## **Multiphase Drives for EV Applications** Centre for Mechatronics and Hybrid Technology Electrical and Computer Engineering, McMaster University Ahmed Salem

## **Project Statement**

## **Objectives:**

- Develop a six-phase inverter based on the requirements of the drive.
- Reduce the size of the DC-link bank of capacitors.

### Tasks:

- Literature review on multiphase drives.
- Build up a scaled down prototype of six-phase inverter.
- Developing new control technique.
- Developing new switching technique for the capacitor sizing.

## Why Multiphase Drives

### **Multiphase Drives Features:**

- 1. Lower Power/Current Rating per Phase.
- 2. Fault-tolerance operation.
- 3. Torque density improvement.
- 4. Lower Dc-Link Current Ripples.



The figure shows a schematic of one phase-leg of the inverter used in Tesla Model S which has for the upper part 6 switches connected in parallel. The inverter comprises of 36 IGBT in total. The multiphase concept overcomes the problems associated with paralleling IGBT's.







## **Modulation Techniques**

### 1. Space Vector Modulation (SVPWM) Based on **Vector Space Decomposition (VSD): Pros**:

• Full control of voltage vectors in different subspaces • Compensation of non-torque production harmonics. Cons:

Requires high computational power.

Requires additional controllers to compensate the effects of machine back EMF's.



## 2. SVPWM based on voltage classification method

Simple technique in implementation Unable to eliminate the xy subspace harmonics.



Using two references







Using one reference

## **Fault-Tolerance Capability**

• Unlike Three-phase drives, Multiphase drives operates with high torque range under faulty conditions. • Three-phase drives has 29% maximum output torque with output torque ripples under optimal current control. • Six-phase Drives under one-phase loss can operate up till 69.5% under optimal current control with no torque ripples and minimum losses..

### **Remedial Solution to increase the torque range under** single-phase faults:

• The proposal is to provide a neutral connection to the dc-link midpoint and by applying global optimization the torque range reaches 81.6% which represents 11% increasement.





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# **EECOMOBILITY (ORF) & HEVPD&D CREATE**

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