THE DESIGN OF ECU FOR ENGINE POWERED BY LPG

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ABSTRACT

Today's engines are using an electrical control unit for engine management and reducing of engine emissions. The ignition system and fuel mixture control to engine it's the main function of the standard ECU (electrical control unit). The conversion to engine powered by LPG (Liquefied Petroleum Gas) is complicated for these types of engines. Paper deals with an ECU as additional system for conversions of standard engine to LPG powered engine.

1 INTRODUCTION

Three basic methods are used for conversion of a standard engine to LPG powered engine [3]. Fist method is using vacuum by engine. The system supplies a constant fuel mixture to the engine by air. It is not applicable to electrical control engine with calorifier. Therefore, the system was completed by an actuator (electrical valve) to control of engine fuel mixture. It's controlled by engine work state. Second method is using the continual fuel injection. The LPG is supplied near to engine valve. It is better system conversion than first. Third system is using the sequential injection directly into the engine cylinder. This system is the best of conversion systems. The engine power is higher for the LPG than the standard fuel.

The design of additional control unit for first conversion system will be discussed in the next sections [1], [2]. The mechanical construction of high pressure LPG part and design isn't subject to discussing.

2 DESIGN OF THE CONTROL SYSTEM

The setting of actuator value based on the engine work state is the main function of the LPG ECU. This engine work state is defined by engine rpm and engine load [2]. The vacuum by engine depends on engine load. The barometric air pressure is measured by the manifold absolute pressure sensor (MAP). The engine speed (RPM) and the vacuum by engine (LOAD) are the main parameters for specification of the LPG mixture. The engine coolant temperature (ECT) can express the engine temperature. The throttle position (TPS), ETC and air temperature intake into the engine (ACT) they are the next parameters for the control system. Double dimensional table is used for main controlling of the actuator. The engine load is on axis x and engine speed is on axis y. The actuator position is identified by x and y parameters. The number of table cells must be great enough or the interpolation in the table must be used [2]. Secondary parameters are applied for the actuator value correction. The LPG enrichment is determined by coolant temperature of the engine. The next fuel enrichment is performed when the throttle position is increased. It's equal as choke and acceleration pump for an old engine type. Thus, the actuator position is computed from all input parameters. The LPG mixture optimum must be supplied into the engine for reduction of the vehicle emissions. The O_2 sensor is implemented into the control unit for monitoring engine emissions. The output voltage from the sensor is determining richness or poorness of fuel mixture. The both regions are divided by sharp limit. The global overview of LPG electrical control unit is illustrated in fig. 1.

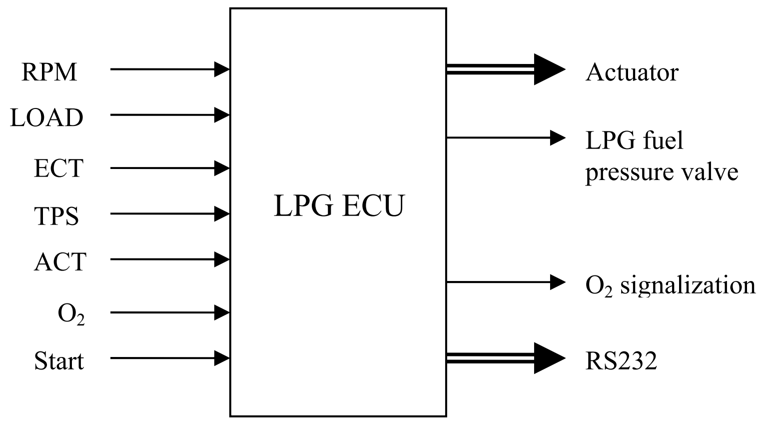

Fig. 1: *Global overview of LPG ECU system*

The actuator is driven by four wires. It's a step motor with two coil winding. Except of the electrical valve controlling, the LPG control unit has to switch the LPG high-pressure intake on. If the engine is stopped, the LPG high-pressure intake must be stopped too. It's from the safety reasons in order to prevent the LPG leakage.

The output with the individual states signalization is implemented for verification of correct optimal fuel mixture. The LED diodes are connected on this pin. The actual state of engine emission is signalized by this LED diodes. The communication port RS232 is designed to monitoring all system variables. Writing of the system variable into the LPG ECU is possible by this port too.

3 IMPLEMENTATION OF ALGORITHMS

The system processor has to have peripheries as counter/timer, analogue to digital converter, analogue comparator and serial interface. The microprocessor of ATMEL Company was chosen. Its type is ATmega8. The chip features are: 8kB flash for program storing, 1kB SRAM for variables storing, 512B EEPROM, two times 8bit counter/timer, one 16bit counter/timer, 6 channel analogue to digital converter and analogue comparator. The program behavior on the stimulation you can see in fig. 2.

The system is in stand-by mode at startup. If the reset signal is detected, the system will be woken up. Then, the startup system initialization is performed. In the next step program is waiting on system interrupt. The subroutine for event is evoked by the interrupt.

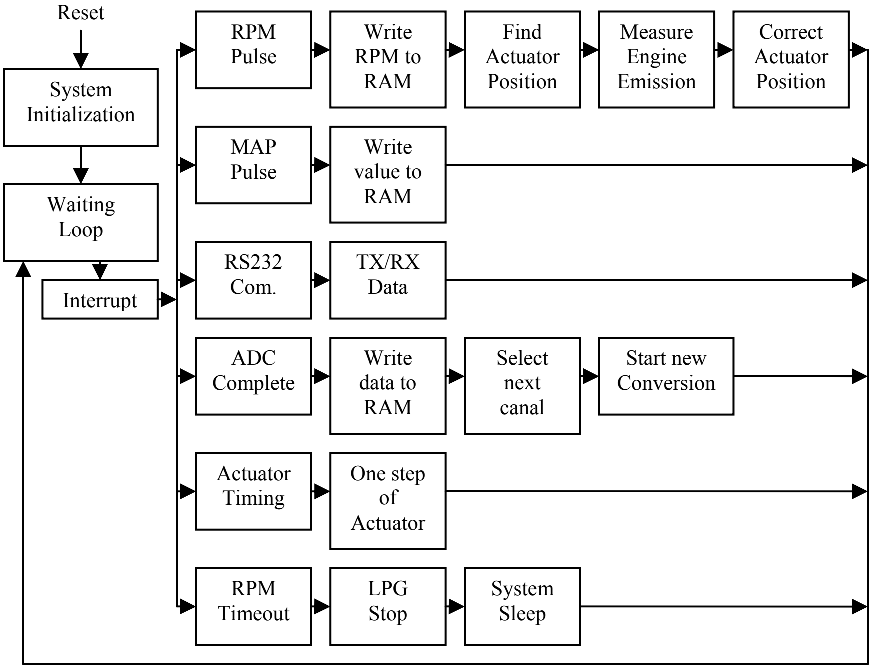

Fig. 2: *Flow chart of the implemented algorithms.*

Three main parts are base for the program. The engine vacuum and engine speed are measured by first and second part. Specification of actuator position and its correction by engine emission is implemented in the part for the engine speed measurement. The step motor position is determined according to the engine work state. The engine response is monitored and the position of step motor is corrected in order to the emission requirements would be optimal. The O2 sensor is used to determine of the residual oxygen in the exhausts. The sensor's output voltage is dependent on the value of residual oxygen. The change between both regions is rapidly sharp. It's necessary to consider the delay of all engine system.

3.1 MEASUREMENT OF THE ENGINE EMISSION

In this particular implementation, 40 cycles of the engine was chosen as a period for the engine emission measurement. During this period, the error function of emission measurement is added to the value of step motor position which is determined from the fuel mixture table. The ideal principle of emission measurement is illustrated in fig. 3.

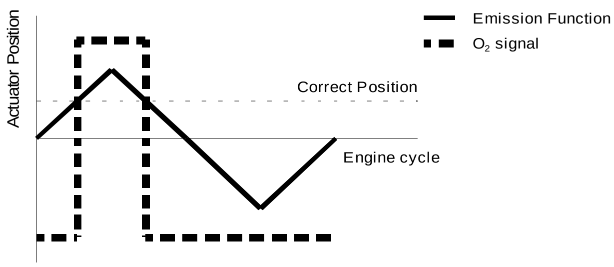

Fig. 3: *The principle of engine emission measurement*

It's possible to exactly specify the correct value of step motor position based on the pulse width as you can see in fig. 3. If the optimal value (the pulse width is 50 %) is reached, this new value is stored into the table in the RAM memory.

4 PROGRAM FOR MANAGEMENT OF THE LPG ECU

The monitoring program has been developed for the purpose of verification a correct function of LPG control unit. It's composed of two basic parts. First part of monitor program is for displaying and setting global system variables. The fig. 4 shows an example of the system monitoring at an engine work state.

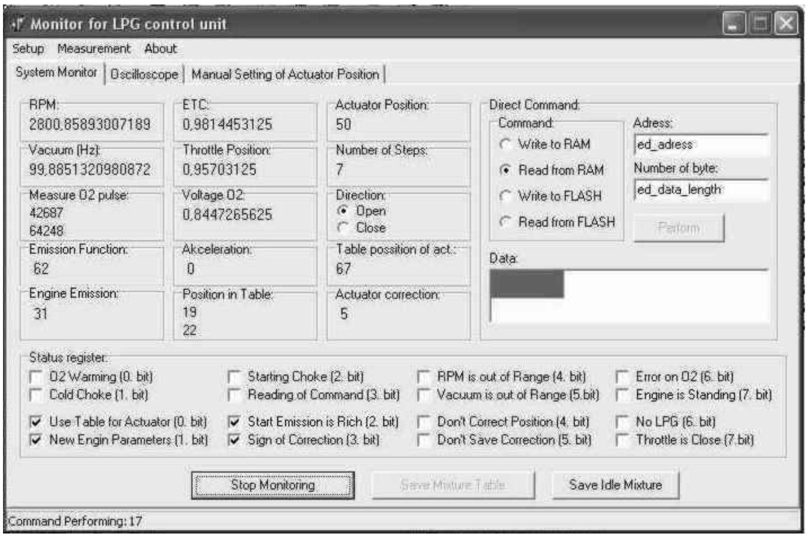

Fig. 4: *View of Monitor Program - Monitoring*

The part of monitor program named *Oscilloscope* has been implemented for deep studying of various dependencies of the system parameters. Following fig. 5 demonstrates a dependance of voltage versus O_2 of the sensor and actual value of engine's sucking under-pressure. Note that there is a high load of engine approximately at half of the graph.

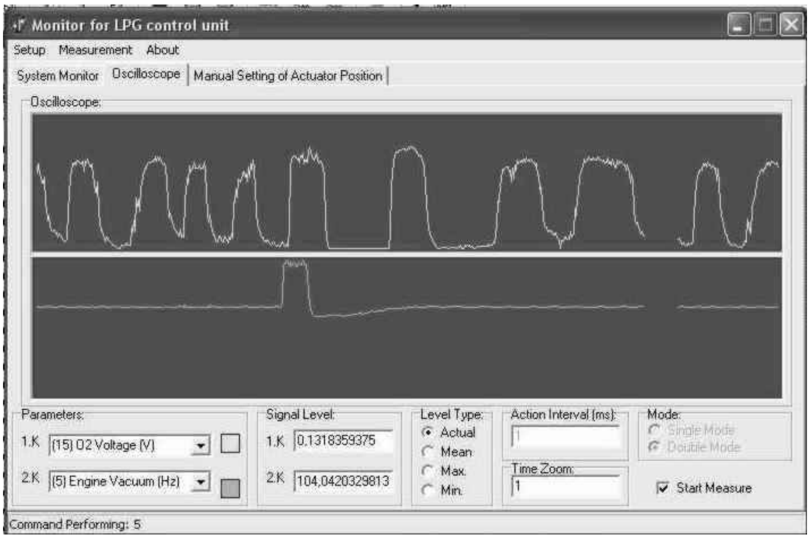

Fig. 5: *View of Monitor Program – Oscilloscope*

5 CONCLUSION

Upper mentioned algorithms and principles were merged together forming resulting system, which was then realized on universal layout board (see fig. 6). For proper function of the circuit it is supposed the user knowledge a fuel mixing table in memory, which was build-up from experimentally measured data in beginning tests of the system. This table is updated continuously, that's why it automatically takes optimal values if updating process is long enough. The system was tested at Ford SCORPIO. The designed system works correctly and reliably as the test results shown. The emission limits are under the emission requirements. If the system passes the homologation exam, it could be used in a common traffic.

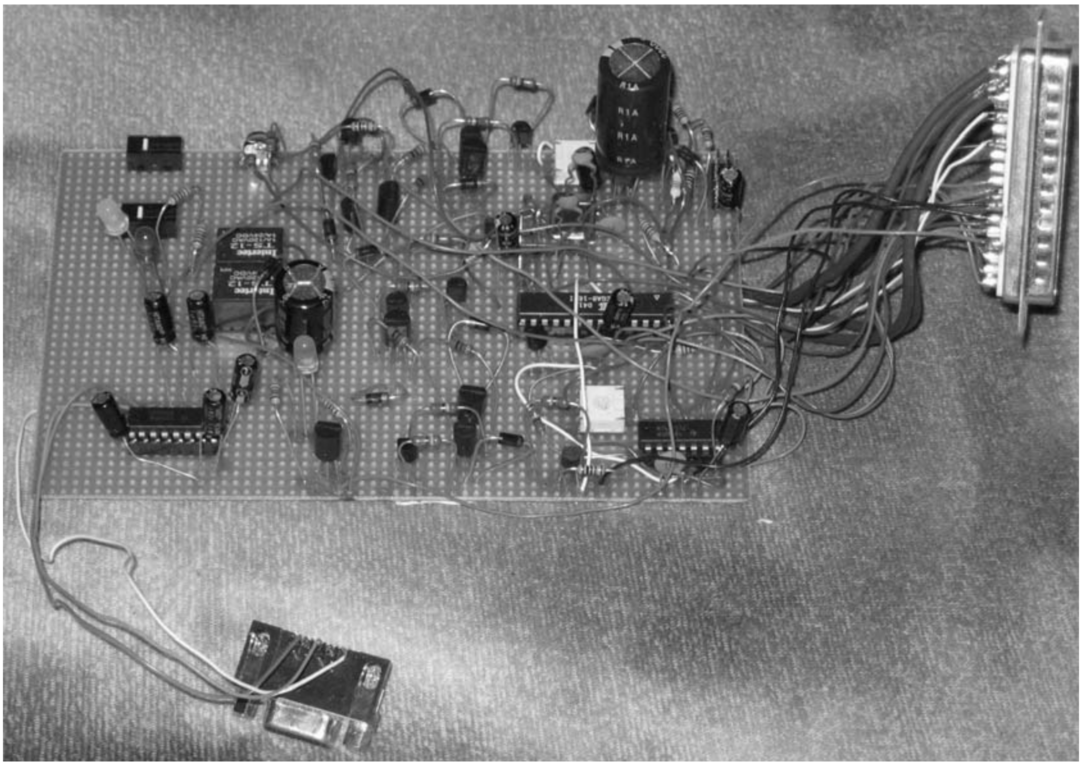

Fig. 6: *Complete system circuit*

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