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THE DESIGN OF TECHNICAL SOLUTION FOR THE FUEL LEVEL TRACKING IN MODERNIZED BVP M-80AB2

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Abstract: *Within the modernization of the infantry fighting vehicle (Serb. BVP), a new concept of the modernized vehicle has been adopted, which included a displacement of fuel tanks. The fuel tanks are moved from the fighting compartment to the over-tracks panels in the rear part of the vehicle, one on the left and one on the right side. According to this, it was necessary to study the problem both theoretically and practically, and to provide a new functional solution for tracking the fuel level in the tanks. This included the selection of the sensors for detecting the fuel level in the tanks, the indicator placed on the driver's control board used to indicate the current fuel level in each of the tanks, the designing of electrical scheme to connect the sensors and the indicator, the designing and making of appropriate electrical installation. All this had to be installed on the vehicle and the functionality of the new solution in whole had to be checked.*

Key words: *BVP, modernization, fuel system, sensor, indicator, electrical scheme.*

1. INTRODUCTION

The BVP M-80A infantry fighting vehicle represents the most important and widespread modification of the BVP M-80 vehicle. This vehicle served as the basis for the development of other vehicle variants for different purposes.

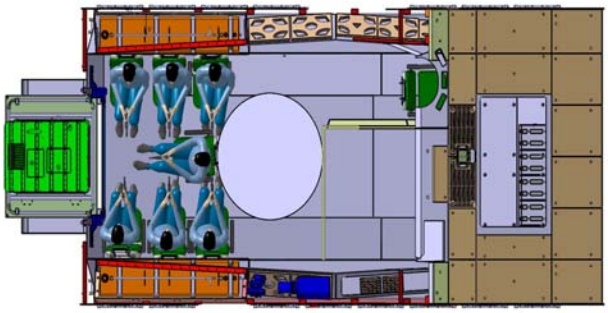

Figure 1. Conceptual solution of the PT modernized base of the BVP vehicle

The centre of modernization on BVP M-80A is on modernization of the basis of the vehicle which consists of the change of the concept of the vehicle's basis, the goal of it being the increase of commodity for the crew and the useful space. The goal of modifying (cutting) the lateral diagonal panels of the infantry vehicle and moving the fuel reservoir out of the vehicle (on the continuous track panels), was to increase the space for the crew and equipment and the increase of the security of the crew against explosions of the fuel and fires. For the new construction of the fuel reservoir (Figure 2), it was necessary to choose appropriate sensors for detecting the fuel level in the reservoir, the indicator on the control panel of the driver and serves for pointing the current fuel level in each of the reservoirs, project electrical scheme for connecting the giver and the indicator and make appropriate electrical installation.

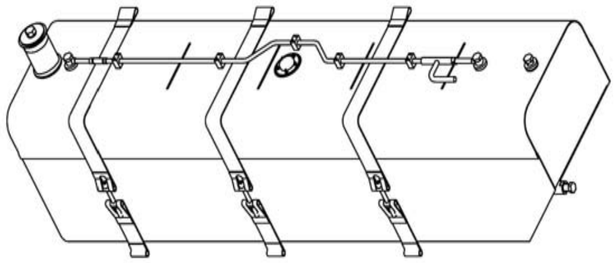

Figure 2. New construction of the fuel tank

Solving the problems described demanded studying the basic principles of the functioning of the sensors and indicators, their availability at the market, so as some of the existing solutions, about which we will discuss in this study.

2. ANALYSIS OF THE EXISTING METHODS OF THE SOLUTIONS FOR TRACKING THE FUEL LEVEL IN THE FUEL RESERVOIRS

Measuring the level of liquid in some of the reservoirs gives the insight to the liquid volume, and when the density is familiar the liquid volume, we have at disposition in the reservoir too. Beside visual and mechanical methods, which, historically looking, are the oldest, the most important in the contemporary techniques are electrical methods for measuring the levels.

The methods of measuring can be divided into continual and discrete. With continual methods we can continuously track the current level, while discrete measuring gives the signal when the liquid level increases or decreases, in comparison to the set point.

2.1.Traditional methods of continual measuring of the liquid level

In Figure 3 there are some of the methods for continuous level measuring shown. The device in Figure 3a uses the float which tracks the changes of the level and, affecting the converter for measuring translatory position gives the electrical signal proportional to the liquid level.

In Figure 3b there is the device which functions at the similar principle. In this case the float hangs on the rope over the reel. In that way, the moving of the rope converts into the angular position which is measured by the adequate converter, most frequently by helicoidal potentiometer. By this method the highest precision of the liquid level measuring is achieved.

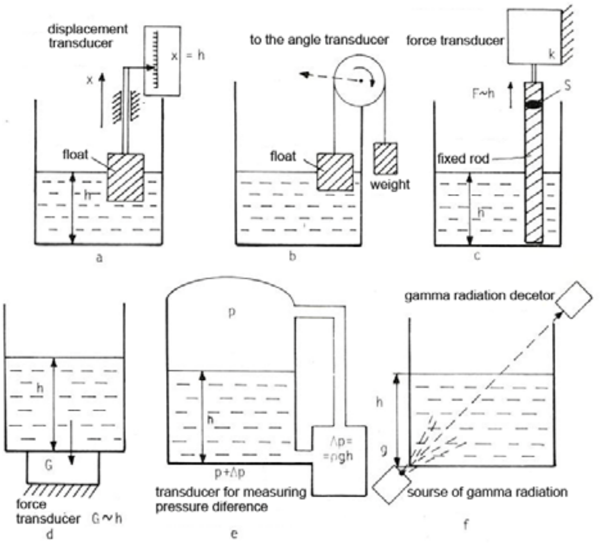

Figure 3. Shows some of the methods for continuous level measurement

In the Figure 3c the rod of constant intersection is fixed onto the converter for force measuring. When the reservoir is empty the weight of the rod affects the converter. The end of the rod is then just above the bottom. When the liquid is poured into the bowl, the rod starts raising because of the thrust force. The thrust force is in linear proportion to the liquid level.

Direct measuring of the liquid level, no matter the geometry of the reservoir, can be conducted by electrical scale which measures the weight of the reservoir continuously.

In the devices of this type, the measuring tracks or magneto strictive converters for force measuring are used, Figure 3d.

In the Figure 3e the method of measuring the level according to differentiating the pressure at the bottom and on the top of the bowl, is shown. The difference of pressure is in linear dependence of the level. In this case it is necessary to know the density of the liquid. The principle of continuous determination of the liquid level according to absorption of radiation, is shown in Figure 3f.

The device consists of the source of the radiation and detector of radiation set so the rays can go through the liquid layer which is in proportion to the level. The output signal of the radiation detector, for adequate liquid, is calibrated directly in the units of the level.

2.2. Capacity converters for continuous measuring of the liquid level

Capacity converters have the shape of the plate or coaxial cylinder with constant longitudinal capacity, Figure 4 [2]. The space between the electrodes is set so that the liquid can easily fulfil the interspace to the level equal to the liquid level. The good feature of the capacity converters is that they don't have the moving parts so that they are not prone to wearing out. Besides that, the prices of these converters are relatively low, and the accompanying circuits are mostly of the simple construction.

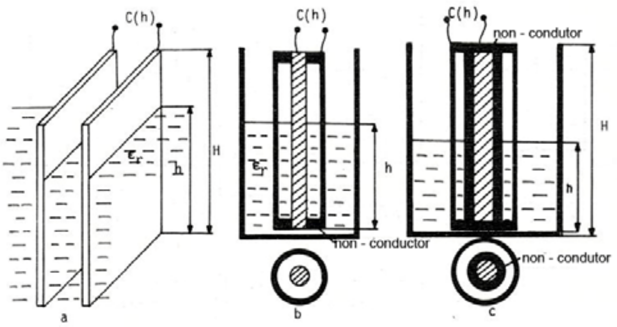

Figure 4. Capacitive transducers for continuous level measurement

The plate and coaxial converters are used for measuring the liquid levels which, in electrical view, conduct as good dielectrics. For example, those are different oils, gasoline, petroleum, all liquid carbon dioxides. Frequently, only one electrode is used at the plate converters for measuring the level of dialectical liquids, and it is set in parallel to the metal wall which plays the part of the other electrode. Coaxial converter is used for measuring with liquids which act as conductors. Those are piped water, water from rivers and seas, and different acids. In order to disable the galvanized contact between the electrodes, the inner electrode is covered with the layer of the isolator of constant thickness. In the part of the converter which is sunk into the liquid, only isolator of the inner electrode serves as the dielectric. The converter above the liquid level has the shape of cylindric capacitor, with the doble layer of dielectric, one of which is the air. The common feature of all capacity converters for continuous measuring the liquid levels is that their capacity is near linear to the function of the level [2].

2.3. The bridges for measuring the levels by capacitive converters

In Figure 5, there are typical alternate measuring bridges for measuring the levels by capacitive converters. The power supply of the bridges is conducted from the sinus generator while the instrument for measuring effective values at the voltage is used as the indicator. The first bridge is of symmetrical type. The balance of the bridge is achieved by variable capacitor C1 in the zero or some other referenced position.

The output signal of the bridge represents nonlinear function of capacitance, so the scale of the voltmeter is nonlinearly calibrated by the level.

The second bridge also has symmetrical construction, whereby the secondaries of symmetrical transformer play the part of two branches. The bridge is characterized by some advantages because of the small impact of parasite capacitance of the converters C1 and C2. The variable capacitor Cd is used for balancing the bridge.

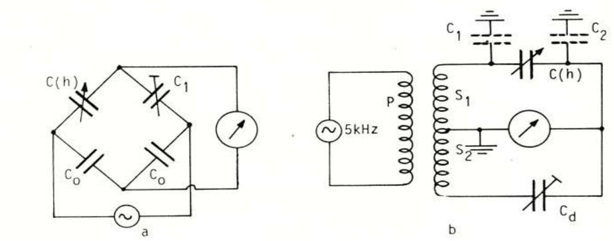

Figure 5. Alternating bridges for level measurement with capacitive transducers

2.4. The method of discrete measuring of the liquid level

The devices for discrete measuring of the liquid levels give the discrete signal when at one moment the level surpasses some certain critical value, Figure 6. The signal is used for automatically protection of overflowing the reservoir, or as the alarm in case when the liquid level drops below the lowest value allowed.

In case of conductive liquids, the pair of electrodes which act as an open switch in the air, and as a closed switch in the liquid, is used as the most simplified conductor, Figure 6a.

For dielectric liquids the small aerial capacitor, whose capacitance increases dramatically at the moment of sinking, is used, Figure 6b.

In Figure 6c there is the device with self-heated resistors vertically set at equal mutual space. Converters are included in relay devices on whose ends there are the lightbulbs. When the resistor is in the air, the output signal is equal to the zero and the adequate lightbulb does not light up. The converters sunk in the liquid give the signal so that the adequate lightbulbs light up. Thus, the indicator with the lightbulb gives the quasi-continuous Figure from which the current level can be seen.

Optoelectronic conductors for discrete measuring of transparent and non-transparent liquids are shown in the Figures 6d and 6e. The sensor for transparent liquids consists of the prism, light bulb and photo electronic detector.

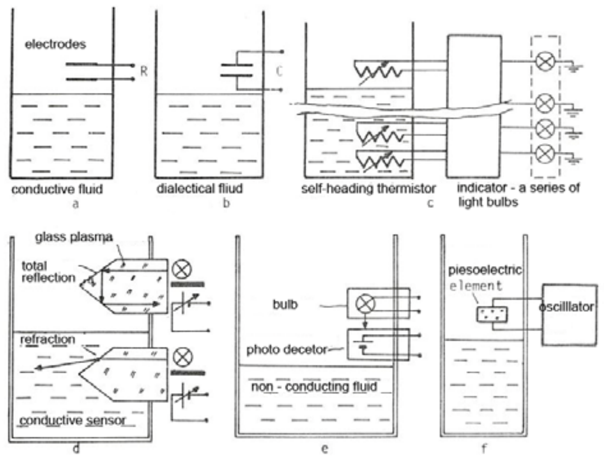

Figure 6. Discrete methods of liquid level measurement

For non-transparent liquids it is enough to set the lightbulb and the photodetector one opposite the other. At the moment when the non-transparent liquid fills the space between the lightbulb and the detector, the change of the output signal occurs.

In Figure 6f there is the discrete method of measuring where piezoelectric and magnetoelectric vibrator switched as the oscillatory element of some oscillator, are used as the converter. When the converter is in the air the damping has the low values, the oscillators can keep up. When the liquids come into contact with the converter, mechanical loses increase which cause the end of oscillations of the oscillator. The disappearance of the output voltage from the oscillator represents the signal when a set level is surpassed. The advantage of this method is that it doesn't depend on electrical or optical characteristics of the fluids.

2.5. The description of the fuel level measuring on the existing BVP M-80A

The reservoirs for fuel are located in the middle of the back part of the fighting vehicle. They are made from aluminium sheet and set on the front and back carrier of the reservoir, and covered by the felt sealants. Showing the fuel level in the reservoirs is conducted from the indicator of the fuel level to the control panel of the driver, by including the switch of the fuel level indicator for left and right reservoir.

BVP M-80A has got electrical fuel level giver type 403, and the electrical fuel level indicator is used as an indicator, type 404, which were produced by Teleoptik from Zemun [1].

The electrical fuel level is of the potentiometer type. The position of the scroller on the potentiometer is determined by the position of the float in the reservoir. Otherwise, when the reservoirs are smaller, when the precision is not obligatory (e.g., cars), the indicators with float fastened by the lever which rotates around the immobile support, are used. The other end of the lever moves the scroller of the round potentiometer, thus getting the electrical signal proportional to the level.

The electrical fuel level indicator servers for pointing the fuel level together with the giver (Figure 7). It is made with the electrical scale inbuilt in a metal protective box with the inner lightning of the dial. It works on the principle of electromagnetic coupling, crossed coil and rotating magnet. Including the indicator in the circuit, the hand takes the position which matches the fuel level in the reservoir.

Figure 7. Type 404 fuel gauge

When the fuel level in the reservoir decreases to the value between 1/6 and 1/9 of the reservoir volume, the signal contact switches off, and the lightbulb signalling the fuel level switches on (the red light turns on). This is enough to make a warning to the driver that the reservoir should be refilled. Electric fuel level indicator is built in the control panel at the angle of 15^{o} to 90^{o}. That is the angle which the flat line of the dial makes the horizontal flat line. It is protected from the water breaking into it on the front side. Rated voltage is 24V in one way. The giver and the indicator are connected by the cable electric installation, according to the scheme connection in Figure 8 [1].

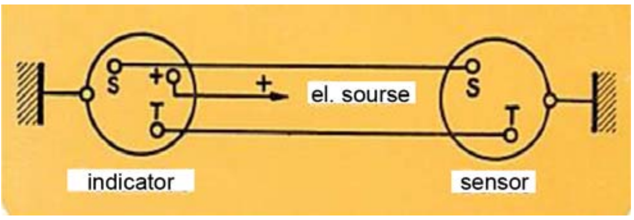

Figure 8. Schematic of the connection of the transmitter 403 and the pointer 404

2.6 The description of the measuring of the fuel level in the reservoirs on the prototype and modernized BVP M-80AB1

The HYDAC system for showing the liquid level is applied on the prototype I of modernized BVP M-80AB1. HNT 1200 is chosen as the giver (Figure 9). It is the magneto strictive sensor with extremely precise measuring of the liquid level. The available lengths of the sensor are from 250 to 700 mm. In this case, the sensor HNT1226-B-0410-000 with the output signal from 0 to 10V, the length 410 mm, is chosen, and it is due to the construction of the reservoir on the modernized IFV. The output signal enables the connecting with every measuring and control devices from HYDAC ELEKTRONIC. HYDAC offers the givers HNT1200 in the main box made of noncorrosive steel, resistant to the pressures, for implantation in the reservoir. Two fuel level givers were needed for the implantation, one on every reservoir

Figure 9. HYDAC HNT 1200 magnetostrictive transmitter

The principle of the measuring for this giver is based on measuring the time of the signal passing (ultrasound range) through the medium (Figure 10). The ultrasound time passing is proportional to the distance and it is measured electronically [4].

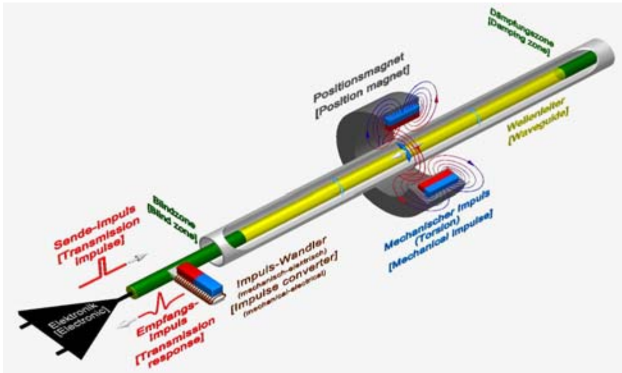

Figure 10. Principle of operation of a magnetostrictive sensor

Ferromagnetic wire (magnetostrictive measuring element, waveguide) is set in the protective pipe and the impulse of the current passes through it. The current impulse makes radial magnetic field around the wire. The contactless magnetic system which generates vertical magnetic field relative to the wire, is used as the position sensor (the permanent magnet). When the two magnets meet at the measuring point, the torsional impulse starts off radially from the wire and vertically from the floating magnet, this torsional impulse moves as the structural one in both directions of the wire.

Ultrasound signal is recorded by the converter in the head of the sensors and is converted in the output electric signal. The time difference between the starting impulse and returning torsional impulse is corrected to the output signal by the measuring electronics, which is proportional to the moving and makes it available as analogue or digital signal, which is pointed on the pointing device. These givers are precise, they can be used for oil level measuring, but are very expensive, 300 euros [4].

As the indicator for these sensors HYDAC offered digital unit HDA 5500. HDA 5500 are microprocessor, controlled units for display and supervision, designed for installation in the laboratories. There are different versions available with three analogue inputs maximum, analogue output and up to four relay outputs. Analogue input signals are displayed in accordance to the settings the user chooses. In our case we used HDA5500-0-1-DC-000 device, which has one analogue input.

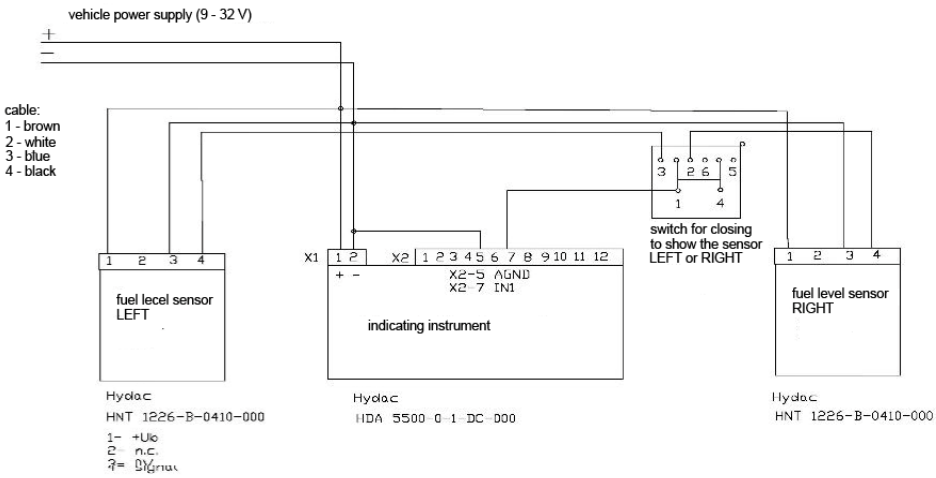

Figure 11. - Electrical connection diagram of the fuel level measurement system in BVP M-80AB1

With the help of the switch the display of the fuel level is enabled in the left or right reservoir depending on the position the switch is in. All those devices are interconnected by cable installation according to the given electric scheme of connecting (Figure 11).A new place for installation had to be chosen because of its construction and the lack of the space on the existing control panel, and the previous device was round and a lot smaller. The switch for choosing the left or right sensor had to be moved too. In Figure 11 there is a new place for installation shown, and the device with the switch too.

The sensor chosen was not satisfactory because of the temperature characteristics (work on 0° -50° C), so as due to low mechanical characteristics caused by vibrations appearing on the spot of installation on the vehicle. Namely, designed for the work in the laboratory conditions, so it cannot be used for the installation, and for that reason it was necessary to choose a new indicator for BVP M-80AB2. Due to the price of the sensor used it was necessary to consider a new fuel level giver. A new electronic installation had to be set because of the change of the indicator and the giver, and the place of the installation.

3. THE DEVELOPMENT OF THE SYSTEM FOR FUEL LEVEL MEASURING ON THE PROTYPE AND MODERNIZED VEHICLE BVP M-80AB2

For the prototype II, a new modernized vehicle BVP M-80AB2, and due to the working conditions and price, it was necessary to choose new fuel level givers, so as a new indicator. Namely, the previously chosen system installed on the protype I, was not satisfactory considering all the conditions set.

While choosing the indicator the place for installation, the construction of the reservoir and its dimensions all had to be considered. In comparison to the giver chosen, an adequate indicator had to be chosen, considering the chosen giver, whereby the place for installation on the control panel of the driver had to be considered also.

3.1. Choosing the fuel level sensors

The device VDO Ø54 mm Fuel tubular sender 400 mm was chosen considering the conditions set for the fuel level sensor. The label of the type: VDO 224-011-000-400G (Figure 12). This is the tubular sensor of the fuel level with the resistance (empty-full) 74.9-2.5 Ω, length 400 mm diameter of the tube 54 mm, voltage 24 V. Temperatures for functioning -25° to 65° C [3].

Figure 12. Place of installation of indicator with switch

The principle of functioning of the tubular devices is somewhat different in comparison to potentiometer devices. The fuel goes through the technological hole which is located at the bottom of the device, to the protective nozzle. The float is on the surface of the fuel. As the result of the element position change, there is a change of the resistance with increasing or decreasing the fuel level.

When the fuel reservoir is full, the float is on the top of the protective nozzle. With decreasing of the fuel, the float drops, which causes the increase of the resistance in the area of the wire.

The fuel level giver is chosen according to the dimensions of the reservoir. As the depth of the reservoir is 400 mm, there will be a certain amount of the fuel which the giver will not be able to show, but regardless to that, it is necessary to refill the reservoir as soon as the scale on the indicator comes ear zero.

VDO is well-known producer of the givers and indicators. It is used in automobile industry and shipbuilding. The price is 100euros, which is more acceptable in comparison to HYDAC.

3.2. The choosing of the fuel level indicator in the reservoirs according to the giver chosen

The device VDO Cockpit International Fuel level 90-0.5 Ω, 52 mm, 24 V (Figure 13) was chosen as the fuel level indicator. The label of the type: VDO 301-040-002G.Temperatures for functioning -30^o to 85^o C. Operating voltage 21.5-30V dc [3].

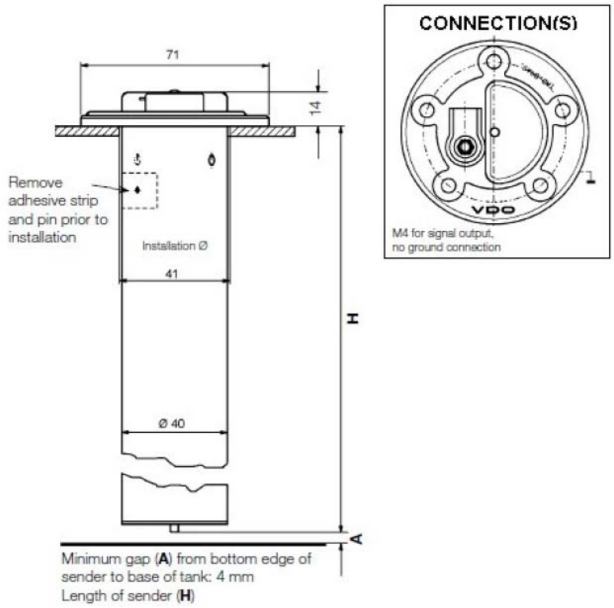

Figure 13. VDO fuel level sender

3.3. Choosing the place for installation of the fuel level giver

The characteristics of the indicator which VDO offers for installation on the existing control panel are: diameter 52mm, operating voltage 24V, signals empty-full: 90-0.5 Ω. Due to these characteristics the installation is possible on the existing control panel (Figure 14), i.e., on the place the giver and the indicator were installed first on BVP M-80A, Figure 15.

Figure 14. Place of installation of indicators and switches

The chosen indicator satisfies the demanded conditions in the view of operating on the temperature and vibrations which appear on the vehicle. And due to its construction and the mode of connecting- it is more acceptable than HYDAC's device which is installed on BVP M-80AB1. Namely, now it's possible to install the indicator and the switch on the same place on the control panel as in BVP M-80A.

Figure 15. VDO fuel level indicator

3.4. Electrical schemes and installation for connecting the giver and the indicator

These are the demands which are defined with modernization of infantry fighting vehicle:

When installing new devices in modernized BVP M-80AB1/AB2 there must not be degradation in the supplying of the power for consumers and recharging of the batteries, in comparison to BVP M-80A.

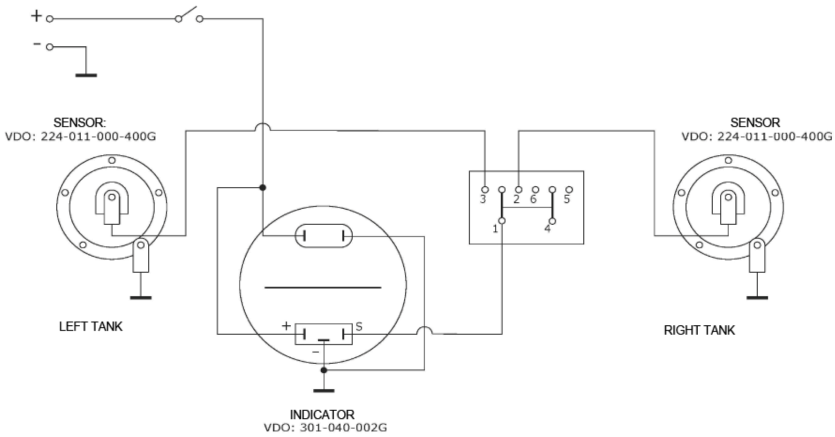

Figure 16. Connection diagram

Electrical installation needs to be rated voltage 24V and there needs to be the switch of the mass. Electrical installation, electrical devices and systems, and measuring and control devices of BVP M-80AB1/AB2 should be produced class K2 according to SORS 5706. Other demands for electrical equipment which is not modernized should be in accordance with PKP electric equipment of BVP M-80A. In modernized BVP M-80AB2 the existing electrical installation and electrical equipment will be kept with reparation and instalment of extra installation considering the needs of voltage of the new components installed of the modernized set (TKI equipment).

All devices in new system should be connected by cable electrical installation according to the scheme of connecting. In Figure 16, the scheme of connecting and electrical installation for newly installed system for fuel level display is presented.

4. CONCLUSION

For modernized BVP M-80AB2 it was necessary to design technical solution of the fuel level tracking system in the reservoir. First, the available methods and existing givers used for this kind of measuring were analysed. Then, the previous solutions of these systems of continuous track fighting vehicles were analysed. The analysed systems included BVP M-80A and prototype I BVP M-80AB1. In the next phase, the sensor adapted to the demands and conditions of the vehicle was chosen. The sensor chosen was the one which can be installed on provided places on the reservoirs, meets the demands and the price is lower than in previous solution. The sensor selection made it possible for the indicator to be chosen in the system which accomplished full functionality and satisfies temperature and mechanical demands, and fits in the old place on the control panel. The problem of placing the indicators, which occurred in previous solution, was avoided by this. In the end, electrical scheme for connecting the system elements was defined. Thus, the system allowing the fuel level tracking in the reservoirs of BVP M-80AB2 was completed. At the moment, the check of the vehicles operating is being conducted on the field.

5. Refferences

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