Torque measurement
with AksIM

The measurement of torque using rotary encoders plays a decisive role in numerous technical and industrial applications. Torque is a fundamental phenomenon that arises from the action of forces that cause a body to rotate around its axis. This phenomenon is widely used in machines, devices, motors and other systems.

Encoders are devices that enable precise measurement and recording of rotations or movements. When measuring torque, encoders provide important information about the torque exerted on the system. They can be used to monitor operating conditions, improve efficiency, prevent overloads and ensure operational safety. In today's robotics industry, there is a growing demand for robots with higher performance, accuracy and cost efficiency. Magnetic encoders offer a solution to meet these evolving requirements.

Thanks to the smart integration of RLS encoders, we can measure torque with some additional calculations, allowing engineers and users to immediately identify potential problems in the system, monitor its performance and improve maintenance processes. This enables optimization of operation and extension of the system's lifetime, which is crucial for industrial and technical applications where precision, reliability and safety are paramount.

Robotic arm

Measuring torque with encoders and advanced sensor integration

Modern robotics faces significant demands, such as efficiency, low costs, and precision, which can be achieved with the right approach. Often two encoders are installed per joint of a robot to ensure higher accuracy (up to 80% improved), but we can get even more benefits from it. One encoder measures the speed of the motor, while the second encoder measures the actual movement of a joint. Torque in robotic arms is usually measured with torque sensors. There are different types of torque sensors, including strain gauge-based sensors, piezoelectric sensors and optical sensors. These sensors convert the mechanical torque into an electrical signal, which can then be measured and interpreted by the robotic control system. Through the smart integration of RLS encoders, we can avoid the use of these sensors and achieve more with fewer components.

To understand how torque can be measured, we first need to know some basics. Torque is equal to the product of the applied force, the distance between the point of application and the axis of rotation and the sinϕ of the angle between the force and the lever arm.

$$T = r \times F \times \sin\phi \quad (1)$$

So let us assume we want to measure the torque of a rotating hollow shaft (robot joint). With RLS encoders, we can measure the angle of rotation, which can help us determine the deflection of a shaft (similar principle to strain gauges). To achieve this, we need to place one encoder at the input point and one on output point of the rotating part.

Once we have the data from both rotating points, we can calculate the torque by following the steps below. The deflection angle can simply be determined as the difference between two measuring points (2). Please note that both encoders should be positioned at the same starting point.

$$\Delta\phi = E_1 - E_2 \quad (2)$$

$\Delta\phi$ = Angle of deflection [°]
E_1 = Position of Encoder 1 [°]
E_2 = Position of Encoder 2 [°]

Now we need to calculate the polar moment of inertia (J) for our hollow shaft. It is important to remember that each shape has its own J. In this case, J is equal to the second moment of area about the z-axis (I_z) and thanks to the perpendicular axis theorem we can relate it to the second moment of area of the other two axes:

$$J = I_z = I_x + I_y \quad (3)$$

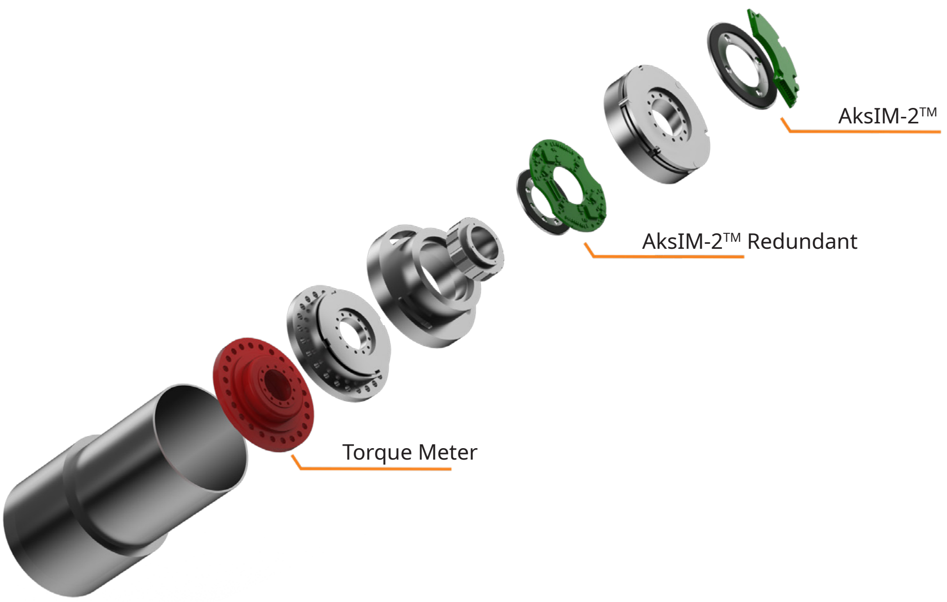
$$J = \frac{\pi(D^4 - d^4)}{32} \quad (4)$$

J = Polar moment of inertia [mm^4]
D^4 = Outer diameter [mm^4]
d^4 = Inner diameter [mm^4]

In this case torque can be simply specified as:

$$T = \frac{G\,J\,\Delta\phi}{L} = \frac{G\,\frac{\pi(D^4 - d^4)}{32}\,\Delta\phi}{L} \quad (5)$$

G = Shear modulus [MPa]
J = Polar moment of inertia [mm^4]
$\Delta\phi$ = Angle of deflection [rad]
L = Length of the shaft [mm]



Robotic joint

When measuring torque with the help of two RLS encoders, torque meter is not required. This kind of principle decreses robot production costs.
For precise results it's also important to measure shear modulus of our rotating hollow shaft (if we take standard ones the results can vary).

Head office

RLS Merilna tehnika d.o.o.

Poslovna cona Žeje pri Komendi
Pod vrbami 2
SI-1218 Komenda
Slovenia

T +386 1 5272100
E mail@rls.si

www.rls.si

Global support

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