AN5373

Mass Movement Vehicle Alarm Sensors

Application Note

AN5373-1.1 July 2000

1. INTRODUCTION

The Dynex Semiconductor Mass Movement Sensor (MMS) is a volumetric microwave Doppler radar sensor that operates at 2.45 GHz in the ISM band.

The MMS is ideal for use in vehicle security systems and is compatible with existing alarm systems that incorporate a volumetric sensor input. The sensor is supplied as a fully assembled and tested unit, designed for housing in a customer's own case following the Dynex Semiconductor guidelines.

The sensor is suitable for use in all classes of vehicles including:

- Saloons, Touring and SUV's
- Cabriolet, Convertibles and Roadsters
- Light and Heavy Commercial Vehicles

The MMS detection range can be adjusted so that the microwave beam coverage is confined within the desired area of the vehicle.

Microwave radar technology offers benefits over competing technologies,

- Extremely low false alarm level
- Immunity to climatic change
- Single sensor - Easy Installation
- Sensor can be hidden behind trim
- High level of EMC immunity
- Protection with windows and load space doors open

2. FUNCTIONALITY

The sensor utilises the Doppler effect principle. A frequency stabilised transistor oscillator is used to generate a RF signal at 2.450GHz. This signal is transmitted via a planar patch antenna structure embodied into the design of the printed circuit board to produce a free space RF beam pattern approximating to a hemi-spherical ellipse.

The RF beam shape within a vehicle will be modified due to internal reflections and resonance's particular to the vehicle and its internal structure.

The size and material of a target determines the amplitude of the received Doppler signal, the velocity of a target determines the Doppler frequency.

Reflections within the vehicle from stationary objects such as the seats and steering column produce no Doppler shift and therefore do not trigger the sensor. However, movement within the defined sensor range will be detected and generate an alarm event.

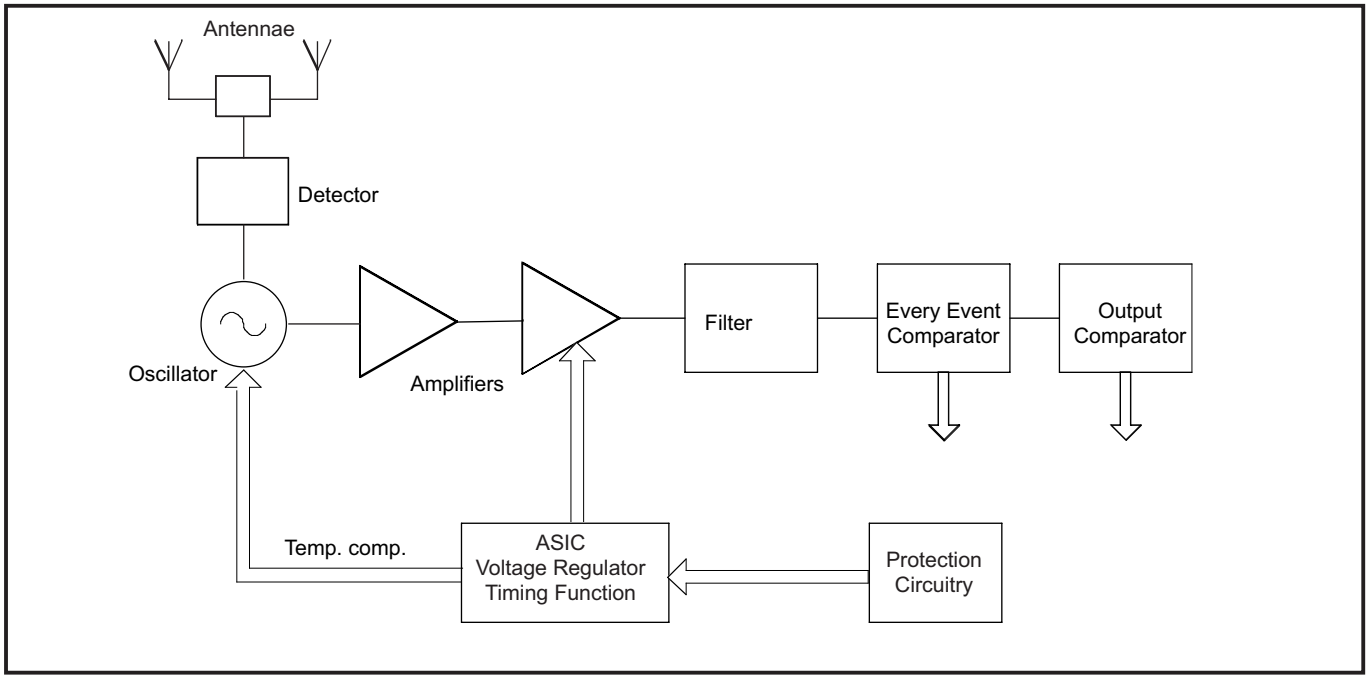


Fig. 1: MMS schematic

The Doppler frequency (D_f) generated by a moving target within the sensor detection area is equal to,

$$D_f = \frac{2vf_o}{c}$$

where fo is the signal transmitted frequency, v is the velocity of the target and c is the velocity of light.

The frequency shifted signal is received by the same antenna structure and is mixed with the transmitted signal to generate the base band Doppler signal. The low frequency, low amplitude Doppler signal is then processed by a custom designed mixed signal ASIC.

A block schematic of the MMS alarm sensor is shown in Figure 1.

The ASIC first amplifies and filters the Doppler signal to remove noise. The analogue signal is then processed by an 'every event' window comparator which generates a digital output for every signal that exceeds the comparator thresholds.

The 'every event' digital output can be fed to an external alarm control unit for further software signal processing to determine if the detected targets constitute a real alarm event. If the alarm control unit does not have a software algorithm capability then the MMS can integrate the 'every event' outputs to generate a main alarm event output.

3. IN CAR PERFORMANCE

The performance specification of a volumetric sensor based system is primarily determined by balancing the three main requirements,

- Zero False Alarms
- Full Interior coverage
- Guaranteed Theft detection

No known system can meet these three needs simultaneously, but a balance of performance parameters can be tempered to any one customer's personal preference.

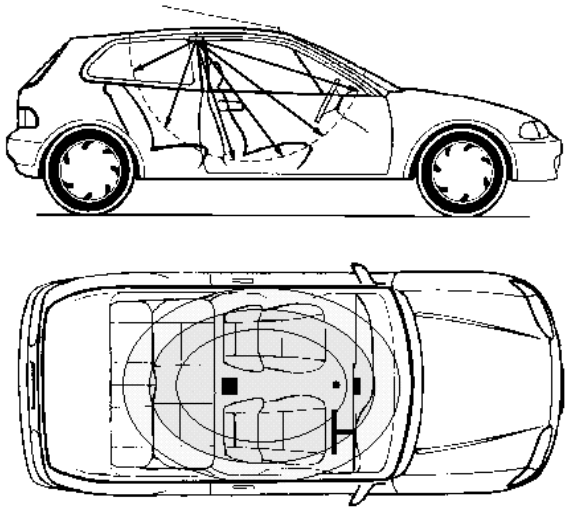
To understand the trade-off between system performance parameters it is useful to define certain terminology.

False Alarms

A false alarm is an action or situation that does not threaten the welfare of the interior of the vehicle. It is convenient however to categorise 'false alarms' into two categories: Accidental and Intentional.

Accidental False Alarms:

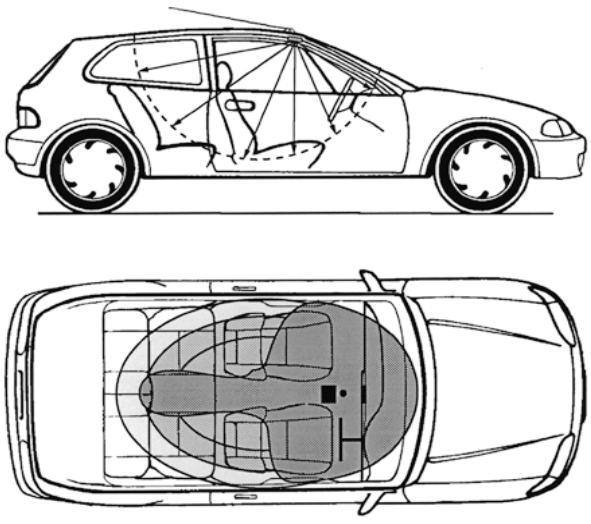
This may refer to such occurrences commonly experienced with ultrasonic sensors, such as; climatic changes, strong winds buffeting the vehicle, shock waves from aircraft take-off, insects within the car, EMC.



Interior detection

Steering Wheel:	Weak	Rear Parcel Shelf:	Weak
Front Seats:	Good	Side Doors:	Good
Rear Seats :	Good	Door Pockets:	Poor
Radio:	Good	Glovebox:	Weak

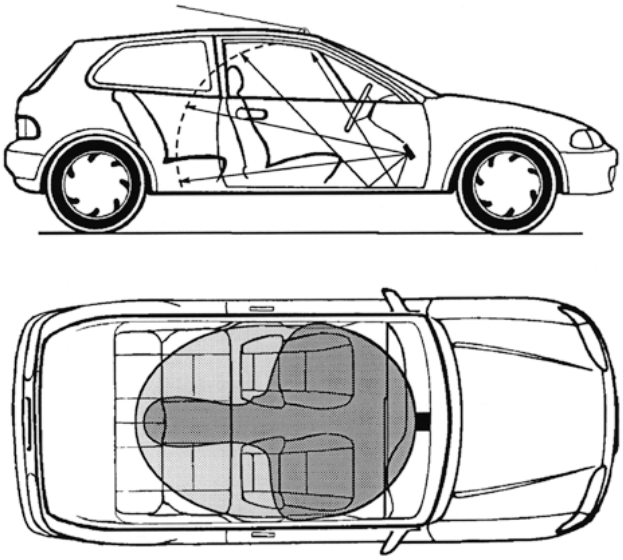
Fig. 2: Centre roof mounted



Interior detection

Steering Wheel:	Good	Rear Parcel Shelf:	Poor
Front Seats:	Good	Side Doors:	Good
Rear Seats :	Weak	Door Pockets:	Good
Radio:	Good	Glovebox:	Good

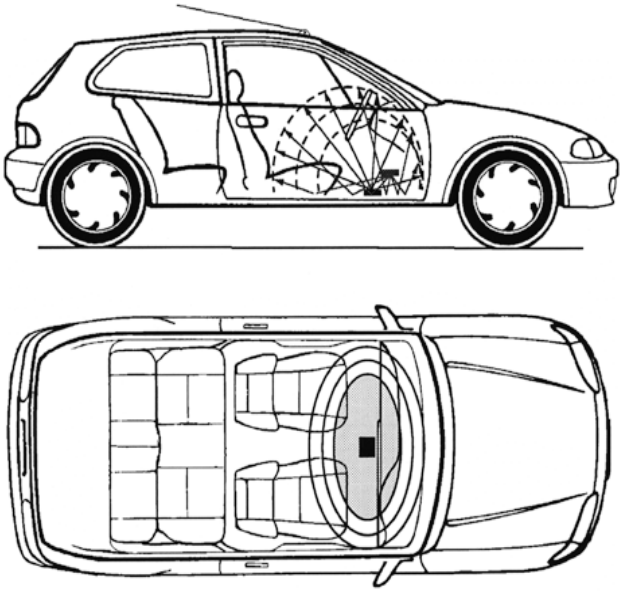
Fig. 3: Front roof mounted



Interior detection

Steering Wheel:	Weak	Rear Parcel Shelf:	Poor
Front Seats:	Good	Side Doors:	Good
Rear Seats :	Poor	Door Pockets:	Good
Radio:	Good	Glovebox:	Good

Fig. 4: Front centre console mounted



Interior detection

Steering Wheel:	Weak	Rear Parcel Shelf:	Poor
Front Seats:	Weak	Side Doors:	Good
Rear Seats :	Poor	Door Pockets:	Weak
Radio:	Good	Glovebox:	Good

Fig.5: Front floor mounted

Intentional False Alarms:

An example of an intentional false alarm is by rocking the vehicle as to cause the interior contents to move and generate an alarm event. An intentional false alarm is characterised by the intent of someone to trigger the alarm to cause nuisance or to deactivate the volumetric sensor.

Ultimately any volumetric sensor can be triggered if the intent is strong enough. The primary objective is to make the security system immune to simple intentional false alarm events.

Interior Coverage

The interior coverage of the sensor is the internal volume of the vehicle within which it is possible to reliably detect a thief attempting to steal the vehicle itself or the major valuable contents.

Definition of the interior coverage is partially dependent upon the alarm system philosophy.

The main parameters that interior alarm sensors would like to detect are,

- Theft of the vehicle (back–up to the immobiliser)
- Theft of vehicle accessories (radio)
- Theft of personal items from the vehicle
- Window breakage
- Arm or hand entering the vehicle interior

Illustrations of the interior coverage that can be realistically achieved with the MMS are shown in Figures 2 to 5.

It must be recognised however that interior coverage is a compromise between acceptable interior detection and the potential for ‘false alarms’.

The optimal solution is ultimately subject to the judgement of the vehicle manufacturer in balancing this compromise.

4. FITMENT/INSTALLATION

Where?

As can be seen from Figures 2 to 5 the position of the sensor within the vehicle strongly influences the effective interior coverage.

Issues that determine the optimal position include,

- Vehicle Type (Saloon, Coupe, Touring, Cabriolet, Sport Utility, Commercial)
- Priority of Interior Coverage
- Position of sunroof/interior lights
- Access to wiring harness

Because of the shadowing effects of large metal linings commonly

designed into seats, the central roof is a preferred mounting position in most vehicles. If styling considerations prohibit this, then the front courtesy light mounting should also be considered.

Front centre console mounting below the radio is most commonly preferred for cabriolet vehicles with the sensor pointing slightly downwards to give maximum coverage without raising the RF beam above roof level. Two seater sports cars can also have the sensor mounted between the seats. In four seater cabriolet vehicles a rear sensor may also be required.

Mounting the unit high up on the front fascia/dashboard especially in cabriolet vehicles is not generally recommended due to the increase in false alarms induced through the windscreen.

The sensor can be hidden behind plastic of fabric trim panels or styled covers to improve the aesthetics.

How?

The coverage of the unit should be adjusted so that false alarms are minimised whilst interior detection is maximised. A slight increase in the detection zone is commonly experienced at sub zero temperatures amounting to approximately 10% increased range from ambient.

It should be noted that 2.450GHz RF signals are attenuated by the vehicle glass, but will allow for some detection outside the vehicle. Sufficient applications testing should be performed to ensure the 'leakage' through the glass doesn't generate accidental false alarms.

5. SENSITIVITY/ RANGE ADJUSTMENT

The detection range of the sensor can be factory set for OEM requirements or field adjustable via a potentiometer for aftermarket use. The detection range can also be electronically programmed if the vehicle alarm control unit supports the programming protocol. Electronic gain programming (via the alarm control unit) allows a single sensor to be easily adapted to suit a wide range of vehicles, or 'in service' sensitivity adjustments are possible.

6. ELECTRICAL REQUIREMENTS

The sensor utilises an internally regulated voltage supply and can accept input voltages between +9V and +16V for normal operation.

The sensor produces a 'self-check' pulse at switch on to test the system integrity. The output circuit is also actively muted until the vehicle environment is electrically quiet.

7. CUSTOMISATION OPTIONS

Signal Processing

Signal processing within the MMS constitutes the 'intelligence' of the sensor, as previously described possible options to the user for signal processing include;

- Output of the 'every event' signal to allow remote software signal processing by the main alarm control unit.

- Additional baseband filtering defined by discrete off-chip components.

Connectors

The majority of Vehicle Manufacturers define their own connector assemblies for the MMS. Most VM's already have fully qualified connector systems for their vehicles. Dynex Semiconductor's policy is to use an approved connector system for the particular application.

Should no approved connector be available Semiconductor will recommend a suitable connector for the application.

Case

For OE fitment the plastic case is normally a custom design for each application.

Dynex Semiconductor will help the customer and advise on the casing requirements for the MMS. It is important that black cases do not have carbon loading but are dyed black, some white case pigments contain metallic oxides, these can also effect the transmitted RF beam.

If the MMS is hidden behind a trim panel then a natural coloured high temperature ABS is an ideal plastic case material.

8. QUALITY ASSURANCE

The MMS has successfully completed full Product Validation test programmes from European vehicle manufacturers.

Detailed design FMEA's have been performed on the MMS and subsequent identified potential failure modes minimised.

RF Type Approvals

The MMS conforms to the International RF homologation standards required for this type of product.

This type approval testing includes measurement of frequency stability, fundamental and harmonic transmitted power levels and a spurii measurement.

The MMS is fully Type Approved for use in Europe, Scandinavia, USA, Canada, Hong Kong and South Africa. Further approvals are undertaken as required.

Insurance Approvals

The majority of European countries have National vehicle testing bodies that approve and certify the performance of vehicle security systems. These approvals include the detection and false alarm performance of volumetric sensors.

Each vehicle application has to be individually approved. The MMS has been fully approved in all its current applications and complies with the European vehicle directive EC95/56 when fitted to a vehicle.

EM Susceptibility

The effective isotropic radiated power (EIRP) level transmitted by the sensor at 2.450GHz is very low requiring the device to be protected against electromagnetic interference generated by the vehicle and from external sources.

The sensor is compliant to vehicle manufacturer specifications at electric field strengths of 50V/m over the frequency range 1MHz to 1GHz. One application requires immunity to 100V/m, significant vehicle testing was required but this high level of EMC immunity has been achieved.

Vehicles fitted with a MMS are compliant to EC95/54.

9. SPECIFICATION

Operating Frequency	2.450 GHz
Microwave output power	<1 mW
Operating voltage range	9V to 16V
Supply current	3.5 mA typ.
Switch on time for full functionality	15s typ.
Maximum supply voltage	-14V to +27V
Output pin (open collector)	20 mA max.
Operational temperature range	-40°C to +85°C
Weight (PCB + connector) only	65g
PCB size (approx.)	75 x 65 x 10* mm

*Height depends upon connector used

These products are protected by European Patent Apps 94305008.8, 98300287.0 and 9905934.7 and other Worldwide patents.

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Datasheet Annotations:

Dynex Semiconductor annotate datasheets in the top right hard corner of the front page, to indicate product status. The annotations are as follows:-

Target Information: This is the most tentative form of information and represents a very preliminary specification. No actual design work on the product has been started.

Preliminary Information: The product is in design and development. The datasheet represents the product as it is understood but details may change.

Advance Information: The product design is complete and final characterisation for volume production is well in hand.

No Annotation: The product parameters are fixed and the product is available to datasheet specification.