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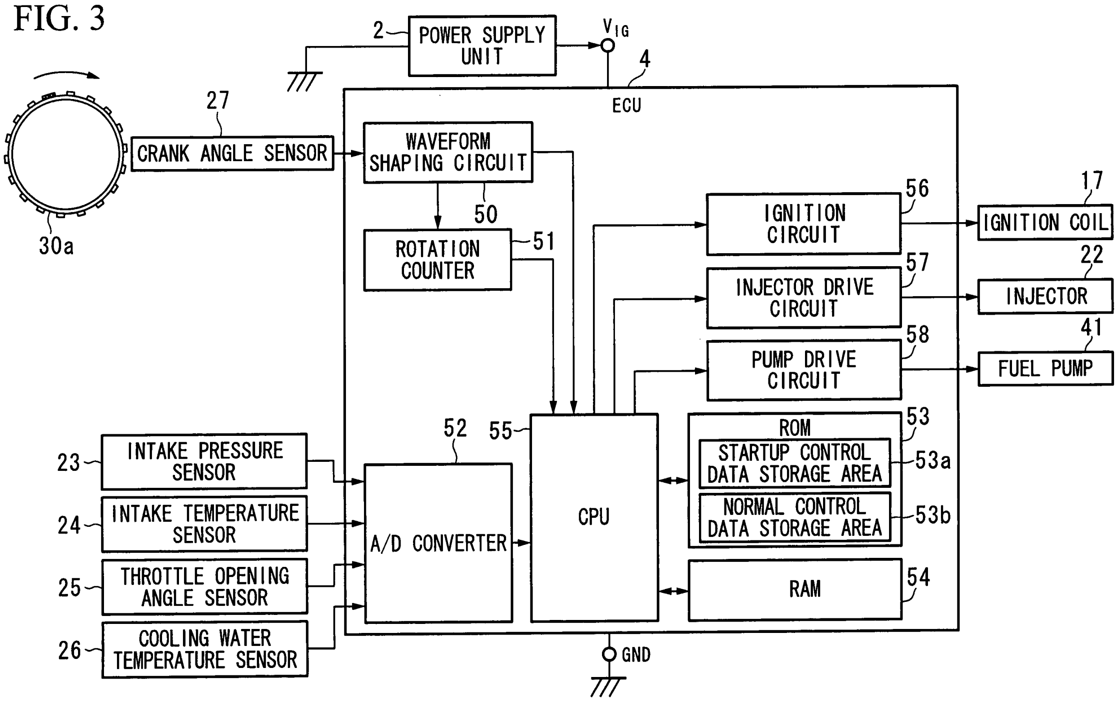
(54) **Engine control apparatus**

(57) A engine control apparatus includes: a read-only memory (53) storing data needed for startup control and normal control of an engine (1); and a control processing unit (55) operating the startup control and the normal control of the engine (1) on the basis of the data stored the read-only memory (53); the control processing unit (55) executing: an initial processing containing a startup area check processing for checking a storage area of the data needed for startup control (53a) in the read-only memory (53); a startup control processing for performing the startup control of the engine (1) on the basis of the data needed for startup control; a normal area check processing for checking the storage area of the data needed for normal control (53b) in the read-only memory (53); and a normal control processing for performing normal control of the engine (1) on the basis of the data needed for the normal control.

FIG. 3



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an engine control apparatus, and, in particular, to an engine control apparatus having a check function of a read only memory in the apparatus as an initial processing upon starting.

Description of Related Art

[0002] Typically, an engine control apparatus such as an ECU (Engine Control Unit) performs a SUM check of a ROM (Read Only Memory) in the apparatus as an initial processing upon starting. For example, techniques for the ROM check in the engine control apparatus which have been known are as shown in (1) to (3) (see below).

(1) Engine startup control and engine normal control are performed after a SUM check to all of storage area in the ROM is completed.
(2) A SUM check of the ROM is performed after an engine startup operation has begun as disclosed in Japanese Unexamined Patent Application, First Publication No. 2004-308476.
(3) SUM is performed by reading out single-byte data at one time when a ROM check is performed.

[0003] In the above-mentioned technique (1), it takes a long time to bring an engine to normal control. Therefore, in the system to bring the engine to the normal control at an early stage using limited electric power such as a batteryless system, there is a problem in that startability of the system is deteriorated. In the above-mentioned technique (2), without a data storage area of the engine startup control in the ROM being checked, the engine startup control is performed. Therefore, there is a problem in that, there is a possibility of causing a degradation of reliability of the system, and, as a result, the required processing to prevent any degradation of reliability is complicated. In the above-described technique (3), loop count of the processing which performs SUM after single-byte data is read out from the ROM is increased. Therefore, there is a problem in that, it takes a long time to bring an engine to normal control, and, as a result, startability of the system is deteriorated.

[0004] The invention was conceived in view of the above-described circumstances and it is an object thereof to provide an engine control apparatus that, when an engine is being started, prevents any deterioration in startability and any degradation of reliability, and that is able to check a read only memory.

SUMMARY OF THE INVENTION

[0005] The invention employs the following means to solve the above-described problems and achieve the object.

[0006] In order to achieve the above-described object, the engine control apparatus of this invention, includes: a read-only memory storing data needed for startup control and normal control of an engine; and a control processing unit operating the startup control and the normal control of the engine on the basis of the data stored in the read-only memory.

[0007] Moreover, the control processing unit executes: an initial processing containing at least a startup area check processing for checking a storage area of the data needed for the startup control in the read-only memory after activation; a startup control processing for performing the startup control of the engine on the basis of the data needed for startup control after the initial processing has been finished; a normal area check processing for checking the storage area of the data needed for normal control in the read-only memory when the startup control processing has not been executed yet; and a normal control processing for performing normal control of the engine on the basis of the data needed for normal control after the startup control processing and the normal area check processing have been finished.

[0008] Moreover, it is preferable that, in the engine control apparatus of the invention, the control processing unit calculate a check SUM of the storage area by reiteration of a readout processing reading out the maximum data which can be read out from the storage area at one time and an addition processing splitting the data read out by the readout processing into single-byte data and adding each split single-byte data in the startup area check processing and the normal area check processing.

[0009] According to the invention, in an initial processing after activation of ECU 4, a check of storage area of the data needed for startup control is only performed without all memory area in a read-only memory being checked unlike in the conventional technique. Therefore, initial processing time is shortened, and an engine is able to be brought to startup control at an early stage. The engine is definitely placed in a fully firing state and brought to normal control for the short period of cranking by the single startup operation. As a result, any deterioration in startability of a system is prevented.

[0010] According to the invention, a data storage area needed for the startup control in the read-only memory is checked before the startup control is performed. A data storage area needed for the normal control in the read-only memory is checked before the normal control is performed. By these checks, any degradation of reliability of a system is prevented.

[0011] According to the invention, when the read-only memory is checked, a readout processing and an addition processing are reiterated. In the readout processing, the maximum data which can be read out from the storage area at one time is read out. In the addition processing, data read out by the readout processing are split into single-byte data, and then each split single-byte data is added. By this reiteration of a readout processing and an addition processing, loop count of the processing needed for calculation of a check SUM is decreased. Therefore, check time of a data storage area needed for the startup control, namely, initial processing time is shortened further, and thereby, the startability of the system is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG 1 is a structural schematic view showing an engine control system that is provided with an engine control apparatus (ECU 4) according to an embodiment of the invention.

FIG. 2 is a detailed explanatory diagram showing a rotor 30a constituting a generator 30 according to an embodiment of the invention.

FIG 3 is a structural block diagram of the engine control apparatus (ECU 4) according to an embodiment of the invention.

FIG 4 is a timing chart relating to an operation of the engine control apparatus (ECU 4) according to an embodiment of the invention.

FIG 5 is a flowchart relating to an operation of the engine control apparatus (ECU 4) according to an embodiment of the invention.

FIG. 6 is an explanatory diagram showing a technique for SUM check of a ROM by the engine control apparatus (ECU 4) according to an embodiment of the invention.

FIG 7 is a supplemental explanatory diagram showing a problem of a batteryless engine control system.

DETAILED DESCRIPTION OF THE INVENTION

[0013] An embodiment of the invention will be described with reference made to the drawings. FIG 1 is a structural schematic view showing an engine control system that is provided with the engine control apparatus (referred to below as an ECU) of the embodiment. As shown in FIG. 1, the engine control system of the embodiment is schematically formed by an engine 1, a power supply unit 2, a fuel supply unit 3, and an ECU (Engine Control Unit) 4. A batteryless system that is not provided with a battery, but instead performs engine startup by manual cranking (for example, by kick-starting) is described as an example of the engine control system of the embodiment.

[0014] The engine 1 is a four-stroke single-cylinder engine, and schematically includes a cylinder 10, a piston 11, a conrod 12, a crankshaft 13, an intake valve 14, an exhaust valve 15, a spark plug 16, an ignition coil 17, an intake pipe 18, an exhaust pipe 19, an air cleaner 20, a throttle valve 21, an injector 22, an intake pressure sensor 23, an intake temperature sensor 24, a throttle opening angle sensor 25, a cooling water temperature sensor 26, and a crank angle sensor 27.

[0015] The cylinder 10 is a hollow circular cylinder-shaped component that is used to make the piston 11 that is located inside it undergo a reciprocating motion by repeating a four-stroke cycle consisting of intake, compression, combustion (i.e., expansion), and exhaust. The cylinder 10 has an intake port 10a, a combustion chamber 10b, and an exhaust port 10c. The intake port 10a is a flow path that is used to supply a mixture formed from air and fuel to the combustion chamber 10b. The combustion chamber 10b is a space that is used to store the aforementioned mixture and cause a mixture that has been compressed in the compression stroke to be combusted in the combustion stroke. The exhaust port 10c is a flow path that is used to discharge exhaust gas from the combustion chamber 10b to the outside in the exhaust stroke. Moreover, a water cooling path 10d that is used to circulate cooling water is provided in an outer wall of the cylinder 10.

[0016] The crankshaft 13 that is used to convert the reciprocating motion of the piston 11 into rotational motion is joined via the conrod 12 to the piston 11. The crankshaft 13 extends in a direction that is orthogonal to the reciprocation direction of the piston 11. A flywheel (not shown), a mission gear, a kick gear that is joined to a kick pedal that is used to start the engine 1 manually, and a rotor 30a of the power supply unit 2 (described below) are joined to the crankshaft 13.

[0017] The intake valve 14 is a valve component that is used to open and close an aperture portion of the air intake port 10a which is near to the combustion chamber 10b, and is joined to a camshaft (not shown). The intake valve 14 is driven to open and close in accordance with the respective strokes by this camshaft. The exhaust valve 15 is a valve component that is used to open and close an aperture portion of the air exhaust port 10c which is near to the combustion chamber 10b, and is joined to a camshaft (not shown). The exhaust valve 15 is driven to open and close in accordance with the respective strokes by this camshaft.

[0018] The spark plug 16 has electrodes that face towards the interior of the combustion chamber 10b, and is provided in a topmost portion of the combustion chamber 10b. The spark plug 16 generates a spark between the electrodes by a high-voltage ignition voltage signal that is supplied from the ignition coil 17. The ignition coil 17 is a transformer that is formed by a primary coil and a secondary coil. The ignition coil 17 boosts an ignition voltage signal that is supplied from the ECU 4 to the primary coil, and supplies an ignition voltage signal from the secondary coil to the spark plug 16.

[0019] The intake pipe 18 is an air supply pipe, and has an intake flow path 18a provided inside it. The intake pipe 18 is joined to the cylinder 10 so that the intake flow path 18a is connected to the intake port 10a. The exhaust pipe 19 is a pipe for discharging exhaust gas, and has an exhaust flow path 19a provided inside it. The exhaust pipe 19 is joined to the cylinder 10 so that the exhaust flow path 19a is connected to the exhaust port 10c. The air cleaner 20 is located upstream from the air flowing through the interior of the intake pipe 18. The air cleaner 20 purifies air taken in from the outside and supplies it to the intake flow path 18a. The throttle valve 21 is provided inside the intake flow path 18a, and pivots by a throttle (not shown) or an accelerator. Namely, the cross-sectional area of the intake flow path 18a is changed by the pivoting of the throttle valve 21, and the air intake quantity is accordingly changed. The injector 22 has an injection aperture that injects fuel that is supplied from the fuel supply unit 3 in accordance with injector drive signals that are supplied from the ECU 4. The injector 22 is provided inside the intake pipe 18 so that the injection aperture faces the intake port 10a.

[0020] The intake pressure sensor 23 is, for example, a semiconductor pressure sensor that utilizes a piezoresistive effect. The intake pressure sensor 23 is provided in the intake pipe 18 at a position downstream from the airflow passing through the throttle valve 21 so that a sensitive surface of the intake pressure sensor 23 is oriented towards the intake flow path 18a. The intake pressure sensor 23 outputs intake pressure signals that correspond to the intake pressure inside the intake pipe 18 to the ECU 4. The intake temperature sensor 24 is provided in the intake pipe 18 at a position upstream from the airflow passing through the throttle valve 21 so that a sensitive portion of the intake temperature sensor 24 is oriented towards the intake flow path 18a. The intake temperature sensor 24 outputs intake temperature signals that correspond to the intake air temperature inside the intake pipe 18 to the ECU 4. The throttle opening angle sensor 25 outputs throttle opening angle signals that correspond to the opening angle of the throttle valve 21 to the ECU 4. The cooling water temperature sensor 26 is provided so that a sensitive portion of the cooling water temperature sensor 26 is oriented towards the cooling water path 10d of the cylinder 10. The cooling water temperature sensor 26 outputs cooling water temperature signals that correspond to the temperature of the cooling water flowing through the cooling water path 10d to the ECU 4. The crank angle sensor 27 outputs a crank angle signal each time the crankshaft 13 rotates by a predetermined angle in synchronization with the rotation of the crankshaft 13.

[0021] The power supply unit 2 includes a generator 30, a regulate rectifier 32, and a condenser 33. The generator 30 is a magnetic AC generator and includes a rotor 30a, permanent magnets 30b, and 3-phase stator coils 30c, 30d, and 30e. The rotor 30a is joined to the crankshaft 13 of the engine 1 and rotates in synchronization therewith. The permanent magnets 30b are mounted on an inner circumferential side of the rotor 30a. The 3-phase stator coils 30c, 30d, and 30e are coils that are used to obtain generated output. Namely, in the generator 30, as a result of the rotor 30a (in other words, the permanent magnets 30b) rotating relative to the fixed stator coils 30c, 30d, and 30e, 3-phase. AC voltage is generated by electromagnetic induction from the stator coils 30c, 30d, and 30e. The generated 3-phase AC voltage is output to the regulate rectifier 32.

[0022] As shown in FIG 2, a plurality of projections is formed on an outer circumference of the rotor 30a extending in the rotation direction of the rotor 30a. Specifically, a plurality of projections (i.e., auxiliary projections) $30a_2$ whose length is shorter in the rotation direction, and a projection (i.e., a crank angle reference projection) $30a_1$ whose length in the rotation direction is longer than that of the projections $30a_2$, are formed on the outer circumference of the rotor 30a. Here, the length of the crank angle reference projection $30a_1$ is, as an example, approximately twice the length of the auxiliary projections $30a_2$. The plurality of auxiliary projections $30a_2$ and the crank angle reference projection $30a_1$ are provided so that the respective rear ends of each of the plurality of auxiliary projections $30a_2$ and the crank angle reference projection $30a_1$ are located at the same angular interval (for example, at 20° intervals). In the embodiment, the crank angle reference position is a position to the front in the rotation direction of a position corresponding to the top dead center TDC, for example, the position of BTDC 10° which is a position of 10° before the top dead center. In addition, the position of the rear end of the crank angle reference projection $30a_1$ matches the crank angle reference position. Moreover, the permanent magnets 30b are mounted on the inner circumferential side of the rotor 30a. Specifically, the permanent magnets 30b that are constructed with an N pole and an S pole forming one set are placed every 60° along the inner circumferential side of the rotor 30a.

[0023] The aforementioned crank angle sensor 27 is, for example, an electromagnetic pickup sensor and, as shown in FIG 2, is provided in the vicinity of the outer circumference of the rotor 30a. Specifically, the crank angle sensor 27 outputs a pair of pulse signals having mutually different polarities as a crank angle signal each time the crank angle reference projection $30a_1$ and the auxiliary projections $30a_2$ pass the vicinity of the crank angle sensor 27 to the ECU 4. More specifically, the crank angle sensor 27 outputs a pulse signal having a negative polarity amplitude when the front end of each projection goes past in the rotation direction, and outputs a pulse signal having a positive polarity amplitude when the rear end of each projection goes past in the rotation direction.

[0024] The description returns now to FIG 1. The regulate rectifier 32 includes a rectifier circuit 32a and an output voltage regulator circuit 32b. The rectifier circuit 32a includes six rectifier circuits that are connected in a 3-phase bridge structure and are used to rectify the 3-phase AC voltage input from the respective stator coils 30c, 30d, and 30e. The rectifier circuit 32a rectifies this 3-phase AC voltage to DC voltage and outputs it to the output voltage regulator circuit 32b. The output voltage regulator circuit 32b regulates the DC voltage input from the rectifier circuit 32a, and generates power supply voltage for the ECU 4 which it then supplies to the ECU 4.

The condenser 33 is a smoothing condenser for stabilizing the power supply, and both ends thereof are connected between the output terminals of the output voltage regulator circuit 32b.

[0025] The fuel supply unit 3 is formed by a fuel tank 40 and a fuel pump 41. The fuel tank 40 is a container that is used to hold fuel such as, for example, gasoline. The fuel pump 41 is provided inside the fuel tank 40, and pumps out fuel inside the fuel tank 40 and supplies it to the injector 22 in accordance with pump drive signals input from the ECU 4.

[0026] As shown in FIG 3, the ECU 4 includes a waveform shaping circuit 50, a rotation counter 51, an A/D converter 52, a ROM (Read Only Memory) 53, a RAM (Random Access Memory) 54, a CPU (Central Processing Unit) 55, an ignition circuit 56, an injector drive circuit 57, and a pump drive circuit 58. The ECU 4 which is constructed in this manner is driven by power supply voltage that is supplied from the power supply unit 2. A V_{IG} terminal of the ECU 4 is connected to an output terminal on a positive pole side of the output voltage regulator circuit 32b. A GND terminal of the ECU 4 is connected to a ground line and to an output terminal on a negative pole side of the output voltage regulator circuit 32b.

[0027] The waveform shaping circuit 50 performs waveform shaping to change pulse form crank angle signals that are input from the crank angle sensor 27 into square-wave pulse signals (for example, to change negative polarity crank angle signals into high level signals, and change positive polarity crank angle and ground level crank angle signals into low level signals), and outputs the waveform-shaped signals to the rotation counter 51 and the CPU 55. Namely, these waveform-shaped crank angle signals are signals whose cycle is the length of time it takes for the crankshaft 13 to rotate 20°. These waveform-shaped crank angle signals are referred to hereinafter as timing signals. The rotation counter 51 calculates the engine speed based on the timing signals, and outputs a rotation count signal that shows the relevant engine speed to the CPU 55. The A/D converter 52 converts into digital signals output signals of the intake pressure sensor 23, the intake temperature sensor 24, the throttle opening angle sensor 25, and the cooling water temperature sensor 26. The A/D converter 52 generates digital signals of intake pressure values, intake temperature values, throttle opening angle values, and cooling water temperature values by this digital conversion, and then outputs these digital signals to the CPU 55.

[0028] The ROM 53 is read-only non-volatile memory in which data (for example, control programs, table data, map data, and the like) needed for the startup control and the normal control of the engine 1 are stored in advance. As shown in FIG.3, a memory area in the ROM 53 is divided into a startup control data storage area 53a which stores data needed for the startup control (referred to below as startup control data) and a normal control data storage area 53b which stores data needed for the normal control (referred to below as normal control data). The RAM 54 is working memory that is used to temporarily hold data when the CPU 55 is executing various types of arithmetic processing.

[0029] The CPU 55 performs control of the engine 1 based on startup control data and normal control data that is stored in the ROM 53, timing signals that are output from the waveform shaping circuit 50, the rotation count signals (namely, the engine speed) that are output from the rotation counter 51, the intake pressure values, the intake temperature values, the throttle opening angle values, and cooling water temperature values that have been converted by the A/D converter 52.

[0030] As described in detail below, the CPU 55 executes an initial processing, a startup control processing, a normal area check processing, and a normal control processing. The initial processing contain at least a startup area check processing in order to check (i.e., SUM check) the startup control data storage area 53a in the ROM 53 after activation of ECU 4. In the startup control processing, the startup control of engine 1 is performed on the basis of the startup control data after the initial processing has finished. In the normal area check processing, the normal control data storage area 53b in the ROM 53 is checked (i.e., SUM check) when the startup control processing has not been executed yet. Furthermore, in the normal control processing, the normal control of engine 1 is performed on the basis of the normal control data after the startup control processing and the normal area check processing have finished. The initial processing is given the highest priority, and the startup control processing and the normal control processing are given the second-order priority. The normal area check processing is given the lowest priority.

[0031] "Startup control" is control in order to bring the engine 1 to a fully firing state by performing an initial fuel injection (simultaneous injection), an initial energization, and an initial ignition at the predetermined timing on the basis of timing signals. "Normal control" is control in order to drive the engine 1 based on a fuel injection quantity, a fuel injection timing, and an ignition timing. The fuel injection quantity, the fuel injection timing, and the ignition timing are calculated by arithmetic processing based on various types of engine data such as an engine speed, intake pressure values, intake temperature values, throttle opening angle values, and cooling water temperature values.

[0032] The ignition circuit 56 is provided with a condenser (not shown) that accumulates V_{IG} voltage, namely, the power supply voltage which is supplied from the power supply unit 2, and, under the control of the above-described CPU 55, discharges the electric charge which has accumulated in the condenser as an ignition voltage signal to a primary coil of the ignition coil 17. Under the control of the above-described CPU 55, the injector drive circuit 57 generates injector drive signals in order to cause a predetermined quantity of fuel to be injected from the injector 22, and outputs these injector drive signals to the injector 22. Under the control of the above-described CPU 55, the pump drive circuit 58 generates pump drive signals in order to cause fuel to be supplied from the fuel pump 41 to the injector 22, and outputs these pump drive signals to the fuel pump 41.

[0033] Next, with reference made to FIGS. 4 and 5, a description will be given of the operation of the ECU 4 (in particular, the CPU 55) upon the startup of the engine 1 in an engine control system that is provided with the ECU 4 of the embodiment that is constructed in the manner described above. FIG 4 is a timing chart showing a chronological mutual relationship between crank angel signals that are input from the crank angle sensor 27, timing signals that are input from the waveform shaping circuit 50, and various types of processing that are executed by the CPU 55. FIG. 5 is a flowchart of the operation of the CPU 55 after the startup of CPU 55.

[0034] In the embodiment, because the engine control system is assumed to be a batteryless system, it is not possible for power supply voltage to be supplied to the ECU 4 unless 3-phase AC voltage from the generator 30 is generated by the rotation of the crankshaft 13. Accordingly, when a user is starting up the engine 1, it is necessary to perform a predetermined starting operation (in the embodiment, this involves kick-starting), and cause the crankshaft 13 to rotate. In the embodiment, as shown in FIG. 4, a startup operation begins at the time t1, and, at the time t2, the power supply voltage that is supplied to the ECU 4 from the power supply unit 2 reaches a voltage value, which is required in order for the ECU 4 to be activated. Namely, the ECU 4 is activated at the time t2, and the CPU 55 commences the operation shown in the flowchart in FIG. 5. A crank angle signal is generated with an increase in the power supply voltage after the startup operation has performed. However, if ECU 4 is not activated, the timing signal is not generated for a period from the time t1 to the time t2 because the waveform shaping circuit 50 does not operate.

[0035] As shown in FIGS, CPU 55 disables any interrupt input after CPU 55 has been activated at the time t2 (step S1). Namely, when a timing signal is input as an interrupt signal to CPU 55 after ECU 4 has been activated, CPU 55 ignores the interrupt input of the timing signal. CPU 55 executes a read and write (R/W) check of a general purpose register (step S2), an R/W check of RAM 54 and clear of write data (step S3), an SFR initial setting related to the function of the CPU 55 such as a setting of input-output port (step S4), a SUM check of a startup control data storage area 53 a in the ROM 53 (step S5 : a startup area check processing), and an initializing processing of an application (step S6) sequentially as an initial processing after activation of ECU 4.

[0036] The CPU 55 of the embodiment reiterates a readout processing and an addition processing when a SUM check of the startup control data storage area 53a in the ROM 53 is performed. In the readout processing, the maximum data which can be read out from the startup control data storage area 53a at one time are read out. In the addition processing, data read out by the readout processing are split into single-byte data, and then each split single-byte data is added. By this reiteration of a readout processing and an addition processing, the CPU 55 calculates a check SUM of the startup control data storage area 53a. FIG 6 shows a technique for calculating check SUM if 4-byte data are read out at one time from the startup control data storage area 53a and the CPU 55 is assumed to be a 32-bit CPU for example. This 4-byte data are sequentially divided from an upper digit to a lower digit into single-byte data, such as "third" data, "second" data, "first" data, and "zero" data.

[0037] As shown in FIG 6, the CPU 55 reads out (load) 4-byte data at one time from the startup control data storage area 53a, and then adds single-byte "zero" data in the 4-byte data to a check SUM. The CPU 55 shifts the 4-byte data to the right by one byte, and then adds single-byte "first" data to a check SUM. This arithmetic processing is reiterated until CPU 55 adds single-byte "third" data to a check SUM. After that, the CPU 55 reads out next 4-byte data at one time from the startup control data storage area 53a again, and then adds the data to a check SUM in the above-described ways sequentially. The CPU 55 compares a check SUM value obtained finally in the above-described way with a predetermined reference value. By this comparison, the CPU 55 determines whether startup control data stored in the startup control data storage area 53a of the ROM 53 is correct data or not.

[0038] As shown in FIG. 5, CPU 55 enable an interrupt input when the above-described initial processing has been finished (the time t3 in FIG 4) (step S7). At the time t3 or later, the CPU 55 monitors an interrupt input of a timing signal, and begins a startup control processing in order to bring the engine 1 to a fully firing state by performing an initial fuel injection (simultaneous injection), an initial energization, and an initial ignition at the predetermined timing (step S8).

[0039] Specifically, CPU 55 controls an injector drive circuit 57 and a pump drive circuit 58 so as to perform the simultaneous injection in synchronization with the time (the time t3 in FIG 4) that a falling edge of a first timing signal is generated after the initial processing has finished. However, for example, as shown in FIG 4, if the period of time for which the startup control processing is not performed from the initial processing ending time t3 to the startup control beginning time t4 exists, CPU 55 determines a timing in order to perform a normal area check processing given the lowest priority for the period from the time t3 to the time t4. For the period from the time t3 to the time t4, namely, for the period from the time that the initial processing has been finished to the time that the falling edge of the following first timing signal is generated, a SUM check of a normal control data storage area 53b in the ROM 53 is performed (step S9: normal area check processing).

[0040] In the step S9, CPU 55 calculates a check SUM of the normal control data storage area 53b by the reiteration of a readout processing and an addition processing in the same way as the startup area check processing of step S5. In the readout processing, the maximum data which can be read out from the normal control data storage area 53b at one time is read out. In the addition processing, data read out by the readout processing are split into single-byte data, and then each split single-byte data is added. As shown in FIG 4, for the period from the time t3 to the time t4, the normal area check processing has not been completely finished.

[0041] When a falling edge of a first timing signal is generated after the initial processing has finished at the time t4 before the normal area check processing has not been completely finished, the CPU 55 controls an injector drive circuit 57 and a pump drive circuit 58 so as to perform the simultaneous injection as startup control processing given the higher priority. When the simultaneous injection has been finished at the time t5, the CPU 55 determines a timing in order to perform the normal area check processing given the lower priority again. The CPU 55 performs a SUM check of the normal control data storage area 53b in the ROM 53, continuously.

[0042] At the time t6, the falling edge of the timing signal corresponding to a crank angle reference position BTDC of 10° before the compression top dead center TDC is generated. The CPU 55 controls the ignition circuit 56 so as to perform an initial energization and an initial ignition as a startup control processing given higher priority in synchronization with the falling edge of the timing signal. If a SUM check of the normal control data storage area 53b has not been finished at the time, the SUM check of the normal control data storage area 53b in the ROM 53 is performed after the initial energization and an initial ignition, continuously.

[0043] The time t7 is the time that the engine 1 is placed in a fully firing state after the above-described startup control processing has been finished and the SUM check of the normal control data storage area 53b is finished. At the time t7 or later, CPU 55 calculates a fuel injection quantity, a fuel injection timing, and an ignition timing by arithmetic processing on the basis of various types of engine data such as engine speed, intake pressure values, intake temperature values, throttle opening angle values, and cooling water temperature values, and then controls the engine 1 on the basis of these results of the arithmetic processing (step S10: normal control processing).

[0044] The description was given of the operation of the ECU 4 (CPU 55) after the startup operation was performed in the manner described above. As shown in FIG. 4, in the operation of the CPU 55, the simultaneous injection, the energization, and the ignition in the startup control is performed while a crankshaft 13 is rotating 720° (namely, two revolutions). The reason is that the compression top dead center of an ignition timing is reached just one time, while the crankshaft 13 is rotating two revolutions.

[0045] In the embodiment, engines that are started by manual cranking using kick-starting and the like have a high possibility of being cranked approximately three revolutions in a single startup operation in a case of large displacement volume and high compression ratio engine. Therefore, it is preferable that the initial processing be finished while the crankshaft 13 is completing single revolution and the startup control processing be finished while the crankshaft 13 is completing the residual two revolutions in order to finish the initial processing and the startup control processing in a single startup operation (the transition to the fully firing state of the engine). As shown in FIG 7, in the case of a batteryless system, the engine is not brought to the fully firing state for the period from the activation of the ECU 4 to the compression top dead center and the engine speed is reduced. Accordingly, the power supply voltage is decreased and the ECU 4 runs down. Therefore, it is necessary to finish the initial processing and the startup control processing at an early stage and to be brought to the normal control.

[0046] However, as the conventional technique, in the technique that the engine startup control and the engine normal control are performed after a SUM check to all of storage area in the ROM is completed, it takes a long time to finish the initial processing. Therefore, the compression top dead center of the ignition timing is not reached during the residual cranking, and thereby, the startup operation must be performed many times (deterioration in startability).

[0047] According to the embodiment, in the initial processing after activation of the ECU 4, only the SUM check of a startup control data storage area 53a in the ROM 53 is performed. Therefore, initial processing time is shortened. Namely, initial processing is finished and the startup control processing is started at an early stage (at least, before a single revolution of the crank is completed) after the startup operation is performed and ECU 4 is activated. Therefore, the majority of the residual cranking period (for example, after two revolutions of the crank are completed) is allowed for the startup control processing. The engine is placed in a fully firing state and brought to normal control by the single startup operation. As a result, any deterioration in startability of a system is prevented.

[0048] According to the embodiment, before the startup control is performed, the SUM check of a startup control data storage area 53a stored the data needed for the startup control is performed. Moreover, before the normal control is performed, the SUM check of a normal control data storage area 53b stored the data needed for the normal control is performed. Therefore, any degradation of reliability is prevented. In the embodiment, the readout processing reading out the maximum data (in the embodiment, four bytes) which can be read out from ROM 53 at one time and the addition processing splitting the data read out by the readout processing into single-byte data and adding each split single-byte data are reiterated when the SUM check of the ROM 53 is performed. By the reiteration of the readout processing and the addition processing, loop count of the processing needed for calculation of the check SUM is decreased. Therefore, the SUM check time of the startup control data storage area 53a, namely, initial processing time is shortened further, and thereby, the startability of the system is improved.

[0049] In the above-described embodiment, when the SUM check of the ROM 53 is performed, the maximum data which can be read out at one time from the ROM 53 assume to be four bytes under the assumption that the CPU 55 be a 32-bit CPU. However, the amount of data read out at one time from the ROM 53 may change depending on the performance of CPU 55. For example, if the 64-bit CPU is used as the CPU 55, the data may be read out by eight bytes. For example, if the 16-bit CPU is used as the CPU 55, the data may be read out by two bytes. The data are not always read out in a plurality of bytes and the data may be read out in single-byte as in the conventional technique.

[0050] In the above-described embodiment, the batteryless system is described as an example. However, an engine control system that is provided with a battery would have the same problem as the batteryless system when the residual voltage of the battery is decreased to the inoperative level of the starter. The invention can be applied to the engine control system that is provided with a battery if the system can be started up by manual cranking (for example, by kick-starting).

[0051] A read-only memory is able to be checked without causing any deterioration in startability of a system and any degradation of reliability of the system when an engine is being started up.

Claims

1. A engine control apparatus comprising:

   a read-only memory (53) storing data needed for startup control and normal control of an engine (1); and
   a control processing unit (55) operating the startup control and the normal control of the engine (1) on the basis of the data stored the read-only memory (53);
   the control processing unit (55) executing:
   an initial processing containing at least a startup area check processing for checking a storage area of the data needed for startup control (53a) in the read-only memory (53) after activation;
   a startup control processing for performing the startup control of the engine (1) on the basis of the data needed for startup control after the initial processing has been finished;
   a normal area check processing for checking the storage area of the data needed for normal control (53b) in the read-only memory (53) when the startup control processing has not been executed yet; and
   a normal control processing for performing normal control of the engine (1) on the basis of the data needed for normal control after the startup control processing and the normal area check processing have been finished.

2. The engine control apparatus according to claim 1, wherein
   the control processing unit (55) calculates a check SUM of the storage area by reiteration of a readout processing reading out the maximum data which is able to be read out from the storage area at one time and an addition processing splitting the data read out by the readout processing into single-byte data and adding each split single-byte data in the startup area check processing and the normal area check processing.

FIG. 1

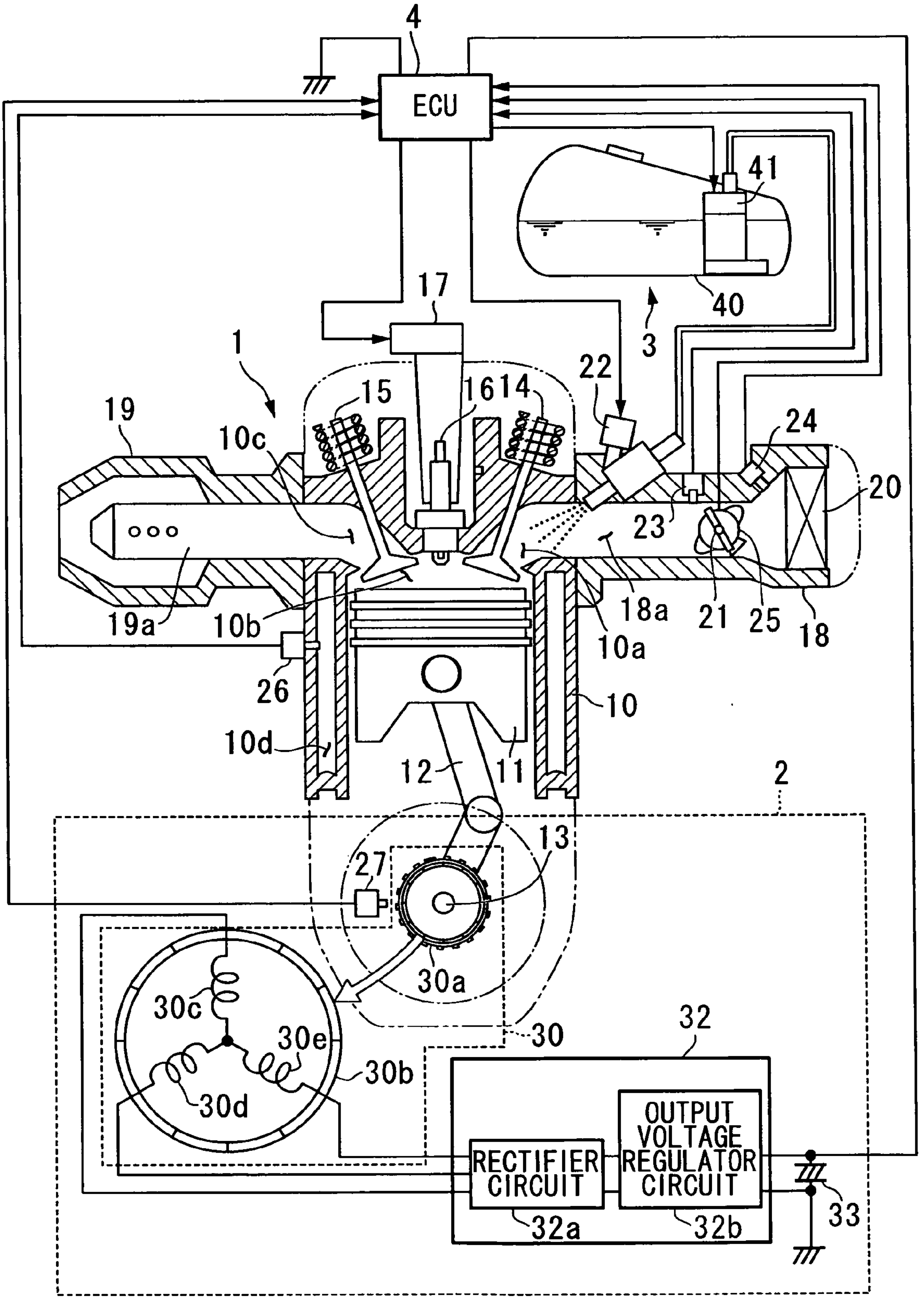

4
ECU
41
40
3
17
1
22
15
16
14
19
10c
24
20
23
21
25
18
18a
19a
10b
10a
26
10
10d
12
11
2
13
27
30a
30c
30e
30
30b
30d
32
OUTPUT VOLTAGE REGULATOR CIRCUIT
RECTIFIER CIRCUIT
32a
32b
33

FIG. 2

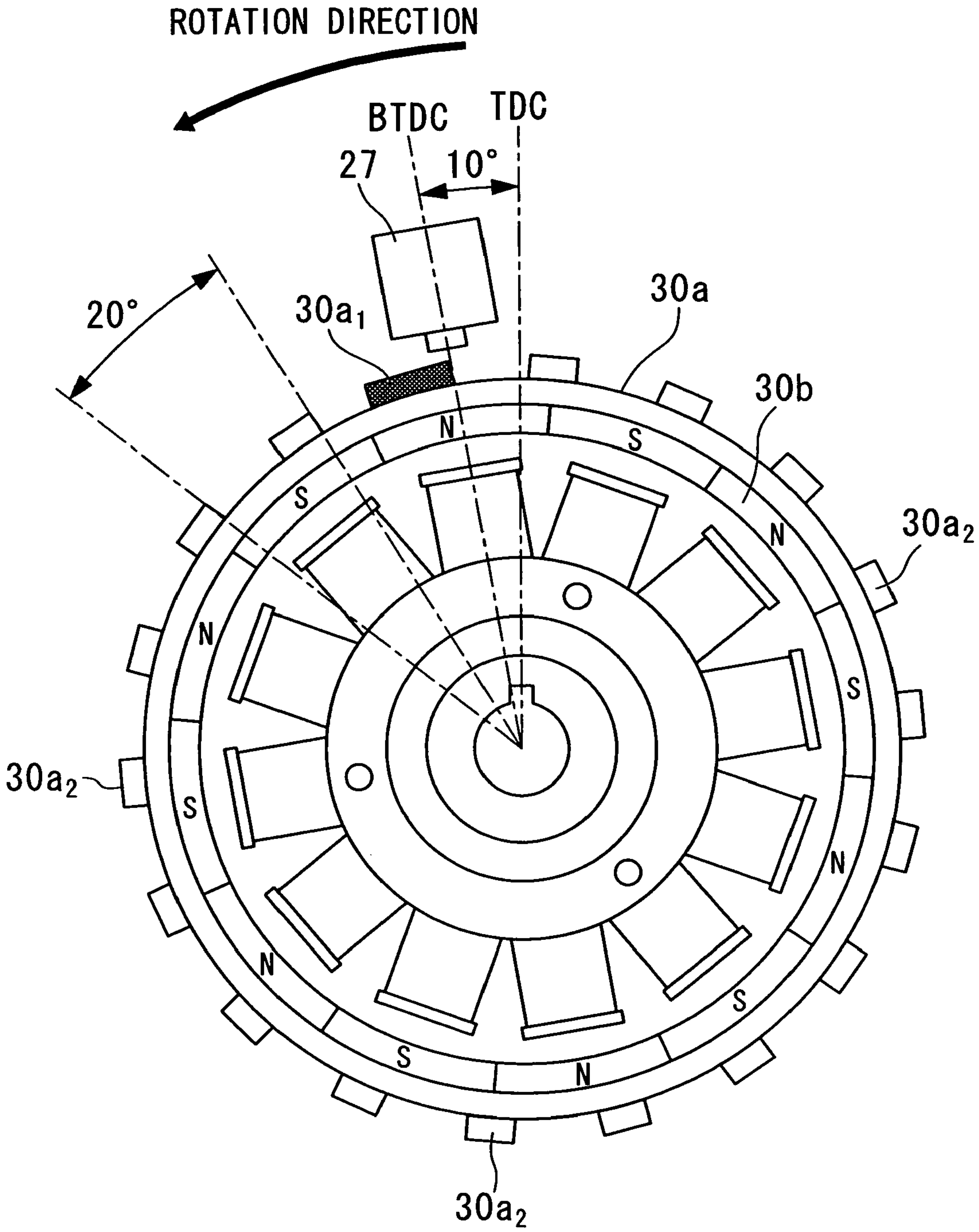

ROTATION DIRECTION
BTDC
TDC
27
10°
20°
30a₁
30a
30b
30a₂
N
S
30a₂
30a₂

FIG. 3

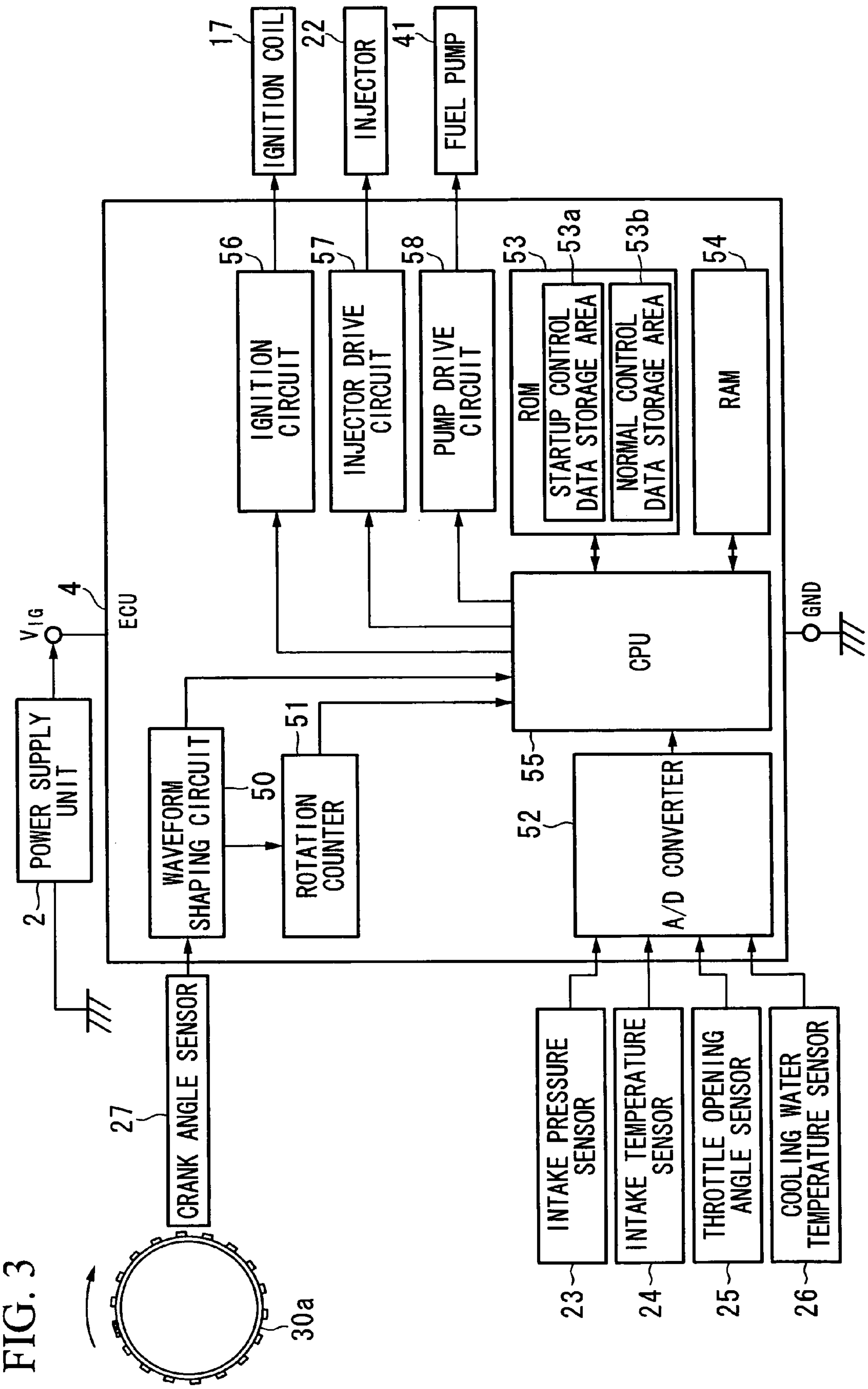
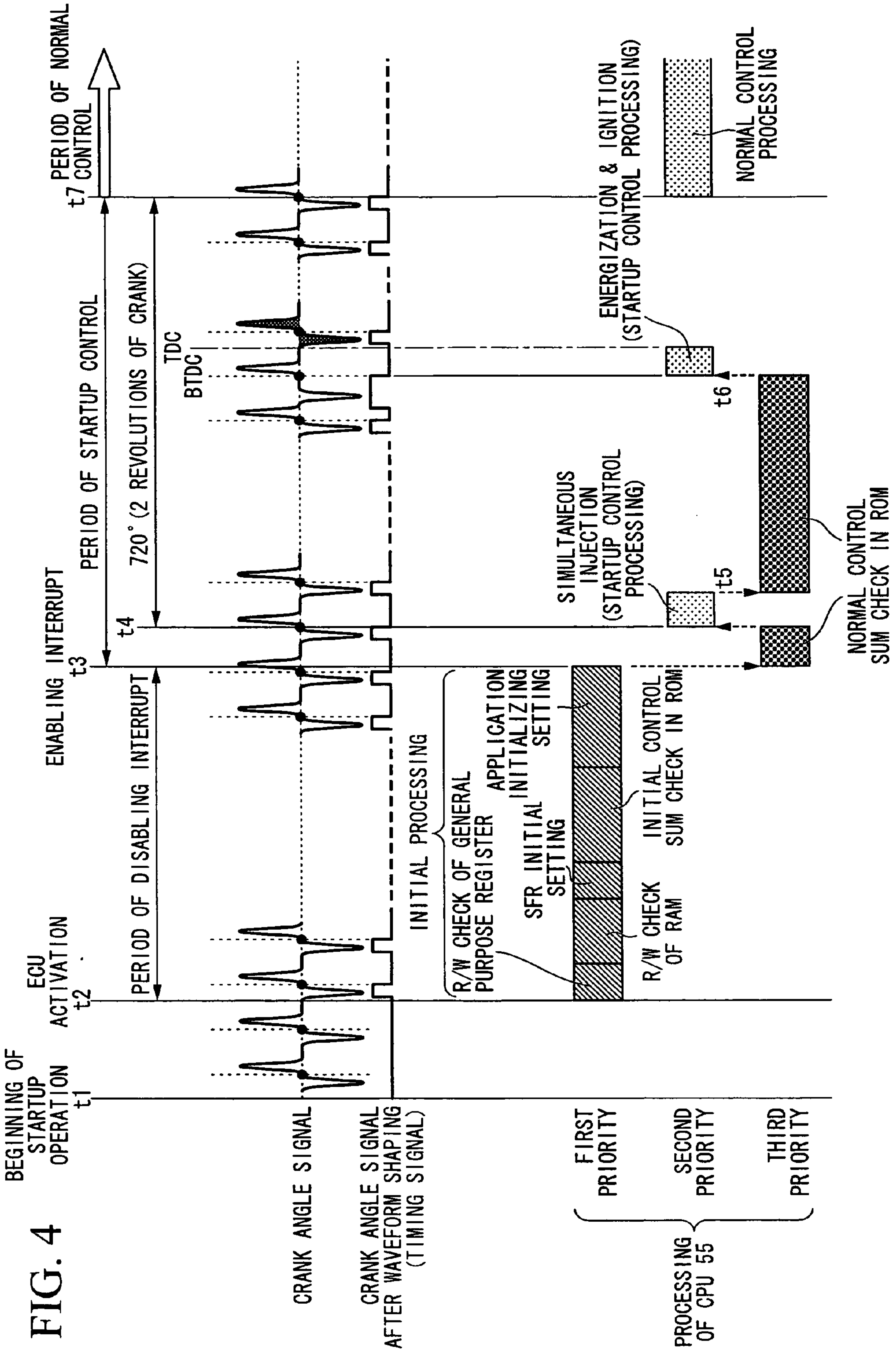

IGNITION COIL
INJECTOR
FUEL PUMP
17
22
41
ECU
4
V_{IG}
POWER SUPPLY UNIT
2
IGNITION CIRCUIT
56
INJECTOR DRIVE CIRCUIT
57
PUMP DRIVE CIRCUIT
58
ROM
53
STARTUP CONTROL DATA STORAGE AREA
53a
NORMAL CONTROL DATA STORAGE AREA
53b
RAM
54
CPU
55
GND
WAVEFORM SHAPING CIRCUIT
50
ROTATION COUNTER
51
A/D CONVERTER
52
CRANK ANGLE SENSOR
27
30a
INTAKE PRESSURE SENSOR
23
INTAKE TEMPERATURE SENSOR
24
THROTTLE OPENING ANGLE SENSOR
25
COOLING WATER TEMPERATURE SENSOR
26

FIG. 4



BEGINNING OF STARTUP OPERATION
t1
ECU ACTIVATION
t2
ENABLING INTERRUPT
t3
t4
t5
t6
t7
PERIOD OF NORMAL CONTROL
PERIOD OF DISABLING INTERRUPT
PERIOD OF STARTUP CONTROL
720° (2 REVOLUTIONS OF CRANK)
TDC
BTDC
CRANK ANGLE SIGNAL
CRANK ANGLE SIGNAL AFTER WAVEFORM SHAPING (TIMING SIGNAL)
INITIAL PROCESSING
R/W CHECK OF GENERAL PURPOSE REGISTER
SFR INITIAL SETTING
APPLICATION INITIALIZING SETTING
R/W CHECK OF RAM
INITIAL CONTROL SUM CHECK IN ROM
SIMULTANEOUS INJECTION (STARTUP CONTROL PROCESSING)
ENERGIZATION & IGNITION (STARTUP CONTROL PROCESSING)
NORMAL CONTROL SUM CHECK IN ROM
NORMAL CONTROL PROCESSING
FIRST PRIORITY
SECOND PRIORITY
THIRD PRIORITY
PROCESSING OF CPU 55

FIG. 5

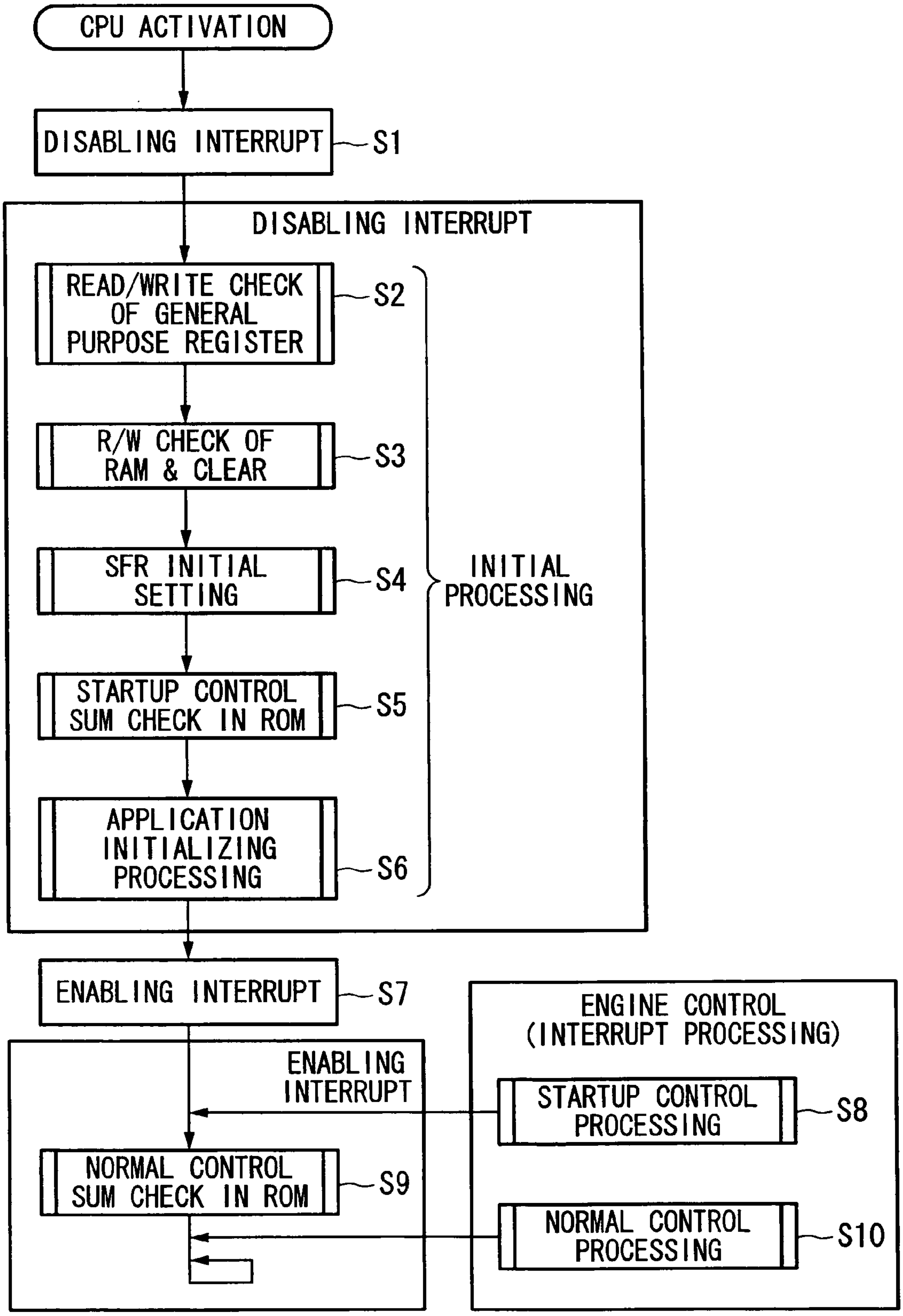
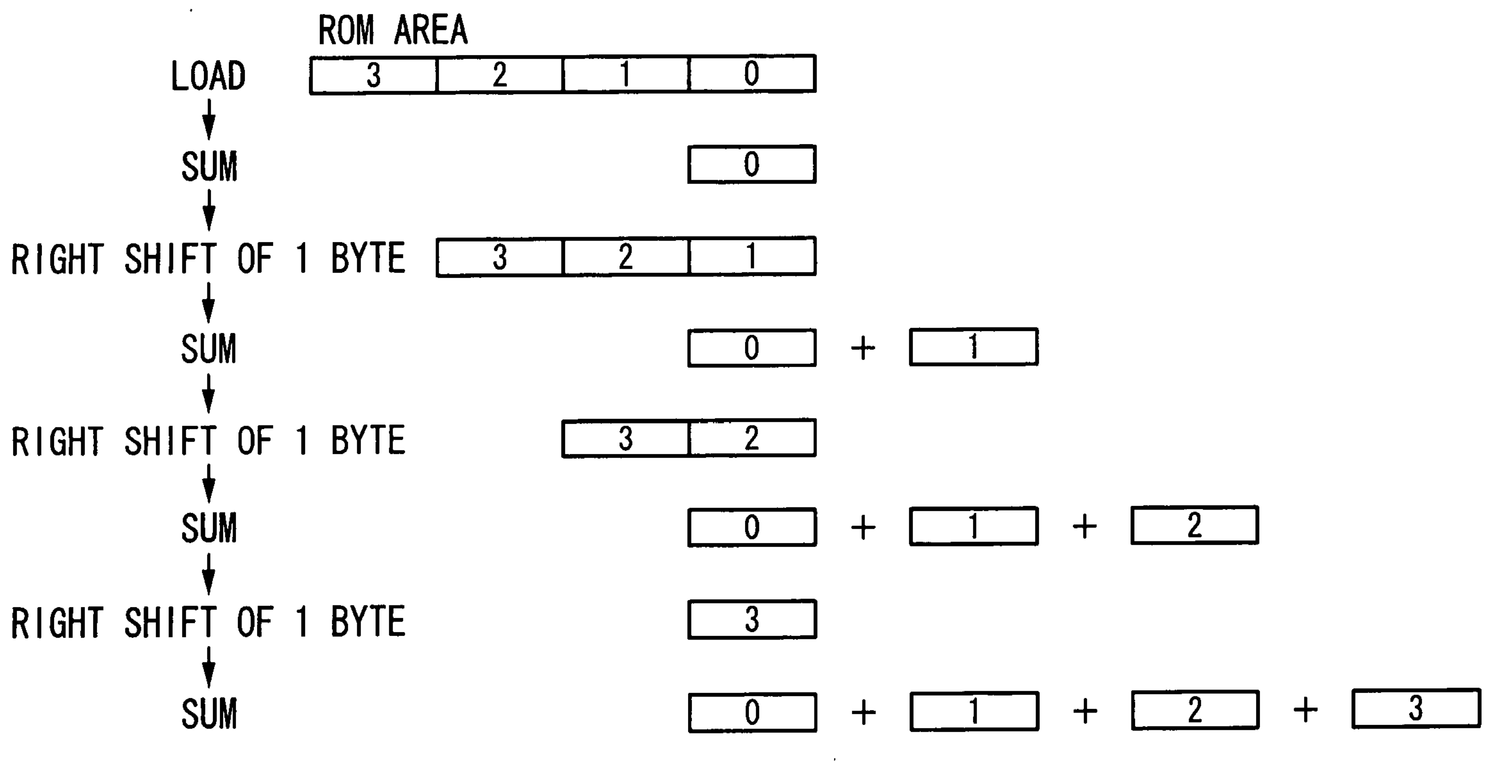
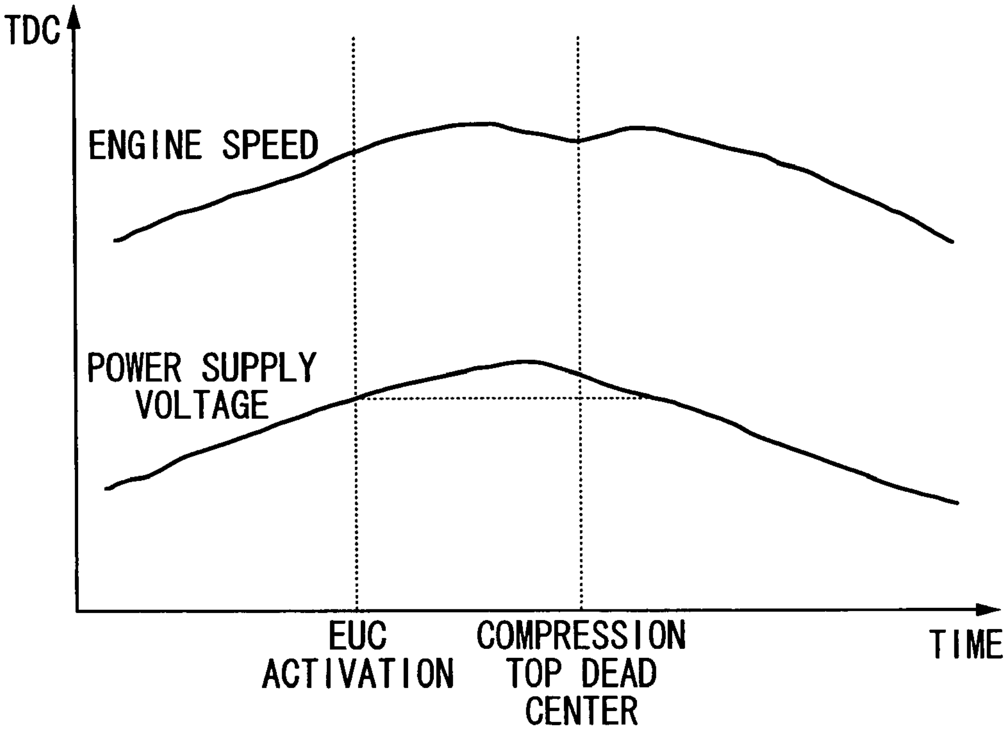

CPU ACTIVATION
DISABLING INTERRUPT
S1
DISABLING INTERRUPT
READ/WRITE CHECK OF GENERAL PURPOSE REGISTER
S2
R/W CHECK OF RAM & CLEAR
S3
SFR INITIAL SETTING
S4
INITIAL PROCESSING
STARTUP CONTROL SUM CHECK IN ROM
S5
APPLICATION INITIALIZING PROCESSING
S6
ENABLING INTERRUPT
S7
ENABLING INTERRUPT
NORMAL CONTROL SUM CHECK IN ROM
S9
ENGINE CONTROL (INTERRUPT PROCESSING)
STARTUP CONTROL PROCESSING
S8
NORMAL CONTROL PROCESSING
S10

FIG. 6



ROM AREA
LOAD
SUM
RIGHT SHIFT OF 1 BYTE
SUM
RIGHT SHIFT OF 1 BYTE
SUM
RIGHT SHIFT OF 1 BYTE
SUM
3
2
1
0
+

FIG. 7


TDC
ENGINE SPEED
POWER SUPPLY
VOLTAGE
EUC
ACTIVATION
COMPRESSION
TOP DEAD
CENTER
TIME

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2004308476 A **[0002]**