



ROTARY TORQUE SENSOR DCM-140(R)

Operation Manual

PLA140.203.000.000 RE

Rev. 02

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This Manual provides information for service personnel how to perform installation, commissioning and maintenance of the Rotary Torque Sensor DCM-140(R) (hereinafter referred to as the DCM-140(R)).

The DCM-140(R) exploitation is allowed to be used by personnel who has studied this manual, set of exploitation documentation and passed safety training.

The DCM-140(R) is intended to control of the rig's rotary driven shaft torque and revolutions for the following drilling parameters calculation: ROTARY TORQUE and ROTARY RPM. The sensor is made as part of the DEL-150 Drilling and Well Workover Monitoring System (hereinafter referred to as the DEL-150).

Scope of application is explosive zones of premises and outdoor facilities according to Ex-marking. The DCM-140(R) is manufactured in accordance with the requirements of ISO 9001:2015.

In order to exclude the possibility of mechanical damage, violation of electroplating and paint coatings, the rules of storage and transportation of the device should be observed. When studying the rules of operation, it is also necessary to be guided by the technical description and operating instructions of the DEL-150 System.

The DCM-140(R) housing is a cylindrical sleeve with flanges at the ends for mounting in a cardan drive mechanism, in which it is necessary to control the amount of torque. One of the flanges has a radial hole covered with a lid. A PCB and a battery power supply unit are located inside the housing. Strain-gauge elements are glued on the inside surface of the housing. There is a cylindrical channel in which a radio module with antenna and LED are placed on the side wall of one of the flanges. The Signal Transducer PS-150 series is required to establish wireless communication between the DCM-140(R) sensor and the MU-150 / MU-150E / MK-140 unit of the DEL-150 System.

1. Technical Characteristics

Name of parameter	Value
Minimum measurement limit, kN·m	0.1
Maximum measurement limit range, kN·m	7...22*
Accuracy, %FS	±1.5
Output signal	Digital
Communication protocol	Modbus
Power supply from the battery, VDC	7.2
Battery lifespan, months	18
Distance range between sensor and the Signal Transducer for stable wireless communication, m	0.2...3
Ex marking, TR CU 012/2011	1ExdbIIBT6GbX
Ex marking, ATEX	II2GExdbIIBT6Gb
Ingress protection	IP65
Ambient temperature range, °C	-45...+65
Dimensions, mm	Ø230* x 110
Weight, kg	14.1*
Service life, min., years	10
Recommended calibration interval, months	12

* depends on the DCM-140(R) configuration

2. Explosion Safety During Operation

Explosion protection is provided by enclosing the electrical parts of the sensor in an explosion-proof housing ("d" type of explosion protection).

3. Requirements for Keeping Equipment Specifications that Cause its Explosion Safety

During operation, it is forbidden to break the seals and open the DCM-140(R) housing.

The Signal Transducer PS-150 series is required to establish wireless communication between the DCM-140(R) sensor and the MU-150 / MU-150E / MK-140 unit of the DEL-150 System. When the MU-150 / MU-150E / MK-140 unit of the DEL-150 System is switched on, it is forbidden to connect and disconnect cable from the Signal Transducer, power cable and grounding conductors. In case of malfunctions, it is necessary to turn off the MU-150 / MU-150E / MK-140 unit and disconnect the power cable from the power source. Then replace the faulty Signal Transducer with a serviceable one by connecting it according to the documentation (operation manual for the DEL-150).

During operation, check the condition of communication cables periodically. If a violation of the protective layer on the

cable lines is detected, replace the damaged cable immediately.

Do not allow sealing violations. If a damage is detected, replace the faulty equipment.

Ensuring explosion safety during operation is according to the safety regulations, applicable to the equipment with which (or as part of which) the equipment is used.

Replacement of the sensor's battery is allowed only outside the explosive zone.



ATTENTION!!! During operation, it is necessary to monitor the equipment status and its cables. In case of any mechanical damage of the equipment or any of the cables connected, further operation is strictly prohibited!

4. Operating Principle

The DCM-140(R) converts mechanical deformations (twisting) into an electrical signal proportional to deformations. Then, using data from non-volatile memory entered during calibration, the DCM-140(R) calculates the torque value as well as rotation speed. The result is converted into a digital code and transmitted over the radio channel to the MU-150 / MU-150E / MK-140 unit of the DEL-150 System via Signal Transducer PS-150 series for recording and viewing.

5. Installation



NOTIFICATION. Installation and further commissioning of the equipment should be carried out only by qualified specialists.

Before installing the DCM-140(R), it is necessary to make sure that:

- Basic dimensions at the processing facilities correspond to the dimensions of the DCM-140(R) (see Fig. 1);
- Fixing bolts and screws are present;
- There is no damage of the Signal Transducer's connector insulation;
- There is no external damage of the components;
- There is no damage of insulation of the signal cable between the Signal Transducer and the MU-150 / MU-150E / MK-140 unit.

Disregard of this instruction may lead to a serious failure of the DCM-140(R).



ATTENTION!!! When dismantling the DCM-140(R) sensor, it is strictly forbidden to use a cutting tool (angle grinder, etc.), as well as a cutter or welding equipment to exclude heating of the DCM-140(R) housing to high temperatures. Disregard of these instructions may result in serious failure of the DCM-140(R).

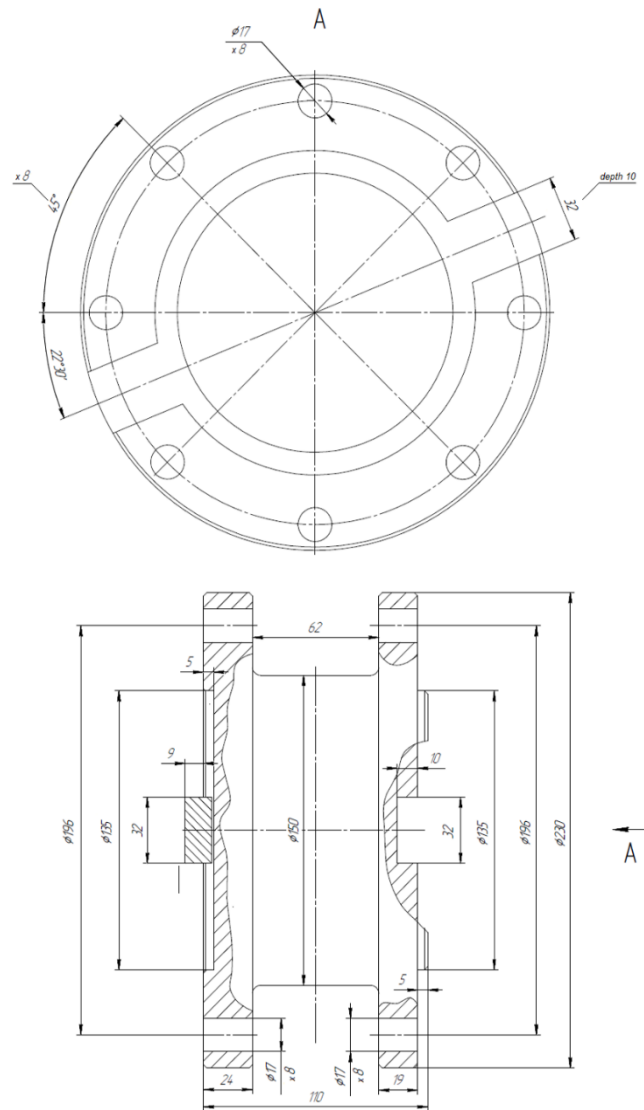
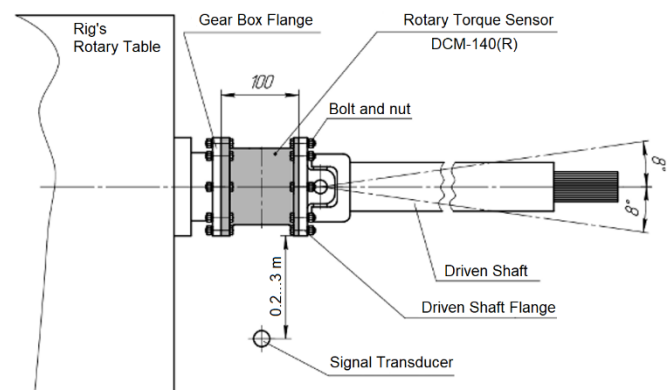


Figure 1. Example of the DCM-140(R) overall dimensions

The DCM-140(R) is installed on the rig's rotary flanges between gear box flange and driven shaft flange (see Fig. 2, 3).



Deviation of the driven shaft with respect to the rotary gear box shall not exceed 8 degrees

Figure 2. Installation drawing of the DCM-140(R)

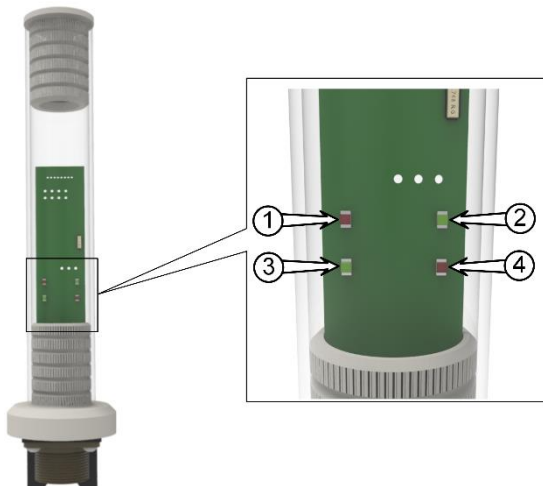


Figure 3. Installation example of the DCM-140(R)

The DCM-140(R) communicates with the MU-150 / MU-150E / MK-140 unit of the DEL-150 System via the PS-150(R) or PS-150(RA) Signal Transducer. Both of Signal Transducers are connected by the WY20/WY20 universal commutation cable to the MU-150 / MU-150E / MK-140 unit and are installed at a distance of no more than 3 meters in line of sight from the DCM-140(R).

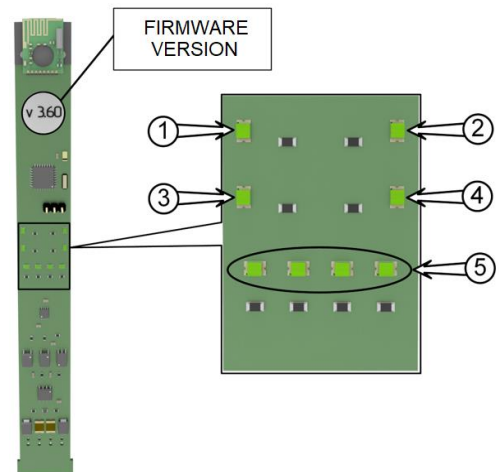
5.1. The PS-150(R) Signal Transducer

The PS-150(R) is made in a transparent enclosure, which allows to observe LEDs located on the board when the transducer works (see Fig. 4 and Fig. 5).



1. **Power Supply.** LED lights up constantly when the power is on;
2. **Connection.** LED blinks when receiving data from the DCM-140(R);
3. **Low Battery Charge.** LED lights up when the battery is low;
4. **Connection Error.** LED lights up briefly when communication errors occur or lights up constantly when communication with DCM-140(R) is lost.

Figure 4. The PS-150(R) Signal Transducer (type #1)



1. **Power Supply.** LED lights up constantly when the power is on;
2. **Connection.** LED blinks when receiving data from the DCM-140(R);
3. **Low Battery Charge.** LED lights up when the battery is low;
4. **Connection Error.** LED lights up briefly when communication errors occur or lights up constantly when communication with DCM-140(R) is lost.
5. **Battery Charge Level.**

Figure 5. The PS-150(R) Signal Transducer (type #2)

The PS-150(R) has the following technical characteristics:

Name of parameter	Value
Frequency range, GHz	2.4
Output power, mW	15
Max. distance for stable wireless communication, m	3
Power supply range, VDC	12...18
Ex marking, TR CU 012/2011	1ExibIIBT5Gb
Ex marking, ATEX	II2GExib[ib]IAT3Gb
Ingress protection	IP65
Ambient temperature range, °C	-45...+65
Dimensions, mm	Ø30 x 150
Weight, kg	0.2

The PS-150(R) has nameplate with the Firmware version (see Fig. 5). The 3.60 and above versions are suitable to communicate with the DCM-140(R) sensors that are equipped by both, "black" and "white" radio modules (see Fig. 6), however, this version is set up for "black" radio module by default. To adjust the PS-150(R) to the required DCM-140(R) it is necessary to connect to the Signal Transducer by USB-RS485 converter and service cable, to setup dedicated COM-port in the browser and using the MBarw service software set the value of register #9 to "00001" for "black" radio module (see Fig. 7) or to "00257" for "white" one (See Fig. 8). Press the "Write" button then.

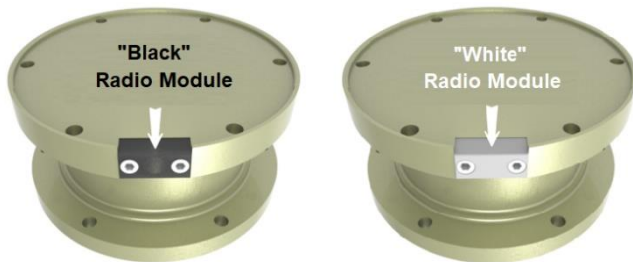


Figure 6. Types of radio module of the DCM-140(R)



NOTIFICATION. The PS-150(R) with the Firmware version earlier than 3.60 is suitable to communicate with the "white" radio module only.

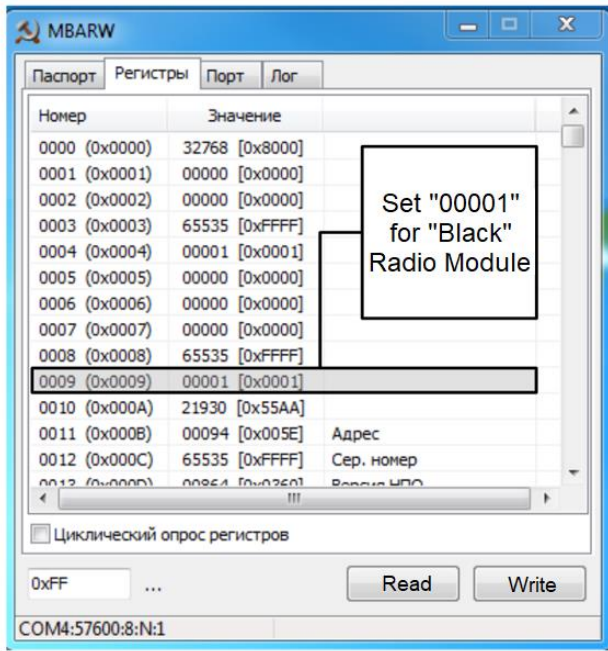


Figure 7. MBARW service software interface (the PS-150(R) setup)

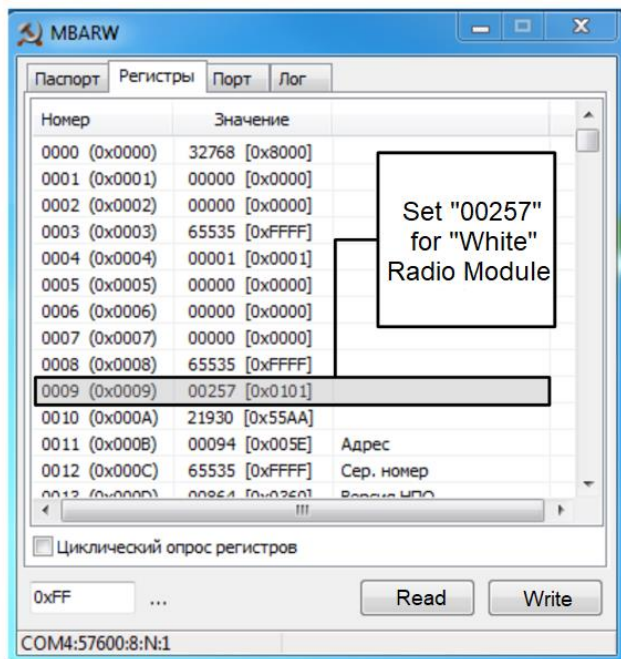
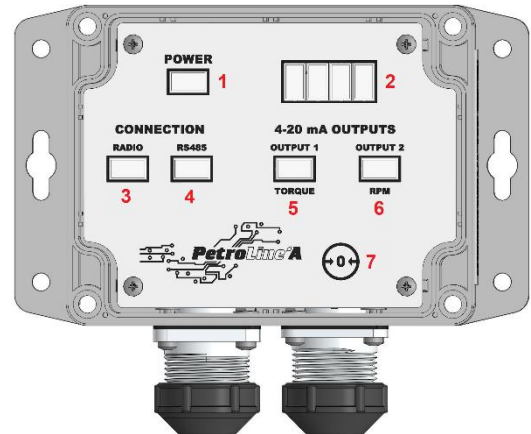


Figure 8. MBARW service software interface (the PS-150(R) setup)

5.2. The PS-150(RA) Signal Transducer

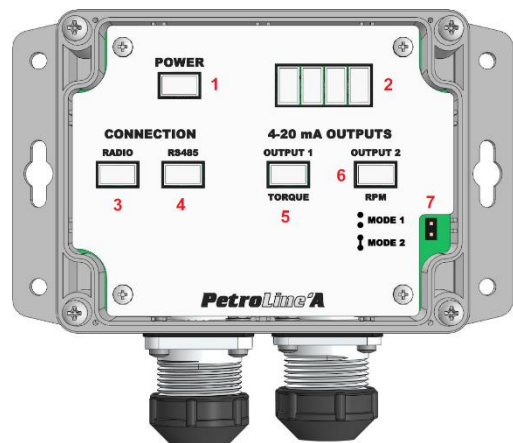
The PS-150(RA) Signal Transducer is intended to interface with the 3rd party equipment. It provides communication with the DCM-140(R) as well as 4...20 mA analogue outputs proportional to the ROTARY TORQUE and ROTARY RPM parameters to external equipment.

This Signal Transducer includes two modifications: with and without switch of the working mode (See Fig. 9 and Fig. 10). The switch allows matching the PS-150(RA) to the "black" or "white" radio module of the DCM-140(R) sensor.



1. **Power Supply.** LED lights up constantly when the power is on;
2. **Battery Charge Level.**
3. **Radio.** LED blinks by green in normal operation, lights up briefly by red when error occurs and lights up constantly by red when communication is lost;
4. **RS-485.** LED blinks when receiving data from the DCM-140(R);
5. **Torque.** LED lights up constantly;
6. **RPM.** LED lights up constantly;
7. **Reset button.** Zeroing of the ROTARY TORQUE parameter.

Figure 9. The PS-150(RA) Signal Transducer without switch



1. **Power Supply.** LED lights up constantly when the power is on;
2. **Battery Charge Level.**
3. **Radio.** LED blinks by green in normal operation, lights up briefly by red when error occurs and lights up constantly by red when communication is lost;
4. **RS-485.** LED blinks when receiving data from the DCM-140(R);
5. **Torque.** LED lights up constantly;
6. **RPM.** LED lights up constantly;
7. **Switch.** MODE 1 corresponds to the "black" radio module of the DCM-140(R), MODE 2 corresponds to the "white" radio module.

Figure 10. The PS-150(RA) Signal Transducer with switch

The PS-150(RA) has the following technical characteristics:

Name of parameter	Value
Accuracy of DAC, %FS	± 0.25
Qty of the analogue outputs, ea.	2
Analogue output range, mA	4...20
Load resistance range, Ohm	0...250
Number of DAC bits	16
Conversion function of the input signal	Linear
Digital output interface	RS-485
Digital output communication protocol	Modbus
Power supply range, VDC	10...30
Power consumption, max., W	1
Ex marking, TR CU 012/2011	1ExibIIBT5Gb
Ex marking, ATEX	II2GExib[ib]IIAT3Gb
Ingress protection	IP65
Ambient temperature range, °C	-45...+65
Dimensions, mm	150 x 110 x 55
Weight, kg	0.2

The PS-150(RA) with the Firmware version 4.21 and above are suitable to communicate with the DCM-140(R) sensors that are equipped by both, “black” and “white” radio modules (see Fig. 6), however, this version is set up for “black” radio module by default. To adjust the PS-150(RA) to the required DCM-140(R) it is necessary to connect to the Signal Transducer by USB-RS485 converter, service cable and using the mm_calibrat service software perform the following adjustments:

1. Setup dedicated COM-port in the browser;
2. Setup COM-port in the mm_calibrat software by clicking button 1 (see Fig. 11):
 - PORT: is the same one that was selected in the browser earlier;
 - The rest of parameters according to the field 2 on Fig. 11;
3. Click Save button 3;
4. Click Run button 4;
5. Check the Signal Transducer's serial number in the field 5;
6. Chose the required check box in the field 6:
 - CRC8 – “white” radio module of the DCM-140(R);
 - CRC16 – “black” radio module of the DCM-140(R);
7. Restart power supply of the Signal Transducer to check settings.



NOTIFICATION. The PS-150(RA) with the Firmware version earlier than 4.21 is suitable to communicate with the “white” radio module only.

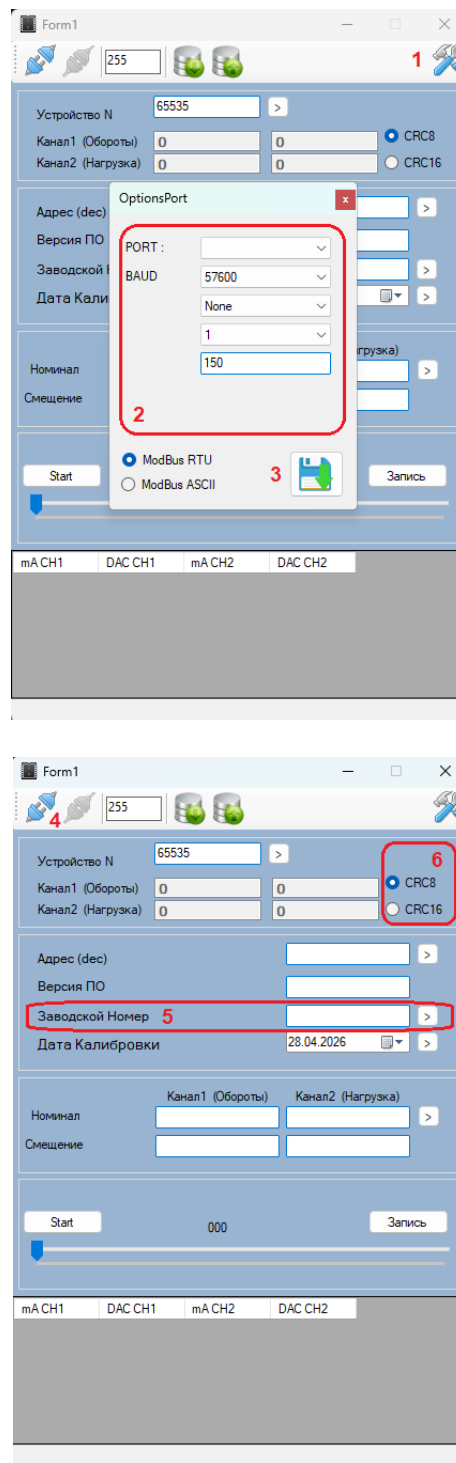


Figure 11. mm_calibrat service software interface (the PS-150(RA) setup)

For zeroing of the readings at the analogue output, it is necessary to press and hold the reset button of the PS-150(RA) for 10 seconds (see Fig. 9). After that, the current value will be recorded in non-volatile memory and the readings of the analogue output will be adjusted by this value.

The PS-150(RA) has two analogue outputs with the following settings:

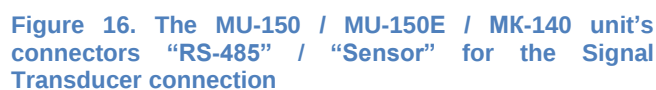
- ROTARY RPM: 4 mA = 0 RPM, 20 mA = 300 RPM;
- ROTARY TORQUE: 4 mA = 0 kN*m, 20 mA = 10 kN*m.

Adjustment of the outputs' values are performed via the

The PS-150(RA) has a few configurations suitable for different applications. The PS-150(R3A2) is used for separation plugs for both, ROTARY TORQUE and RPM signals. The PS-150(R2V2) is intended for providing analogue outputs in 1...5 VDC range. The associated connection drawings are shown on Fig. 12, 13, 14.



The cable from the Signal Transducer is connected to any of the connectors of the MU-150 / MU-150E / MK-140 unit marked "RS-485" / "Sensor" (see Fig. 16).



For functional test of the DCM-140(R) it is necessary to communicate the sensor with the Signal Transducer PS-150 series, to connect the Signal Transducer to the MU-150 / MU-150E / MK-140 unit then, to turn power on and to make sure that the parameters ROTARY TORQUE and ROTARY RPM are displayed on the MU-150 / MU-150E EL screen (see Fig. 17).



- “Active Mode”. LED that is located on the DCM-140(R) blinks synchronically with LED #2 of the PS-150(R) (see Fig. 4, 5) or with LED #4 of the PS-150(RA) (see Fig. 9, 10);
- “Standby Mode”. LED that is located on the DCM-140(R) blinks ones per 3 sec.

If the connection with the DCM-140(R) is lost, the following symbols are displayed opposite ROTARY TORQUE and

ROTARY RPM parameters on the MU-150 / MU-150E EL screen:

Malfunction	Possible Reason	Troubleshooting
Symbols "----"	• The commutation cable to the Signal Transducer PS-150 series is damaged; • The Signal Transducer outage	• Checking of integrity of the commutation cable; • Reconnection of the commutation cable to free connector of the MU-150 / MU-150E / MK-140 marked "RS-485" / "Sensor"; • Replacement of the Signal Transducer
Symbols "???"	• The DCM-140(R) sensor's battery is discharged (LED blinking is absent); • Distance from the Signal Transducer to the DCM-140(R) is more than 3 m.; • The DCM-140(R) outage	• Battery replacement; • Adjustment of distance between the Signal Transducer and the DCM-140(R); • Replacement of the DCM-140(R)
Parameter is absent	• The commutation cable is damaged; • The Signal Transducer outage; • The MU-150 / MU-150E / MK-140 unit's PCB RS-485 outage; • Sensor address is not correct	• Checking of integrity of the commutation cable; • Reconnection of the commutation cable to free connector of the MU-150 / MU-150E / MK-140 marked "RS-485" / "Sensor"; • Checking of sensor address according to the DEL-150 System Operation Manual

9. Settings of the DCM-140(R)

When the sensor installation is completed, it is necessary to turn on the MU-150 Control Module and to enter the setting mode using the MU-150's keyboard (see Fig. 18).



Figure 18. The MU-150 Control Module keyboard

Proceed in the following order to reach out required parameter:

1. Unblock the keyboard by pressing **SHIFT** + **ENTER** simultaneously;
2. Enter OPERATING PARAM'S menu by pressing **SHIFT** + **3** simultaneously;
3. Use  ,  and **ENTER** to select required parameter. To return to the previous menu, use **ESC** .

9.1. Setting of ROTARY TORQUE Parameter

	
Setup the required settings is described below	

- **MAX / MIN** – the maximum and minimum values that are required for activating alarm and relay output. Alarm is activated when 95% of this value is reached. When 100% is reached, the assigned relay of the MU-150 / MU-150E / MK-140 blocking unit (if available) will change its state (i.e. it will close or open the electrical circuit of the actuator);
- **SET ZERO** – zeroing of the parameter value by pressing



- **FACTOR** – rotary gear ratio that is available in the rotary technical specification. As soon as the DCM-140(R) sensor is attached to the rotary flange directly (see Fig. 19), this gear ratio is set in the FACTOR field. In cases where it is not possible to install the DCM-140(R) on the rotary flange and it is mounted on the flange of an angular gearbox or bearing assembly (see Fig. 20), it is necessary to consider all gear ratios of the mechanisms located between the DCM-140(R) and the rotary table. The required FACTOR will be equal to multiplication of all intermediate values of the gear ratios;

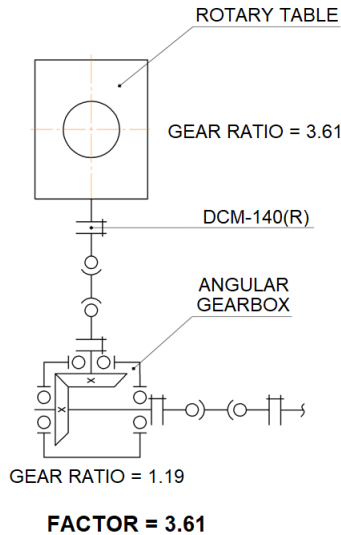


Figure 19. Example of the transmission diagram #1

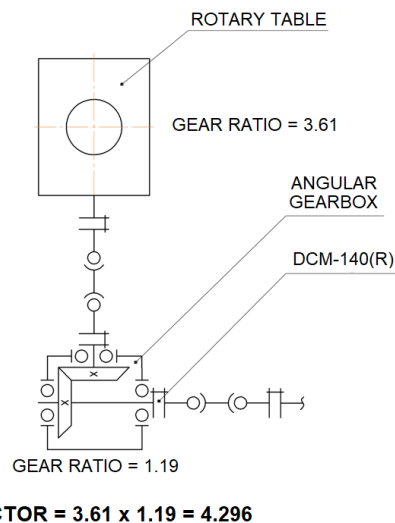


Figure 20. Example of the transmission diagram #2

- **INV.VALUE** – turn on in case ROTARY TORQUE parameter is a negative value;
- **AIN SETTINGS** – setting up an analog input (for using 3rd party sensor with an analog output);
- **AOUT SETTINGS** – setting up an analog output when the PS-150(4K) Signal Transducer is connected;
- **UNITS** – changing of units of measurements.

9.2. Setting of ROTARY RPM Parameter

	H.TONGS ROTARY TORQUE ROTARY RPM TOPDRIVE T.VELOCITY
Setup is similar to the previous described ROTARY TORQUE parameter setup	ROTARY RPM,rpm MAX 00000 MIN _____ FACTOR 001.0000 AIN SETTINGS MIN 000000 MAX 000020 AOUT SETTINGS MIN _____ MAX _____

The required FACTOR value can be figured out as described below:

1. Set the value "1" for the FACTOR;
2. Run the rotary table on the rig with known rotational speed (N1);
3. Check the value of the ROTARY RPM parameter shown in the DEL-150 System (N2) while running rotary table;
4. Calculate FACTOR as N1/N2;
5. Set this new calculated value in the FACTOR field.

10. List of Critical Failures and Possible Issues in Maintenance Leading to Equipment Failures and Actions to Prevent these Failures (troubleshooting)

Incorrect power supply can lead to equipment failure.

Incorrect set maximum values for parameters can lead to incorrect operation of the external controlled equipment if the maximum level for the controlled parameter is exceeded.

A short circuit or a break circuit in the power and communication lines of the Signal Transducer, may cause loss of communication with the sensor with the following failures: lack of parameter data, symbols "?????" or "----" instead of parameter data, lack of data on other parameters.

In case of failure of the sensor or Control Module, it is necessary to check the equipment technical condition according to the Clause #8 of this Operation Manual. If

troubleshooting did not lead to proper operation, it is necessary to stop operation and replace with obviously serviceable equipment. Defective equipment should be sent for repair to the manufacturer or to the specialized authorized service center.

In case of failures that can lead to emergency situations, it is necessary to replace the equipment that has failed. If necessary, disable additional external devices.

11. Maintenance Procedure

Maintenance is carried out in the following order:

1. Cleaning the sensor's and the Signal Transducer's enclosure from contamination;
2. Checking the safety of seals (if available);
3. Checking the presence and strength of the mounting components;
4. Cleaning of connectors and terminals from contamination;
5. Checking for the absence of visible mechanical damages;
6. Replacement and (or) repair of damaged cable products;
7. Replacement of damaged connectors.

The contacts of the connector should be washed with an alcohol-gasoline mixture (need 3 ml.) using a soft brush. Connectors after cleaning and drying should be treated with Vaseline or similar lubricant. It is recommended to treat the threads on the connectors with graphite grease.



NOTIFICATION. Absence of maintenance records in the passport (section "Maintenance Records") **ENTAILS VIOLATION OF THE OPERATION RULES, and the manufacturer has the right to withdraw from warranty obligations**

12. Changing of the Battery Module Procedure



ATTENTION!!! The battery module is replaced only in a safe area

The battery module changing is carried out in the following order (See Fig. 21):

1. Install the DCM-140(R) on a flat horizontal surface and using a tube wrench S24 unscrew the sensor's cap;
2. Disconnect the connector located at the top of the battery module on the board by pressing the connector lock from below;
3. Using a 4 mm hex key unscrew the screws securing the battery module;
4. Remove the battery module;
5. Install a new battery module, first making sure that there are no foreign particles in the sensor and repeat the steps in reverse order. After fixing the battery module, it is necessary to make sure that there is no its backlash relative to the body of the DCM-140(R).



NOTIFICATION. Detachment of the battery module does not affect the DCM-140(R) settings

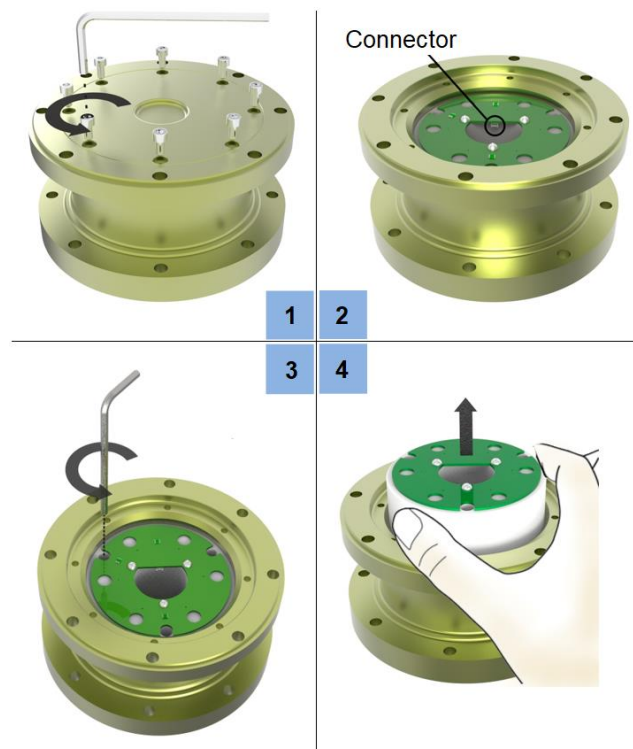


Figure 21. Changing of the battery module



ATTENTION!!! The battery cells are replaced only together with the assembly of battery module (see Fig. 22)



Figure 22. Battery module assembly

13. Limit Conditions Parameters

In case of severe mechanical damage, leakproofness violations, seals violations, heating of parts to unacceptable temperatures, supply of unacceptable currents and voltages, change of calibration data, further use is unacceptable or impractical, or restoration of its serviceable or operable condition is impossible or impractical.

14. Marking and Packaging

The DCM-140(R)'s nameplate includes the following components (see Fig.23):

1. Trademark or name of the manufacturer;
2. Part number;
3. Name and model;
4. Serial number;
5. Manufacturing year;

6. Explosion protection marking together with certificate number;
7. Technical characteristics.

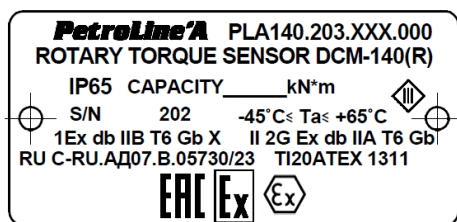


Figure 23. Example of the DCM-140(R) marking

Other data required by regulatory and technical documentation may also be reflected on the nameplate.

Boxes made of plywood with metal handles for carrying are used to transport the DCM-140(R) as part of the DEL-150 System.

15. List of Components

Full completeness is indicated in the passport for equipment released by the manufacturer.

16. Repair

Repair of the DCM-140(R) is carried out at the manufacturer or at a specialized authorized service center.



NOTIFICATION. Absence of repair records in the passport (section "Repair Records") ENTAILS VIOLATION OF THE OPERATION RULES, and the manufacturer has the right to withdraw from warranty obligations

17. Storage

The equipment requires careful handling, storage in dry, clean rooms with a constant temperature from -50°C to +65°C and a relative humidity of no more than 80%.

The long-term storage requires conservation, according to the requirements of the equipment conservation instructions. The equipment arriving at the warehouses in the manufacturer's containers are not unpacked, packed on flat pallets and stacked or in the cells of the racks.

Factory-sealed devices are not allowed to be opened in warehouses.

Small devices and devices arriving in individual packaging are stored in box pallets with installation in a stack.

Devices and components without individual packaging should be stored in shelving cells no more than 3 rows in height with the use of cushioning materials between them.

Small devices and products arriving without packaging can be stored in small-cell racks and cabinets, while devices or products of the same type should be stored in one cell.



NOTIFICATION. Absence of storage records in the passport (section "Storage Records") ENTAILS VIOLATION OF THE OPERATION RULES, and the manufacturer has the right to withdraw from warranty obligations

18. Transportation

Transportation of the equipment is allowed by all types of closed transport. The DCM-140(R) in a package for transportation allows the impact of transport shaking with an acceleration of 30 m/s² with a frequency of 100 beats per minute or 1500 beats with that acceleration.

19. Disposal

The DCM-140(R) is disposed of in accordance with the requirements and norms applicable in the oil and gas industry.

20. Warranty Obligations

The warranty period is 12 months from the date of sale.

A full description of the warranty obligations is described in the equipment passport.

RPE Petroline-A LLC
Address: 53A Lermontova St., Naberezhnye Chelny,
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