

電機控制
(Electric Machinery Control)
(EE484000)

Course introduction

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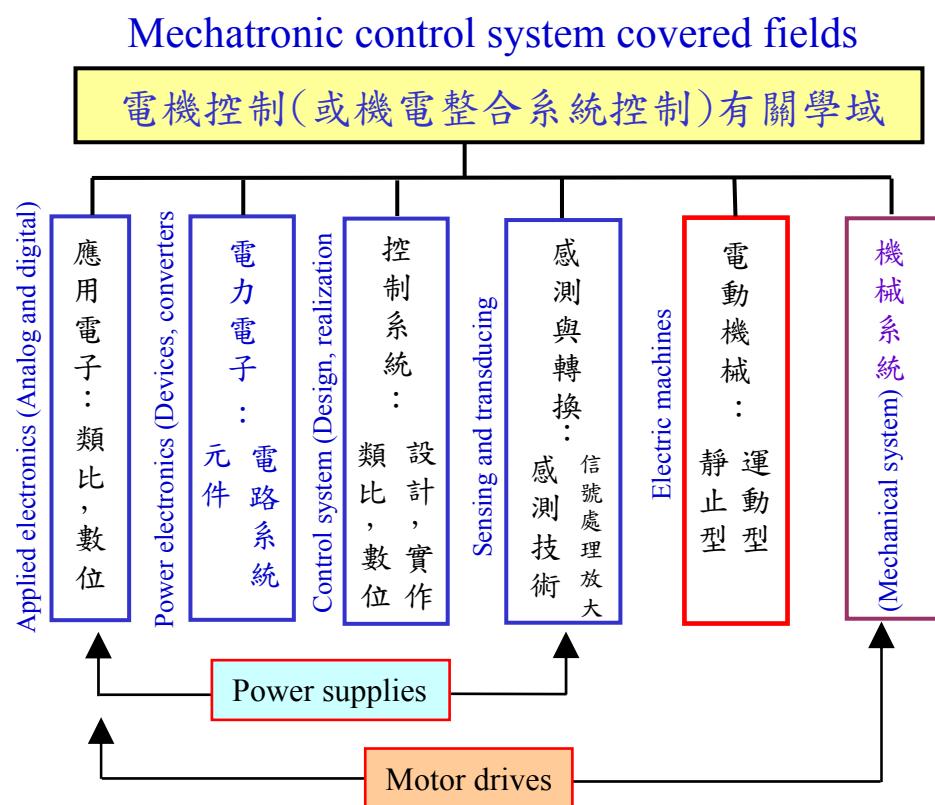
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電機控制 (EE484000) 課前介紹

(Electric Machine Control (EE484000): Course Introduction)

(廖聰明, C. M. Liaw)

- 目的 (Purposes)：介紹一些工業控制系統之理論與操作實務，構建此類系統必要組件之結構與工作原理。(Introduce the theories and operation affairs of some industrial control systems, the structures and operation principles of constituted components in these systems.)
- 所涉及領域 (Covered fields)：



- 內容 (Contents)：如下頁所列 (See the following pages)。
- 教材 (Teaching materials)：原則上由任課老師提供講義 (Distributed lecture notes)。
- 考核方式 (Evaluation)：作業、考試 (Exercises and tests)。
- 實驗 (Experiments)：視實際需要及時間儘量提供。

Electric Machine Control (電機控制) (EE484000) (C. M. Liaw)

Contents

- Introduction to electric machine control and mechatronics (機電整合).
- Overview of power semiconductor devices.
- Introduction to motor drives and their applications.
- Dynamic and static specifications of sensors and transducers.
- Sensors and transducers (for mechatronic system control).
- Signal conditioning circuits for sensors and transducers.
- V/I, I/V, F/V, V/F, A/D, D/A converters.
- Shielding and grounding of power electronic systems.
- Analog controllers.
- Digital controllers (fuzzy controller).
- Power electronic converters (AC-DC and DC-DC converters).
- DC motor drives (converter-fed and chopper-fed)
- Overview of Some AC motor drives and special motor drives:
 - Modulation techniques and harmonic analysis for power converters.*
 - Inverters (DC-AC converters).*
 - Induction motor drives.*
 - Permanent-magnet synchronous motor (PMSM) drives (Brushless DC Motor (BDCM) drives).*
 - Switched-reluctance motor (SRM) drives.*
- Experiments ([Solid-state DC motor control](#), AC/DC controlled rectifiers (Optional)).

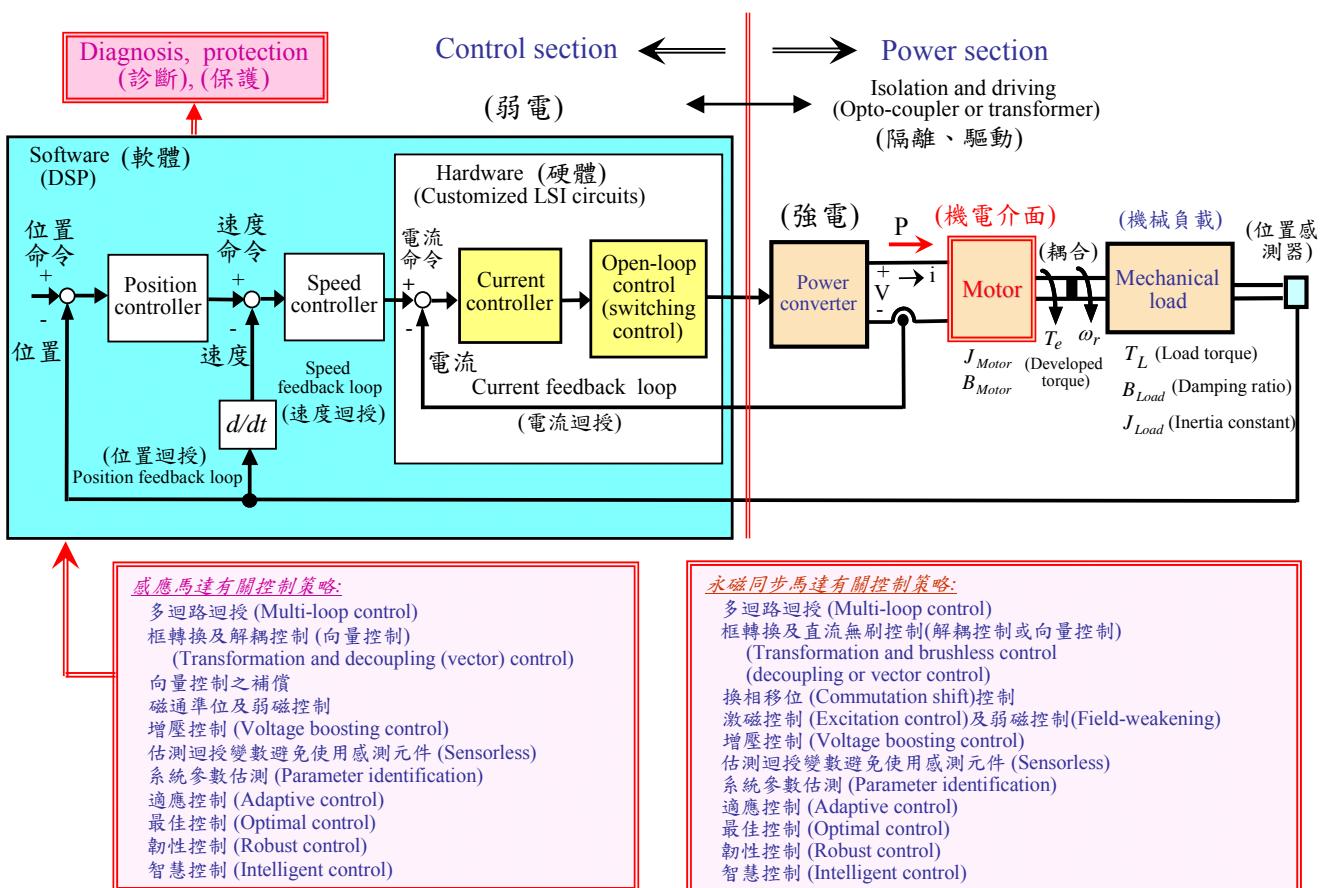
Text books:

- 講義 (Handouts).
- Timothy J. Maloney, *Modern industrial electronics*, 5th Ed., Pearson Prentice Hall, 2004.

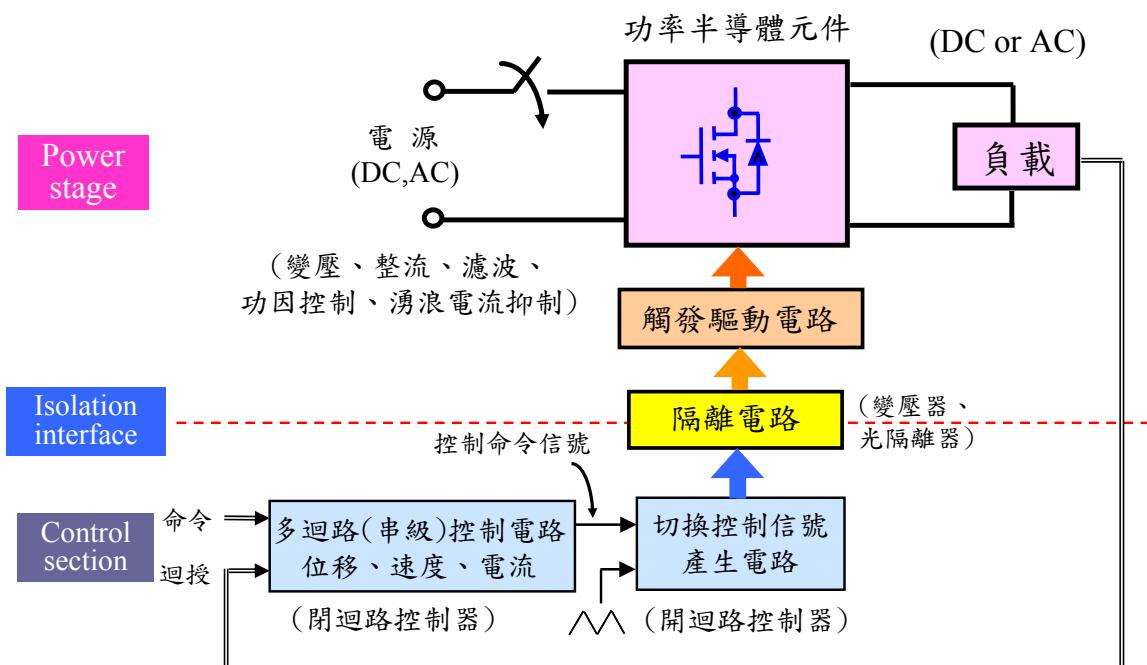
Reference books:

- R. Krishnan, *Electric motor drives: modeling, analysis and control*, Prentice Hall, 2001.
- J. M. Jacob, *Industrial control electronics*.
- J. M. Jacob, *Power electronics: principles and applications*, Delmar Thomson Learning, 2002.
- G. K. Dubey, *Power semiconductor controlled drives*, Alpha Science, UK, 2001.
- Sergey E. Lyshevski, *Electromechanical systems, electric machines and applied mechatronics*, CRC Press, 2000.
- Ned Mohan et al., *Power Electronics: Converters, Applications and Design*, 3rd Ed., John Wiley & Sons, Inc., 2003.
- P. C. Sen, *Thyristor DC Drives*.
- B. K. Bose, *Modern Power Electronics and AC Drives*, Prentice Hall PTR, New Jersey, 2002.
- B. K. Bose, *Power Electronics and Motor Drives: Advances and Trends*, Academic Press, 2006.
- Robert W. Erickson and Dragan Maksimovic, *Fundamentals of Power Electronics*, 2nd Ed., Kluwer Academic Publishers, 2001.
- P. C. Krause, O. Waszczuk and S. D. Sudhoff, *Analysis of Electric Machine and Drive System*, New York: The Institute of Electrical and Electronics Engineers, Inc., 2002.
- John Chiasson, *Modeling and high-performance control of electric machines*, John Wiley & Sons, 2005.
- Gregorio Romero Rey and Luisa Martinez Muneta, *Electrical Generation and Distribution Systems and Power Quality Disturbances*, INTECH Open Access Publisher, 2011.
- Others.

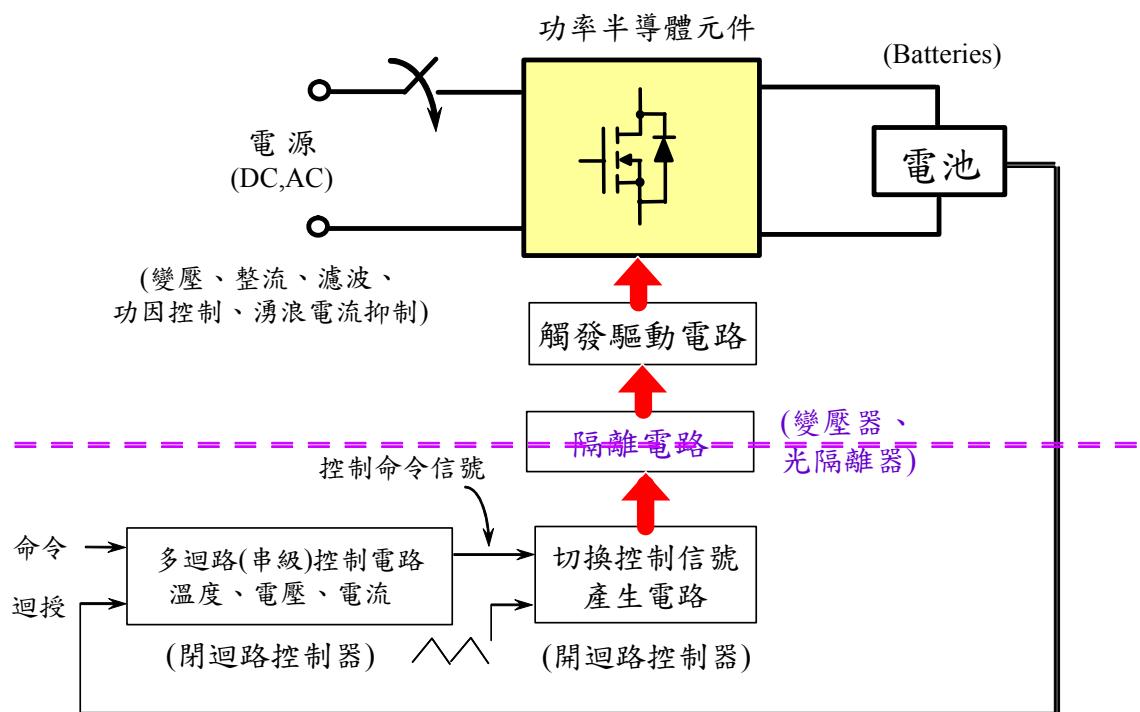
機電整合及電機電子整合介紹 (馬達驅動系統 (Motor drive system))



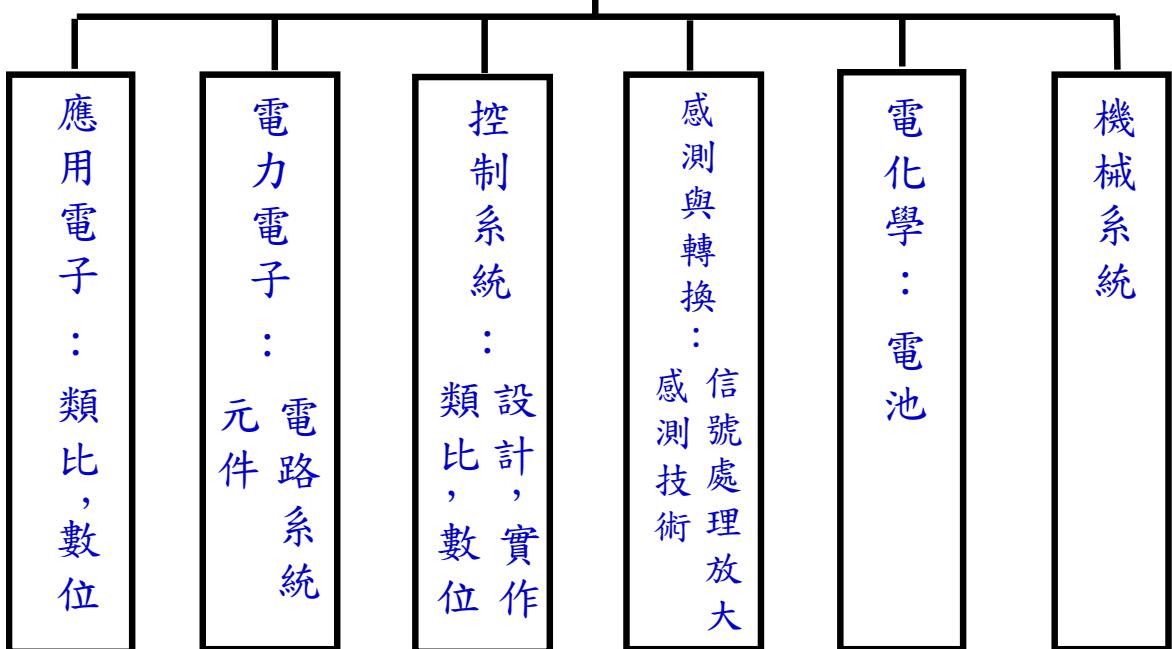
電力電子電路基本組成



電池充電電路基本組成



電池系統研發有關學域



Classifications and related affairs of chargers

1. Classified in terms of power levels and time of charging (One example of classification that suits the US residential power source):

Level 1: Common household type of circuit in the US rated to 120 V and up to 15 A.

Level 2: Permanently wired electric vehicle supply equipment used specially for electric vehicle charging rated up to 240V, up to 60 A, and up to 14.4 kW.

Level 3: Permanently wired electric vehicle supply equipment used specially for electric vehicle charging rated greater than 14.4 kW.

Emergency charger: which charges the battery pack of a vehicle in six to eight hours.

Standard charger: which charges the battery pack in two to three hours.

Rapid charger: which charges the battery pack in ten to fifteen minutes (fast chargers).

2. Conductive or inductive

Inductive charger offers advantages of safety, power compatibility, connector robustness and durability to the users of electric vehicles but on the expense of a lower efficiency and the need of new equipment at charging sites.

3. Single-phase or three-phase.

4. Isolated (galvanic isolation) or non-isolated.

5. Charging methods: battery types? CC and/or CV? Quick charger: CC?

Saeid Haghbin, Sonja Lundmark, Mats Alakula and Ola Carlson, “Grid-Connected Integrated Battery Chargers in Vehicle Applications: Review and New Solution,” IEEE Trans. Ind. Electronics, vol. 99, pp. xx-xx, 2012.

分類	大容量急速充電器	中容量急速充電器	倍速充電器	普通充電器
外観				
仕様	電圧: DC500V 電流: 125A 電力: 50kW 充電時間: 約15~30分 (充電率0~80%)	電圧: DC500V 電流: 60A 電力: 20kW 充電時間: 約30分~1時間 (充電率0~80%)	電圧: 単相AC200V 電流: 20A 電力: 4kW 充電時間: 約7時間 (充電率0~80%)	電圧: 単相AC100V 電流: 15A 電力: 1.5kW 充電時間: 約14時間 (充電率0~80%)
充電方法				

急速充電器(指示受信)



図 2 CHAdeMO プロトコルの流れ



図1 チャデモプロトコルによるEV用急速充電器の概念図

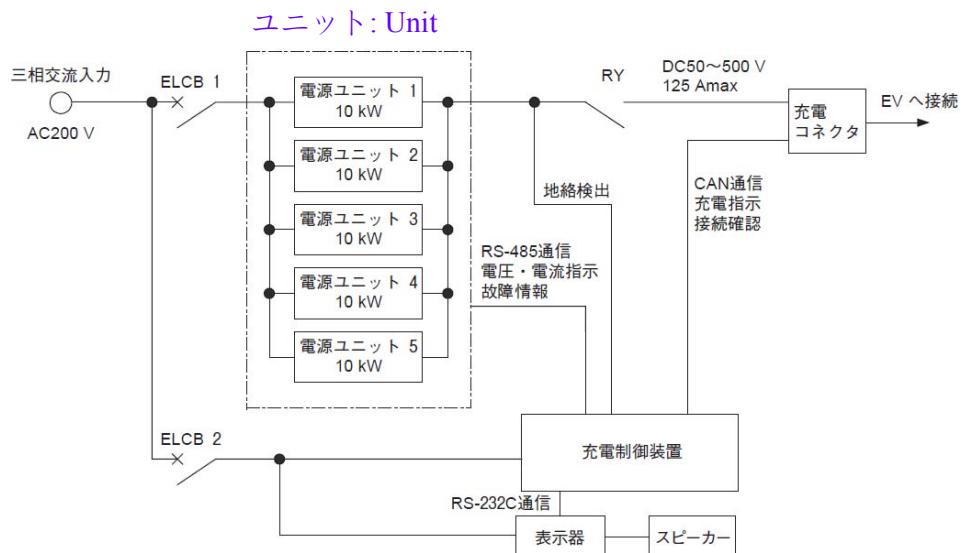
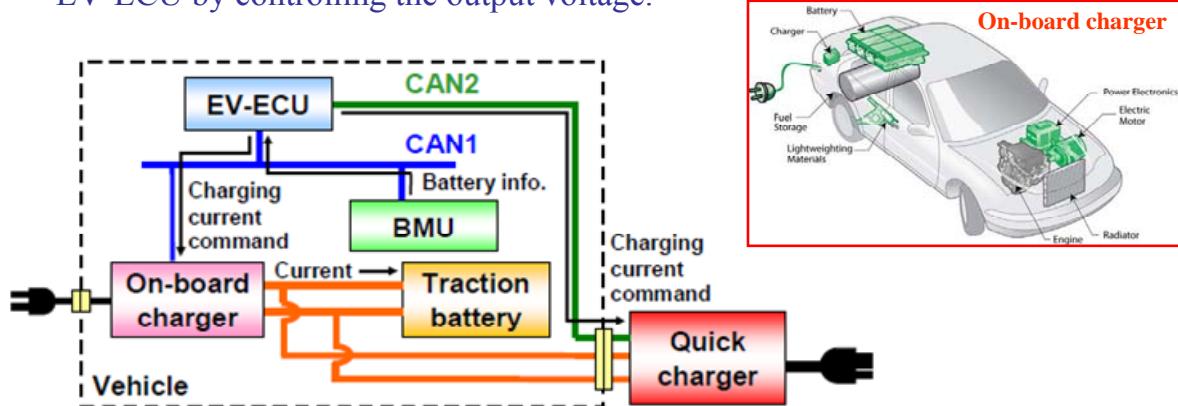


図2 EVC-50KA の構成

Charging Control System of i-MiEV

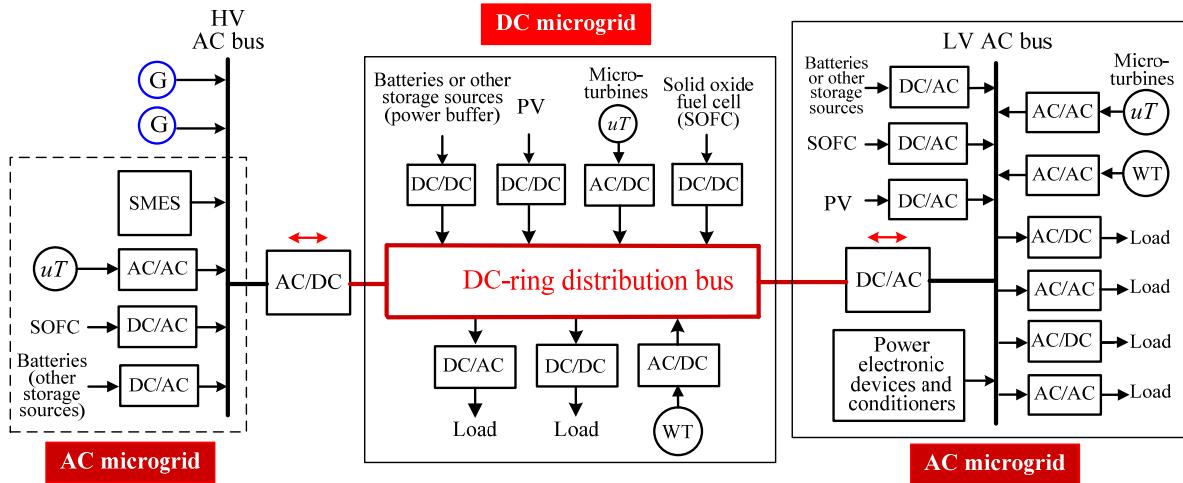
The BMU (Battery Management Unit) monitors the conditions of all 88 cells of the traction battery and sends information (maximum and minimum cell voltage, maximum and minimum cell temperature, battery current, etc.) to the EV-ECU (integrated vehicle controller). The EV-ECU calculates charging current command according to the battery information, and sends it to the on-board charger or the quick charger via CAN bus. Then the on-board charger or the quick charger generates charging current according to the command from the EV-ECU by controlling the output voltage.



其他應用：

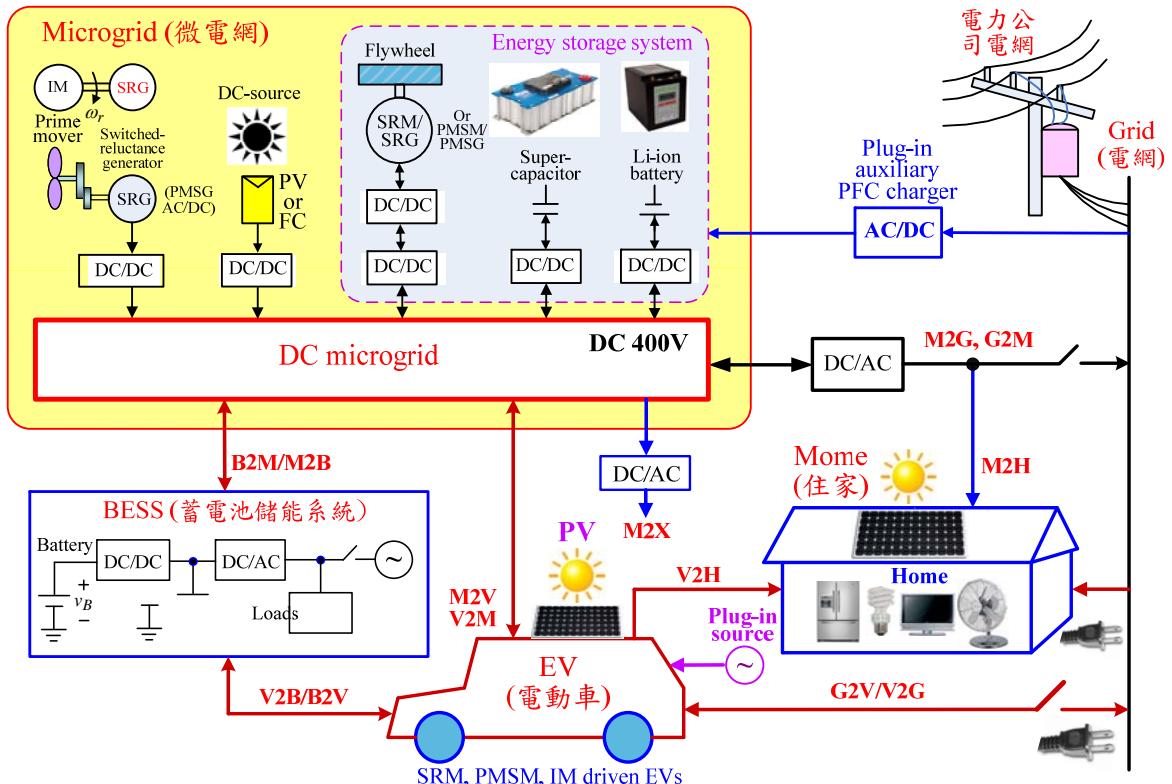
通信分散式電源架構 (Distributed power architecture, DPA)、不斷電電源供應器 (Uninterruptible power system, UPS)、各式切換式電源供應器、電腦周邊設備、分散式發電源 (Distributed generator, DG) 配電系統、再生式發電源 (Renewable energy source, RES) 配電系統、微電網 (Micro-grid)、儲能系統、彈性交流系統、乏補償器、功因校正控制器、電子式日光燈及照明裝置、感應加熱器、電焊器(Welder)、家電電器 (空調機、冷凍冷藏庫、洗衣機等)、電動車輛 (Electric vehicles)、軌道車輛、工廠自動化設備、輔助電源供應器 (Auxiliary power unit, APU)、電梯、軍事設備、電動工具、自動化設備、機器人、醫療器具、其他。

Typical distributed power system and micro-grid system configurations



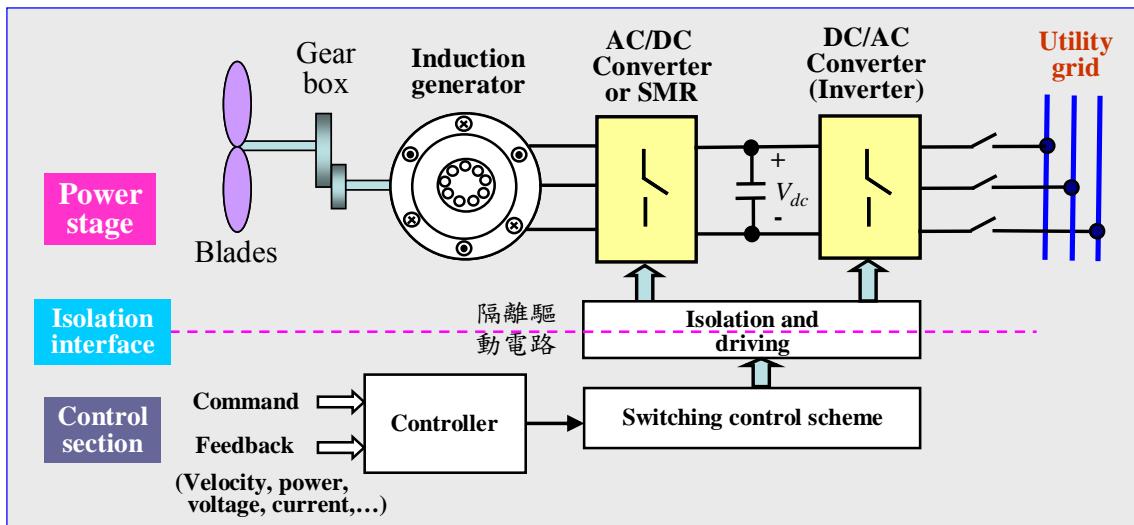
綠能系統、微電網及電動車之應用可增進總體能源使用效率並降低碳排放，結合電動車輛之微電網可利用電動車輛內含電池/超電容及內燃機/燃料電池等提供額外之儲存能源。然而綠能系統、微電網及電動車均為一整合性系統，含能源、發電機、儲能系統、電力電子、控制、能源管理等，唯有其組成元件之妥適組建與搭配，適當之能源管控，始可建構一成功且高效率之總體系統。電力電子在節能與微電網之成功應用上扮演極關鍵之角色。

System configuration of micro-grid incorporating with EV and BESS



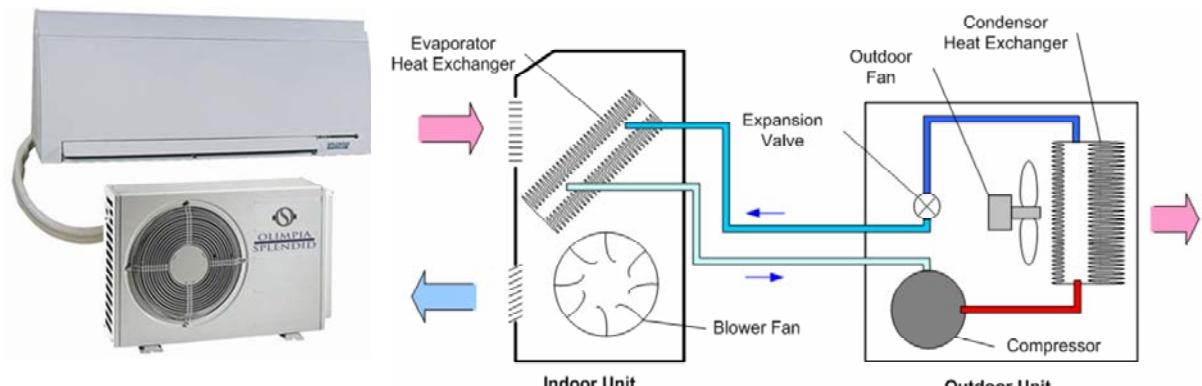
風力發電系統 (Wind generator system)

為一含風渦輪機、機械、電動機械、電力系統、電力電子轉換器、控制器、感測與轉換等之整合系統，唯有各組成子系統本身之適當設計、系統組件間之妥善搭配、適當之總體操作及管理控制，始可得優良之運轉性能。



■ Requirements: Reliable, higher efficiency, smaller volume and low weight, low cost, miniaturization, low vibration and acoustic noise, etc.

Home air conditioner trends

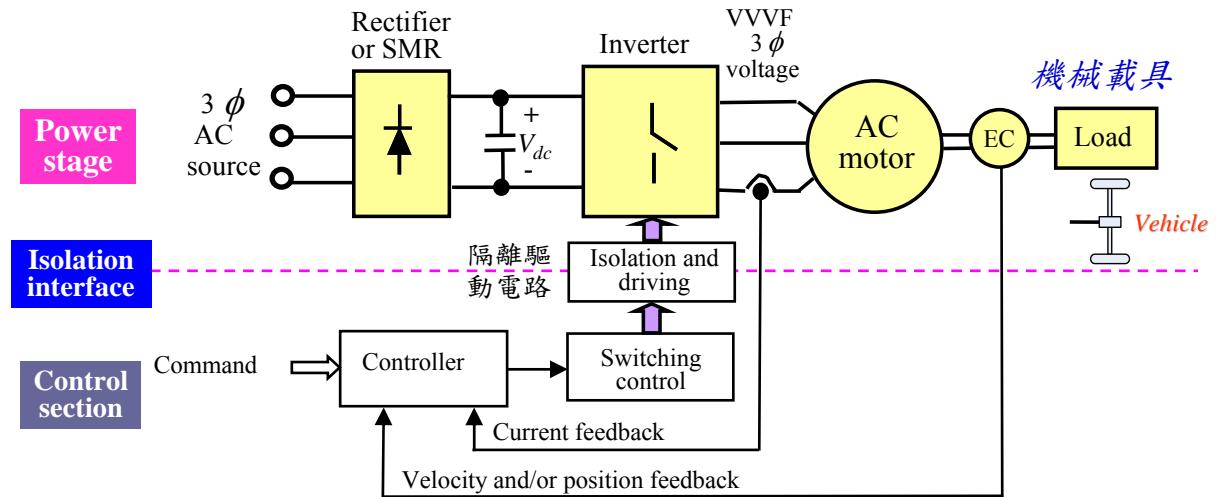


Trends:

- Compressor motor: Induction motor >> Permanent-magnet synchronous motor (PMSM) (Specifically Interior PMSM (IPMSM))
- Vector control (brushless control)
- Sensorless control.
- Square-wave type PMSM >> sinewave type PMSM.
- Front-end switch-mode rectifier (SMR)>> provide boostable and well-regulated DC-link voltage with good line drawn power quality.
- Common digital control environment for: Outdoor compressor PMSM, outdoor condenser fan motor, front-end switch-mode rectifier (SMR).
- DSP or ASIC + microcontroller, or FPGA + microcontroller.

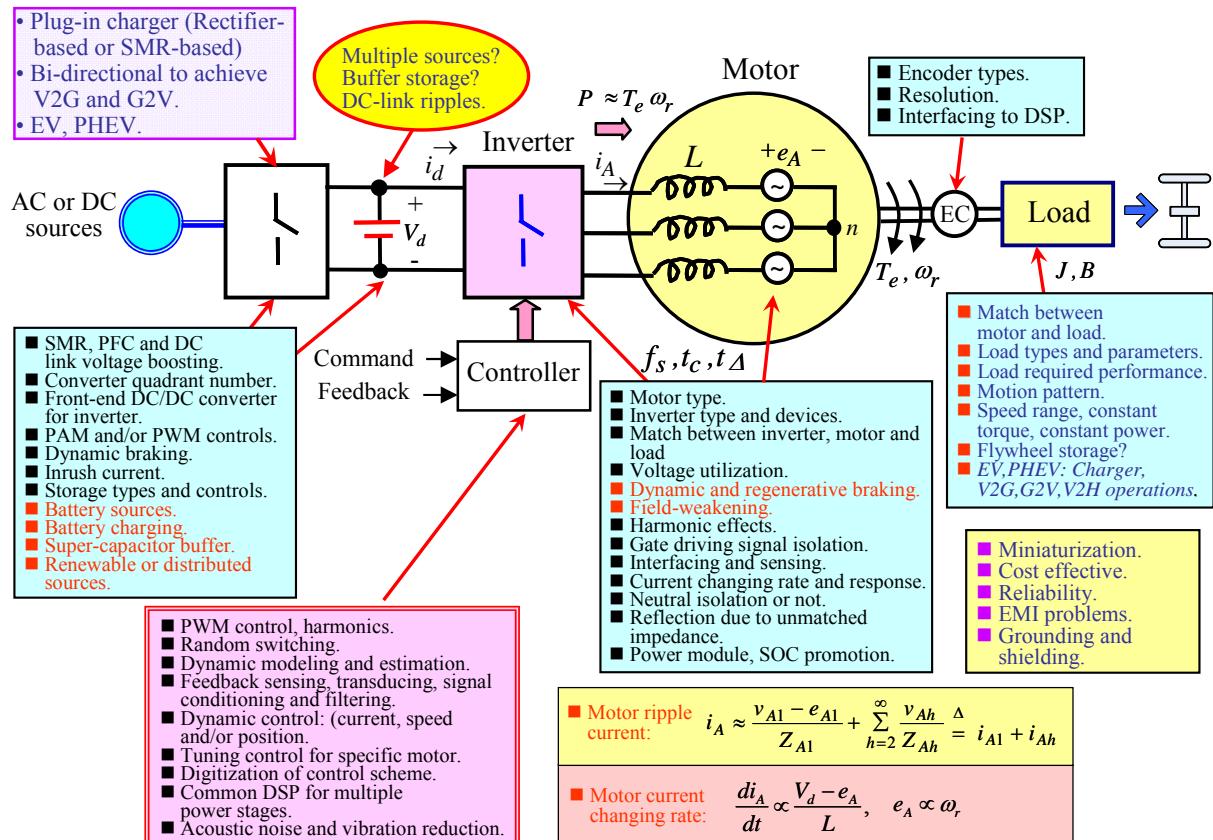
馬達驅動系統 (Motor Drive) 簡介

為一含 **馬達、機械載具、轉換器、控制器、感測與轉換** 等之整合系統，唯有馬達本身之適當設計與驅動系統組件間之妥善搭配，始可得優良之運轉控制性能。

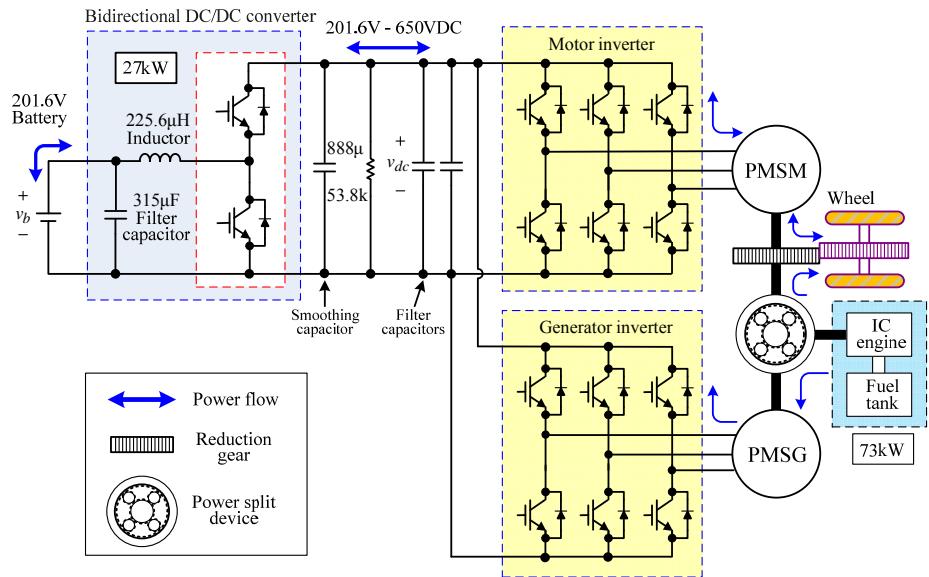


● Requirements: reliable, low cost, miniaturization, smaller volume and weight (modularization and integration), higher efficiency (energy saving), lower vibration and acoustic noise, etc.

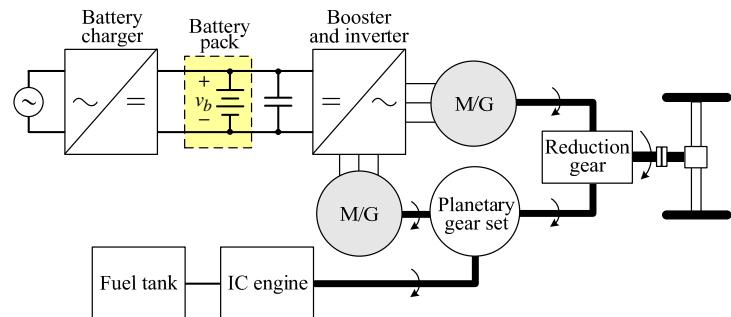
Some Key Issues of Motor Drives (馬達驅動系統一些關鍵事務)



Schematic of power control unit in 2010 Prius Synergy HEV



Configuration of Plug-in series/parallel HEV



1

Key Components and Issues of EV

- Motor:
 - ☒ DC brush motor (DCM) (Least used).
 - ☒ Induction motor (IM).
 - ☒ Permanent-magnet synchronous motor (PMSM).
 - ☒ Switched-reluctance motor (SRM).
- Power electronic converter and its switching control:
 - ☒ DC/DC converters (DCM).
 - ☒ Inverters (Sine-wave, square-wave) (IM, PMSM).
 - ☒ Asymmetric bridge converter (Unipolar square-wave) (SRM).
- Traction battery.
- Storage devices (Super-capacitor, flywheel).
- Energy management technology.