

IMU-based inclinometers for mobile machines

Kübler (Germany) provides dynamic inclinometers based on the six-DOF (degrees of freedom) IMU (inertial measurement unit) technology. Integration of sensor data into the existing machine architecture is fulfilled via CANopen.

(Source: Adobe Stock)

The precise determination of tilt and position angles in mobile machinery requires close cooperation between the measurement system and the communication architecture. In dynamic applications, it is not enough simply to capture accurate sensor data – what is crucial is its reliable and time-critical integration into the machine control system.

In this context, CANopen has established itself as the industrial standard solution. Combination of modern IMU sensor technology and CANopen communication makes it possible to calculate complex motion data precisely and to integrate it deterministically into control systems.

Six-DOF IMU sensor technology

The basis for the attitude determination lies in the combination of acceleration and angular rate sensors within a six-DOF inertial measurement unit. Whilst acceleration sensors always measure the sum of gravity and motion acceleration, gyroscopes provide information on the angular velocity of a body.

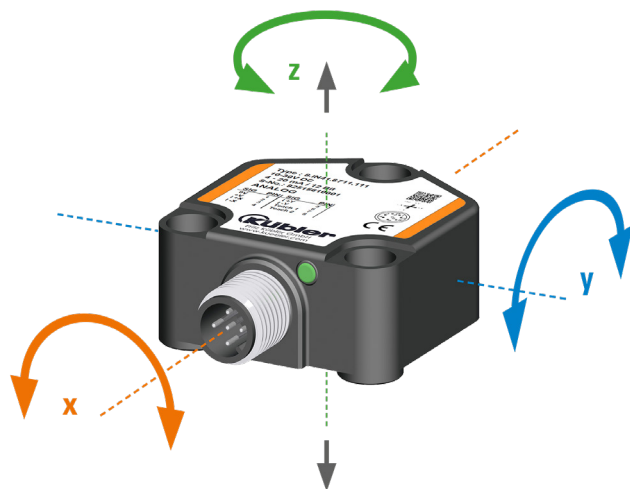


Figure 1: Data acquisition from three accelerometers and three gyroscopes – one for each of the X, Y, and Z axes (six degrees of freedom) (Source: Kübler)

These two measurement principles are physically complementary, but each has its own weaknesses. Acceleration is susceptible to interference during dynamic operation, whilst the integration of angular velocity leads to a drift over the long term. It is only possible through their combination that the basis for a stable attitude determination is established.

Sensor fusion and orientation calculation

The actual stabilization of the measured values is achieved via sensor fusion algorithms that link both signal sources together. The short-term dynamics of the gyroscopes are utilized to accurately map rapid movements, whilst gravity serves as a long-term reference for correcting systematic errors.

The result of this continuous processing is stable orientation data, which can be represented in the form of Euler angles (intuitively interpretable) or alternatively as a quaternion (numerically stable without singularities). These values form the basis for all downstream control and regulation tasks.

CANopen communication

The integration of sensor data into industrial systems is carried out via CANopen, which has become well-established in the field of mobile machinery and embedded controllers. The key strength of this CAN-based higher-layer protocol lies in its clear structuring into real-time data, configuration data, and network control.

Time-critical measured values such as inclination angle are transmitted cyclically via process data objects (PDOs). This direct, time-predictable and priority-based communication enables stable integration into control loops where delays or jitter are not tolerable.

In parallel, CANopen enables flexible parameterization of the sensor via SDOs (service data objects). Properties such as filter behavior, damping, or internal calculation modes can be adjusted during operation without ▶

compromising time-critical data transmission. This concept is complemented by network management (NMT), which ensures the defined operating state of the sensor within the network.

System integration and architecture

The key advantage of IMU-based sensor systems lies in their flexible architecture. Depending on the application, the sensor can either provide calculated inclination values exclusively or additionally output complete raw data from acceleration and rate-of-rotation sensors.

In both cases, the CANopen interface remains identical, which significantly simplifies integration into existing control systems. The actual complexity of the sensor fusion remains entirely encapsulated within the sensor itself, whilst communication is clearly standardized.

Performance in dynamic applications

In real-world scenarios, sensors are frequently exposed to strong vibrations, accelerations, and rapid changes of direction. Exactly under these conditions the advantages of the combined IMU and the CANopen architecture become apparent.

The internal sensor fusion ensures a largely stable position calculation, whilst CANopen ensures that this information reaches the control system without any significant delay. This maintains the control performance even under dynamic loads.

Conclusion

The device is used in mobile machinery, construction machinery, agricultural machinery, and in autonomous vehicle platforms. In these sectors, both robust measurement data and reliable real-time communication are crucial for the functionality of the overall systems. CANopen plays a key role in integrating sensor data into existing machine architecture without the need for proprietary interfaces or complex additional solutions. ◀

Author



Simon Tritschler
Kübler
presse@kuebler.com
www.kuebler.com

PEAK
BY HMS NETWORKS



Mobile diagnostic devices PCAN-Diag

CAN diagnostics made easy

Reliable diagnostics in the field or in the lab: The PCAN-Diag FD and PCAN-MiniDiag FD diagnostic devices offer compact, ready-to-use functionality for technicians who require robust and reliable results in any situation. Ideal for commissioning CAN and CAN FD systems and troubleshooting malfunctions.

- ✓ FOR CAN & CAN FD
- ✓ STANDALONE OPERATION
- ✓ READY TO USE IMMEDIATELY AND EASY TO OPERATE
- ✓ FIELD-READY

WWW.PEAK-SYSTEM.COM



HMS