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(54) Title: TRANSMISSION WITH DISCRETE CLUTCH SHIFTING MANAGEMENT

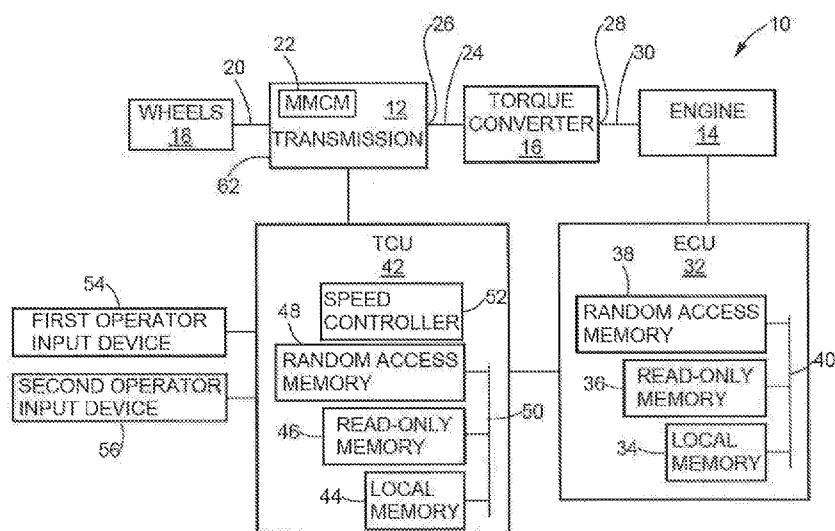


FIG. 1

(57) Abstract: An automatic transmission (12) may include a multi-mode clutch module (MMCM) (22) including an outer race (58), an inner race (60) disposed radially inwardly from the outer race (58), and at least one reverse pawl (64) and at least one forward pawl (66) disposed radially between the outer race (58) and the inner race (60). An electronic transmission control unit (TCU) (42) may be configured to control the MMCM (22) from operating in a lock state to operate in a one-way clutch (OWC) state, during an upshift request when the TCU (42) determines a power-off state of an engine, such that the at least one reverse pawl (64) is actuated from a lock state wherein the at least one reverse pawl (64) is engageable with the inner race (60) to an OWC state position wherein the at least one reverse pawl (64) is unengageable with the inner race (60) so that the transmission (12) operates in a desired gear of the upshift request.

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- *of inventorship (Rule 4.17(iv))*

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TRANSMISSION WITH DISCRETE CLUTCH SHIFTING MANAGEMENT

Field of Disclosure

[0001] The present disclosure relates generally to transmissions, and more particularly to shifting management for a transmission with a discrete clutch.

5 Background of Disclosure

[0002] Many vehicles typically include a transmission interposed between an engine and driveshaft components to selectively control torque and speed ratios between a crankshaft and the driveshaft. Some transmissions may be a manually operated automatic transmission such that a driver may manually operate a shift lever located in the vehicle which commands gear
10 changes to the automatic transmission.

[0003] As an example, a clutch unit such as a discrete-type clutch may be utilized in the automatic transmission for shifting between various gear ratios. For instance, when the discrete-type clutch is installed in low/reverse position and first gear is applied the forward pawls of the discrete-type clutch are engaged and loaded under positive engine torque and the
15 reverse pawls are engaged and loaded under negative engine torque, such as during engine braking. As such, with the forward pawls engaged, during an engine power-off upshift, for example, the reverse pawls are also engaged and become loaded due to the engine braking involved in the process. Prior to actuating the discrete-type clutch for completing the upshift, however, the reverse pawls must be unloaded.

20 **[0004]** U.S. Patent No. 6,409,630 ('630 patent) discloses a power-off upshift control method for a transmission. While the method of the '630 patent discloses controlling the transmission during a power-off upshift, it fails to disclose controlling of any clutch during such power-off upshift operations.

25 Summary of Disclosure

[0005] In accordance with an aspect of the disclosure, a sample sequence of steps for a method for managing an automatic transmission is provided. The method may entail receiving an upshift request via a first operator input device. Another step may be

determining whether an engine state is in a power-off state. Yet another step may be transmitting an increase engine torque signal request when the engine state is determined as being in the power-off state. A further step may be determining whether an engine slip speed is positive. An even further step may be controlling a multi-mode clutch module (MMCM) of the automatic transmission to operate in a one-way clutch (OWC) state when the engine slip speed is determined positive. A still further step may be determining whether the MMCM is operating in the OWC state. Yet another further step may be transmitting a terminate engine torque increase request when the MMCM is determined as operating in the OWC state. Another further step may be controlling the transmission to operate in a desired gear when the MMCM is operating in the OWC state.

[0006] In accordance with another aspect of the disclosure, an automatic transmission is provided. The automatic transmission may include a multi-mode clutch module (MMCM) including an outer race, an inner race disposed radially inwardly from the outer race, and at least one reverse pawl and at least one forward pawl disposed radially between the outer race and the inner race. An electronic transmission control unit (TCU) may be configured to control the MMCM from operating in a lock state to operate in a one-way clutch (OWC) state, during an upshift request when the TCU determines a power-off state of an engine, such that the at least one reverse pawls is actuated from a lock state wherein the at least one reverse pawl is engageable with the inner race to an OWC state position wherein the at least one reverse pawl is unengageable with the inner race so that the transmission operates in a desired gear of the upshift request.

[0007] In accordance with yet another aspect of the disclosure, a vehicle is provided. The vehicle may include an engine including an electronic engine control unit (ECU). An automatic transmission may be operatively coupled to the engine. A multi-mode clutch module (MMCM) may be operatively disposed in the automatic transmission. The MMCM may include an outer race, an inner race disposed radially inwardly from the outer race, and at least one reverse pawl and at least one forward pawl disposed radially between the outer race and the inner race. The vehicle may also include a first operator input device and a second operator input device. An electronic transmission control unit (TCU) may be in operative communication with the ECU, the automatic transmission, the MMCM, the first operator input device, and the second operator input device. The TCU may be configured to:

receive an upshift request via the first operator input device; determine whether an engine state of the engine is in a power-off state; transmit an increase engine torque request signal to the ECU when the engine state is determined as being in the power-off state; determine whether an engine slip speed is positive; control the MMCM to operate in a one-way clutch (OWC) state when the engine slip speed is determined positive; determine whether the MMCM is operating in the OWC state; transmit a terminate engine torque increase request to the ECU when the MMCM is determined as operating in the OWC state; and control the transmission to operate in a desired gear of the upshift request when the MMCM is operating in the OWC state.

[0008] These and other aspects and features of the present disclosure may be better appreciated by reference to the following detailed description and accompanying drawings.

Brief Description of Drawings

[0009] FIG. 1 is a block diagram illustrating an exemplary vehicle including an exemplary transmission, in accordance with an embodiment of the present disclosure;

[0010] FIG. 2 is a side view of an exemplary multi-mode clutch module of the exemplary transmission, with sections removed and broken away, in accordance with an embodiment of the present disclosure;

[0011] FIG. 3 is a series of plots illustrating a shift sequence of the exemplary transmission, in accordance with an embodiment of the present disclosure; and

[0012] FIG. 4 is a flow chart illustrating a sample sequence of steps which may be practiced in accordance with the teachings of the present disclosure.

[0013] It should be understood that the drawings are not to scale, and that the disclosed embodiments are illustrated only diagrammatically and in partial views. It should also be understood that this disclosure is not limited to the particular embodiments illustrated herein.

Detailed Description

[0014] Referring now to FIG. 1, an exemplary vehicle constructed in accordance with the present disclosure is generally referred to by reference numeral 10. The vehicle 10 may be any type of vehicle such as, but not limited to, automobiles, trucks, vans, and other well-known vehicles. The vehicle 10 includes a transmission 12, an engine 14, a torque converter

16, and drive wheels 18. The engine 14 may be any type of internal or external combustion engine such as, but not limited to, gas turbine engines, diesel engines, and other engines well-known in the industry. The transmission 12 is operatively coupled to the drive wheels 18 via a transmission output shaft 20 and other mechanical components (not shown) such as, but not limited to, a final drive shaft, a transfer case, and a differential. The transmission 12 includes a multi-mode clutch module (MMCM) 22, which is a discrete-type clutch (e.g. cannot vary force), in operative engagement with a gear set of a plurality of gear sets (not shown) to provide a plurality of selective gear ratios between the transmission output shaft 20 and a turbine shaft 24 splined to a transmission input 26 of the transmission 12.

[0015] The torque converter 16 is disposed between the transmission 12 and the engine 14 such that the torque converter 16 is operatively coupled to the turbine shaft 24 and is also operatively coupled to the engine 14 via a torque converter input 28, which may be splined to an engine output 30 of the engine 14. The engine 14 is in communication with an engine control unit (ECU) 32 configured to control various operating components and parameters of the engine 14, such as engine torque. The ECU 32 may be implemented by one or more microprocessors or controllers from any desired family or manufacturer. In some embodiments, the ECU 32 includes a first local memory 34 in communication with a first read-only memory 36 and a first random access memory 38 via a first bus 40.

[0016] Moreover, in some embodiments, the transmission 12 is an automatic transmission and is in communication with a transmission control unit (TCU) 42 configured to control the transmission 12 and, in particular, the MMCM 22 for selectively changing between the various gear ratios. The TCU 42 may be implemented by one or more microprocessors or controllers from any desired family or manufacturer. In some embodiments, the TCU 42 includes a second local memory 44 in communication with a second read-only memory 46 and a second random access memory 48 via a second bus 50. The TCU 42 is in communication with the ECU 32 and is configured to generate and transmit engine torque requests to the ECU 32. In some embodiments, the TCU 42 further includes a speed controller 52 configured to generate and transmit engine torque requests to the ECU 32.

[0017] The TCU 42 is also in communication with a first operator input device 54 and a second operator input device 56. In some embodiments, the first operator input device 54 is a shift lever disposed in the vehicle 10. The first operator input device 54 is configured to

transmit shift request signals, such as upshift request signals, when toggled, to the TCU 42 for controlling the transmission 12 and, in particular, the MMCM 22. The second operator input device 56 is, in some embodiments, a foot pedal disposed in the vehicle 10. The second operator input device 56 is configured to transmit a power-on signal to the TCU 42 when the second operator input device 56 is depressed and configured to transmit an engine power-off signal to the TCU 42 when the second operator input device 56 is un-depressed (e.g. when the operator lifts foot off of the foot pedal). In some embodiments, the TCU 42 is configured to receive engine speed signals and turbine speed signals for determining engine slip speed such that a positive engine slip speed is defined as the engine speed being greater than the turbine speed and a negative engine slip speed is defined as the engine speed being less than the turbine speed.

[0018] With reference to FIG. 2, the MMCM 22 of the transmission 12 includes an outer race 58 and an inner race 60. In an embodiment, the outer race 58 is securely coupled to a transmission case 62 (depicted in FIG. 1) of the transmission 12 such that the outer race 58 is stationary with respect to the transmission case 62. The inner race 60 is disposed radially inwardly from the outer race 58 and is rotatable with respect to the outer race 58. In an embodiment, the inner race 60 is also coupled to a carrier of a gear set of the plurality of gear sets (not shown) of the transmission.

[0019] The MMCM 22 further includes at least one reverse pawl 64 and at least one forward pawl 66 disposed radially between the outer race 58 and the inner race 60. In some embodiments, the at least one reverse pawl 64 and the at least one forward pawl 66 are pivotally disposed on a plate 68 coupled to the outer race 58. The MMCM 22 may be selectively actuated to position the at least one reverse pawl 64 and the at least one forward pawl 66 into various combinations of engaged and unengaged positions with respect to the inner race 60.

[0020] The MMCM 22 includes a lock state such that the at least one reverse pawl 64 and the at least one forward pawl 66 are actuated into a lock position so that the at least one reverse pawl 64 and the at least one forward pawl 66 are engaged (e.g. in position to transmit torque dependent upon positive or negative engine torque) with the inner race 60. As such, when the MMCM 22 is in the lock state and under positive engine torque, the at least one forward pawl 66 is loaded such that the at least one forward pawl 66 locks against the inner

race 60 to hold the inner race 60 stationary, with respect to the outer race 58, by preventing the inner race 60 from rotating in a first direction 70. Moreover, while still in the lock state but under negative engine torque, on the other hand, the at least one reverse pawl 64 is loaded instead such that the at least one reverse pawl 64 locks against the inner race 60 to hold the inner race 60 stationary, with respect to the outer race 58, by preventing the inner race 60 from rotating in a second direction 72, which is an opposite direction from the first direction 70.

[0021] The MMCM 22 also includes a one-way clutch (OWC) state in which the at least one forward pawl 66 and the at least one reverse pawl 64 are actuated in an OWC state position. As such, the at least one forward pawl 66 is engaged with the inner race 60 while the at least one reverse pawl 64 is unengaged (e.g. lifted off from the inner race 60) with the inner race 60 such that, under positive engine torque, the at least one forward pawl 66 is loaded to lock against the inner race 60 and prevent the inner race 60 from rotating, with respect to the outer race 58, in the first direction. While under negative engine torque, on the other hand, the inner race 60 is free to rotate in the second direction 72 as the at least one forward pawl 66 overruns because the at least one reverse pawl 64 is unengaged with the inner race 60.

[0022] The MMCM 22 further includes a free state in which both the at least one reverse pawl 64 and the at least one forward pawl 66 are actuated in a free state position such that both the at least one reverse pawl 64 and the at least one forward pawl 66 are unengaged (e.g. lifted off from) the inner race 60, which is free to rotate in either the first direction 70 or the second direction 72.

[0023] The MMCM 22 may actuate the at least one reverse pawl 64 and the at least one forward pawl 66 into the lock state, the OWC state, and the free state via a single cam, a first and a second cam, centrifugally, or in any combination thereof, to name a few non-limiting examples. In an embodiment, a cam of the MMCM 22, such as cam 73 exemplarily illustrated in FIG. 2, actuates both the at least one reverse pawl 64 and the at least one forward pawl 66 into the various states. In some embodiments, the at least one reverse pawl 64 is actuated via a cam and the at least one forward pawl 66 is centrifugally actuated. In some other embodiments, the at least one reverse pawl 64 is actuated via a first cam and the at least one forward pawl 66 is actuated via a second cam.

[0024] During operation, the TCU 42 is configured to control the transmission 12 based on the shift requests signals received from the first operator input device 54. A shifting change, such as an engine power-off upshift, for example, involves a shift sequence for completing such a shift change, as exemplarily illustrated in FIG. 3. The engine power-off upshift may be any type of engine power-off upshift. The series of plots 74 illustrated in FIG. 3 are depicted adjacent one another to provide a visual comparison with respect to time of changes in the speed of the engine 14 at an engine speed curve 76, the speed of the turbine shaft 24 at a turbine speed curve 78, the engine torque at an engine torque curve 80, the state of the MMCM 22 at a MMCM state curve 82, the shift request via the first operator input device 54 at a gear ratio curve 84, the state of the at least one forward pawl 66 at a forward pawl state curve 86, and the state of the at least one reverse pawl 64 at a reverse pawl state curve 88.

[0025] As illustrated in the series of plots 74, the transmission 12 is initially operating in first gear such that the engine speed is greater than the turbine speed depicting a positive engine slip speed; the engine torque is positive; and the MMCM 22 is in the lock state with the at least one forward pawl 66 engaged and loaded with the inner race 60 due to the positive engine torque. At the first time marker 90, the second operator input device 56 is un-depressed initiating the engine power-off, upshift transition such that the engine slip changes from positive to negative (e.g. the engine speed is less than the turbine speed); the engine torque is negative; and the MMCM 22 is still in the lock state but with the at least one reverse pawl 64 engaged and loaded with the inner race 60, instead of the at least one forward pawl 66 being loaded, due to the change from positive engine torque to negative engine torque.

[0026] At a second time marker 92, the first operator input device 54 is toggled such that an upshift request signal is transmitted to the TCU 42 for transmitting an engine torque increase to the ECU 32. As illustrated between the second time marker 92 and a third time marker 94, the engine speed is increasing to become greater than the turbine speed such that the engine slip transitions from negative to positive for increasing the engine torque. During this period, the TCU 42 determines, based on the positive engine slip speed, that the at least one forward pawl 66 is engaged and loaded with the inner race 60 and then controls the MMCM 22 to operate in the OWC state such that the at least one reverse pawl 64 is actuated to be un-engageable with the inner race 60. With the MMCM 22 in the OWC state, the TCU 42 controls the transmission 12 to enter the desired gear such that the inner race 60 is free to

rotate in the second direction 72 under negative engine torque. Moreover, the TCU 42 transmits a terminate engine torque request to the ECU 32 and then the TCU 42 controls the MMCM 22 to transition from the OWC state to the free state. As illustrated between the third time marker 94 and a fourth time marker 96, with the MMCM 22 in the free state, the ECU 32 controls the engine torque based on an engine demand torque, which may be based on demands via the second operator input device 56. At the fourth time marker 96, the power-off upshift request is completed such that the transmission operates in the desired gear.

[0027] FIG. 4 illustrates a flow chart 400 of a sample sequence of steps which may be performed to manage an automatic transmission during an engine power-off upshift request.

As illustrated at block 410, the TCU 42 receives an upshift request signal via the first operator input device 54. At decision block 412, the TCU 42 determines whether the engine is in a power-off state or a power-on state. If the TCU 42 determines that the engine is in the power-on state via the power-on signal received from the second operator input device 56 indicating that the second operator input device is depressed, then the TCU 42 initiates an engine power-on upshift sequence, as illustrated in block 414. On the other hand, if the TCU 42 determines that the engine is in the power-off state via the power-off signal received from the first operator input device 54, then the TCU 42 transmits the increase engine torque request signal to the ECU 32 for increasing engine torque, as illustrated at block 416.

[0028] As the engine torque is increasing, the TCU 42 determines whether the engine slip is positive (e.g. the engine speed is greater than the turbine speed), as illustrated in decision block 418. If the TCU 42 determines that the engine slip speed is negative, then the TCU 42 continues to transmit the increase engine torque request signal to the ECU 32, as illustrated by the return loop to block 416. If the TCU 42 determines that the engine slip speed is positive, then the TCU 42 controls the MMCM 22 to operate in the OWC state, as illustrated at block 420. As illustrated at decision block 422, the TCU 42 determines whether the MMCM 22 is operating in the OWC state. If the TCU 42, determines that the MMCM 22 is not operating in the OWC state, then the TCU 42 continues to control the MMCM 22 to operate in the OWC state, as illustrated by the return loop to block 420. If the TCU 42 determines that the MMCM 22 is operating in the OWC state, then the TCU 42 transmits a terminate engine torque increase request to the ECU 32, as illustrated at block 424, and controls the transmission to operate in the desired gear such that the inner race 60 rotates in

the second direction 72 as necessitated by operating in the desired gear. As illustrated at block 426, as the transmission 12 is operating in the desired gear, the TCU 42 then controls the MMCM 22 to operate in the free state.

Industrial Applicability

5 **[0029]** Based on the foregoing, it can be seen that the present disclosure can find applicability in various types of vehicles such as, but not limited to, automobiles, trucks, vans, and other well-known vehicles. Through the novel teachings set forth above, the automatic transmission 12 provides an engine power-off upshift while utilizing a discrete-type clutch, such as the MMCM 22. Moreover, the automatic transmission 12 of the present
10 disclosure may overcome the challenges presented in other transmission designs when controlling a discrete-type clutch implemented in a transmission during such an upshift request.

[0030] For example, during an engine power-off upshift request, reverse pawls of a discrete-type clutch of a typical transmission may be engaged and loaded due to negative
15 engine torque as a result of engine braking. With the reverse pawls engaged, however, various gear sets of such a transmission that are in operative association with the reverse pawls may be prevented from rotating appropriately such that upshifting may not be achieved. The automatic transmission 12 of the present disclosure, on the other hand, overcomes such challenges by controlling the MMCM 22 to unload or unengaged the reverse
20 pawls based on positive engine slip speed during such an upshift request so that the transmission 12 provides proper rotation of the gear sets therein for operating in the desired gear.

What is claimed is:

1. A method of managing an automatic transmission (12), the method comprising:

receiving an upshift request via a first operator input device (54);

determining whether an engine state is in a power-off state;

5 transmitting an increase engine torque request signal when the engine state is determined as being in the power-off state;

determining whether an engine slip speed is positive;

controlling a multi-mode clutch module (MMCM) (22) of the automatic transmission (12) to operate in a one-way clutch (OWC) state when the engine slip speed is determined positive;

determining whether the MMCM (22) is operating in the OWC state;

transmitting a terminate engine torque increase request when the MMCM (22) is determined as operating in the OWC state; and

controlling the transmission (12) to operate in a desired gear when the MMCM (22) is operating in the OWC state.

2. The method of claim 1, further including controlling the MMCM (22) to operate in a free state when the transmission (12) is operating in the desired gear.

3. The method of claim 1, wherein transmitting an increase engine torque signal request further includes transmitting the increase engine torque signal request to an electronic engine control unit (32).

4. The method of claim 1, wherein transmitting a terminate engine torque increase request further includes transmitting the terminate engine torque increase request to an electronic engine control unit (32).

5. The method of claim 1, wherein controlling a multi-mode clutch module (MMCM) (22) of the automatic transmission (12) to operate in a one-way clutch (OWC) state further

includes controlling the MMCM (22) of the automatic transmission (12) from operating in a lock state of the MMCM (22) to operate in the OWC state.

6. The method of claim 1, wherein determining whether an engine state is in a power-off state further includes determining whether the engine state is in the power-off state based on an engine power-off signal via a second operator input device.

7. An automatic transmission (12), comprising:

a multi-mode clutch model (MMCM) (22) including an outer race (58), an inner race (60) disposed radially inwardly from the outer race (58), and at least one reverse pawl (64) and at least one forward pawl (66) disposed radially between the outer race (58) and the inner race (60); and

an electronic transmission control unit (TCU) (42) in operative communication with the MMCM (22), the TCU (42) configured to control the MMCM (22) from operating in a lock state to operate in a one-way clutch (OWC) state, during an upshift request when the TCU (42) determines a power-off state of an engine, such that the at least one reverse pawl (64) is actuated from a lock state wherein the at least one reverse pawl (64) is engageable with the inner race (60) to a OWC state position wherein the at least one reverse pawl (64) is unengageable with the inner race (60) so that the transmission (12) operates in a desired gear of the upshift request.

8. The automatic transmission (12) of claim 7, wherein the TCU (42) is further configured to: receive the upshift request via a first operator input device (54), determine the engine power-off state of the engine via receiving a power-off signal from a second operator input device (56), transmit an increase engine torque signal request when the engine is determined as being in the power-off state, and determine an engine slip speed is positive before controlling the MMCM (22) from operating in the lock state to operate in the one-way clutch (OWC) state.

9. The automatic transmission (12) of claim 8, wherein the TCU (42) is further configured to transmit the increase engine torque signal request to an electronic engine control unit (32).

10. The automatic transmission (12) of claim 8, wherein the TCU (42) is further configured to transmit a terminate engine torque increase request to the electronic engine control unit (32) when the MMCM (22) is determined as operating in the OWC state.

11. The automatic transmission (12) of claim 10, wherein the TCU (42) is further configured to control the MMCM (22) to operate from the OWC state to a free state when the transmission (12) is operating in the desired gear such that both the at least one reverse pawl (64) and the at least one forward pawl (66) are unengageable with the inner race (60).

12. A vehicle (10), comprising:

an engine (14) including an electronic engine control unit (ECU) (32);

an automatic transmission (12) operatively coupled to the engine (14);

a multi-mode clutch module (MMCM) (22) operatively disposed in the automatic transmission (12), the MMCM (22) including an outer race (58), an inner race (60) disposed radially inwardly from the outer race (58), and at least one reverse pawl (64) and at least one forward pawl (66) disposed radially between the outer race (58) and the inner race (60);

a first operator input device (54);

a second operator input device (56);

an electronic transmission control unit (TCU) (42) in operative communication with the ECU (32), the automatic transmission (12), the MMCM (22), the first operator input device (54), and the second operator input device (56), the TCU (42) configured to:

receive an upshift request via the first operator input device (54);

determine whether an engine state of the engine (14) is in a power-off state;

transmit an increase engine torque request signal to the ECU (32) when the engine state is determined as being in the power-off state;

determine whether an engine slip speed is positive;

control the MMCM (22) to operate in a one-way clutch (OWC) state when the engine slip speed is determined positive;

determine whether the MMCM (22) is operating in the OWC state;

5 transmit a terminate engine torque increase request to the ECU (32) when the MMCM (22) is determined as operating in the OWC state; and

control the transmission (12) to operate in a desired gear of the upshift request when the MMCM (22) is operating in the OWC state.

10 13. The vehicle (10) of claim 12, wherein the TCU (42) is further configured to control the MMCM (22) to operate in a free state when the transmission (12) is operating in the desired gear.

14. The vehicle (10) of claim 12, wherein the first operator input device (54) is a shift lever disposed in the vehicle (10).

15 15. The vehicle (10) of claim 12, wherein the second operator input device (56) is a foot pedal disposed in the vehicle (10).

103

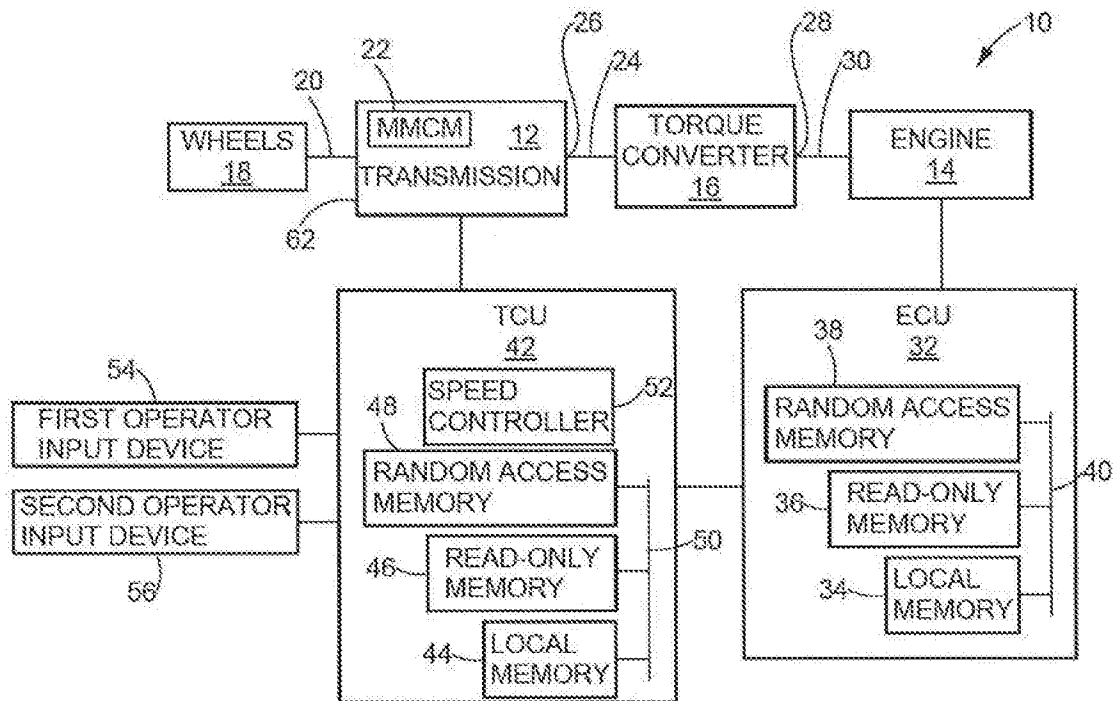


FIG. 1

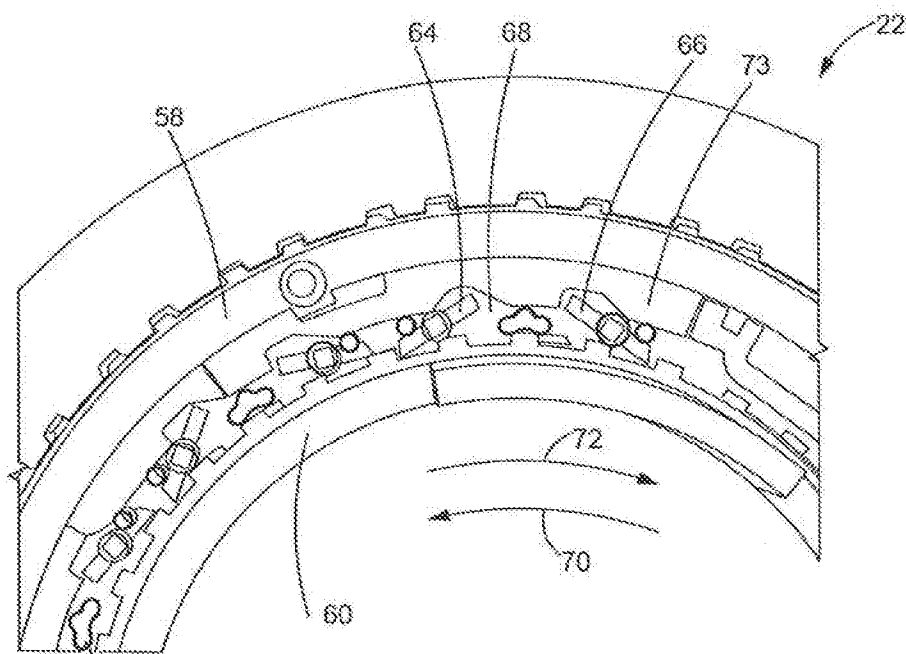


FIG. 2

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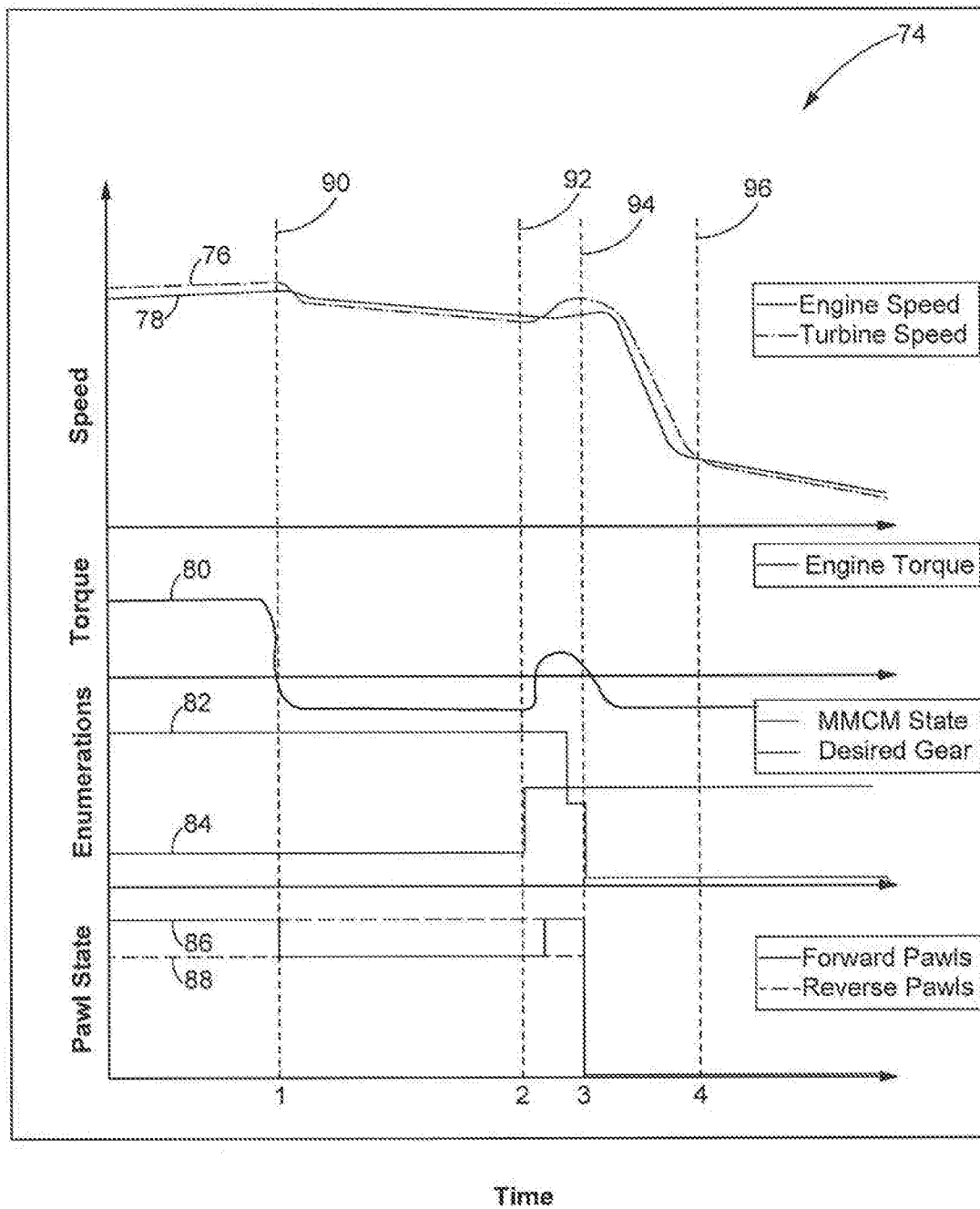


FIG. 3

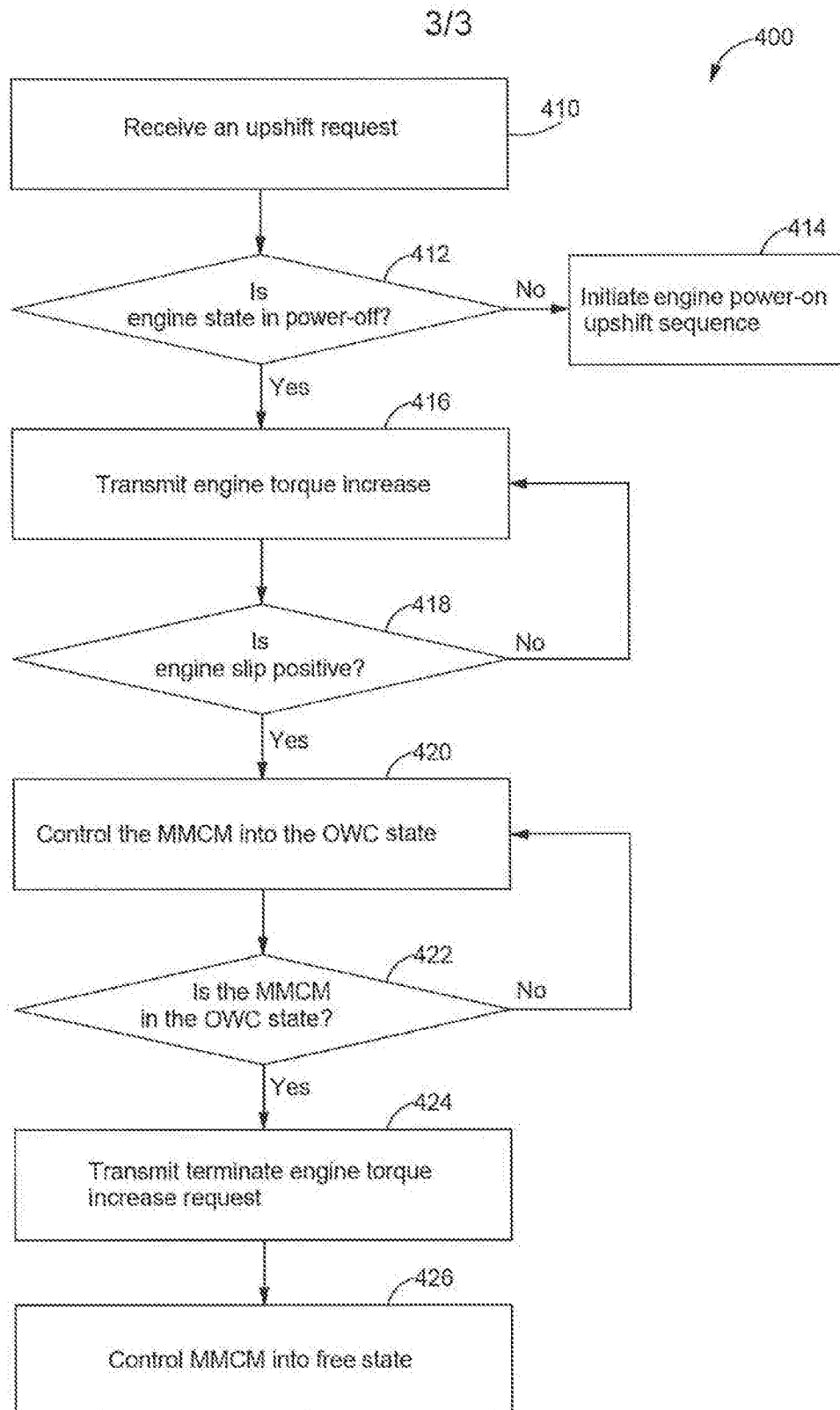


FIG. 4

A. CLASSIFICATION OF SUBJECT MATTER**F16H 61/04(2006.01)i, F16D 48/00(2006.01)i, F16D 41/08(2006.01)i**

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)

F16H 61/04; B60W 20/00; F16H 3/44; B60W 10/02; F02D 29/00; F16H 61/08; B60K 41/02; B60K 41/04; F16D 48/00; F16D 41/08

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: engine power-off, upshift, multi-mode clutch, one-way clutch, engine torque, and slip

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001-0007844 A1 (YU, PYUNG-HWAN) 12 July 2001 See abstract, paragraphs [0020]-[0023] and figures 1, 2.	1-15
A	US 2015-0080174 A1 (BORGWARNER, INC.) 19 March 2015 See paragraphs [0018]-[0030] and figures 2-7.	1-15
A	US 5106348 A (KOIVUNEN, ERKKI A.) 21 April 1992 See column 4, line 15 - column 5, line 21 and figures 1, 1a.	1-15
A	JP 2007-291895 A (TOYOTA MOTOR CORP.) 08 November 2007 See paragraphs [0032], [0044], [0065] and figures 3, 7, 8.	1-15
A	US 2005-0137054 A1 (YU, PYUNG HWAN) 23 June 2005 See paragraphs [0041], [0042] and figure 2.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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