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How Does EMI Harm—and Help—in the Robotics World?

Design engineers must pay attention to potential EMI issues early in the design cycle and determine how proper motor selection could manage these threats. Sometimes, though, EMI can be intentionally used for security reasons.

High-speed brushless dc motors (BLDC) are widely used in electric vehicles, automated industrial applications (e.g., submarine subsystems), aerospace applications, and in the field of robotics. This article will discuss the electromagnetic-interference (EMI) effects on robotics.

We know that EMI occurs when two or more electromagnetic fields interfere with one another and subsequently distort each other.

Robot designers need to fully understand EMI and how to prevent it from impacting robotic performance. What are the best approaches to minimizing EMI effects on their designs?

Designers must first look for the most optimum motor for their robot design. The best bet for reducing EMI in a robotic design is an ironless core motor structure because it has a much smaller magnetic energy during commutation. Thus, the choice is clear—the BLDC motor will typically be the best option in robotics.

Conductive and Radiative EMI

EMI noise can occur as conductive and radiative noise. Radiated EMI noise typically isn't much of a problem in BLDCs for robotics. The conductive EMI can flow through the common dc current path or through parasitic elements or ground planes.

Conductive EMI has two types: common mode (CM) and different mode (DM). CM noise flows in the same direction through circuit elements and returns through the ground plane. DM noise flows in one direction through one element and will return by other elements in the circuit. High dv/dt creates CM noise. High di/dt creates DM noise.

Commutation is the action of steering currents or voltages to the proper motor phases to produce an optimum motor torque. In a BLDC motor the coils don't move, so there's no need for brushes and a commutator. In this class of motor, the permanent magnet rotates by changing the direction of the magnetic fields generated via the surrounding stationary coils.

Electromagnetic-field simulation software for design and analysis of electric motors is available via Ansys Maxwell.

Integrated Motor Drivers

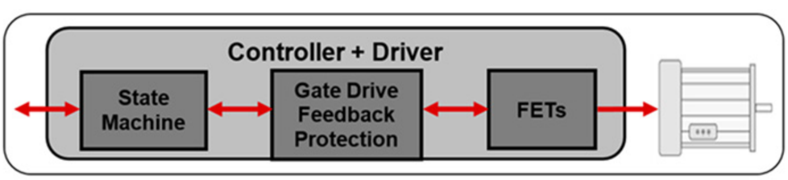
Integrated motor drivers combine all that's needed to drive a BLDC motor *(see figure)*. These integrated drivers will typically have field-effect transistors (FETs), gate drivers, and state machines.

Integration will eliminate the routing of long wires from the electronic control unit (ECU) to the motor. Integrated BLDC motor drivers also have the advantage of a smaller printed-circuit-board (PCB) size, as well as a lower overall system price tag.

Drones and Unmanned Aerial Vehicles (UAVs) Are Robots, Too

Dynamic, remotely operated navigation devices, such as drones and UAVs, also are robots (mechanical). EMI sources that a UAV/drone may encounter are power lines, power substations, and communication towers. EMI shielding may be used in this case.[2]

As an example, let's consider a multi-hundred-kilovolt electric distribution tower. If the UAV/drone flies within



Shown is an intelligent integrated BLDC motor driver.

100 feet, communications will be lost and there may be a telemetry failure. Data transmission will be disrupted around 250 feet.

In this scenario, a non-conductive UAV/drone airframe will help to minimize EMI interference.

EMI Disabling of Illegal Drone/UAV Usage

Drones/UAVs can be deployed illegally when used in terrorism and as spycams. Research is ongoing regarding anti-drone methods. These methods, such as applying intentional EMI (IEMI) to drones/UAVs, are especially used to disrupt drone/UAV sensor modules.[3]

Examples of illegally deployed drones include:

- Smuggling contraband into prisons
- Mapping/photographing prison areas for potential escape plans
- Terrorism
- Illegal surveillance of large crowds, stadiums, or people
- Infiltrating conferences/meetings to gain sensitive information
- Interference with aircraft

Drones will maintain a stable flight when their variety of sensors, both inside and outside, operate in coordination. If a few sensors are affected by an external interference, it could result in a serious malfunction. In addition, since sensor modules like inertial measurement units (IMUs) are essential for most drones, introducing disturbances in these sensor modules is an effective means of neutralizing the drone.

Listed below are the targets, methods, and characteristics for different anti-drone categories:

High-power IEMI targets electronic circuitry via an antenna deploying a high-power EMI wave, which will destroy or degrade the offending drone device:

- Targeting an unprotected electronic system via a Cassegrain Antenna with 37- to 40-dB gain using a pulse method with a few kV/m peak field that has a pulse repetition frequency (PRF) of 300 Hz to 1 kHz.
- Targeting a commercial drone, such as DJI Phantom 3, with an ultra-wideband (UWB) electromagnetic pulse (EMP).
- Targeting a commercial quadcopter drone with a horn antenna using a narrowband pulse from 100 MHz to 3.4 GHz that has a PRF of 1 kHz.
- Targeting a minimal sensor network (MULLE) using a horn antenna with a continuous wave (CW) at 2 to 3 GHz with a peak field of 0.24 to 0.36 kV/m.
- Targeting a commercial off-the-shelf (COTS) quadcopter with an antenna that has a CW at 100 MHz to 2 GHz and a field from 75 to 95 V/m.

Low-power IEMI targets the following:

- An analog sensor target can be disrupted via an antenna coil using resonant frequency for efficient coupling.
- A digital sensor target using Bulk Current Injection (BCI) or Direct Power Injection (DPI).
- Targeting the communication module using an antenna with in-band jamming

Non-RF methods:

- An acoustic MEMS sensor using mechanical resonance.
- Optical flow using a laser that will degrade the received image of the optical flow sensor, leading to malfunction.

Drone detection systems also may be deployed to prevent leaking of sensitive data, stealing passwords, illegal photography, and robberies via access of aerial photography, recordings, CCTV, passwords, and security locations. Again, a controlled EMI disturbance will disable the drone.

Summary

Robotics developers need to fully understand EMI interference to completely prevent their robot designs from behaving erratically or even being severely damaged via rogue EMI signals. Ironless core motors can reduce EMI.

Design engineers need to pay attention to potential EMI issues early in the design cycle and determine how proper motor selection could manage EMI threats. Shielded cables can help, as will adequate testing all through the design cycle. The use of ferrite beads on PCBs also will help.

References

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