Does Electromagnetic Interference Cause Sudden Acceleration in Automobiles?

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Vehicular Electronics Laboratory Facilities

Electronics Lab

EMC Test Facility

Chassis Dynamometer

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T. Hubing Background

EDUCATION
B.S. (E.E.), Massachusetts Institute of Technology, 1980
M.S. (E.E.), Purdue University, 1982
Ph.D. (E.E.), North Carolina State University, 1988

PROFESSIONAL EXPERIENCE
2006 – present  Michelin Professor of Vehicular Electronics, Clemson University
1999-2006  Professor of Electrical and Comp. Eng., Univ. of Missouri-Rolla
Summer 2002  Visiting Faculty at Sandia National Laboratories, Albuquerque, NM
Summer 2000  Visiting Professor at Okayama University, Okayama, Japan
1995-1999  Associate Professor of Electrical Engineering, Univ. of Missouri-Rolla
1989-1995  Assistant Professor of Electrical Engineering, Univ. of Missouri-Rolla
Spring 1989  Adjunct Assistant Professor, North Carolina State University
1982-1989  Staff Engineer, Electromagnetic Compatibility Laboratory, IBM Communications Products Division, Raleigh NC

PROFESSIONAL ACTIVITIES
American Society for Engineering Education
Fellow of the Applied Computational Electromagnetics Society
Fellow of the Institute for Electrical and Electronics Engineers (IEEE)
IEEE Electromagnetic Compatibility Society
- President (2002 - 2003)
Automobiles are Complex Electronic Systems
Automobiles are Complex Electronic Systems!

F-35 Joint Strike Fighter
5.7 Million Lines of Code

Boeing 787 Dreamliner
6.5 Million Lines of Code

Today’s Typical Luxury Car
~ 100 Million Lines of Code
Systems Capable of Actuating the Throttle and/or Brakes

Adaptive Cruise Control (ACC)
- Forward Radar
- Vehicle Speed
- Throttle

Anti-lock Braking System (ABS)
- Brake Pedal Position
- Vehicle Speed
- Wheel Speed

Automated Parking System
- Forward Position
- Right Side Position
- Rear Position
- Vehicle Speed
- Steering Wheel Angle
- Steering Angle
- Throttle

Electronic Stability Control (ESC)
- Steering Wheel Angle
- Yaw Rate
- Lateral Acceleration
- Wheel Speed

BRAKES
- Throttle
Automotive EMC Today
Automotive EMC Standards Organizations

- International Electrotechnical Commission (IEC)
  - CISPR, TC77
- International Organization for Standards (IOS)
  - TC22, SC3, WG3
- Society of Automotive Engineers (SAE)
  - Surface Vehicle EMC Standards Committee
Automotive EMC Standards

Emissions Tests:

- CISPR 12
  - Vehicle Level Emissions
- CISPR 25
  - Component Level Emissions
- SAE J551-5
  - 9 kHz – 30 MHz, Broadband
- IEC 61967
  - Integrated Circuit Emissions
Automotive EMC Standards

CISPR 25 ALSE

(Absorber Lined Shielded Environment)
Automotive EMC Standards

Vehicle Immunity Tests:

- ISO 11451-2, SAE J551-11
  - Radiated Field Immunity
- ISO 11451-3
  - On-Board Transmitter Susceptibility
- ISO 11451-4
  - Bulk Current Injection
- ISO 10606, SAE J551-15, IEC 61000-4-2
  - Electrostatic Discharge
Automotive EMC Standards

Vehicle Immunity Tests:

- SAE J551-16
  - Reverberation Chamber Immunity
- SAE J551-17
  - Power Line Disturbances
- ISO 11452-8
  - Magnetic Field Immunity
- ISO 10606, SAE J551-15, IEC 61000-4-2
  - Electrostatic Discharge
Automotive EMC Standards

Component Immunity Tests:

- ISO 11452-2
  - RF Immunity - ALSE
- ISO 11452-3
  - RF Immunity – TEM Cell
- ISO 11452-4
  - RF Immunity - BCI
- ISO 11452-5
  - RF Immunity - Stripline
Automotive EMC Standards

Component Immunity Tests:

- ISO 11452-7
  - Direct Injection
- ISO 11452-11 (Draft)
  - Reverberation Chamber
- ISO 7637-2,3
  - Transient Immunity
- ISO 10605
  - Electrostatic Discharge
Electronic Throttle Control
Accelerator Pedal Position / Throttle

- Employs 2 redundant, but nearly identical hall-effect position sensors.

- Interference that affects one sensor, can affect the other sensor in an identical way, resulting in a bad reading with no error code generated.

- Some competing designs employ 3 sensors; two that increase voltage as pedal is depressed and one that reduces voltage as pedal is depressed. This design should be more reliable.
Cruise Control

- One ECM input determines on/off, set speed, and resume speed.
- A 2-meter floating wire is attached to that input.
- This design is inherently susceptible to radiated electromagnetic interference. We can’t be sure what is done within the ECM software to ensure that the cruise control doesn’t engage and set do to spurious inputs.
Grounding Differences
Grounding Differences
Grounding Differences
Throttle Actuation Differences

Accelerator, Throttle, and Cruise Control integrated in TAC module, not in the ECM

2005 GMC Truck GMC Sierra 2WD
Cruise Control Differences

Model 1: three inputs, using switches
Model 2: one input, using varying resistance values
Are Today’s Cars Vulnerable to EMI?
3 Possible SA Failure Modes

- Bad sensor input - fools ECM into opening the throttle.

- A software “glitch” – gives unintended command to open throttle (may or may not involve a bad input).

- A hardware (microprocessor) malfunction – processor latches up or jumps to wrong subroutine requiring a hard reset.
Some Key Points

- Due largely to the electronics, today’s cars are safer than ever before.

- Even for makes and models with the highest number of reported incidents, sudden acceleration incidents are reported about once in every 600 million miles driven.
Some Key Points

- The electronics in virtually any car sold today is capable of causing the types of failures being reported as “sudden acceleration” events.

- It is not possible to fully model, test or validate the safety of electronic systems in automobiles due to a lack of standard design platforms, meaningful EMC test procedures, or OEM control of subsystem designs.

- Recreating a particular failure mode can be extremely difficult due to the thousands of possible failure mechanisms and software/hardware states.
How Should Automotive Electronic Systems be Designed?
Short-term Recommendations

- A software subroutine that cuts the throttle when the brake pedal is depressed would compensate for a large percentage of the possible failure mechanisms. A hardware solution (e.g. BMW’s approach) should be even more reliable.

- The driver should have some way to override the engine control module (e.g. a key switch that physically removes the power to the ECM).

- Hardware redundancy and fault-tolerant software design would be relatively inexpensive and easy to implement if adopted by the entire automotive industry.
Long-term Recommendations

- Must be able to model all system behavior including all hardware and software interactions.

- This requires design constraints and interface standards.

- Continuous refinement of these standards would be greatly facilitated by the installation of black boxes in automobiles.
Final Thoughts

- Odds of being involved in a sudden acceleration accident are much lower than odds of being involved in other types of car accidents.

- Unintended automotive system behavior is a problem that will certainly get worse without a major change in automotive standards and design practices.