secondary gearbox started

Synchronization of basic gearbox started for assisting secondary gearbox synchronization to obtain synchronous rotational speed

Continue synchronization action

Synchronous rotational speed obtained?

Yes

No

Gear shifting in secondary and basic gearboxes completed
INTERNATIONAL SEARCH REPORT

International application No. PCT/SE2007/050951

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F16H, B60W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>WO 06076944 20 (EF FRIEDRICHSHAFEN AG), 21 July 2006 (27.07.2006), abstract</td>
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<td>US 5195036 A (KIMURA ET AL), 16 March 1993 (16.03.1993), abstract</td>
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Date of the actual completion of the international search  7 April 2008
Date of mailing of the international search report  08-04-2008

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International patent classification (IPC)

F1SE 61/70 (2006.01)
B60W 10/06 (2006.01)
B60W 10/10 (2006.01)

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<td>06076944</td>
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<td>04/03/2004</td>
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**Additional Patent Family Members:**

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