# Chapter 1

# Overview

# 1. Modern Electrical Drives: An Overview

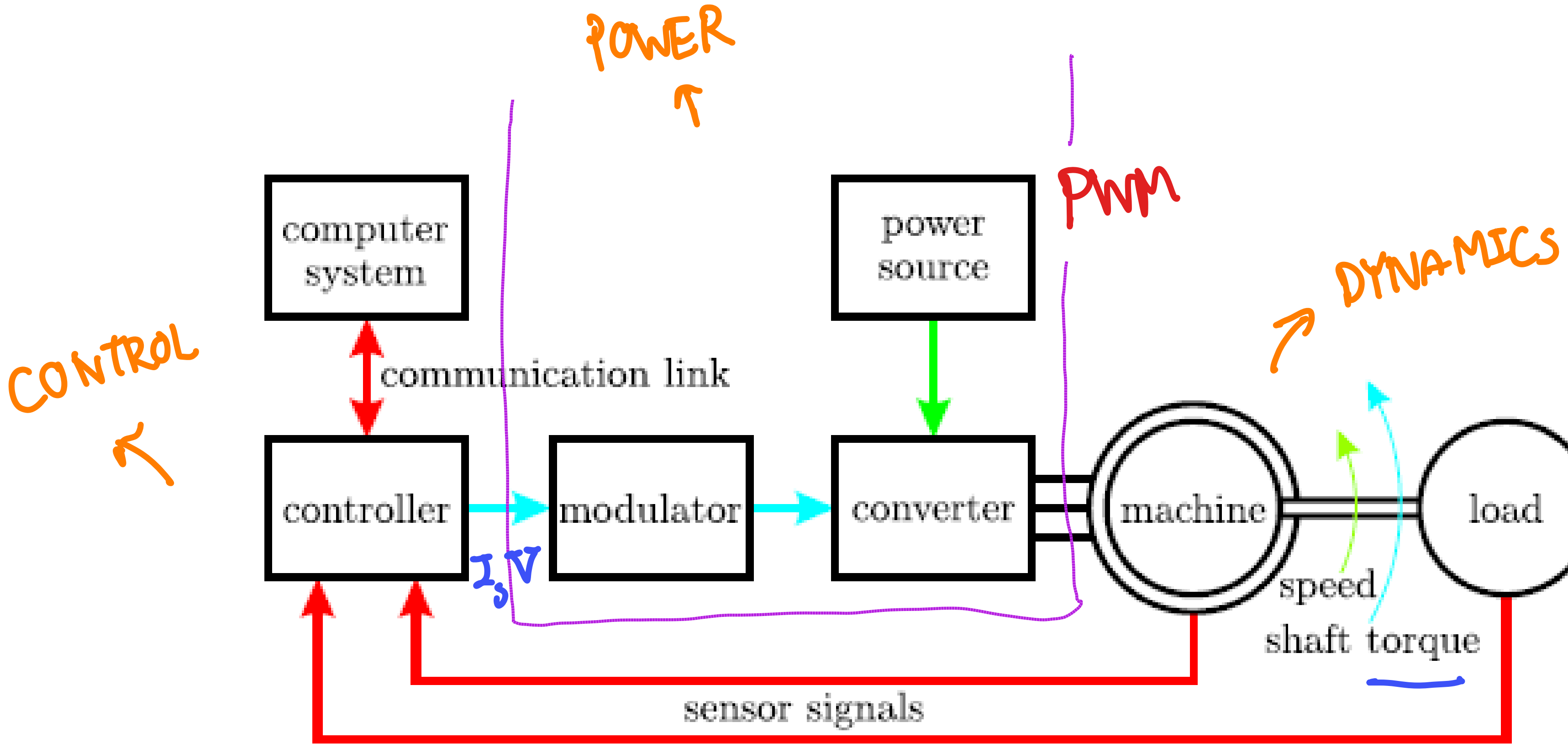


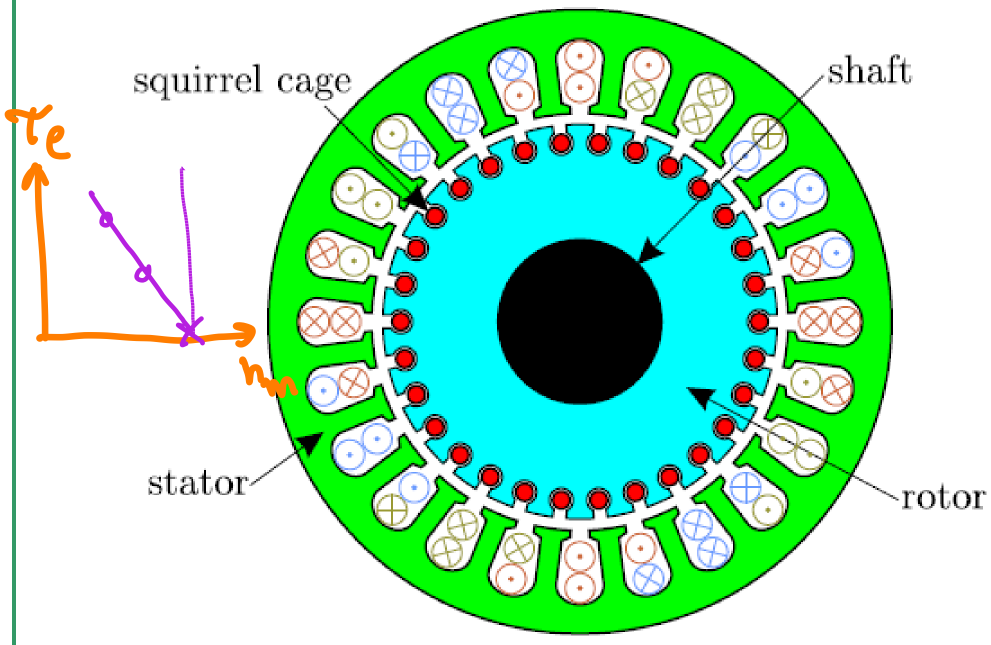

**Fig. 1.1** Typical drive set-up

$n_m = \frac{120 f_e}{P}$

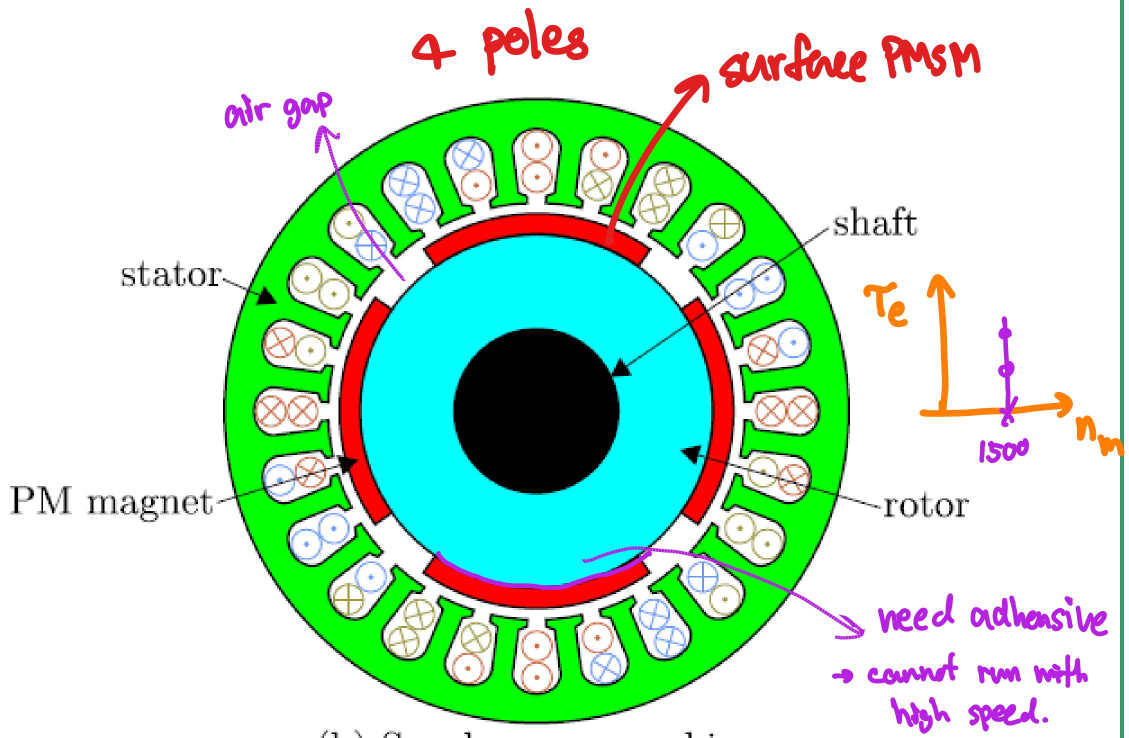
# 1.1 Drive Technology Trends

$f_{elec} = f_{mec}$

## - Electrical Machines : PM Synchronous & Induction Machines



(a) Induction machine



(b) Synchronous machine

- Power Density (Output power to weight ratio KW/kg) is an important performance parameter of the machine.
- With the constraint of acceptable operating temperatures, the power density values were expected to level off around the 0.16 kW/kg value.
- Machines with high speed (e.g. 100,000 rpm) can increase the power density values up to 3.5 kW/kg.

# - Power Converters

- For industrial air-cooled ac to dc converters, the volumetric power density value has increased up to 500 kVA/$m^3$ .

*Key factors :*

-Availability of power semiconductors able to switch more efficiently with lower power dissipation.

- Use of topologies and control techniques to minimize power device losses.

- Improvements to heat-sink technology --> smaller modules.

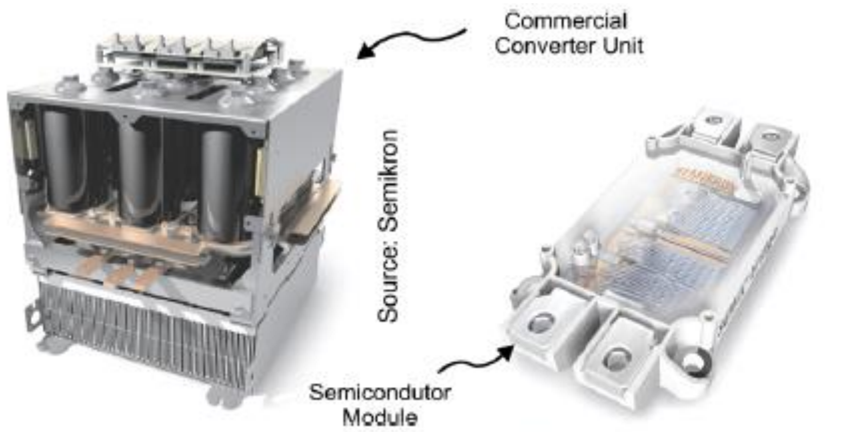



**Fig. 1.5** Example of commercial converter unit and integrated semiconductor module which can be used to build an inverter [58]

**Fig. 1.6** Example of modern inverter technology with standard communication interfaces [72]

- Primary design constraint on the volumetric power density of the converter is thermal.
- The volumetric power density is to a large extend governed by the specific losses of the devices in use, method of cooling and drive operating conditions.

In electric and hybrid vehicles high power-density values for machine and converter are essential. An example of such as drive utilizes a liquid cooled DC to AC converter with a volumetric power density of 6000 KVA/$m^3$ and a 55 kW switched reluctance machine with a power density of approximately 1.2 kW/kg.

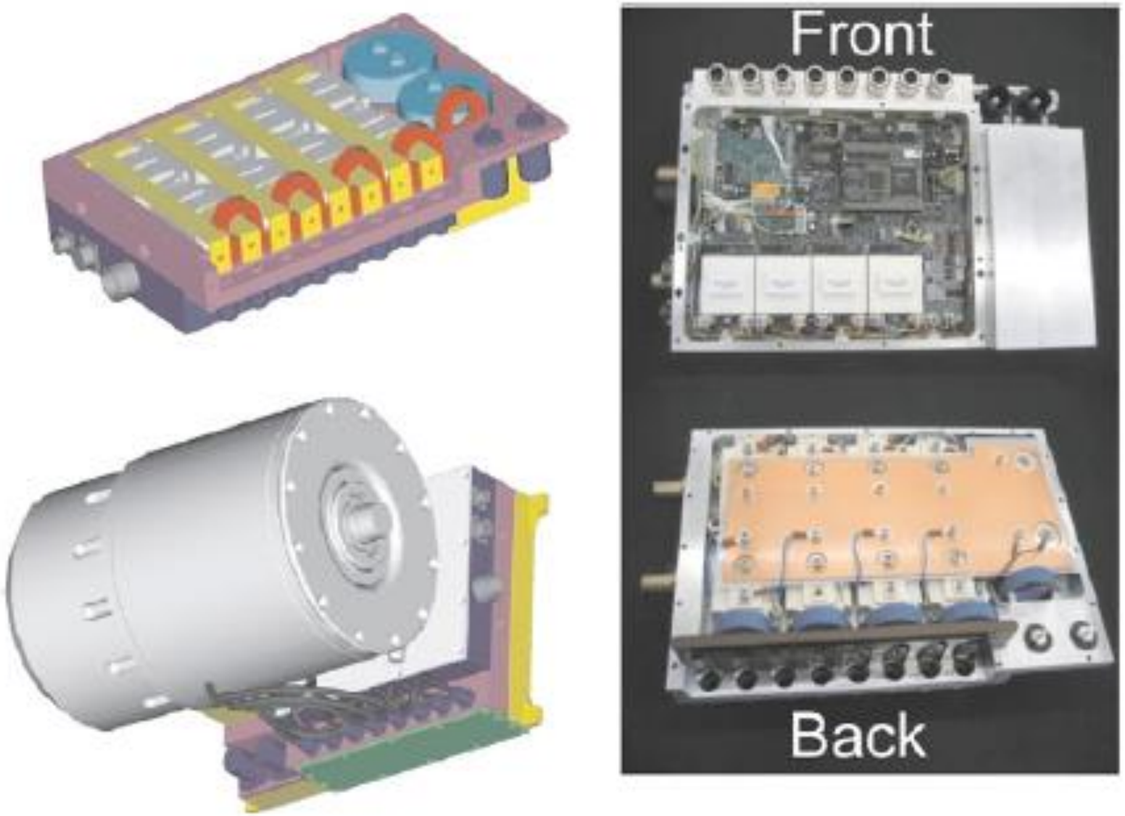



**Fig. 1.7** Example of an electrical vehicle propulsion unit which utilizes a liquid cooled AC–DC converter and 55 kW switched reluctance machine [15, 10]

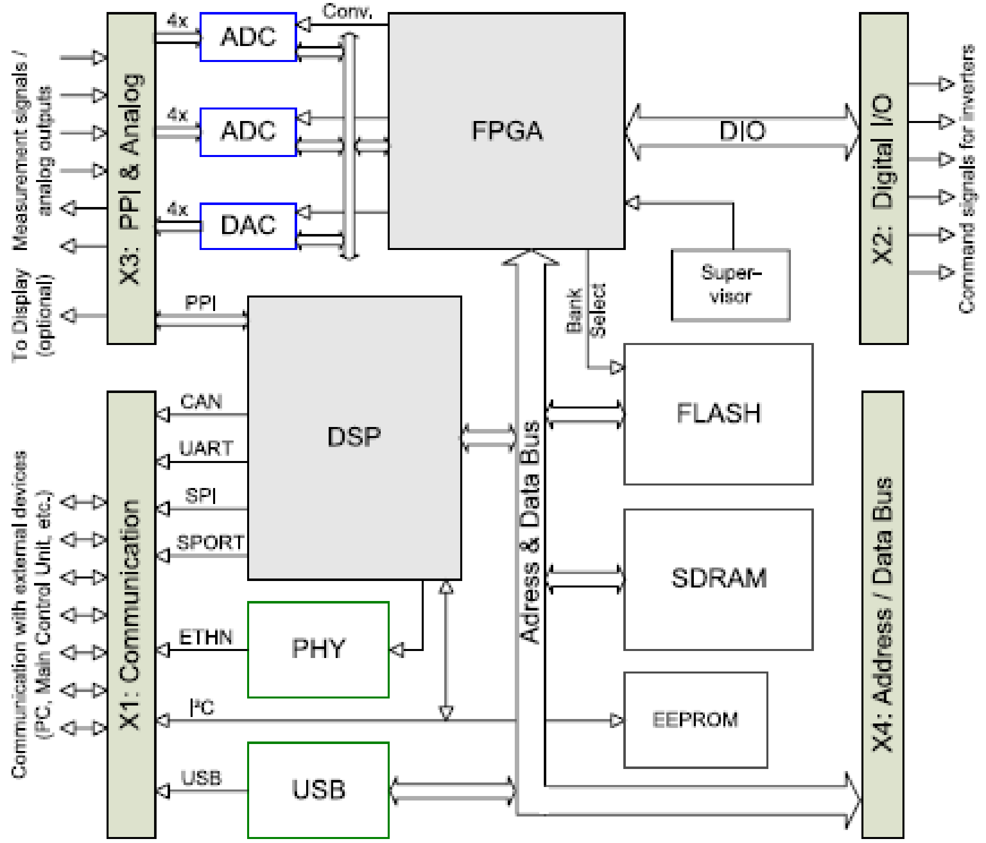
# - Embedded Control

Key innovations :

- Field Oriented Control (FOC) / Vector Control algorithms for AC machines.
- Synchronized space vector, pulse width modulation (PWM) techniques.

- The availability of high performance (fast) fixed point as well as floating point digital signal processor (DSP) and micro-controllers (uC) have simplified the implementation of real time complex control algorithms.

- Availability of a range of programming tools for these DSP and uC units, which utilize high-level programming languages, such as C++, and graphical programming tools, such as MATLAB/SIMULINK or CASPOC, serve to shorten overall drive development times and enhance drive application flexibility.



(a) DSP architecture

# 1.2 Drive Design Methodology

- A closed loop iterative design process is used which encompasses the complete drive.

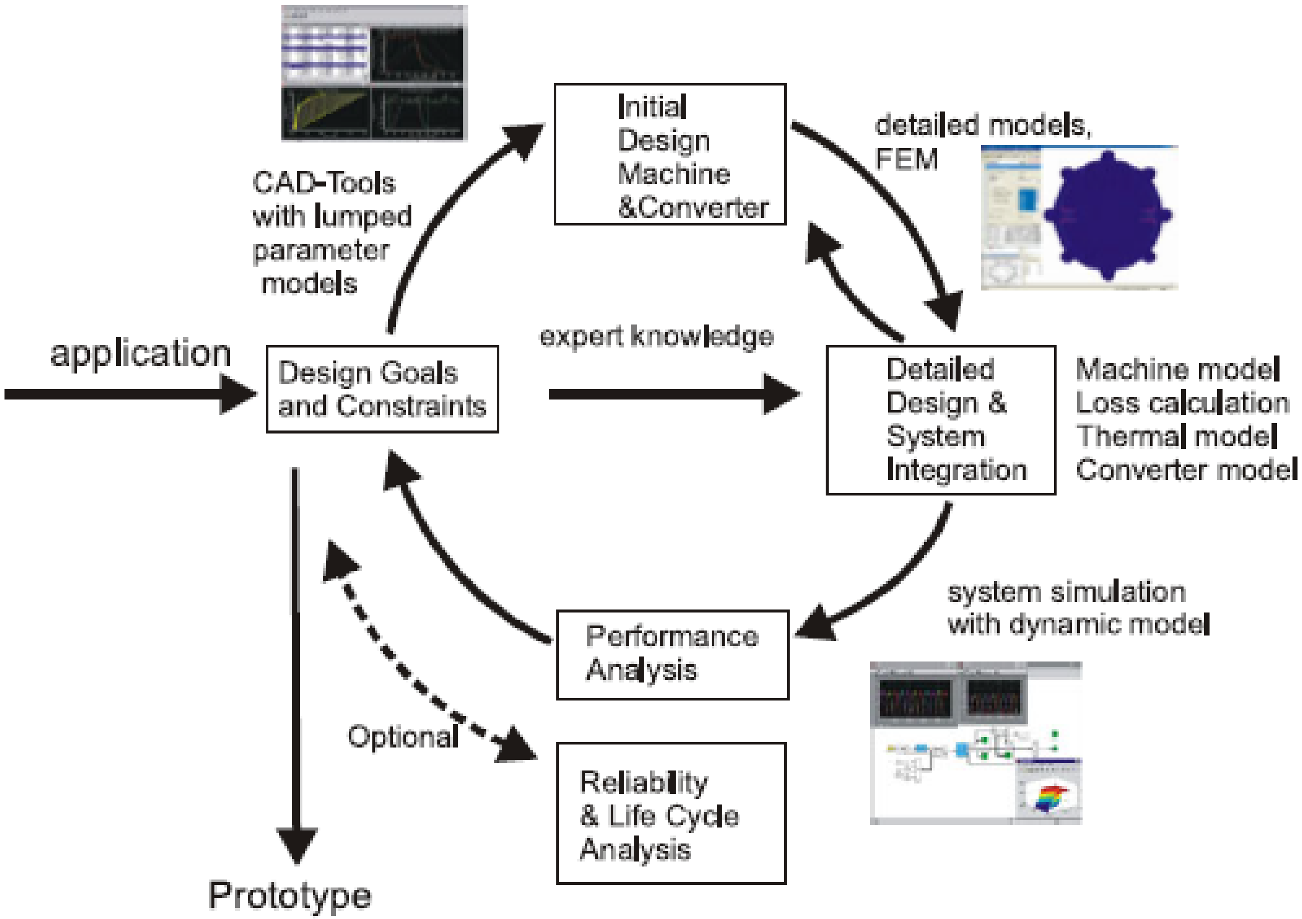



**Fig. 1.9** Typical design methodology used for electrical drives [61, 11, 65]

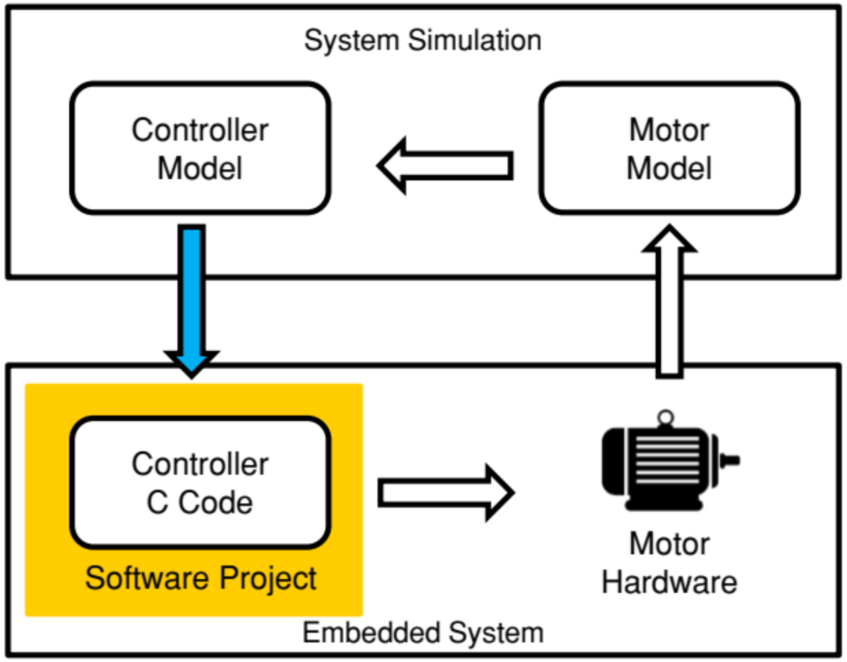
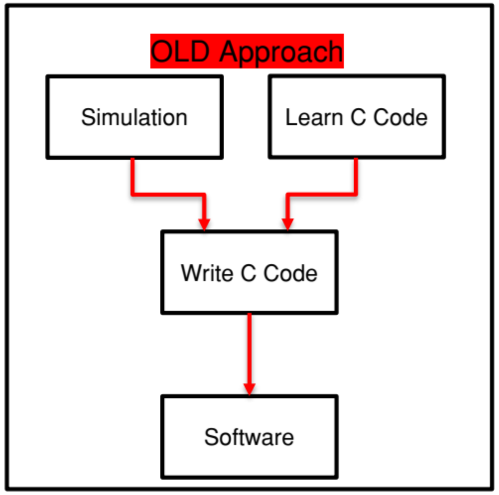
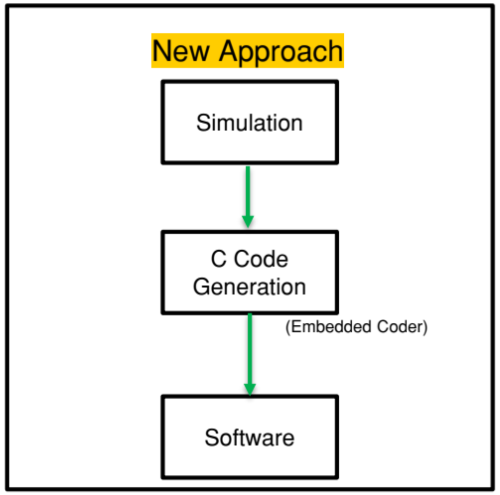


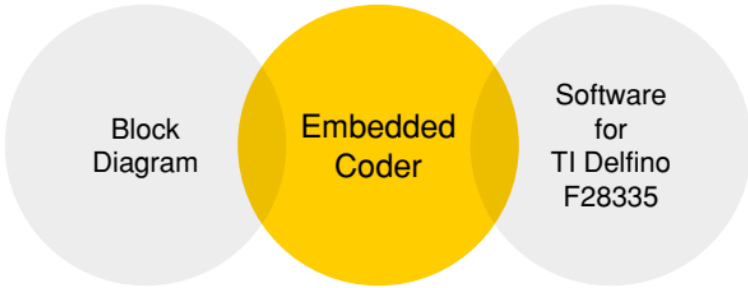

Fig.1 Development & Design Motor control system

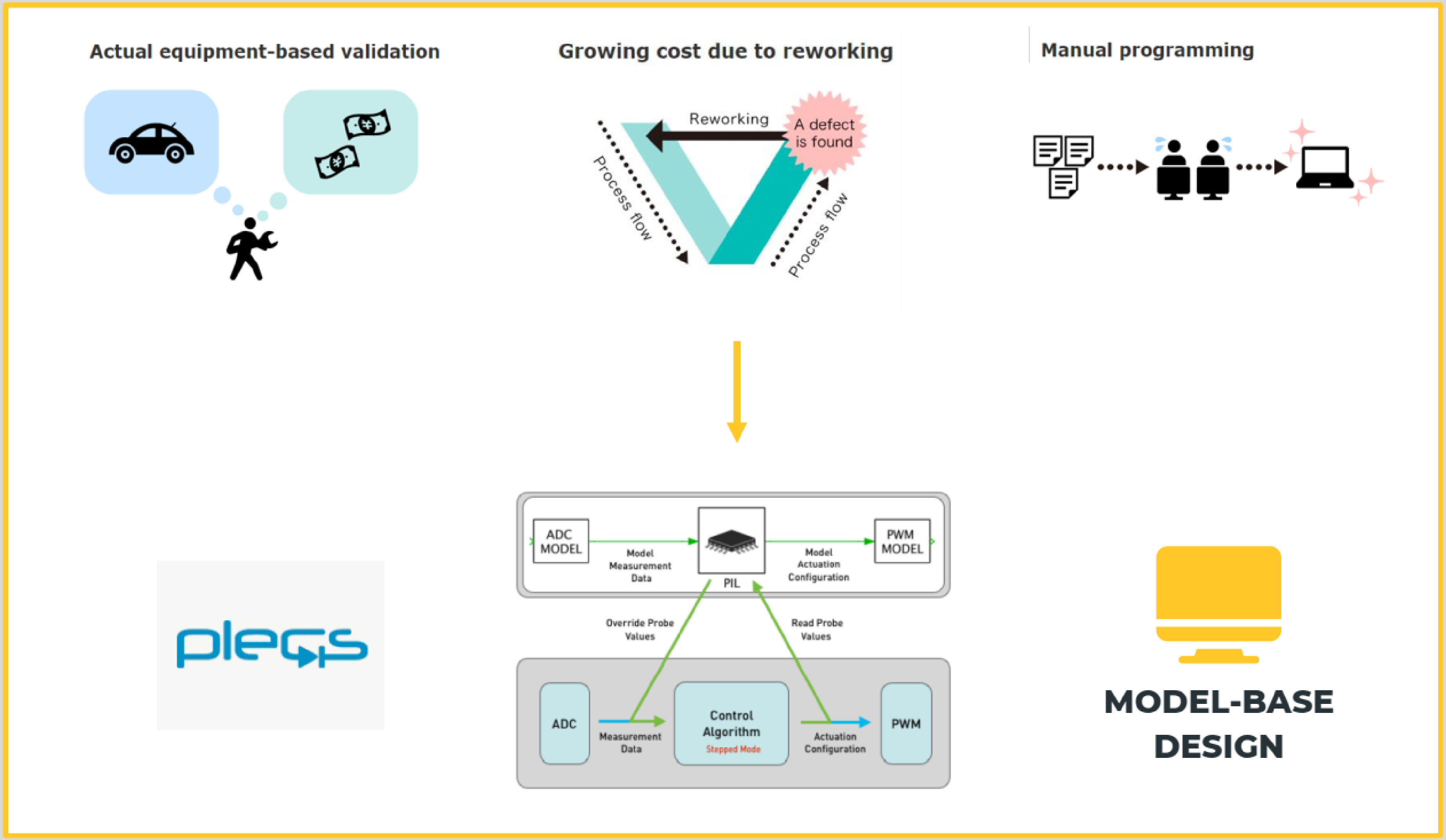



## Objective

- To develop software of a vector controller for Permanent-Magnet Synchronous Motors using Embedded Coder of Matlab/Simulink.



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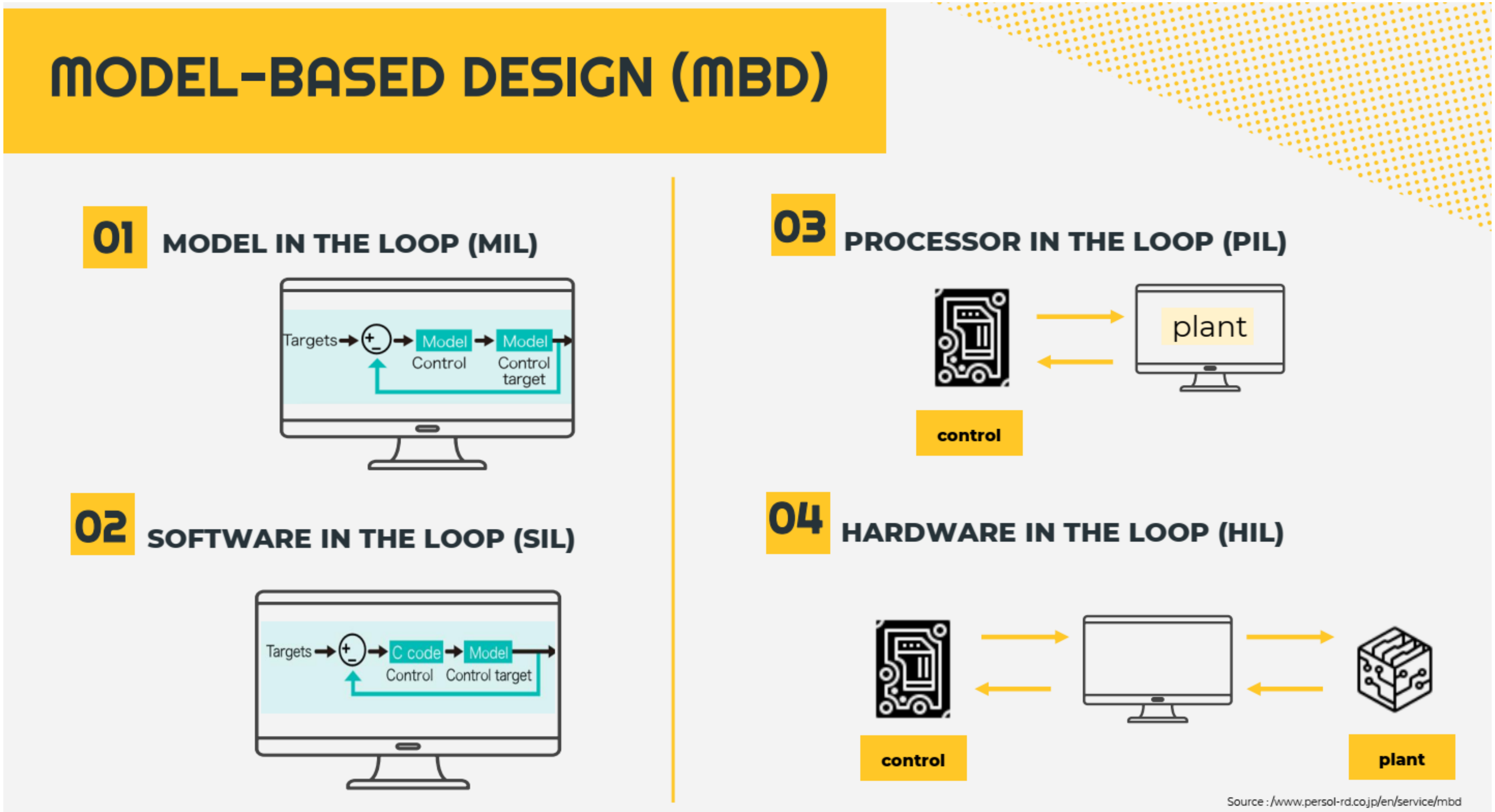
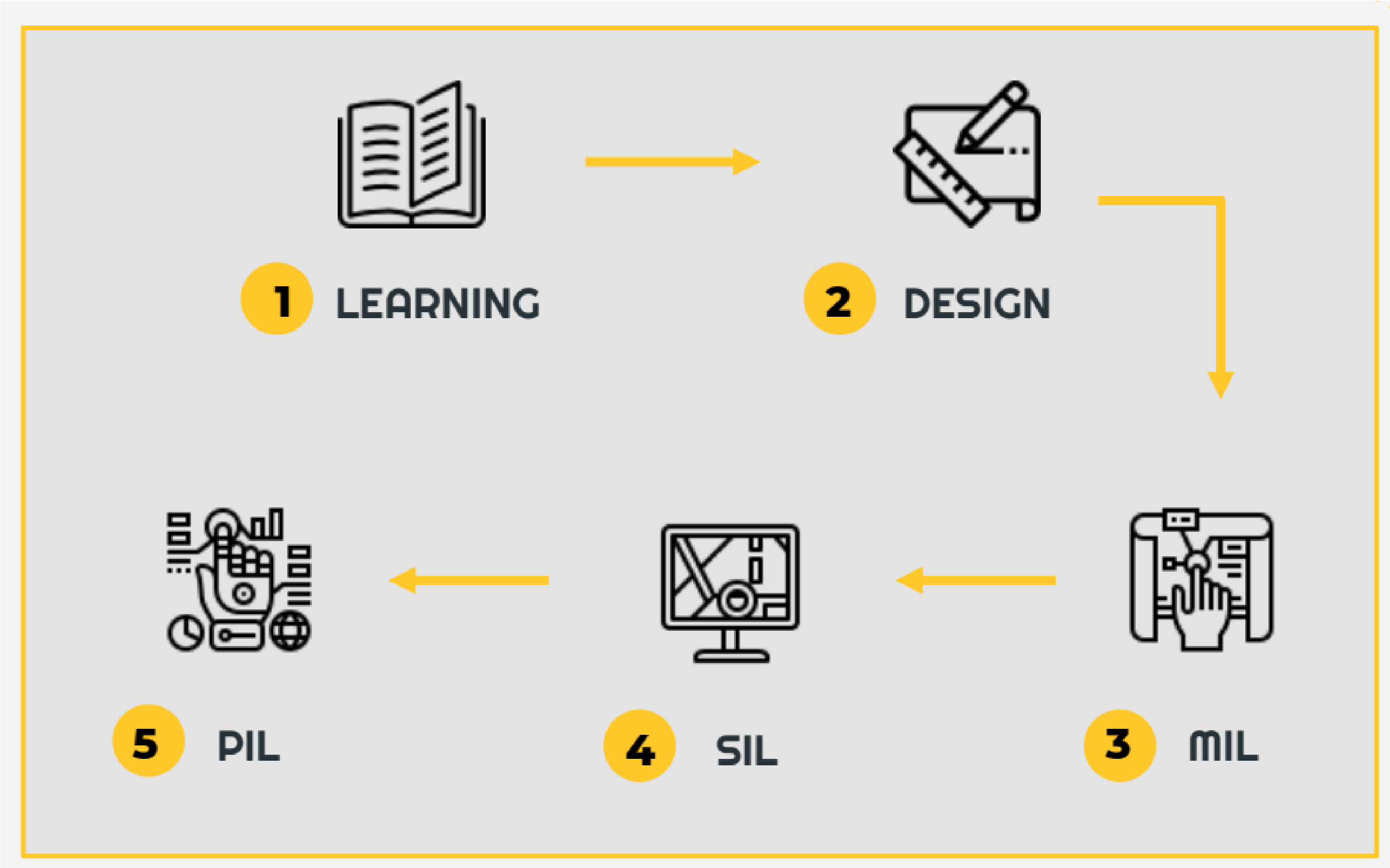

MODEL-BASED DESIGN (MBD)
01 MODEL IN THE LOOP (MIL)
Targets
Model
Control
Model
Control target
02 SOFTWARE IN THE LOOP (SIL)
Targets
C code
Control
Model
Control target
03 PROCESSOR IN THE LOOP (PIL)
plant
control
04 HARDWARE IN THE LOOP (HIL)
control
plant
Source : /www.persol-rd.co.jp/en/service/mbd

# PROCESS



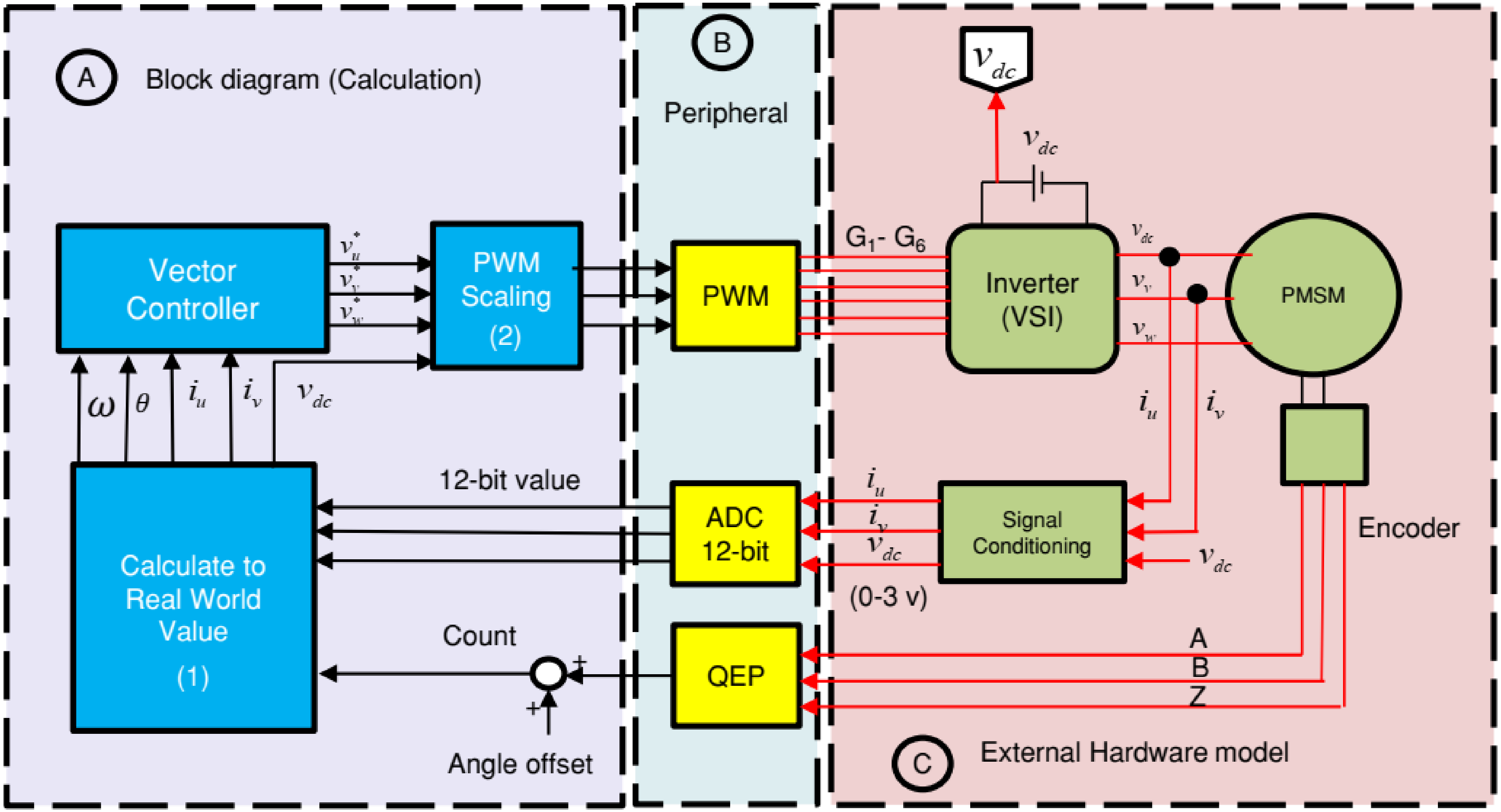



Fig.8 Simulation system of vector controller

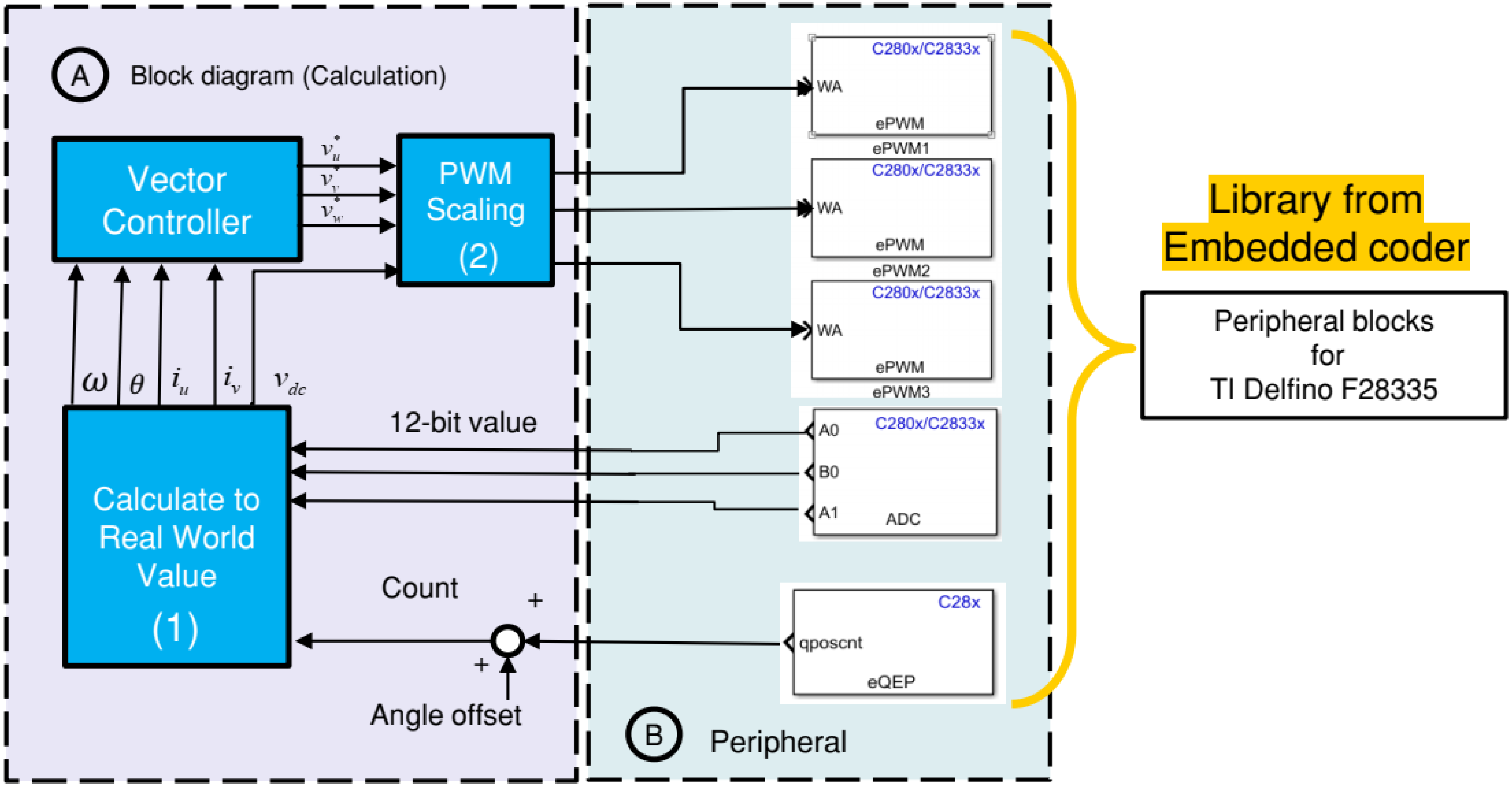



Fig.9 Block diagram for C Code generation

# Result : Simulation of speed control system with vector controller (1)

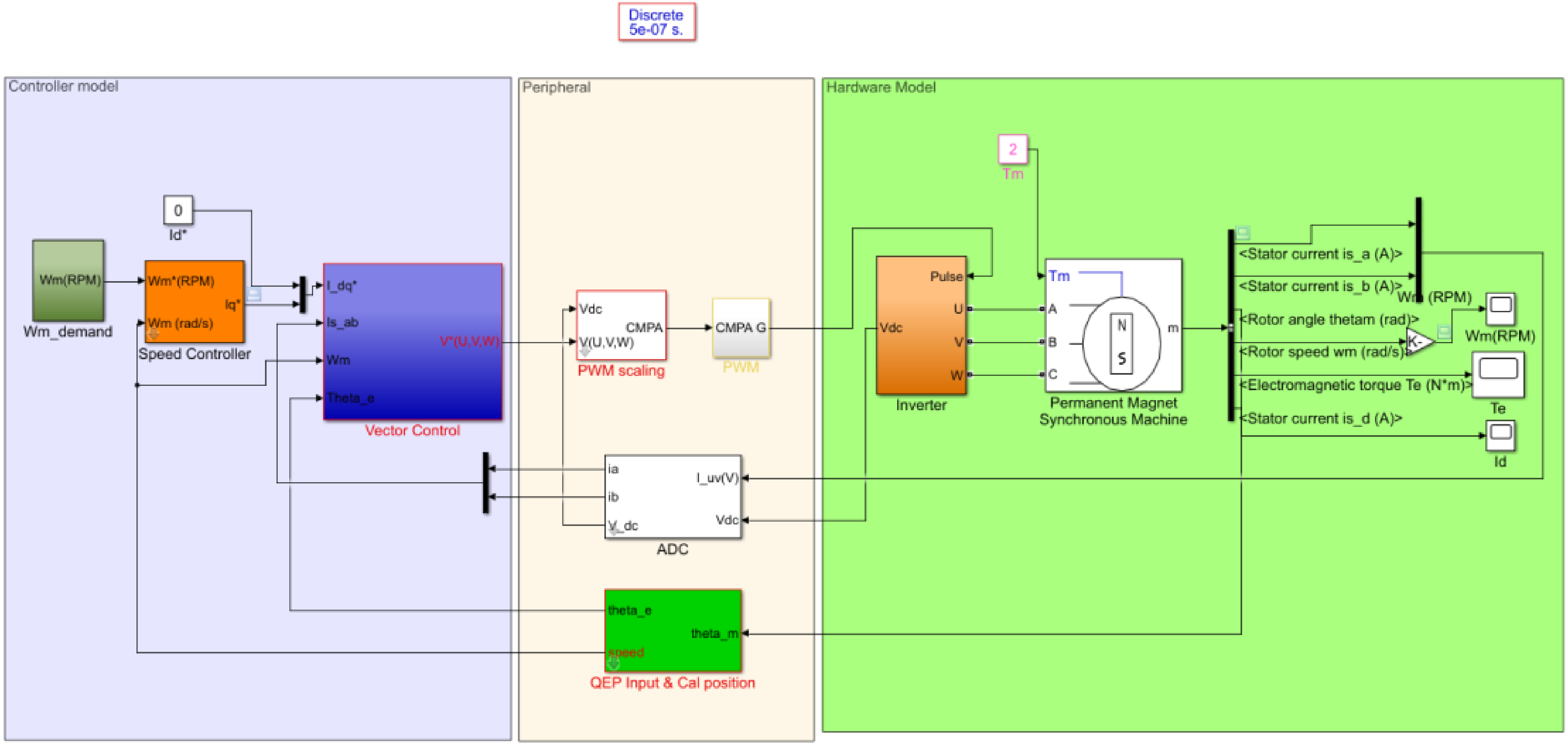



Fig.10 Simulink block diagram of speed control system with vector controller

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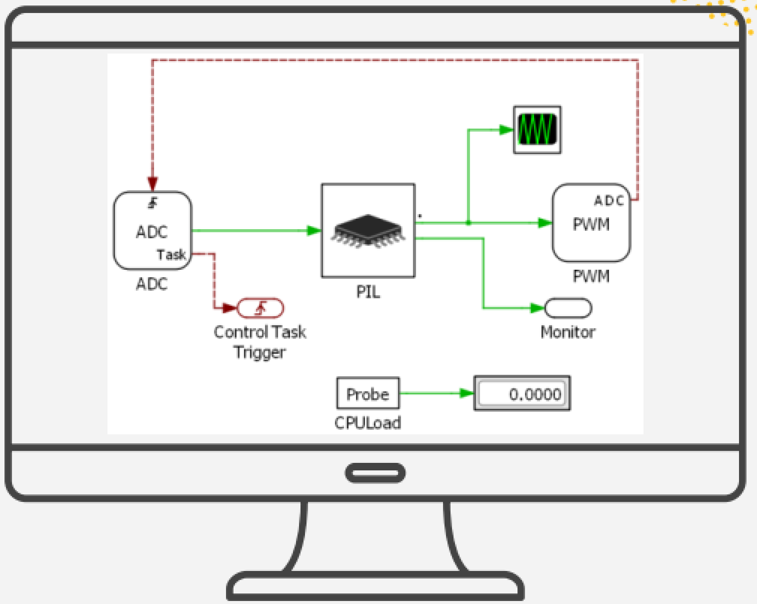
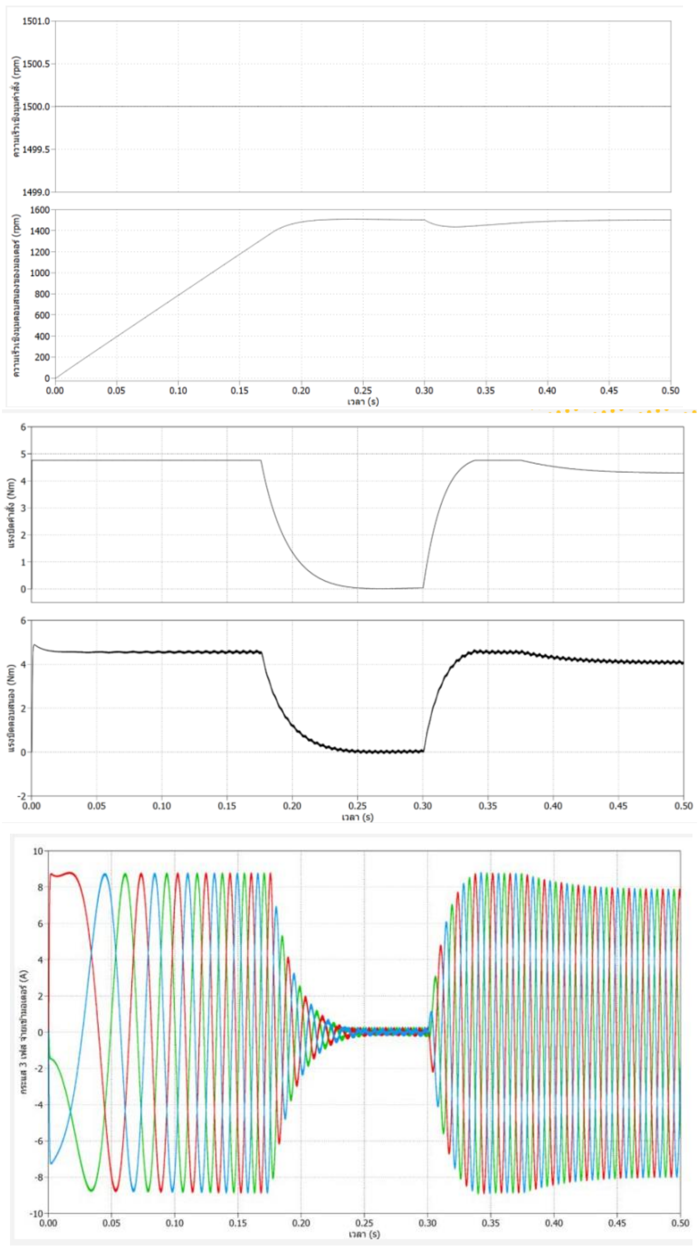



- Response to Step Load
- Large and Small Step Response to speed command
- Speed Reversal

# MIL



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