

Application of AksIM-2 series encoders in quadruped robots

AIDIN ROBOTICS



Customer:
AIDIN ROBOTICS,
South Korea

Industry:
Robotics

Challenge:
Achieving real-time joint feedback required for whole-body coordination and dynamic balance of quadruped robots.

Solution:
AksIM-2 Off-Axis Rotary Absolute Magnetic Encoder Module

Background

The robotics industry is experiencing significant growth, especially in the field of service robots, which are becoming increasingly popular and versatile. While the industrial robot sector has matured and is seeing slower growth, service robots are evolving with diverse designs, including humanoid and animal-inspired forms. These adaptable machines are set to impact various sectors such as cleaning, security, rescue, catering, and military operations.

AIDIN ROBOTICS, based in South Korea, is leading the charge in this transformation. They have recently introduced a quadruped robot, often referred to as a "robot dog." This advanced robot employs AksIM-2 absolute encoders from RLS, a Renishaw associate company, to provide real-time position feedback, ensuring smooth operation and precise control.

A quadruped robot typically consists of three main components: mechanical parts, including the body,

motors, and reducers; sensors that provide feedback data on position, speed, and torque; and a controller, which acts as the robot's brain.



AIDIN ROBOTICS's quadruped robot

Challenge

One of the significant challenges for quadruped robots is maintaining their balance and controlling dynamic. Robots with excellent balance and dynamic capabilities can perform a range of movements, such as walking, running, jumping, climbing, navigating stairs, getting up after a fall, and leaping. These abilities rely on the performance of joint movements, the quality and stability of motion control, and control laws.

In other words, the robot depends on its motion control systems and control laws to achieve full-body coordination and compliant control. The relevant data, such as the simultaneous position, speed, and acceleration of the joint must be fed back to the controller via rotary encoders. This feedback is critical for accurately controlling the dynamics, movement direction, and speed of the four legs.



Robot display

AIDIN's quadruped robot is an advanced mobile robot designed for legged movement, enabling it to navigate various terrains such as stairs, rugged landscapes, and curved surfaces with ease. It can be equipped with different modular equipment for specific applications, allowing it to replace humans in harsh environments, such as explosive ordnance disposal or tasks in areas contaminated with chemicals and radioactive materials.

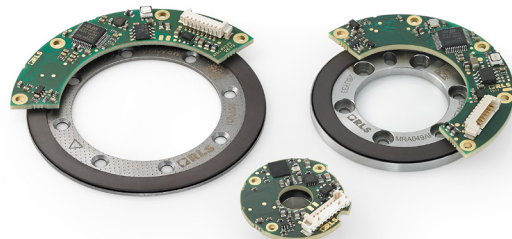
Solution

Each leg is equipped with three axes of rotating joints that control the hip roll, thigh pitch, and calf pitch, with a range of movements up to 60 degrees. This setup offers a total of 12 degrees of rotational freedom across the four legs, enabling movement like that of real quadrupeds. Each joint is driven by a motor and paired with an AksIM-2 series absolute rotary encoder, which provides feedback on the angle of rotation during movement. As a result, the quadruped robot utilizes a total of 12 encoders, ensuring precise control over its motions.

Stable and reliable encoders can significantly enhance a robot's positioning accuracy and motion control capabilities. They are also essential for detecting dynamic loads and preventing motor overload, thereby improving the robot's safety and stability.

For the quadruped robot, the initial "pose" is crucial for overall motion control. The controller needs to know the position of each joint to calculate and determine the robot's current posture. Therefore, AIDIN specified the use of absolute encoders during the selection of components for motion control design. The key advantage of absolute encoders is that they do not require to return to reference after a power outage like incremental encoder, minimizing unnecessary waiting times.

Another key requirement is that the encoder ring scale is of the hollow design, allowing a large amount of cabling to pass through the center. Additionally, designer has to concern if the joint motors generate stray magnetic fields that can interfere with magnetic encoders and cause faulty readings.



AksIM-2 rotary magnetic encoder

Dr. Kim Yong Bum, Chief Technology Officer of AIDIN's R&D department, stated, "RLS' AksIM-2 series is a robot-specific rotary encoder that meets all our demands. Its automatic calibration feature further optimizes installation quality and provides more stable and reliable motion control, which has left a strong impression on me."

Currently, AIDIN has chosen the AksIM-2 series encoder with a resolution of 20 bits, outputting signals via SSI and BISS-C communication protocols.

Results

The AksIM-2 is an absolute magnetic rotary encoder capable of operating within a temperature range of $-40\text{ }^{\circ}\text{C}$ to $+105\text{ }^{\circ}\text{C}$, demonstrating high resistance to shock and vibration. It features a self-calibration function that eliminates errors caused by eccentricity during rotation. Eccentricity is a significant factor affecting encoder accuracy, often resulting from the misalignment of the magnetic ring.

Additionally, the AksIM-2 is equipped with advanced self-monitoring capabilities that continuously check multiple internal parameters. All communication protocols provide error reporting, warnings, and other status signals, which are visualized through an onboard LED.

In the case of the quadruped robot, the inertia generated during movement resembles that of a human walking, introducing non-linear characteristics that complicate the designing of control law. The heavier the robot, the higher the inertia. To effectively address this challenge, the robot's joints are designed with strict spatial and weight limitations, necessitating compact and lightweight encoders.

The AksIM-2 is specifically designed for integration into robotic systems, featuring a readhead designed as a PCB paired with a through-hole magnetic ring. This configuration allows for direct mounting on the motor, making it an ideal fit for the space-constrained architecture of the robot.

Future goals

Dr. Kim stated, "In the future, our quadruped robot will consider adopting a dual-encoder design, meaning that one encoder will be placed at the input and another at the output. By comparing the positional information and speed data from both encoders, as well as the output of the driving current and motor torque, we can assess the magnitude of external forces acting on the joints, thereby enabling safe control of the robot."



AIDIN ROBOTICS team

About RLS

RLS is a Renishaw associate company. RLS produces a range of robust magnetic rotary and linear motion sensors for applications such as industrial automation, metalworking, textiles, packaging, electronic chip / board production, robotics and more.

For more information visit www.rls.si.

About AIDIN ROBOTICS

AIDIN originated from the Robotics Innovation Laboratory in the Department of Mechanical Engineering at Sungkyunkwan University in South Korea. The company focuses on developing and providing robotic solutions for clients such as their quadruped robots.

For more information visit AIDIN ROBOTICS.

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