

USING THE ADXL105 IN HEADLAMP LEVELING SYSTEMS

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Introduction

High energy discharge (Xenon) headlights have become ubiquitous in Europe, and are gaining popularity in North America. While these headlight systems are clearly advantageous from the user's point of view, misaligned headlights create a hazard for oncoming drivers. So much so that most European countries have adopted legislation requiring that automobiles fitted with high energy discharge (HED) headlights have a system that re-aims the headlights to compensate for changes in the tilt of the car relative to the road.

Currently these systems use mechanical front and rear ride height measurements to determine the angle of the car versus the road. While ride height measurement is the most accurate way of measuring automobile inclination relative to the road, these mechanical systems are complex, costly, and require extensive wiring around the car. In addition, as they are exposed to the environment beneath the automobile reliability is a concern. This technical note describes how an ADXL105 accelerometer can be used to replace the ride height measurement system in this application.

System Performance

The headlight tilt compensation system is meant to compensate for long term changes in inclination of the automobile chassis. Current systems have a response time of 3 minutes. The range of motion is approximately $\pm 1.2^\circ$. The headlight positioners typically have a 5 position adjustment range (0.5° per step).

Sources of Tilt

Before attempting to design a headlight leveling system, it is important to understand what makes a car's tilt change relative to the road. They are:

1. Hard acceleration.
2. Hard braking.
3. Attaching / removing a trailer to the car.
4. Placing / removing a heavy load in the trunk.
5. Adding / removing passengers.
6. Filling / emptying of the gas tank.
7. Potholes or bumps in the road.

Hard acceleration and braking, as well as potholes or bumps, can be ignored as they are (relatively) transient events and fall outside the 3 minute pass band. Items 3, 4, and 5, as well as filling of the gas tank, all take place when the car is stationary.

Emptying of the gas tank, a very low speed process, falls inside our pass band and will be dealt with as a special case.

An Accelerometer Based HED Leveling System

An ADXL105 can be fitted to the headlight assembly to measure the tilt of the car. Since all the events that cause a car to alter its inclination relative to the road occur when the car is not moving, the first task of the system is to determine car movement. This is done by looking for characteristic "road noise". While the car is in motion, tilt information is ignored.

When the car is stationary, the HED leveling system looks for changes in car inclination in the 0.3 to 1 Hz range. This will detect events like attaching / removing a trailer, adding / removing objects from the trunk, passengers entering / exiting the car, and filling of the gas tank. In fact, there are normally clues available that a change in automobile load may soon occur. That is, the opening or closing of a door or trunk. The "door ajar" and "trunk open" signals may also be monitored and used to make the algorithm more robust although this is not a requirement.

One sample is taken every half second and compared to the last sample. If a change of inclination is detected, a headlight position adjustment is made if the ignition is on (i.e. the car is running but not traveling). All tilt information is ignored while the vehicle is traveling). If the ignition is not on, the adjustment is delayed until the car is started. By using measurements that are a short time apart, the effects of temperature drift are rejected since temperature changes over a few seconds (or less) will be very small.

Inclination changes due to emptying of the gas tank will be handled by a simple long term timer that will make headlight adjustments in response to driving time. The time period required for adjustment and the magnitude

of the adjustment will vary from car to car depending chiefly upon gas tank capacity and average fuel consumption.

Additional Features

The accelerometer may also be used as a shock sensor and tilt sensor for the automobile's alarm system. See the technical note "Using Micro-Machined Accelerometers in Automobile Security Systems" on the Analog Devices web site (http://www.analog.com/industry/iMEMS/products/ADXL202_top.html) for more details.