## *Prepare your laptop for the hands-on coding session*
### *No prior AI experience required - step by step guided tutorial*

- You're encouraged to bring and use your own laptop for this hands-on coding session—it's the best way to fully experience and learn from the exercise!
- Before the session starts, please make sure your laptop has enough battery (**about 1 hour**) and follow the three steps below to set up your Google Colab environment.

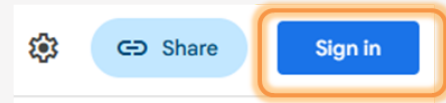**Step 1: Visit the link below to start.**

https://github.com/XinzeLee/ECCE2025

**Step 2: Scroll down and click "Open in Colab"**

README

⚘ ECCE2025

- Open the tutorial in Google Colab:

CO Open in Colab

**Step 3: Sign in with your own google account (top-right corner)**
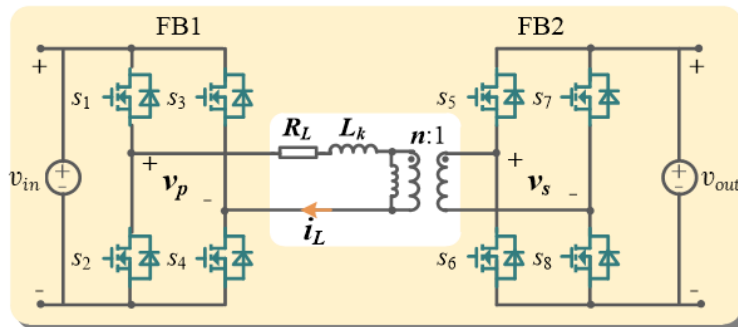
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## 💡Hands-on AI-Based Modulation Design: Background

**Design Task:** Determine modulation parameters $D_1, D_2$

**Objective**: Minimize current stress ($i_{pp}$) and achieve all-switch zero voltage switching (ZVS)

Topology of the Dual Active Bridge (DAB) Converter

Triple phase shift modulation for the DAB converter

$v_{in}$ = 200 V      $v_{out} \in [160 \text{ V}, 240 \text{ V}]$

$f_s$ = 50 kHz      $P_o \in [100 \text{ W}, 1 \text{ kW}]$

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# 💡 *Hands-on AI-Based Modulation Design: Implementation Steps*

**Design Task:** Determine modulation parameters $D_1$, $D_2$
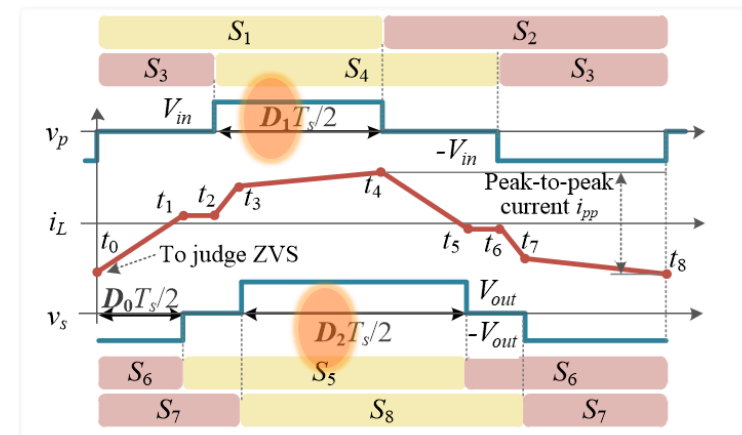**Objective**: Minimize current stress ($i_{pp}$) and achieve all-switch zero voltage switching (ZVS)

**Implementation Steps**

**Step 0.**
**Data Collection** — A dataset was generated in advance using PLECS simulation

**Step 1. (Section 1)**
**Python Dependencies Installation** — Install required Python libraries for data processing, modeling, and optimization

**Step 2. (Section 2)**
**Data Exploration** — Explore and visualize the dataset to understand the relationships between inputs and outputs
- Select independent input features
- Outlier Detection and exploratory data analysis

**Step 3. (Section 3)**
**Data-Driven Modeling** — Current stress (ipp) and number of zero voltage switching are modeled by neural networks
- Inputs: Output power, output voltage, modulation parameters
- Outputs: Current stress (ipp) (*regression*) and number of zero voltage switching (*classification*)

**Step 4. (Section 4)**
**Modulation Parameter Optimization** — Optimize modulation parameters with partical swarm optimization algorithm

$$(D_1^*, D_2^*) = \arg\min_{D_1, D_2} i_{pp}\left(P_L, V_{out}, D_1, D_2\right)$$
$$s.t. \quad \text{number of ZVS switches } n_{ZVS} = 8$$