Abstract: A controller for controlling starting of an engine starts drives a starter motor for starting the engine based on an ON operation performed on a starter switch and determines a timing to stop the starter motor based on an Ne signal input to the controller. When determining that there is an abnormality in an input of the Ne signal, the controller changes conditions to stop the starter motor so that the starter motor stops when an elapsed time has reached a predetermined time after the starter motor has been started. This prevents the starter motor from being driven when the input of the Ne signal has been disrupted and completion of engine starting cannot be verified.
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DESCRIPTION

CONTROLLER FOR CONTROLLING STARTING OF ENGINE

TECHNICAL FIELD

The present invention relates to a controller for controlling starting of an engine wherein the controller starts driving a starter motor based on an ON operation performed on a starter switch and determines a timing to stop the starter motor based on an engine speed signal input to the controller.

BACKGROUND ART

Recently, push-type starter switches that start an engine by depression of a push button are widely used as a starter switch for an engine. A controller for controlling starting of the engine using such a push-type starter switch commences driving of a starter motor based on an ON operation performed on the starter switch (i.e., depressing the push button) and automatically stops the starter motor by determining completion of engine starting based on an engine speed signal transmitted from a rotational speed sensor. In vehicles having such a controller, the engine can be started by depressing the starter switch once at the beginning.

In vehicles having such a controller, if the CPU of the controller malfunctions and fails to output an instruction to stop the starter motor, the starter motor is erroneously driven for a long period. Thus, there has been proposed a controller for controlling starting of the engine that prevents continued driving of the starter motor, as described in Japanese Laid-Open Patent Publication No. 2007-002812. This conventional controller, when the starter motor is driven for a period beyond a predetermined limited period, forcibly stops the starter motor even if
the instruction to stop the starter motor is absent.

It also happens that a rotational speed signal cannot be input to the controller when a rotational speed sensor breaks or the signal line that transmits the rotational speed signal from the rotational speed sensor is broken. However, in such a case, the above controller as described in the Japanese Laid-Open Patent Publication No. 2007-002812 cannot verify whether engine starting is complete thereby failing to stop the starter motor. In addition, when there is an extreme amount of noise relative to the signal, the completion of the engine starting cannot be confirmed as well.

Even in such a case, the conventional controller as described above can prevent the starter motor from being driven because the starter motor is forcibly stopped when the limited period lapses. However, even if there is no malfunction, engine starting sometimes takes longer (e.g., when the engine is in an extremely cold state.) If the limited period is set too short, engine starting may be unsuccessful. Accordingly, the limited period must be set at a certain length or longer so as to allow engine starting even in an extremely cold state. However, if the limited period is set too long, the starter motor may be driven for a long period after engine starting is complete if the completion of the engine starting cannot be detected as described above. This may cause disadvantages such as failure of the starter motor due to overload of the motor when driven for a long time or generation of unpleasant noise.

SUMMARY OF THE INVENTION

An object of the invention is to provide a controller for controlling starting of an engine that preferably prevents the starter motor from being driven after engine
starting even when completion of engine starting cannot be verified.

In one aspect, a starter switch controller for controlling starting of an engine is provided. The controller starts driving a starter motor for starting the engine based on an ON operation performed on a starter switch and determines a timing to stop the starter motor based on an engine speed signal input to the controller. When determining that there is an abnormality in an input of the rotational speed signal, the controller changes conditions to stop the starter motor so that the starter motor stops when an elapsed time after the starter motor has been started has reached a predetermined time.

In another aspect, a starter switch controller for controlling starting of an engine is provided. The controller starts driving a starter motor for starting the engine based on an ON operation performed on a starter switch and determines a timing to stop the starter motor based on an engine speed signal input to the controller. When determining that there is an abnormality in an input of the rotational speed signal, the controller forcibly stops the starter motor when an elapsed time after the starter motor has been started has reached a predetermined time.

Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS
The invention, together with objects and advantages thereof, may best be understood by reference to the
following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a block diagram illustrating an overview of a controller for controlling starting of an engine according to an embodiment of the invention;

Fig. 2 is a timing chart illustrating a control example by the controller of Fig. 1 in a normal condition;

Fig. 3 is a timing chart illustrating a control example by the controller of Fig. 1 during input of an Ne signal that is disrupted;

Fig. 4 is a timing chart illustrating a control example with the controller of Fig. 1 when a starter switch is pressed for a long time during input of the Ne signal that is disrupted; and

Fig. 5 is a flow chart of a routine for determining the time to stop the starter motor performed in the controller of Fig. 1.

BEST MODE FOR CARRYING OUT THE INVENTION

A controller for controlling starting of an engine according to an embodiment of the present invention will now be described with reference to the Figs 1 to 5.

The controller starts driving a starter motor based on an ON operation performed on a starter switch. In addition, timing to stop the starter motor is determined normally based on an engine speed signal (Ne signal) input to the controller. In particular, the starter motor is stopped when the engine rotational speed Ne exceeds a first threshold.

When the timing to stop the starter motor is determined based on the Ne signal, failure of the engine speed sensor or breakage of a signal line may disrupt input of the Ne signal to the controller. Then, completion of
the engine starting cannot be confirmed and the starter motor may be driven after engine starting is complete. To address this, the controller of the present embodiment changes conditions to stop the starter motor when input of the Ne signal is disrupted and forcibly stops the starter motor when an elapsed time after the starter motor is started has reached a predetermined time, thereby preventing the starter motor from being kept driven due to disruption of the input Ne signal.

Fig. 1 illustrates an overview of a controller for controlling starting of an engine of the present embodiment. A starter ECU (Electronic Control Unit) 1 illustrated in Fig. 1 includes a central processing unit (CPU) for performing processing relating to starting control, a read-only memory (ROM) for storing various programs and data for starting control, a random access memory (RAM) for temporally storing the results of the processing, and input/output ports that allow signal input from and output to the outside. The starter ECU 1 is connected to an engine ECU 4 via an in-vehicle network 3. The engine ECU 4 mainly controls the engine after the engine starts. The engine ECU 4 also includes a CPU, a ROM, a RAM, and input/output ports as in the starter ECU 1.

A starter switch 2 is connected to the input port of the starter ECU 1. The starter switch 2 is a push-type switch and disposed in the interior of the vehicle. A drive circuit 8 for the starter motor 9 is connected to the output port of the starter ECU 1. The starter ECU 1 outputs a start signal to the drive circuit 8 to turn on a current relay of the starter motor 9 (starter relay) and outputs a stop signal to the drive circuit 8 to turn off the starter relay so as to control the driving of the starter motor 9. Energization of the starter motor 9 causes the motor 9 to connect with an output shaft of the
engine (cranked) and rotates the output shaft to start the engine.

An Ne sensor 5 for detecting engine rotational speed (Ne signal) is connected to the input port of the engine ECU 4 via a signal line 6. The engine ECU 4 outputs this Ne signal from the Ne sensor 5 to the input port of the starter ECU 1 directly or via a signal line 7. The engine ECU 4 also notifies the Ne signal via the in-vehicle network 3 in response to the request from the starter ECU 1.

The starting control in the controller of the present embodiment will be described in detail below.

Fig. 2 illustrates a control example in a normal condition, i.e., when the Ne signal is input to the starter ECU 1 normally. As illustrated, at time t1, the starter switch 2 is turned ON. Then, at time t2 immediately after the time t1, the starter ECU 1 outputs the start signal to the drive circuit 8 based on the ON operation of the switch 2. This turns on the starter relay thereby starting energization of the starter motor 9.

Energization of the starter motor 9 causes the output shaft of the engine to rotate. Then the Ne sensor 5 outputs pulsed Ne signal correspondingly. The starter ECU 1 receives the Ne signal from the engine ECU 4 via the signal line 7 or the in-vehicle network 3 and monitors the change in the engine rotational speed Ne based on the obtained Ne signal. Then, at time t3, when the starter ECU 1 determines that the engine rotational speed Ne exceeds a first threshold to stop, i.e., that the engine starting is complete, the starter ECU 1 outputs a stop signal to the drive circuit 8 to turn off the starter relay. Thus, in a normal condition, the timing to stop the starter motor 9 is determined based on the Ne signal.
Meanwhile, Fig. 3 illustrates a control example in which the starting control is conducted in a state when input of the Ne signal to the starter ECU 1 is disrupted due to a failure of the Ne sensor 5 or breakage of the signal lines 6 and/or 7. As illustrated, again, the starter switch 2 is turned ON at time t4 and the starter ECU 1 outputs the start signal to the drive circuit 8 based on the ON operation of the switch 2 at time t5 immediately after the time t4, so as to turn on the starter relay.

However, in the example of Fig. 3, the Ne signal is not input to the starter ECU 1 and the starter ECU 1 cannot confirm completion of the engine starting based on the Ne signal. Thus, in this case, the starter ECU 1 stops the starter motor 9 after the starter motor 9 is driven for a predetermined period. In particular, the starter ECU 1 measures the driving period for driving the starter motor 9 based on the value indicated by the counter CNT for measuring the period to drive. The value indicates an elapsed time after the starter motor 9 is started. Then, when the value indicated by the counter CNT has reached a second threshold, the starter ECU 1 outputs a stop signal to the drive circuit 8 to turn off the starter relay. In Fig. 3, the value indicated by the counter CNT has reached the second threshold to stop at time tβ, at which the stop signal is output to turn off the starter relay. The second threshold to stop is set so that the starter motor 9 is stopped at a normal value required for completion of the engine starting, or a value (approximately 2 seconds) required for completion of the engine starting in a normal starting condition (i.e., when the engine starting is not difficult unlike in an extremely cold state.) Thus, in the present embodiment, when the input from the Ne signal is disrupted, the starter ECU 1 changes the conditions to stop the starter motor 9 so that the starter motor 9 is
stopped when the elapsed time after the starter motor is started has reached a predetermined time. In other words, if a condition occurs where the input of the Ne signal is disrupted, the starter ECU 1 forcibly stops starter motor 9 when the elapsed time after the starter motor is started has reached a predetermined time. Therefore, even if completion of engine starting cannot be verified due to disruption of the input of the Ne signal, the continued driving of the starter motor 9 is prevented.

In a case where the starter motor 9 is stopped at the predetermined time when the input of the Ne signal is disrupted, the starter motor 9 is stopped in a relatively short period (e.g., 2 seconds). For this reason, when the time required for starting is long such as in an extremely cold state, the engine cannot be started. Further, while the rotation of the engine for a certain period (e.g., approximately 5 seconds) is required for determining the failure of the Ne sensor 5, such determination cannot be performed when the engine cannot be started within the predetermined time, thereby failing to locate the failure.

To address this, the controller of the present embodiment provides for continued driving of the starter motor 9 when the starter switch 2 is pressed for a long time even if the predetermined time has elapsed, instead of stopping the starter motor 9.

Fig. 4 illustrates a control example when the starter switch is pressed for a long time and input of the Ne signal to the starter ECU 1 is disrupted. As illustrated, again, the starter switch 2 is turned ON at time t7 and the starter ECU 1 outputs the start signal to the drive circuit 8 based on the ON operation of the switch 2 at time t8 immediately after the time t7, so as to turn on the starter relay.
The starter ECU 1 also measures the elapsed time after the starter motor 9 is started using the counter CNT since the input of the Ne signal is disrupted. However, in this case, the ON operation of the starter switch 2 is continued even after the value measured with the counter CNT has reached the second threshold to stop at time t9. Accordingly, the starter ECU 1 does not output the stop signal and the starter relay is kept ON. Instead, the starter ECU 1 outputs the stop signal to the drive circuit 8 to turn the starter relay off at time t10 at which the ON operation of the starter switch 2 ceases.

Fig. 5 is a flow chart of a routine for determining the time to stop the starter motor 9 performed in the controller of the present embodiment. The processing of the routine is performed repeatedly by the starter ECU 1 on a certain control cycle as a regular interrupt processing during the period from the output of the start signal to the output of the stop signal.

When the processing of the routine starts, first, the starter ECU 1 increments a value of the counter CNT in step S501. Next, in step S502, the starter ECU 1 confirms whether the input of the Ne signal is disrupted or not.

If the Ne signal is normally input (S502: NO), the processing proceeds to step S503 in which the starter ECU 1 determines whether the engine rotational speed Ne is equal to or greater than a first threshold to stop. If the determination is affirmative (S503: YES), the starter ECU 1 outputs a stop signal in step S506. If the determination is negative (S503: NO), the processing of the routine ends.

If the input of the Ne signal is disrupted (S502: YES), the starter ECU 1 confirms whether the ON operation
of the starter switch 2 is maintained in step S504. If the
determination is affirmative (S504: YES), the processing of
the routine ends. If the determination is negative (S504:
NO), the processing proceeds to step S505.

In step S505, the starter ECU 1 determines whether a
value indicated by the counter CNT is equal to or greater
than a second threshold to stop. If the determination is
affirmative (S505: YES), the starter ECU 1 outputs the stop
signal to the drive circuit 8 in step S506. If the
determination is negative (S505: NO), the processing of the
routine ends.

The controller for controlling starting of an engine
of an embodiment as described above has the following
advantages.

(1) The timing to stop the starter motor 9 during the
starting period is normally determined based on the Ne
signal while the conditions to stop the starter motor 9 are
changed when the input of the Ne signal is disrupted so
that the starter motor 9 is stopped when the elapsed time
after the starter motor 9 is started has reached a
predetermined time. That is, in the present embodiment,
the starter motor 9 is forcibly stopped when the elapsed
time after the starter motor 9 is started has reached a
predetermined time on condition that the input of the Ne
signal is disrupted. Accordingly, continued drive of the
starter motor is preferably prevented in a case when
completion of the engine starting cannot be verified. In
addition, the driving period of the starter motor 9 during
the starting is limited only in a limited state such as
when the input of the Ne signal is disrupted. Thus, the
predetermined time as described above need not be set long.
This prevents disadvantages such as a failure of the
starter motor 9 due to an overload on the motor 9 driven
for a long time or uncomfortable feeling to the driver.

(2) When the input of the Ne signal is disrupted, the driving period of the starter motor 9 is set to a normal value required for completion of the engine starting, or a value required for completion of the engine starting in a normal starting condition. Accordingly, the predetermined time can be set to a minimum value and unnecessarily long drive of the starter motor 9 can be prevented.

(3) Even when the input of the rotational speed signal is disrupted, the starter motor is forcibly driven after the elapsed time has passed the predetermined time until an OFF operation of the starter switch is performed, so long as the ON operation of the starter switch is maintained. That is, if the ON operation of the starter switch is maintained, the drive of the starter motor 9 beyond the predetermined time is allowed even when the input of the rotational speed signal is disrupted. Thus, engine starting can be complete even in a difficult state such as an extremely cold state.

(4) The driving period of the starter motor 9 is set less than the time required for determining the failure of the Ne sensor s. Thus, normally, the failure cannot be located when the engine cannot be started within a predetermined time. However, in the present embodiment, the continued ON operation of the starter switch 2 allows the extended driving of the starter motor 9 beyond the predetermined time. Thus, by obtaining the time required for determining the failure, the failure can be located.

The above embodiment can be modified as follows.

The continued driving of the starter motor 9 beyond the predetermined time by the continued ON operation of the
starter switch 2 may not be conducted when such continued driving is unnecessary, e.g., when the determination of abnormality of the Ne sensor 5 can be performed within the predetermined time.

In the above embodiment, the period to drive the starter motor 9 when the input of the Ne signal is disrupted is set to a minimum value, or a normal value (approximately 2 seconds) required for completion of the engine starting. However, such period may be adjusted as needed. For example, when the continued driving of the starter motor 9 by the continued ON operation of the starter switch 2 is not conducted, the period to drive the starter motor 9 may be set longer so that engine starting can be accomplished even in an extremely cold state.

Other than disruption of the signal input, an extreme amount of noise relative to the Ne signal can also prevent the detection of the engine rotational speed Ne and thus the completion of the engine starting cannot be verified. Accordingly, such a case may also be determined as an abnormality of the input of the Ne sensor 5. Then, the drive of the starter motor 9 may be controlled as in the disruption of the input of the above embodiment. In other words, when the engine rotational speed Ne based on the Ne signal cannot be detected due to the noise, the starter motor 9 also changes the conditions to stop the starter motor 9 from "when the engine rotational speed Ne exceeds the first threshold to stop" to "when the elapsed time after the starter motor is started has reached a predetermined time". Then, the starter motor 9 may be forcibly stopped when the elapsed time has reached the predetermined time based on such determination.

The starter switch 2 may be of a type other than a push switch. The present invention encompasses any
controller for controlling starting of an engine that determines the timing to stop the starter motor 9 automatically, as opposed to manually, based on the determination of completion of the engine starting regardless of the type of starter switch 2.
CLAIMS

1. A starter switch controller for controlling starting of an engine, wherein the controller starts driving a starter motor for starting the engine based on an ON operation performed on a starter switch and determines a timing to stop the starter motor based on an engine speed signal input to the controller, wherein, when determining that there is an abnormality in an input of the rotational speed signal, the controller changes conditions to stop the starter motor so that the starter motor stops when an elapsed time after the starter motor has been started has reached a predetermined time.

2. A starter switch controller for controlling starting of an engine, wherein the controller starts driving a starter motor for starting the engine based on an ON operation performed on a starter switch and determines a timing to stop the starter motor based on an engine speed signal input to the controller, wherein, when determining that there is an abnormality in an input of the rotational speed signal, the controller forcibly stops the starter motor when an elapsed time after the starter motor has been started has reached a predetermined time.

3. The controller of Claim 1 or 2 wherein the predetermined time is set to a value normally required for completion of the engine starting.

4. The controller of any one of Claims 1 to 3 wherein, even when there is an abnormality in the input of the rotational speed signal, the controller forcibly drives the starter motor after the elapsed time has passed the predetermined time until an OFF operation is performed on the starter switch so long as the ON operation of the
starter switch is maintained.

5. The controller of Claim 4 wherein a rotational speed sensor outputs the rotational speed signal and the predetermined time is less than the time required for determining failure of the rotational speed sensor.

6. The controller of any one of Claims 1 to 5 wherein the starter switch is a push-type switch.

7. The controller of Claim 1 or 2 wherein the abnormality in the input of the rotational speed signal includes disruption of the input from the rotational speed signal or inability to verify the rotational speed signal due to noise.
Fig. 1

Fig. 2
Fig. 4
DETERMINATION OF WHETHER STARTER MOTOR STOPS

INCREMENT DRIVE TIME MEASUREMENT COUNTER CNT

$S501$

$S502$

Ne SIGNAL HALTED?

$S504$

STARTER SWITCH SW KEPT ON?

$S505$

CNT ≥ SECOND THRESHOLD?

$S503$

Ne ≥ FIRST THRESHOLD?

$S506$

OUTPUT STOP SIGNAL

END

**Fig. 5**
INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2008/059848

A. CLASSIFICATION OF SUBJECT MATTER

INV. F02N11/08

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)
F02N

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A document defining the general state of the art which is not considered to be of particular relevance
E1 earlier document but published on or after the international filing date
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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P document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search
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