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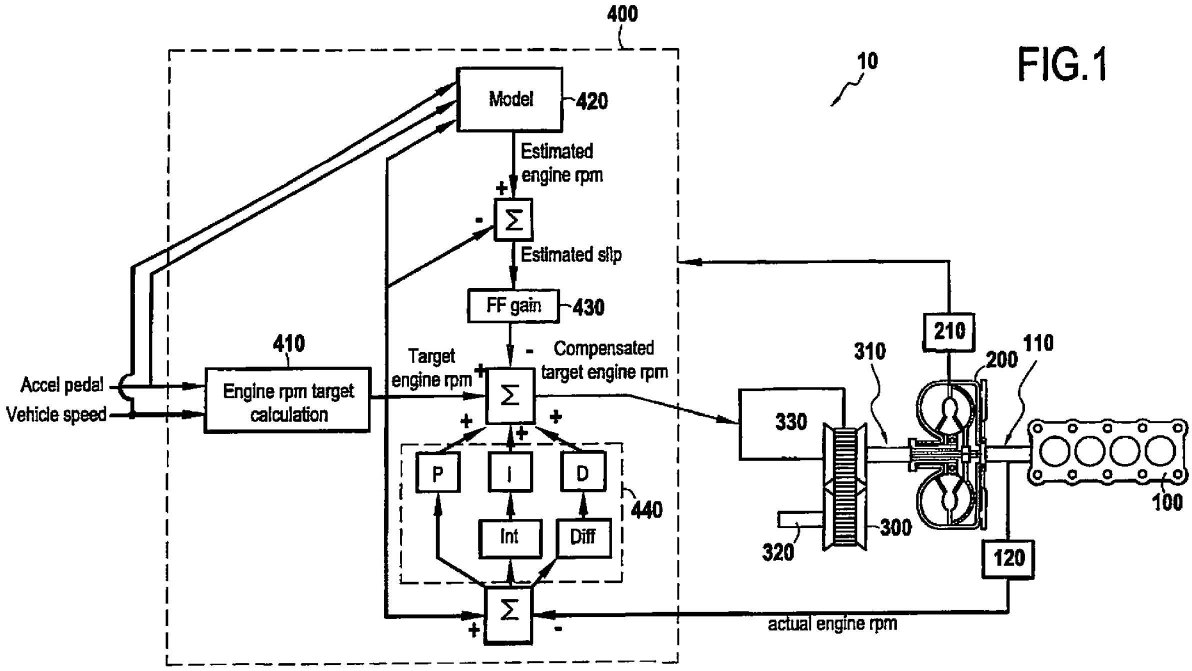
(54) **Title:** DEVICE AND METHOD FOR CONTROLLING A VEHICLE POWERTRAIN

FIG.1



(57) **Abstract:** A control device for a vehicle powertrain and a method controlling a vehicle powertrain using a control device, the control device being configured to receive a request from a lock up torque converter control unit to execute a lock up protocol, the lock up protocol receives an engine rpm target from a transmission control unit, the engine rpm target being based on a current vehicle speed and a current accelerator pedal position; determines an estimated engine rpm using a feed forward model from a torque converter map based on the engine rpm target, accelerator pedal position, engine torque, and a CVT input shaft 310 rpm; determines a feed forward gain based on a lock-up control state; calculates a compensated target engine rpm based on the engine rpm target and the feed forward gain, triggers a CVT shift based on the compensated target engine rpm, and stops the lock up protocol based on a request from the lock up torque converter control unit to stop the lock up protocol.

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[Continued on next page]

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DEVICE AND METHOD FOR CONTROLLING A VEHICLE POWERTRAIN

FIELD OF THE DISCLOSURE

[0001] The present disclosure is related to vehicle power train control, and more particularly to engine and transmission control during a lock up phase of a continuously variable transmission (CVT).

BACKGROUND OF THE DISCLOSURE

[0002] The trend to use lock up torque converters has increased over the past several years due to a market demand for automatic transmission vehicles that are fuel efficient. This is because many automotive consumers prefer automatic transmissions and energy efficient vehicles have become popular. To address this demand, the automotive industry has transitioned to using lock up torque converters rather than basic torque converters.

[0003] The difference between a basic torque converter and a lock up torque converter is that a lock up torque converter has a clutch adapted to, for all intents and purposes, create a mechanical connection between the transmission input shaft and the flexplate of engine, thereby providing a 1:1 drive ratio. This locked up state eliminates the losses that are caused by the phenomenon of slipping in the torque converter.

[0004] However, when a lock up torque converter is used in a powertrain with a CVT, there can be a noticeable impact in the engine rpm and drive force behavior. In particular, when the lock up clutch is closing, the engine rpm may not be aligned with vehicle speed behavior and drive force will reduce causing a feeling of the clutch slipping and inconsistent drive force. This feeling is generally perceived as negative for the driver.

[0005] One approach to solving this problem is disclosed, for instance, in Japanese Patent Application Laid-Open Number JP 2004 116641.

SUMMARY OF THE DISCLOSURE

[0006] The present inventors have recognized that it is desirable to match the control of the lock up torque converter and shift control of the CVT to maintain alignment between the engine rpm and vehicle speed.

[0007] In at least one illustrative embodiment of a control device for a vehicle powertrain according to the present disclosure, the control device is configured to receive a request from a lock up torque converter control unit to execute a lock up protocol, the lock up protocol comprising: receive an engine rpm target from a transmission control unit, the engine rpm target may be based on a current vehicle speed and a current accelerator pedal position; determine an estimated engine rpm using a feed forward model which may be based on the engine rpm target, acceleration pedal position, an engine torque, and a CVT input shaft rpm; and determine a feed forward gain which may be based on a lock-up control state; the protocol further calculates a compensated target engine rpm which may be based on the engine rpm target and the feed forward gain; trigger a CVT shift which may be based on the compensated target engine rpm; and stops the lock up protocol which may be based on a request from the lock up torque converter control unit to stop the lock up protocol.

[0008] By thus matching the control of the lock up torque converter and shift control of the CVT, it is possible to better align the engine rpm and the vehicle speed. Therefore, the feeling of slippage may be less perceptible or may not occur at all and the driver remains comfortable. The lock-up control state may be open, closed, or closing.

[0009] During execution of the lock up protocol, the torque converter may change from an unlocked state to a locked up state. However, during execution of the lock up protocol, the torque converter may change from a locked state to an unlocked up state.

[0010] The synchronization of the execution of the protocol and the CVT transitioning between an unlocked state and locked state helps avoid sudden shocks of the vehicle due to the inertia of the engine. However, the control device may also be active during a lock-up open state.

[0011] The engine rpm target may be stored in a map preloaded on a control unit in the vehicle.

[0012] The feed forward gain may be based on a continuous lock up clutch closing state. The feed forward gain is set to follow a gradual increase in pressure in the lock up torque converter to phase out the effect of the feed forward model.

[0013] The calculation of the compensated target engine rpm further includes an input of a feedback controller value. The feedback controller may be a PID controller. The integration of a feedback controller helps to correct any errors that may be present in the feed forward model.

[0014] The feed forward gain may be a value ranging between 0 and 1 inclusive. The feed forward gain may be 0 when the lock up clutch is in a closed state and the feed forward gain may be 1 when the lock up clutch may be in an open state.

[0015] As aforementioned, the feed forward gain is set to follow a gradual increase in pressure in the lock up torque converter to phase out the effect of the feed forward model. Therefore, as pressure increases in the torque converter the feed forward gain will decrease.

[0016] During the determining of the estimated engine rpm from the torque converter model, the engine torque may be a calculated engine torque. However, when determining the estimated engine rpm from the torque converter model, the engine torque may be the engine torque as determined by an engine ECU.

[0017] When using the estimated engine rpm from the torque converter model, it is not necessary to receive the actual engine rpm. This can be advantageous if a sensor reading the actual engine rpm is malfunctioning.

[0018] The estimated engine rpm from the torque converter model may be calculated by:

$$\sqrt{\frac{Torque}{Capacity}}$$

where, capacity is based on the target engine rpm and the CVT input shaft rpm.

[0019] During the execution of the lock up protocol, the engine rpm target may be based on the estimated engine rpm.

[0020] During a lock up protocol, when the torque converter is moving from an unlocked state to a locked state, the CVT may be configured to downshift.

[0021] In an alternative embodiment, a vehicle comprising the control device described above is provided.

[0022] In an alternative embodiment, a method for controlling a vehicle powertrain is provided, the method comprising the steps of: receiving a request from a lock up torque converter control unit to execute a lock up protocol, the lock up protocol comprising: receiving an engine rpm target from a transmission control unit, the engine rpm target is based on a current vehicle speed and a current accelerator pedal position; determining an estimated engine rpm using a feed forward model that may be based on the engine rpm target, accelerator pedal position, an engine torque and a CVT input shaft rpm; determining a feed forward gain based on the lock-up control state; calculating a compensated target engine rpm based on the engine rpm target and the feed forward gain; triggering a CVT shift based on the compensated target engine rpm; and stopping the lock up protocol based on a request from the lock up torque converter control unit to stop the lock up protocol.

[0023] During execution of the lock up protocol, the torque converter may change from an unlocked state to a locked up state. However, during execution of the lock up protocol, the torque converter may change from a locked state to an unlocked up state.

[0024] The calculation of the compensated target engine rpm further includes an input of a feedback controller value.

[0025] It is intended that combinations of the above-described elements and those within the specification may be made, except where otherwise contradictory.

[0026] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the description, and serve to explain the principles thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Fig. 1 shows a schematic of a vehicle powertrain having a vehicle control device;

[0028] Fig. 2A shows a flow chart demonstrating a feed forward model at commencement of the lock up protocol;

[0029] Fig. 2B shows a flow chart demonstrating a feed forward model during execution of the lock up protocol;

[0030] Fig. 3 shows a chart plotting the relationship between capacity and slip of an example torque converter;

[0031] Fig. 4 shows a chart plotting the compensated engine rpm, engine rpm target, and real engine rpm in the feed forward model during execution of a lock up protocol; and

[0032] Fig. 5 shows a graph of the engine rpm before and after using embodiments present disclosure.

DESCRIPTION OF THE EMBODIMENTS

[0033] Reference will now be made in detail to exemplary embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0034] Fig. 1 shows a vehicle powertrain 10 including an engine 100 having a flexplate 110 and an engine electronic control unit (ECU) 120. The flex plate 110 connects the engine 100 to a lock up torque converter 200. The lock up torque converter 200 may further connected to an input shaft 310 of a CVT 300.

[0035] The lock up torque converter 200 may be adapted to hydraulically couple the flexplate 110 of the engine 100 and the input shaft 310 of the CVT 300 when the lock up torque converter 200 is in an unlocked position; and mechanically couple the flexplate 110 of the engine 100 and the input shaft 310 of the CVT 300 when the lock up torque converter 200 is in the lock up position. The lock up torque converter 200 further includes a lock up torque converter ECU 210 that may be configured to detect the state of the lock up torque converter 200 acquired from internal sensors (not shown), request a lock up protocol, and move the lock up torque converter 200 between lock up and unlocked states, among others.

[0036] The CVT 300 further includes an output shaft 320 that connects to, for example, differential and/or wheels of the vehicle (not shown) and a CVT ECU 330 that is configured to detect the state of the CVT acquired from internal sensors (not shown) and execute a CVT ratio control command.

[0037] The vehicle powertrain 10 may also include a control device 400 that is be configured to communicate with the engine ECU 120, the lock up torque converter ECU 210, and the CVT ECU 330.

[0038] The control device 400 may be configured to execute a lock up protocol. The protocol receives a calculated target engine rpm 410, which is a calculation that may be based on preloaded maps installed in the lock up torque converter ECU 210 and uses a current vehicle speed and current acceleration pedal position.

[0039] The protocol may use a feed forward model 420 that receives the current vehicle speed, current acceleration pedal position, and the target engine rpm 410 to determine an estimated engine rpm 425 from a torque converter map that uses the engine torque and a CVT input shaft 310 rpm.

[0040] The control device 400 may be active only when the torque converter 200 is in an unlocked state or slipping (e.g., in the process of closing or opening). For example, activation of the control device 400 may be triggered by the engine turning on or a request to unlock the torque converter 200. However, deactivation of the control device 400 may be triggered by the engine turning off or a request to lock the torque converter 200. Accordingly, when the control device 400 transitions from a deactivated state to an active state, the control device 400 may be initialized. However, the control device may also be active during a lock-up open state.

[0041] Figs. 2A and 2B show an exemplary feed forward model 420 in detail. With reference to Fig. 2A showing the feed forward model 420 at the initiation of the lock up protocol, the feed forward model 420 receives the calculated target engine rpm 410 and the acceleration pedal position. Using this information, the feed forward model 420 performs an engine torque calculation 421, for example, by calculating the stable condition of the lock up torque converter 200. The stable condition can be found when the torque converter is in the unlocked state 200.

[0042] The torque that is determined in the engine torque calculation 421 is read into an estimated engine rpm calculation 422 expressed as:

$$\sqrt{\frac{Torque}{Capacity}}$$

[0043] The torque that is used in the estimated engine rpm calculation 422 may be from the engine torque calculation 421 discussed above, or alternatively, may be the actual engine torque that is read by the engine ECU 120.

[0044] As can be seen in the equation above, the estimated engine rpm calculation 422 takes into account the torque as well as a capacity 423.

[0045] Capacity 423 may depend on several factors, including but not limited to a slip ratio that is the result of the target engine rpm divided by the input shaft 310 rpm where the input shaft 310 rpm is obtained from the CVT ECU 330. Additionally, the relationship between slip and capacity 423 may be fixed by several factors, inter alia, hardware design of the torque converter 200, converter design, oil type, and oil temperature.

[0046] FIG. 3 shows an example of the torque converter capacity of an actual market torque converter plotted against its slip ratio. In this example, the y-axis range is $0\, to\, 2 \times 10^{-5}$ and the unit of capacity is Nm/rpm^2 and the X-axis is the slip of the torque converter calculated as an output rpm divided by an input rpm. The set of corresponding values for capacity and slip ratio can be pre-stored in the feed forward model 420.

[0047] Referring back to Figs. 1 and 2A, the result of the estimated engine rpm calculation 422 is the estimated engine rpm 425 which is reduced by the target engine rpm 410, resulting in the estimated slip. This estimated slip is multiplied by a gain factor, determined by the feed forward gain 430. Finally the output of the feed forward gain 430 is used to reduce the Target engine rpm to create the compensated target engine rpm that is fed into the CVT ECU 330. The feed forward gain 430 may be a single value being greater than or equal to 0 and less than or equal to 1. The feed forward gain 430 will be described in greater detail with reference to Fig. 5.

[0048] Fig. 2B shows the lock up protocol after being initiated and during operation. The method of determining the estimated engine rpm 425 is substantially the same, except that the engine torque calculation 421 uses the determined estimated engine rpm 425 rather than the target engine rpm 410. Further, the input value for capacity 423 uses the estimated engine rpm 425 rather than the target engine rpm 410. Inputting the determined estimated engine rpm 425 back into the model allows the model to continuously update during the lock up protocol.

[0049] In operation, when the LU torque converter ECU 210 controls the lock-up clutch to be open, closing or opening, for example, when a driver accelerates from a low speed to reach a cruising speed on the interstate. This lock-up control triggers the control device 400 to activate and request the lock-up protocol to initialize. The feed forward model 420 considers the location of the accelerator pedal and the target engine rpm 410, and based on a pre-loaded map, the model uses these values to calculate the engine torque 421.

[0050] Thereafter, capacity 423 is determined, in part, by matching the slip ratio 424 of the target engine rpm 410 and the actual input shaft rpm 120 and finding the capacity for the corresponding ratio. The capacity values 423 associated with predetermined operating conditions can be pre-loaded in the feed forward model 420.

[0051] After the capacity 423 is determined, the estimated engine rpm is calculated 425 using the calculated engine torque 421 and capacity 423. The estimated engine rpm 425 is then reduced by the target engine rpm 410 and multiplied by the feed forward gain 430. The result is used to adjust the target engine rpm 410 to a compensated engine rpm target that is fed into the CVT ECU 330.

[0052] After initialization is complete, the control device 400 performs substantially the same steps except that engine torque calculation 421 uses the determined estimated engine rpm 425 rather than the target engine rpm 410, and the input value for capacity 423 uses the estimated engine rpm 425 rather than the target engine rpm 410. Using the determined estimated engine rpm 425 allows the feed forward model to continuously update until the torque converter is in a locked-up state and the control device 400 is deactivated.

[0053] Turning back to Fig. 1, the control unit 400 includes a feedback control 440 which may be a PID controller. However, this is an exemplary embodiment, and it is envisioned that in other embodiments the feedback control 440 may be a P or PI controller. In an alternate exemplary embodiment, the control unit 400 may not include a feedback control 440.

[0054] When implemented, the control unit 400 may determine a compensated engine target rpm based on the combination of the target engine rpm 410, values fed from the feedback control 440 and the feed forward gain 430 that was determined by the feed forward model 420.

[0055] The compensated engine rpm target is communicated to the CVT ECU 330 and may trigger the CVT 300 to activate the CVT ratio control and shift. In particular, the CVT ECU 330 may cause the CVT 300 to downshift or upshift. For example, when the lock up torque converter 200 is transitioning from an unlocked state to a locked up state, the actual engine rpm may decrease. However, this reduction in engine rpm is actively compensated by the CVT 300 continuously downshifting to align the actual engine rpm and current vehicle speed so that the feeling of the torque converter slipping is reduced or eliminated.

[0056] Shown in Fig. 4 is a graph charting the performance of the feed forward model during a lock up protocol, and in particular, when the lock up torque converter 210 is transitioning from an unlocked state to a locked up state.

[0057] The Y axis shows rpm and the X axis shows time in seconds. From time 1 to 2, the vehicle is accelerating, for example, driving on the interstate approaching a cruising speed. In the graph, the "real engine rpm" is the actual rpm of the engine read from the engine ECU 120; the "target engine rpm" is what is calculated using the preinstalled maps loaded in the CVT ECU 330; and the "FF engine rpm" is the estimated engine rpm 425 determined from the feed forward model 420.

[0058] As shown in the graph, the difference between the real engine rpm and the target engine rpm is large compared to the difference between the feed forward engine rpm and the real engine rpm. The feed forward engine rpm is a closer approximation of the actual engine rpm. However, from the time 3.5 onward where the lock up pressure is increasing and the lock up torque converter 200 is transitioning to a lock up position, the model may no longer appropriately approximate the actual engine rpm.

[0059] To compensate, the feed forward gain 430 may be used. As applied to this graph, the feed forward gain transitions from 1 to 0 as the lock up torque converter 200 is transitioning into a locked up state, thereby phasing out the effect of the feed forward model.

[0060] Fig. 5 shows a graph of the engine rpm before and after using the present invention, which includes the incorporation of the feed forward gain 430 feature. As shown in the graph, the fluctuations of the actual engine rpm before using the vehicle powertrain control device 400 relative to the vehicle speed are large and not linear, thus showing misalignment of the vehicle speed and engine rpm. In comparison, the fluctuations of the actual engine rpm after using the vehicle powertrain control device 10 relative to the vehicle speed are small and mostly linear, thus showing alignment of the vehicle speed and engine rpm.

[0061] The vehicle power train control device 400 may be designed to compensate for the additional engine 100 rpm due to torque converter 200 slip when in the unlocked state. For example, in the case where the torque converter 200 is closing, and transitioning into a locked up state, the slip will reduce from 100% to 0%, approximately. The transfer time from 100% slip to 0% slip may be estimated by the control device 400. This transfer time is generally from the moment a lock up touch is detected to when the torque converter 200 is in a locked up state. Consequently, the feed forward gain 430 transitions from 1, or a suitable value, to 0. The converse is the same.

[0062] Throughout the description, including the claims, the term "comprising a" should be understood as being synonymous with "comprising at least one" unless otherwise stated. In addition, any range set forth in the description, including the claims should be understood as including its end value(s) unless otherwise stated. Specific values for described elements should be understood to be within accepted manufacturing or industry tolerances known to one of skill in the art, and any use of the terms "substantially" and/or "approximately" and/or “generally” should be understood to mean falling within such accepted tolerances.

[0063] Although the present disclosure herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present disclosure.

[0064] It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims.

CLAIMS

1. A control device for a vehicle powertrain, the control device being configured to:

receive a request from a lock up torque converter control unit to execute a lock up protocol, the lock up protocol comprising:

receiving an engine rpm target from a transmission control unit, the engine rpm target being based on a current vehicle speed and a current accelerator pedal position;

determining an estimated engine rpm using a feed forward model from a torque converter map based on an engine rpm target, accelerator pedal position, engine torque, and a CVT input shaft rpm;

determining a feed forward gain based on a lock-up control state;

calculating a compensated target engine rpm based on the engine rpm target and the feed forward gain;

triggering a CVT shift based on the compensated target engine rpm; and

stopping the lock up protocol based on a request from the lock up torque converter control unit to stop the lock up protocol.

2. The control device according to claim 1, wherein during execution of the lock up protocol, the torque converter changes from an unlocked state to a locked up state.

3. The control device according to claim 1, wherein during execution of the lock up protocol, the torque converter changes from a locked up state to an unlocked state.

4. The control device according to any one of the previous claims, wherein the engine rpm target is stored in a map preloaded on the torque converter control unit in the vehicle.

5. The control device according to any one of the previous claims, wherein the feed forward gain is based on a continuous lock up clutch closing state.

6. The control device according to any one of the previous claims, wherein the calculation of the compensated target engine rpm further includes an input of a feedback controller value.

7. The control device according to any one of the previous claims, wherein the feedback controller is a PID controller.

8. The control device according to any one of the previous claims, wherein the feed forward gain is a value ranging between 0 and 1 inclusive.

9. The control device according to any one of the previous claims, wherein the feed forward gain is 0 when the lock up torque converter is in a closed state.

10. The control device according to any one of the previous claims, wherein the feed forward gain is 1 when the lock up torque converter is in an open state.

11. The control device according to any one of the previous claims, wherein, when determining the estimated engine rpm from the feed forward model, the engine torque is a calculated engine torque.

12. The control device according to any one of claims 1-10, wherein when determining the estimated engine rpm from the feed forward model, the engine torque is the engine torque as determined by an engine ECU.

13. The control device according to any one of the previous claims, wherein the estimated engine rpm from the feed forward model is calculated by:

$$\sqrt{\frac{Torque}{Capacity}}$$

wherein, capacity is based on the target engine rpm and the CVT input shaft rpm.

14. The control device according to any one of the previous claims, wherein during the execution of the lock up protocol, the engine rpm target is further based on the estimated engine rpm.

15. The control device according to any one of claims 2 and 4-14, wherein during a lock up protocol, when the torque converter is moving from an unlocked state to a locked state, the CVT is configured to downshift.

16. A vehicle comprising:

a control device according to any one of claims 1 to 15.

17. A method for controlling a vehicle powertrain, the method comprising the steps of:

receiving a request from a lock up torque converter control unit to execute a lock up protocol, the lock up protocol comprising:

receiving an engine rpm target from a transmission control unit, the engine rpm target is based on a current vehicle speed and a current accelerator pedal position;

determining an estimated engine rpm using a feed forward model based on the engine rpm target, accelerator pedal position, an engine torque, and a CVT input shaft rpm;

determining a feed forward gain based on a lock-up control state;

calculating a compensated target engine rpm based on the engine rpm target and the feed forward gain;

triggering a CVT shift based on the compensated target engine rpm; and

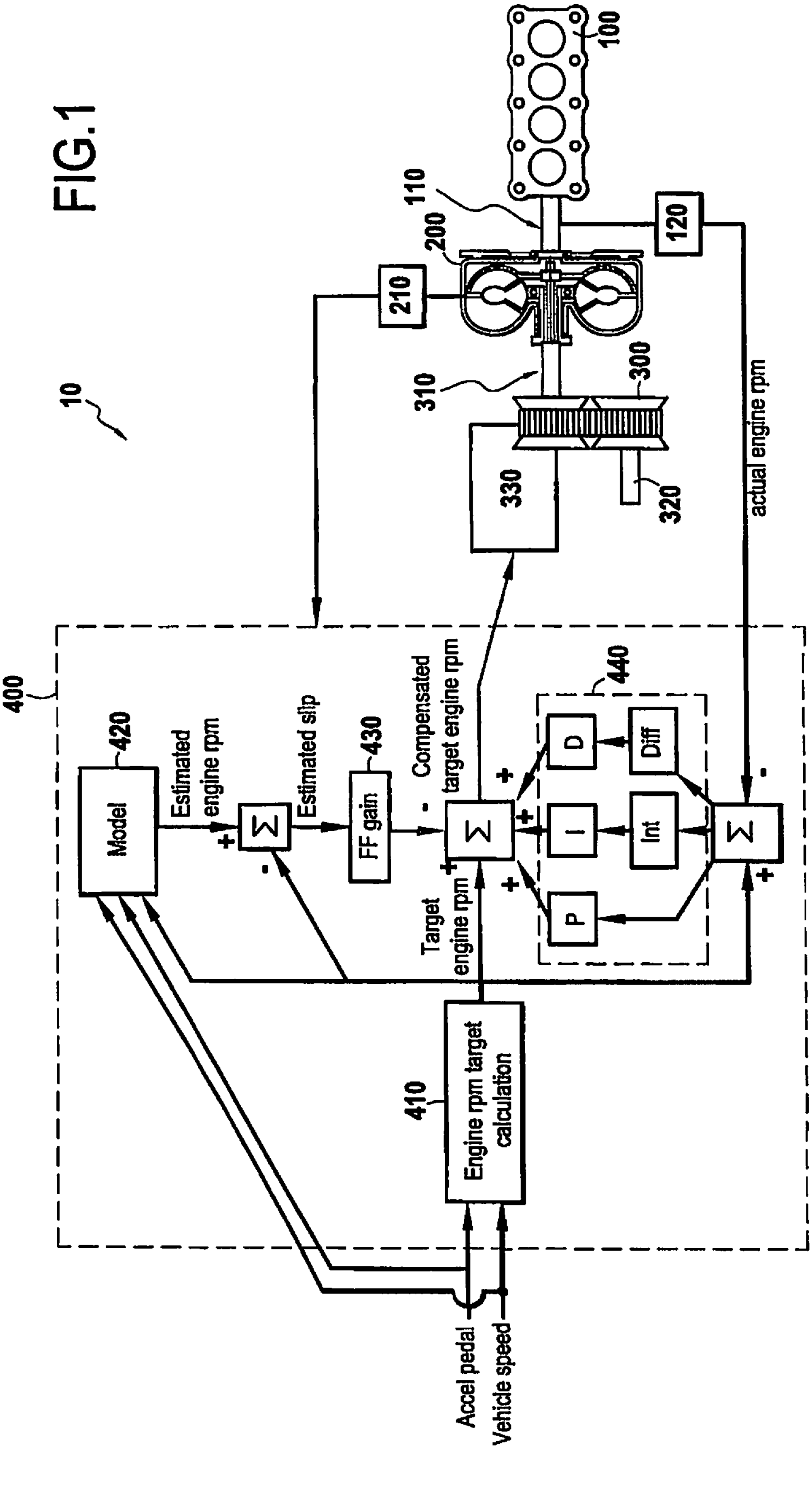
stopping the lock up protocol based on a request from the lock up torque converter control unit to stop the lock up protocol.

18. The method according to claim 17, wherein during execution of the lock up protocol, the torque converter changes from an unlocked state to a locked state.

19. The method according to claim 17, wherein during execution of the lock up protocol, the torque converter changes from a locked state to an unlocked state.

20. The method according to any one of claims 17-19, wherein the calculation of the compensated target engine rpm further includes an input of a feedback controller value.

FIG.1


10
100
110
120
200
210
300
310
320
330
400
410
Engine rpm target calculation
420
Model
Estimated engine rpm
Estimated slip
430
FF gain
Compensated target engine rpm
Target engine rpm
440
P
I
D
Int
Diff
Σ
actual engine rpm
Accel pedal
Vehicle speed

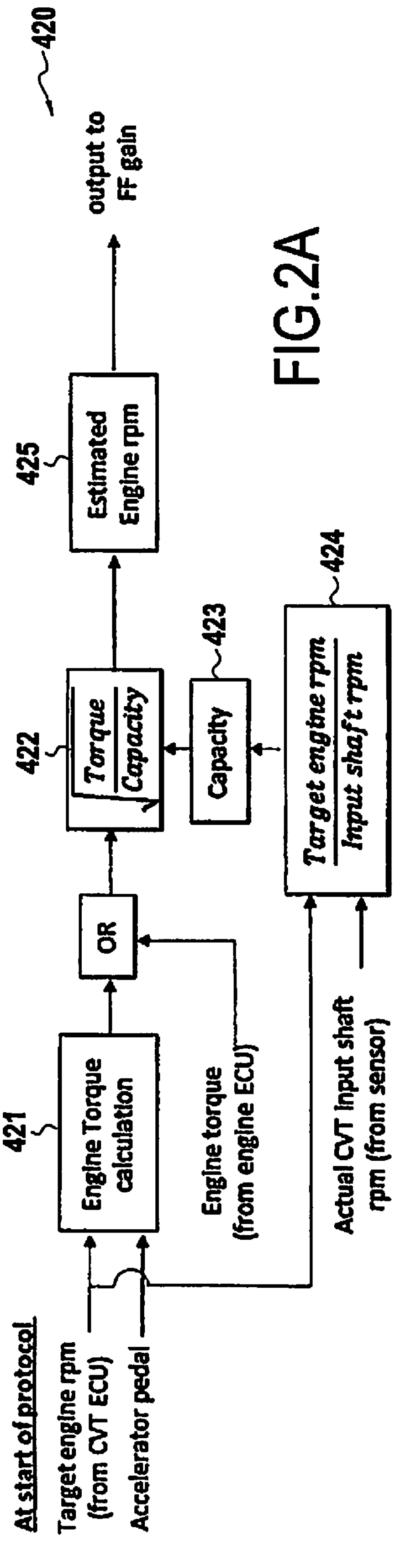

At start of protocol
Target engine rpm (from CVT ECU)
Accelerator pedal
421
Engine Torque calculation
Engine torque (from engine ECU)
OR
Actual CVT Input shaft rpm (from sensor)
422
Torque / Capacity
423
Capacity
424
Target engine rpm / Input shaft rpm
425
Estimated Engine rpm
output to FF gain
420

FIG.2A

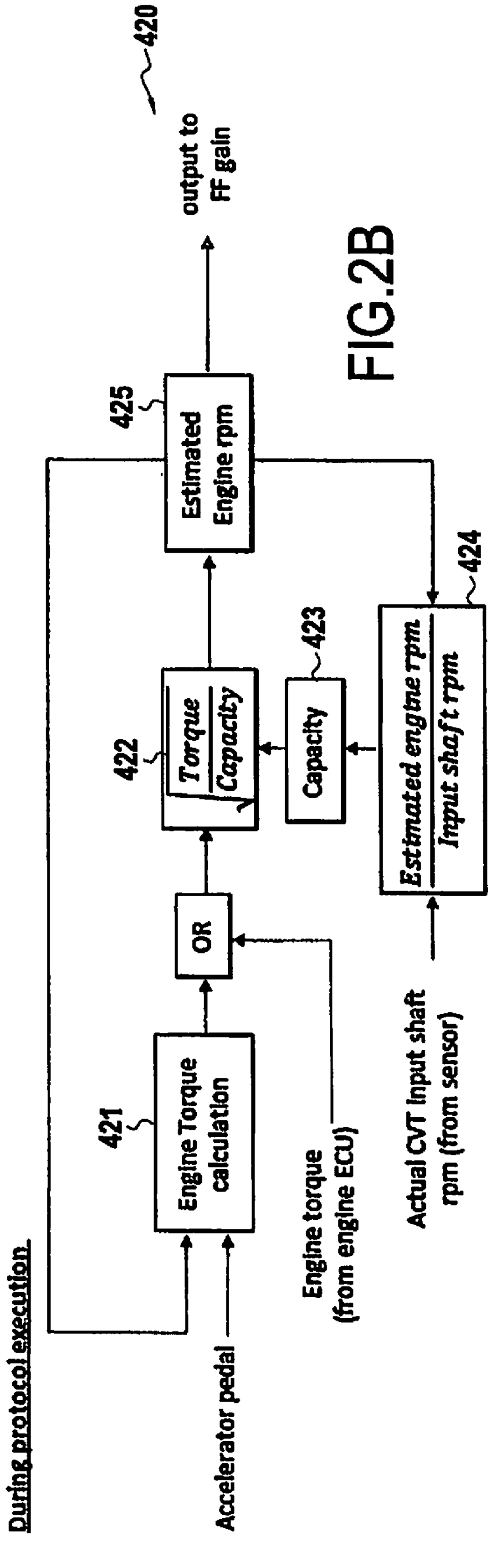

During protocol execution
Accelerator pedal
421
Engine Torque calculation
Engine torque (from engine ECU)
OR
Actual CVT Input shaft rpm (from sensor)
422
Torque / Capacity
423
Capacity
424
Estimated engine rpm / Input shaft rpm
425
Estimated Engine rpm
output to FF gain
420

FIG.2B

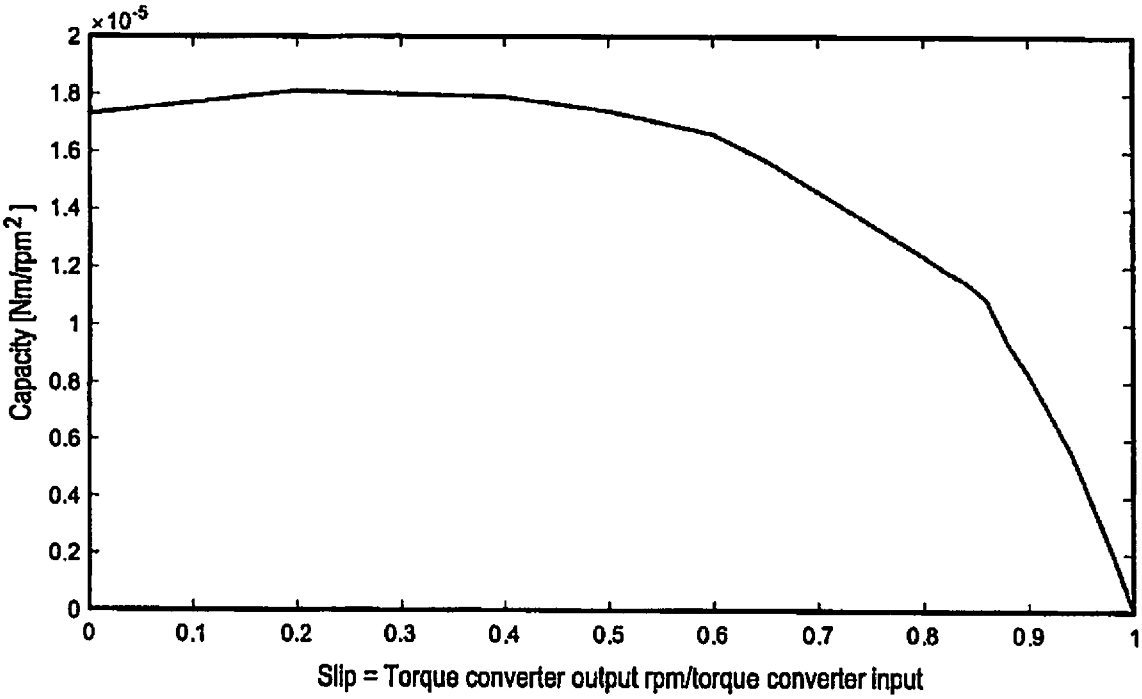

×10-5
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Capacity [Nm/rpm2]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Slip = Torque converter output rpm/torque converter input

FIG.3

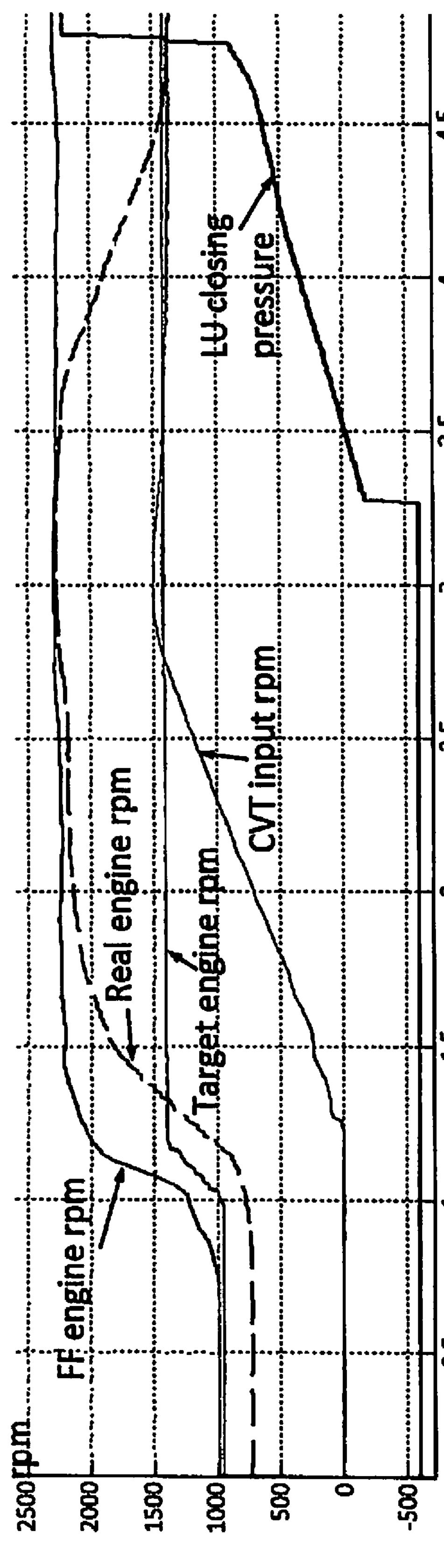

rpm
2500
2000
1500
1000
500
0
-500
0.5
1
1.5
2
2.5
3
3.5
4
4.5
FF engine rpm
Real engine rpm
Target engine rpm
CVT input rpm
LU closing
pressure

FIG.4

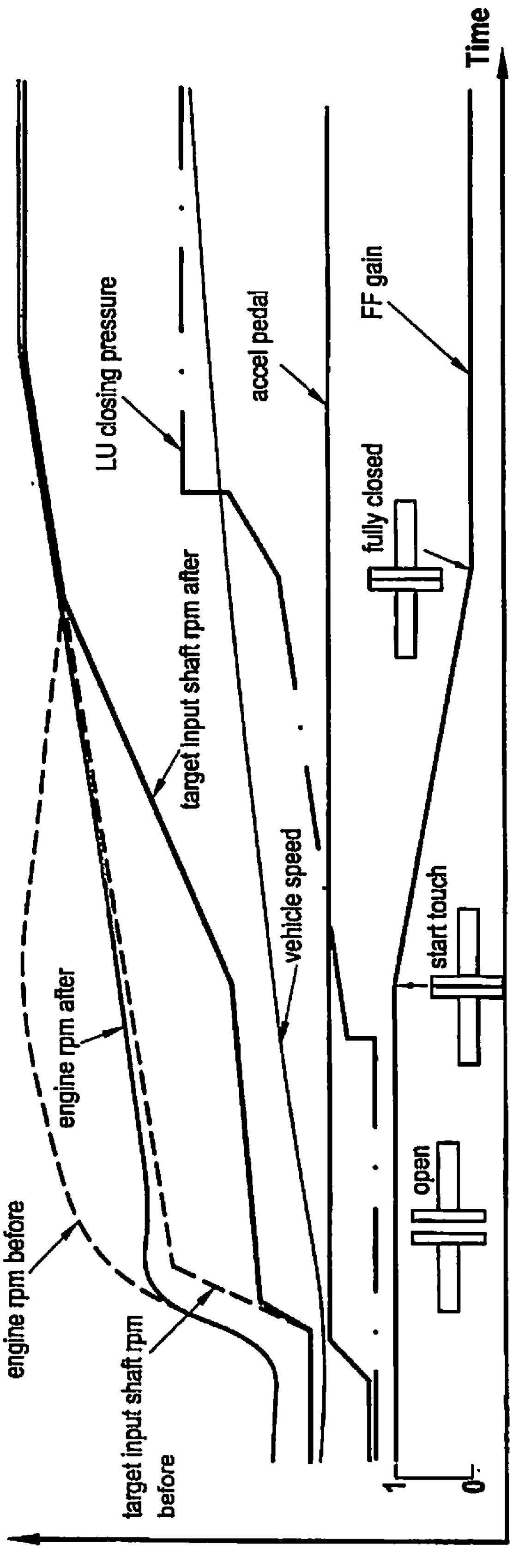

Time
LU closing pressure
accel pedal
FF gain
fully closed
target input shaft rpm after
vehicle speed
start touch
engine rpm after
open
engine rpm before
target input shaft rpm before
1
0

FIG.5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/058021

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H61/14 F16H61/662
ADD.

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 B60W

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 086 513 A (TOMINAGA MASAKAZU [JP]) 11 July 2000 (2000-07-11) column 16, line 42 - column 17, line 13 column 22, line 19 - column 24, line 39 figures -----	1-20
A	US 2002/014958 A1 (INOUE DAISUKE [JP] ET AL) 7 February 2002 (2002-02-07) paragraphs [0038] - [0044]; figures -----	1-20
A	US 6 066 069 A (VORNDRAN RALF [DE]) 23 May 2000 (2000-05-23) abstract; claim 1 -----	1-20
A	JP 2004 116641 A (FUJI HEAVY IND LTD) 15 April 2004 (2004-04-15) cited in the application abstract -----	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
20 November 2018	12/02/2019

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/058021

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