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HYBRID VEHICLE CONTROL SYSTEM

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Abstract. *The hybrid vehicle control system includes a start–stop system for an internal combustion engine. The system works in a hybrid mode and normal vehicle operation. To simplify the start–stop system, there were user new possibilities of a hybrid car, which appeared after the conversion. Results of the circuit design of the proposed system of basic blocks are analyzed.*

Key words*: BLDC motor, conversion of the vehicle, drive, system start–stop, hybrid vehicles.*

СИСТЕМА УПРАВЛЕНИЯ КОНВЕРСИОННОГО ГИБРИДНОГО АВТОМОБИЛЯ

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Аннотация. *Предложена система управления конверсионного гибридного автомобиля, включающая систему старт–стоп для ДВС, работающую как в гибридном режиме, так и в режиме обычного автомобиля. Приведены и проанализированы схемотехнические решения основных блоков предложенной системы.*

Ключевые слова: *вентильный электродвигатель, конверсия автомобиля, электропривод, система старт–стоп, гибридный автомобиль.*

СИСТЕМА КЕРУВАННЯ КОНВЕРСІЙНОГО ГІБРИДНОГО АВТОМОБІЛЯ

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Анотація. *Запропоновано систему керування конверсійного гібридного автомобіля, що включає систему старт–стоп для ДВЗ, що працює як у гібридному режимі, так і в режимі звичайного автомобіля. Наведено та проаналізовано схемотехнічні рішення основних блоків запропонованої системи.*

Ключові слова: *вентильний електродвигун, конверсія автомобіля, електропривід, система старт–стоп, гібридний автомобіль.*

Introduction

Conversion of a conventional car in rechargeable hybrid car provides a significant reduction in the cost of a kilometer of run, improves usability and reduces vehicle emissions [1–3]. But for such a conversion is necessary not only to establish the traction electric drive, but also to provide a simple and at the same time familiar and comfortable for the driver driving the hybrid algorithm.

Modern electric control is based on pulse-width modulation (PWM). The same control principle is used, and to supply fuel in modern internal combustion engines (ICE), so that the transformation vehicle control system is quite simple.

This provides a low-cost hybrid car conversion control system, and will not reduce the economic benefits to transform an ordinary car in rechargeable hybrid car.

Content Analysis

In the hybrid vehicle when driving takes place alternate operation of the electric and internal combustion engines. In some cases, possible mode of collaboration. This fact determines the need for frequent automatic start and stop the engine. A similar need arises in conventional vehicles equipped with start-stop system (sometimes referred to as stop-start). Since the conversion is subjected to a conventional car, consider the start-stop system in a conventional car. Conventional car engine in an urban environment to a third of the total operating time is running idle. During idling engine does not make the vehicle move, and the fuel consumption. Also, there is air pollution. In this situation, the start-stop system can reduce this time [4].

The principle of the start-stop system is to ensure that when the vehicle is stopped, the engine automatically stops, and if necessary, to move on and automatically restarts. Varies operation of the system in the presence of the automatic transmission and manual transmission installed. In the first case, the engine stop takes place after a full stop of the vehicle when the brake pedal is pressed. The motor is restarted after the brake pedal is released. With a manual gearbox the engine stops automatically after the gearbox to neutral and releases the clutch pedal. If you wish to continue driving, will be sufficient to click again on the clutch pedal and then, after pressing the accelerator pedal the engine starts automatically.

The device start-stop is not only positive aspects, but also has some difficulties. Due to the fact that when using such a device substantially increases the amount of the triggering modes, it is necessary to use other types of starters, which will cope with this increased load. Conventional ballasts in this case does not apply. Also setting the start-stop system involves the use of a special type of batteries that are easy to withstand deep discharge and a large number of «charge-discharge» cycles.

It is important to note that not every vehicle stop automatic engine shutdown triggered. The motor will not stop its work in the following cases: if the engine is not warmed up, namely the coolant temperature does not reach 25 degrees; if enabled windshield heating or the air temperature in the passenger compartment below the climate control on 8 degrees; if the engine is not idling; if there are problems with the generator; if the vehicle is stopped after reversing; If the battery charge is not enough to re-start the engine, such as the battery is discharged by more than 50 %; If the steering wheel while maneuvering-integration-rotated through a large angle. All the processes mentioned above are regulated by special sensors, information from which is processed by the system control unit.

It is believed that the start-stop system, can provide up to 10 % fuel economy, emissions in exhaust gases is also smaller. Among the shortcomings can be start-stop device is also noted that when the engine is stopped and the air conditioning stops working. When there is no need for the engine is turned off, turn off the start-stop system can be a special button, which is located on the dashboard. Furthermore enumerable-specific elements of start-stop system used in some vehicles, a voltage regulator, which is a voltage converter DC / DC power of about 180 watts. In the car «Volkswagen Golf» it is fixed in a recess of the front left wheel, and control voltage regulator via the LIN bus.

Its purpose is to stabilize the voltage on-board vehicle network at 12 V, applied to some critical consumers. The need of stabilization due to the fact that a high starting current during the start mode can cause supply voltage variations. The absence of voltage regulation when the voltage level drops due to the operation of a starter can lead to restarting the individual devices in different control units, such as the radio, navigation system, instrument cluster. In this case, a restart can occur in such devices [5].

Naturally, in the hybrid vehicle after the conversion is necessary to use the system «start–stop». However, the functions of start-stop system is part of a hybrid vehicle control system and have their own characteristics.

The purpose and task

Start-stop hybrid vehicle system must:
– maintain control techniques available to the car before the conversion;
– to provide a vehicle motion or by an electric motor or by the internal combustion engine;
– to keep the use of start-stop system in the hybrid mode and normal mode, the car;
– to provide a vehicle deceleration when the service braking mainly due to the electric motor as a generator, and provide enough regenerative

deceleration both while maintaining the generated electric power into the battery, or when the battery is fully charged, to keep the heat energy in the internal combustion engine cooling system;
– ensure the opportunity to save fuel by moving the car in overrun mode with minimal slowdown.
Start–stop vehicle the hybrid conversion system should:
– to ensure the maximum use of existing elements of the system start-up conversioned car and ensure that the minimum cost of additional elements;
– provide minimum flow available onboard electricity, internal combustion engine start. For this purpose, the start-stop system should provide start ICE at a sufficiently high speed of the car without a starter from the kinetic energy of the moving vehicle.

Development of the system start–stop

The operation of the start-stop hybrid vehicle system is based on the following principles:
– Use available starting system when standing or moving at a low speed vehicle;
When the vehicle speed is high enough, the internal combustion engine start-up is carried out using the kinetic energy of a moving car.

Consider what is the difference of the system start–stop hybrid vehicle after the conversion from the system start-stop conventional car. First of all, we note that the launch of the internal combustion engine is made mostly not the vehicle is stationary and the car, scored by electric speed of about 40 km/h.

At this speed the kinetic energy of the car allows you to start the internal combustion engine without a starter. To do this, the driver includes a fourth gear and releases the clutch pedal. In the hybrid vehicle should be provided when starting the internal combustion engine fuel supply switch and automatic disconnection of electric drive. Such an internal combustion engine start-up does not cause any discomfort (push) for the driver and passengers, and corresponds to about their feelings at the time of switching from third to fourth gear manual transmission while driving on ICE.

Fig. 1 shows the fragments of a plot of velocity versus time when driving in urban conditions for different variants of the vehicle acceleration [3].

Fig. 1, A relates to a hybrid regime, and fig. 1, B, C are overclocking mode with an internal combustion engine. Fig. 1, A, B relate to the case when the movement begins with the free space in front of the car (fig. 1, C) when the movement begins in the presence of other vehicles in front of the vehicle, ie, in heavy traffic. As can be seen from fig. 1, C because of the slow-moving vehicle in front of a slow switching of the transmission gear. Fig. 1, A transition from movement in the electrical motor to the movement in the internal combustion engine (4th gear transmission) occurred at a rate of about 38 km/h. In Fig. 1, B, when driving only the internal combustion engine, switching from 3rd to 4th gear speed it occurred at approximately 56 km/h. As you can see, these two points of transition in fig. 1, A and fig. 1, B look almost identical «steps». This means that, as the acceleration and the forces acting on the driver and passenger will also be substantially the same.

This is facilitated by such circumstances:
1) modern gasoline internal combustion engine with fuel injection and electronic engine management system runs fast (0.4–0.8c) [4];
2) in the vehicle provided by the network operating during charging the battery preheater, which in most cases provides start-up of the heated combustion engine [2].

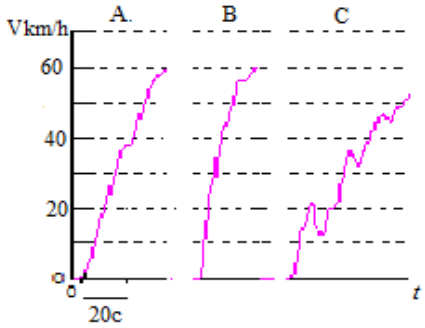

Fig. 1. Velocity versus time when driving in an urban environment

Thus, the main way to start the internal combustion engine becomes launch it from a moving car energy, so the number of the internal combustion engine starts the starter is significantly reduced. Given the very short time of the starter, which also contributes to the preheating of the electrical network, and also have a perfectly acceptable service life of the collector, brushes and starter bearings. To increase the share in the number of positives contacts of the traction relay contacts are shunted additional high-current

power relay coil is switched on together with the inclusion of a starter (fig. 2). Fig. 2 contacts S1 is the starter relay ON.

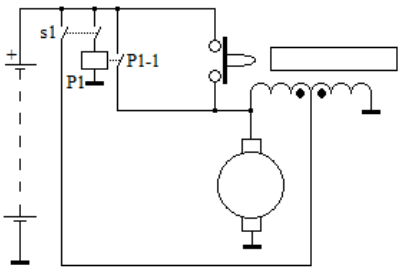

Fig. 2. The additional force P1 relay starter for start–stop system

In a conventional car with start-stop system, you must use a special type of starter batteries, which are easy to withstand deep discharge and a large number of «charge-discharge» cycles. In addition, it is necessary that the battery power consumption control device, because you want to calculate the degree of his rank, to ensure disconnection start-stop system in too deep discharge of the starter battery. In the hybrid vehicle after the conversion of all of these problems are solved by using a conventional starter battery, but with the provision of its charge of the traction battery through the DC-DC converter, which is fast-Sun performs its charge, consumed on the internal combustion engine start-up, ie all the time keeps the starter battery charged. This allows you to keep a normal starter battery and not to the control device of its charge, which saves on the conversion costs. Traction battery has a reserve of electrical energy is many times greater than the starter battery.

In addition, when charging the traction battery from an external electric network at the same time charging the starter battery. Consequently, the power consumption of the traction battery is low and the car run on electric drive or in hybrid mode will decrease slightly. Traction battery has a discharge limit control system and, therefore, the system is switched off and «start–stop» when disconnecting the traction battery. Figure 3 shows a schematic diagram of the system start-stop hybrid car «Lanos-pickup» after conversion.

The system comprises a logical block on the transistors Q1–Q4 and diodes D1–D13, switching unit startup mode (starter or the kinetic energy of a moving car) on the comparator U1.1, logical elements U2.1, U3.1, U4.1, differentiating circuit C1, R1, integrating circuit R2, C2 and support divider comparator (R7, VR1). Additionally, the system comprises a start-stop circuit ICE off nozzles (L1-L4), collected on the diodes D4-D13 and resistors R10-R13, and motor shutdown circuit (Q4, D2, R14, R15).

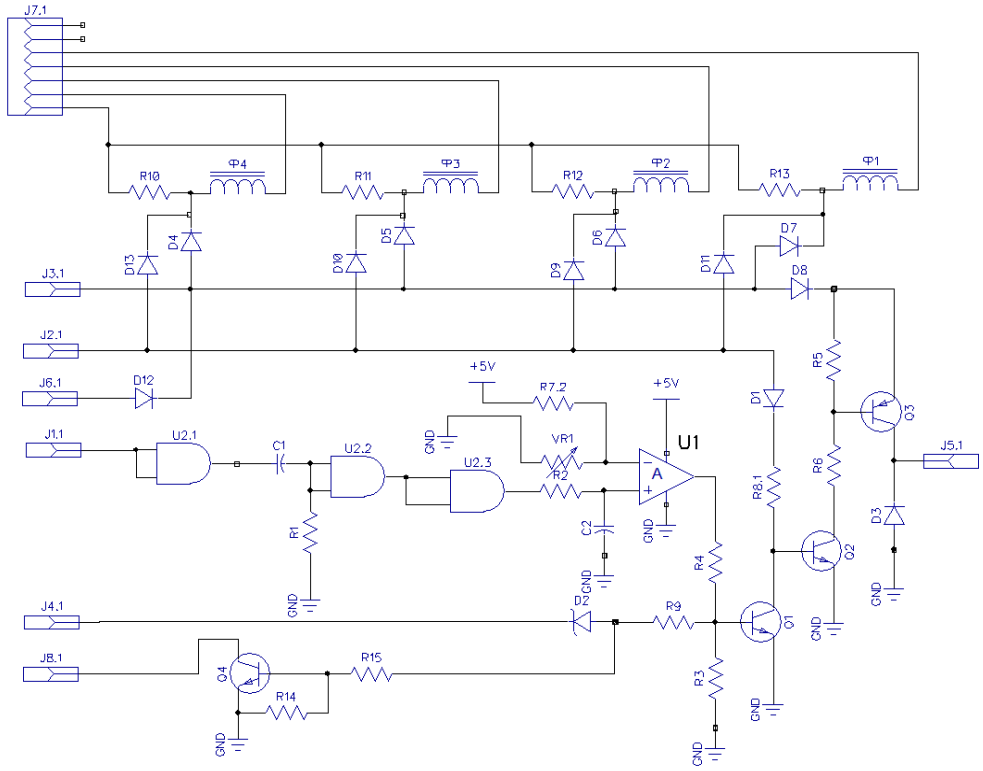

Fig. 3. Schematic diagram of the system start-stop hybrid vehicle conversion after conversion

For J1.1 system connector is connected one of the rotor position sensor or a vehicle speed sensor. By connector J2.1 system connected limit switch, plus 12V supply when fully depressed the clutch pedal, the connector J3.1 system is connected, the supply limit switch plus 12V while pressing the accelerator pedal. Also switch «hybrid – a normal car», is connected to the system connector J6.1. Switch in the «regular car» mode connects12V to the specified connector J6.1. By connector J5.1 system connected starter relay. By connector J4.1 system connected car generator output which is connected to the indicator (light) «Charging Control»).

When the internal combustion engine after start-up idle speed, this pin appears 6V. It unlocks the power zener diode D2 and opening the transistor Q1, which turns off the starter. In addition, it opens the transistor Q4 and via the connector J8.1 includes a relay that switches the signal from the throttle position sensor (accelerator pedal) from the electric motor to the internal combustion engine electronic control system, thereby shutting off the electric motor. J7.1 connector is connected to the connector that comes from the ICE electronic control system to the unit injectors.

Conclusions

The hybrid vehicle control system after conversion retains all the features and control techniques available to the car before the conversion. The control system allows the vehicle or by an electric motor or from the internal combustion engine. In addition it provides a vehicle deceleration when the service braking mostly due to the work of the electric motor as a generator. The developed system start-stop hybrid vehicle which is the result of the conversion, the system uses a conventional starter when standing or moving at low speed the car and uses a sufficiently high speed internal combustion engine start from the kinetic energy of a moving car. This, as well as charging the starter battery from the traction battery have greatly simplify and reduce the cost of start–stop system.

References

1. Бажинов О.В. Конверсія легкового автомобіля в гібридний / О.В. Бажинов, В.Я. Двадненко, М. Хакім. – Х.: ХНАДУ, 2014. – 200 с.
2. Бажинов О.В. Синергетичний автомобіль. Теорія і практика / Бажинов О.В., Смирнов О.П., Сєріков С.А., Двадненко В.Я. – Х.: ХНАДУ, 2011. – 236 с.
3. Бажинов А.В. Экспериментальное исследование бензинового автомобиля конвертированного в гибридный / А.В. Бажинов, В.Я. Двадненко, С.А. Сериков // Вестник ХНАДУ: сб. науч. тр. – 2014 – Вып. 67. – С. 63–68.
4. Егоров В. Как работает система старт–стоп – функция, устройство, виды реализации / В. Егоров. – Режим доступа: http://icarbio.ru/articles/system-start-stop.html.
5. Электронный ресурс. – Режим доступа: http://vwts.ru/electro/start-stop_2009_rus.pdf.

References

1. Bazhy`nov O.V., Dvadnenko V.Ya., Xakim M. *Konversiya legkovogo avtomobilya v gibry`dny`j.* [Conversion of the car into a hybrid. Kharkiv, KhNAHU Publ., 2014. 200 p.
2. Bazhy`nov O.V., Smy`rnov O.P., Syerikov S.A., Dvadnenko V.Ya. *Sy`nergety`chny`j avtomobil`. Teoriya i prakty`ka*. [Synergistic car. Theory and practice]. Kharkiv, KhNAHU Publ., 2011. 236 p.
3. Bazhy`nov A.V., Dvadnenko V.Ya., Sery`kov S.A. *Ekspery`mental`noe y`ssledovany`e benzy`novogo avtomoby`lya konverty`rovannogo v gy`bry`dnyj.* [Experimental study of the petrol vehicle converted into a hybrid]. Vestnik KhNAHU. 2014, Vol. 67. pp. 63–68.
4. Egorov V. *Kak rabotaet systema start–stop – funkcyya, ustrojstvo, vydy realyzacyy.* [How does the system start-stop - function device types implementing]. Avialable at: http: icarbio.ru/articles system-start-stop.html.
5. Elektronnyj resurs: http: vwts.ru/electro/ start-stop_2009_rus.pdf. [Electronic resource: http: vwts.ru/electro/start-stop_ 2009_rus.pdf].

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