Vibration and Tilt Sensors for Vehicle Monitoring

Introduction

Vibration and tilt sensors are essential components in vehicle alarm systems today. Recent technological advancements in the manufacturing of these sensors have improved accuracy, reduced cost, and increased lifetime [3]. Consequentially, alarm systems have become cheaper and readily available on the market. This paper focuses on the commercial applications for vibration and tilt sensors in construction vehicle monitoring systems.

Commercial Applications of Vibration and Tilt Sensors

One application for vibration and tilt sensors would be in the security market. For example, construction companies need more ways to combat equipment theft. Construction vehicles typically remain on a construction site when the workers leave, making them easy targets for theft. Because no more than 10% of stolen equipment is ever recovered, industry sources estimate annual losses from heavy equipment theft are as high as $1 billion [4]. Construction companies face many financial burdens from stolen equipment: vehicle replacement costs, premium increases and insurance deductibles, crew and equipment downtime, and lost revenue [4]. Vibration and tilt sensors can be used to detect when a piece of equipment is being loaded onto a trailer or when the engine is turned on, among other things, which can be used in conjunction with a GPS monitoring device. A fast response time to vehicle theft will increase the chances of the equipment being recovered by over 900% [4].

Underlying Technology behind Vibration and Tilt Sensors

Tilt Sensors

Standalone tilt sensors sense tilt angle or movement. Tilt sensors can be implemented using mercury and roller ball technology. Other tilt sensors are real accelerometers, which make use of the characteristics of piezoelectric ceramics [5]. Tilt sensors containing mercury are cylindrical. There is one wire that extends across the bottom length of the cylinder while the other wire extends only part way into the center of the cylinder. In a resting position with no slant, the liquid mercury makes contact with both leads. When the sensor is tilted, the mercury shifts such that the contact is broken between the two wires [2].

Roller ball tilt sensors make use of a roller ball, photo transistor, and infrared LED. The sensor's initial orientation is at zero-slant. At this orientation, the roller ball is at rest in the crevice of a V-shaped chamber. The infrared beam at this point is being broken by the roller ball. When tilted, the roller ball moves, allowing the infrared beam to be detected by the photo transistor [7].

Vibration Sensors

Vibration sensors are used for measuring linear velocity, displacement and proximity, and acceleration [1]. They are typically implemented using a piezoelectric accelerometer. The sensing element is a crystal which has the property of emitting a charge when subjected to a compressive force. The crystal is connected to a mass such that when the sensor is subjected to a force, the mass compresses the crystal. The signal value can be related to the amount of force imposed on the sensor [5].

Because vibration sensors are true accelerometers, they are sensitive to gravitational acceleration and therefore, can be used as tilt sensors. The bandwidth of the accelerometer must be restricted for use in tilt sensing because detecting tilt requires a very low noise floor [6]. This method of sensing tilt is much more accurate than the tilt sensors described above: vibration sensors can detect a change in inclination to as small as a tenth of a degree while roller ball tilt sensors only detect angles of 10°, 15°, 30°, or 45° [6, 7]

Implementation of Tilt and Vibration sensors

These sensors can be installed on any size vehicle. For greater accuracy, vibration sensors would measure both tilt and vibration. The sensors could be mounted using mechanical threading, magnets, or adhesives, depending on what type of vehicle they are being mounted to [1]. When a vehicle is turned on, the vibrations of the engine would trigger the vibration sensors. The sensors would be able to be tuned to detect different ranges of vibrations, depending on what type of engine drives the vehicle. Tilt sensors would detect when the vehicle is not in its rest position, which could indicate that a thief is stealing a vehicle by towing. These sensors would communicate with a GPS device via an analog-to-digital converter. The GPS device would then transmit the type of sensor that was triggered, as well as the location of that vehicle.

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