ALL NEW ENERGY

銓陽能源科技股份有限公司

BMS Design for Large Battery System

Outline

- Why we need a BMS?
- Why the LiFe battery is better?
- Intrinsic Problem with LiFe?!
- Modular Design
- Communication Interface
- Hierarchical Structure

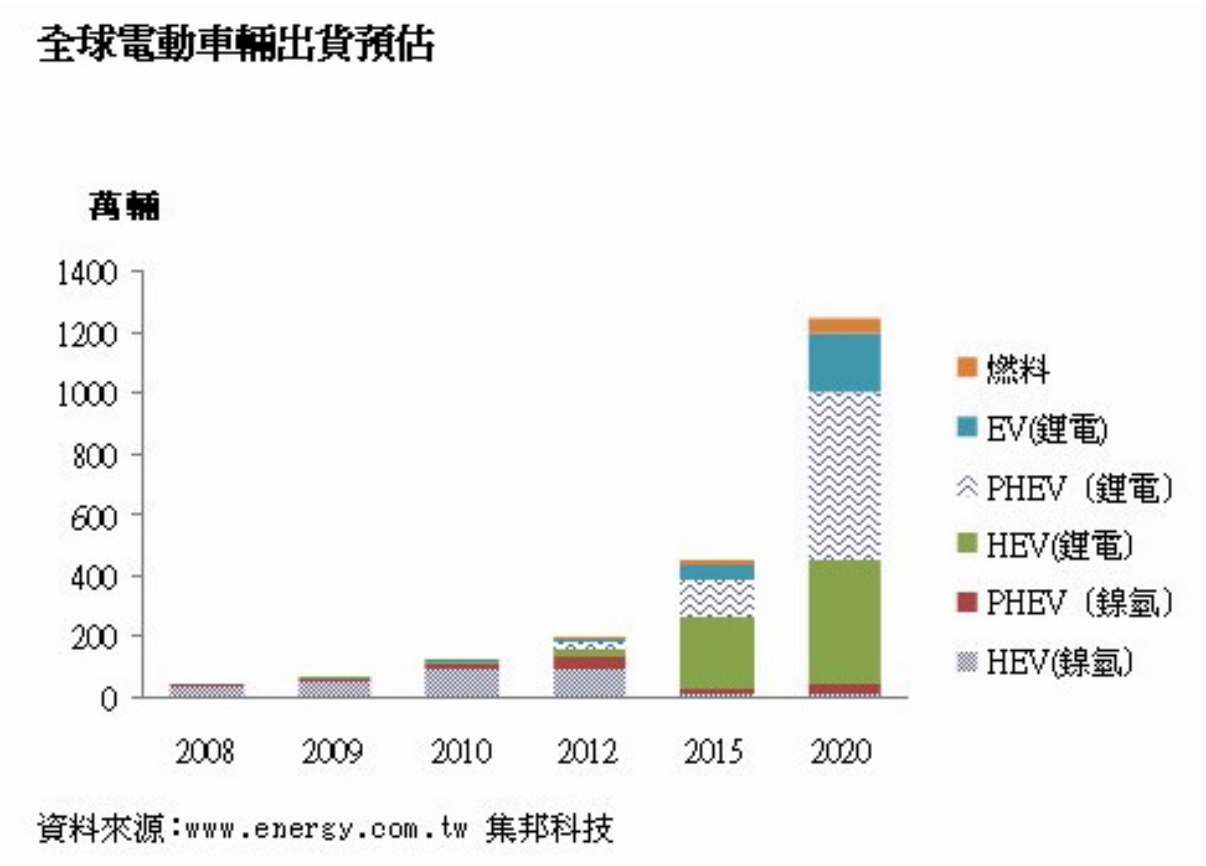
如火如荼的電動車計劃

- 中國將對夜充型電動巴士補助RMB110萬，預計十年達五萬台
- 英國首相布朗全力推動綠色經濟復甦，將大量生產並外銷電動車
- 美國總統歐巴馬公布24億美元推動發展電動車計畫
- 台灣預計四年補助十五萬小型電動機車，每台NT8,000~2,1000
- 電動車產業擾動產業變革，3C保護IC大廠如德儀(TI)、 Linear Tech. 、Maxim 、ADI 、 NS已投入Hybrid Car的鋰錳 battery system.
- 日系的Sanyo及NEC紛紛投入鋰鐵專用保護元件

Make, Model & Type	Features	Status	Views
Audi A1 Sportback PHEV	5 door, 4 passenger, AER 31-62 mi (normal vs efficiency mode), 0-60 mph 8 sec, top speed 120 mph, 20kW electric motor, 1.4L engine. Efficiency mode has slower acceleration and all-electric speed to 62 mph.	**Target Intro:** 2011 **Progress:** concept car at Paris Motor Show 2008 *source: Audi*	
Audi e-tron EV	2 door sports car based on the R8, 2 passenger, range 248 km (154 mi), 0-62mph 4.8 sec, top speed 200 km/h (124mph), 42.4 kWh Li-ion battery pack, 4 hub motors with a combined output of 230kW	**Target Intro:** Not Yet Announced **Progress:** Concept car unveiled at 2009 Franfurt Motor Show *source: Audi*	
BMW MINI E EV	Conversion of MINI 2-door hardtop to 2-seat EV with drivetrain & battery from AC Propulsion, range 150 mi, top speed 95 mph, 35 kWh Li-ion battery back uses 5000+ laptop style batteries, 150kW electric motor, 220Nm torque, 3-4.5 hr recharge on fast charge (240V 48A/32A), 26.5 hr on 120V 12A, wt 3230 lbs	**Target Intro:** no plan announced for mass production **Progress:** Trial fleet of 500 cars in US on 1-year leases to general public, first car delivered on lease May 22, 2009 *source: BMW*	
BMW Vision PHEV	Vision EfficientDynamics, all-new design 2-door 4 seater, 31 mi AER, total range 400 mi, 0-60 mph 4.8 sec, top speed 155 mph, recharge 2.5 hr on 240V, 2 electric motors (1 each axle), 356 hp, 560 lb-ft peak, 1.5L 3-cyclinder diesel engine, 3000+ lbs, Cd 0.22	**Target Intro:** no plan announced for mass production **Progress:** concept car shown at Frankfurt Auto Show *source: BMW*	
BYD Auto e6 EV	4 door crossover, 5 passenger, range 400 km (249 mi), 0-60mph 8 sec, top speed 100 mph, BYD Li-ion Fe battery, 10 min recharge to 50% SOC, 4 power combinations using front & rear motors on some models: 75kW, 75+40kW, 160kW, 160+40kW	**Target Intro:** China 2009, Europe 2010, US 2011 **Progress:** demo units now *source: BYD*	

Picture from: www.pluginamerica.com

Market Trend

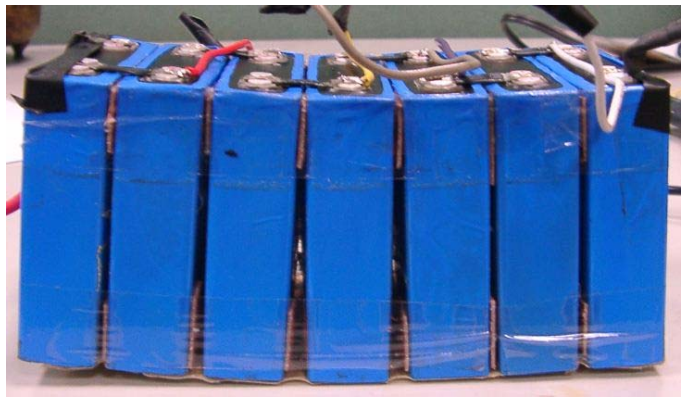


鋰電池的惡夢?

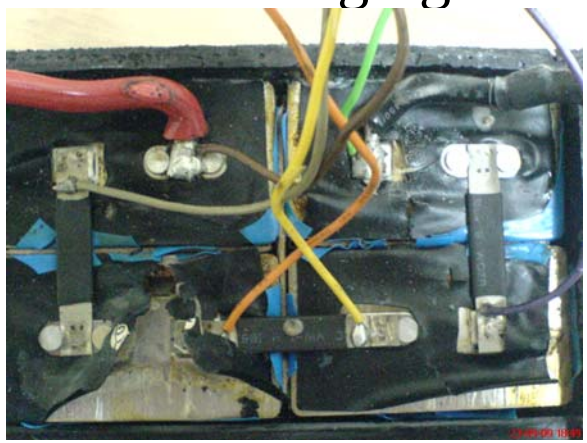
起火爆炸?

From ETEC Report

Over-discharging



Over-charging



The $LiFePO_4$--the Best Lithium Battery

extra-long life and free from explosion issue

- 高溫熱穩定Thermal Stability (No Thermal Runaway)
- 過充不易破壞Permit to Over Charged
- 短路不起火Resist to Directly Short
- 低壓不短路Less Penetration Possibility under Low Voltage
- 強悍的橄欖形結構Olivine Structure (Stronger Bond, even under extreme temperature)
- 不形成針狀結晶No Migrate Out Effect (without non-linear Expansion)
- 沒有鋰或氧析出的可能No Lithium Remains as full Charged (No Firing Probability)

Best Use-effective

due to long life

Anode Material	LiCoO2	LiNiO2	LiMn2O4	LiFePO4
Structure	Oxided Layer	Oxided Layer	Spinel Structure	Olivine Structure
Expect Capacity	130~150	170~200	100~120	140~170
Operation Voltage	3.6V	3.5V	3.8V	3.4V
Safety	Complex	Complex	Simple	Simple
Thermal Stability	Poor	Poor	Fair	Good
Material Reverse	Rare	Enough	Rich	Rich
Material Production	Mass	Experimental	Small	Small
Energy / Weight	466		285	255
Power / Weight	320		400	2000
Cycle Life	>500		>500	>2000
Cost	Much	Much	Low	Low
Application	Small Battery for 3C	Small Battery for 3C	Power Type	Power Type

唯一的可用的電池

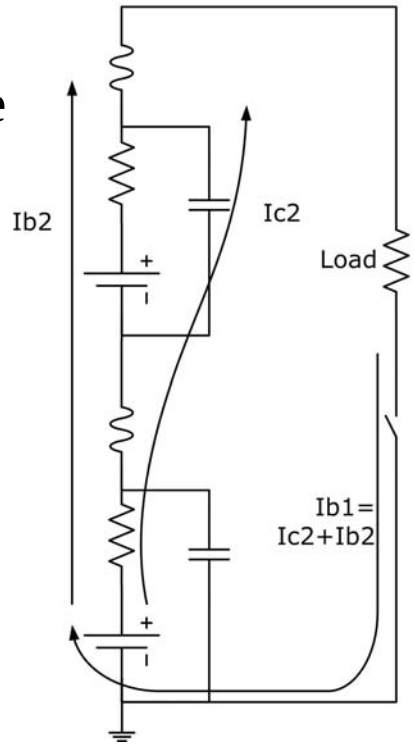
考慮耐久及戶外使用

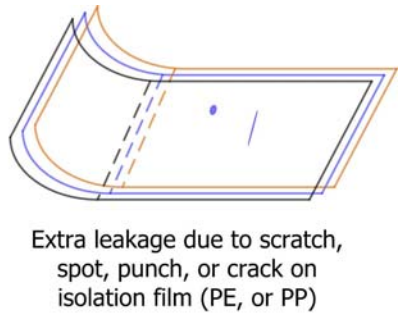
	鉛酸電池	變性鋰錳電池	鐵鋰電池 (Ferrite)
使用中的污染	硫酸蒸氣 (terrible)	無 (good)	無 (good)
使用後的污染	硫酸鉛溶液 (troublesome and terrible)	有機電解液 (Acceptable)	有機電解液 (Acceptable)
安全性	過充時可能有氫、氧逸出 (terrible)	洩氣開閥，不起火不爆炸	洩氣開閥，不起火不爆炸
大量使用後的價格	持平，如果地球還能住	昂貴(錳不足)	更便宜
操作溫度	-5~80℃	-20~65℃	-20~80℃
25℃下的使用次數	400 次	500 次	2000~8000 次
結論	便宜但污染的電池 Problematic battery	室內消費性產品 Consuming battery	耐久性工業製品 Durable battery

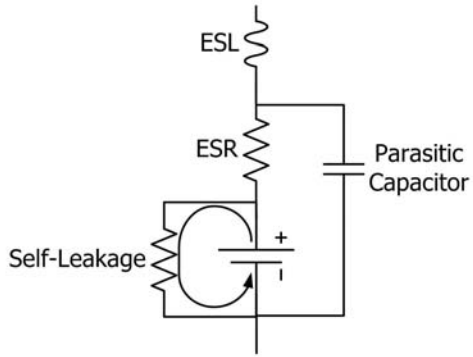
Major Application Consideration—Balance

Initial Capacity Variation, self-leakage, Rush discharge, …

- Powder purification: always with Fe_2O_3, $Li_3 PO_4$, $Fe PO_4$
- Powder size variation: Olivine Structure
- Process variation: film thickness, solution volume, isolation film , …
- ➔Initial capacity Variation
- Self-leakage & self-discharge
- Rush discharge

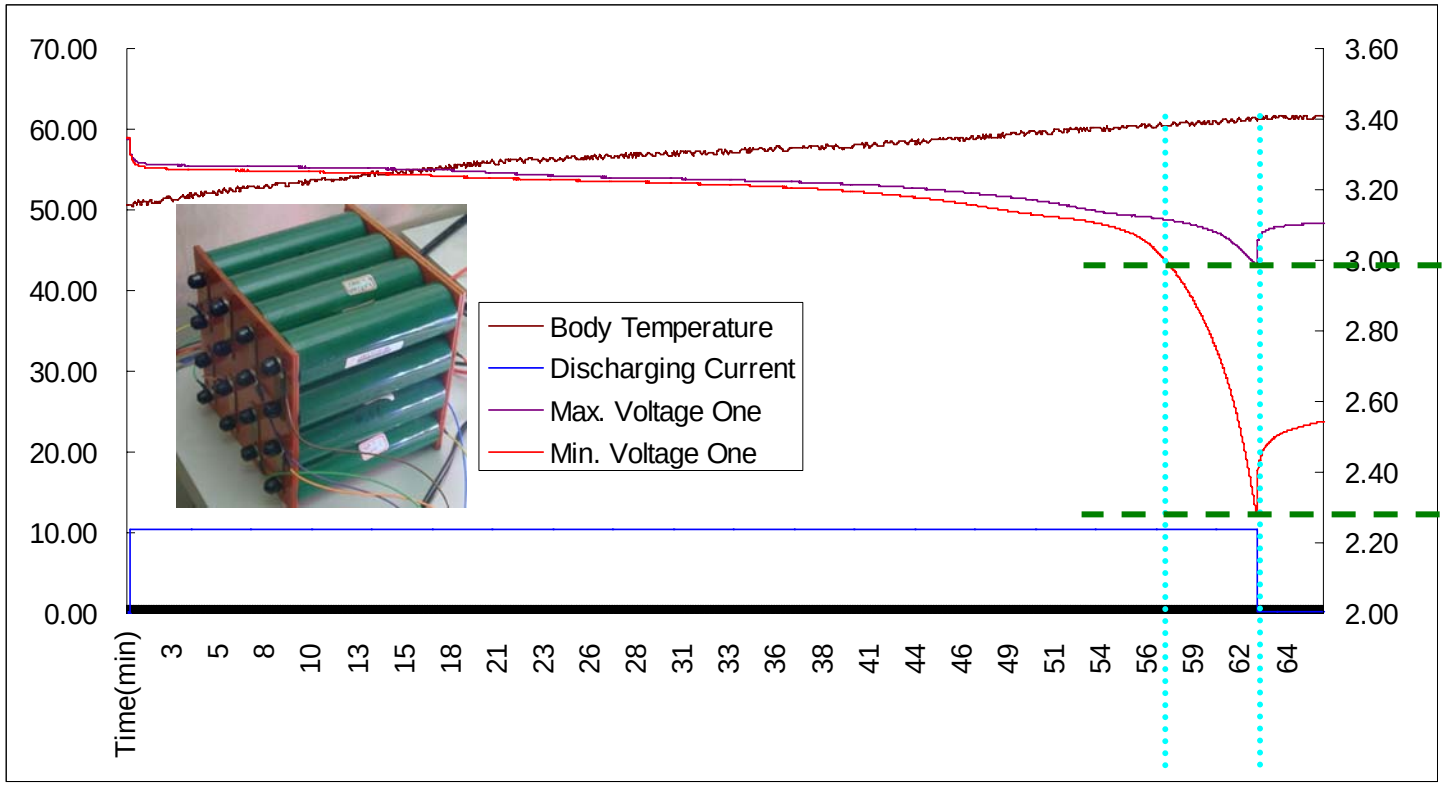






Impact of Initial Capacity Variation

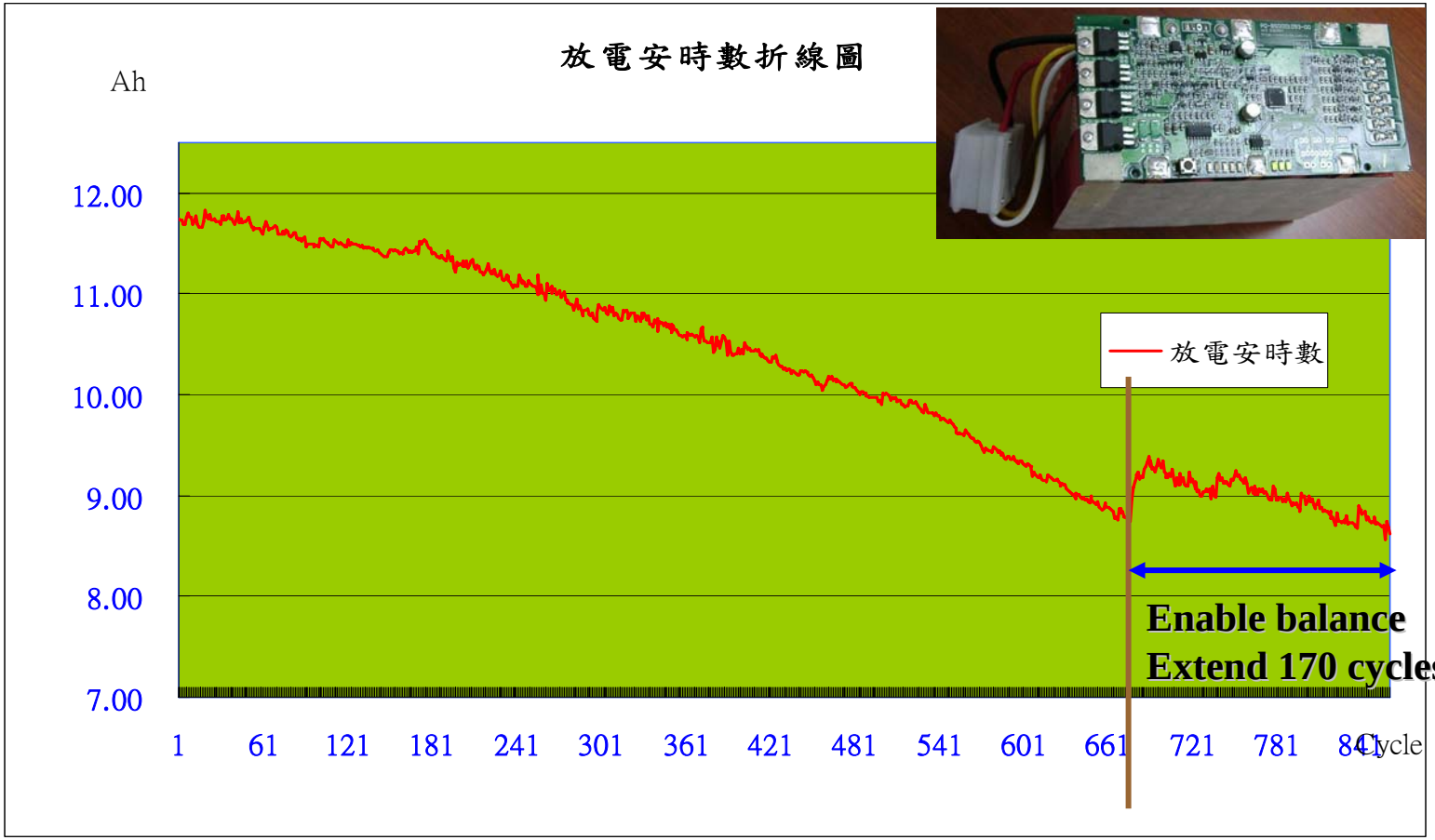
- The PSI battery may get 5% variation after 50 cycles under high temperature (50©).
- Such 5% capacity variation may cause 0.7V voltage variation as fully discharged.
- The impact of initial capacity variation is hard to be covered by total voltage monitor. For example, cell voltage is 2.0V, 2.7V, 2.7V, and 2.7V, and total voltage is 10.1V.



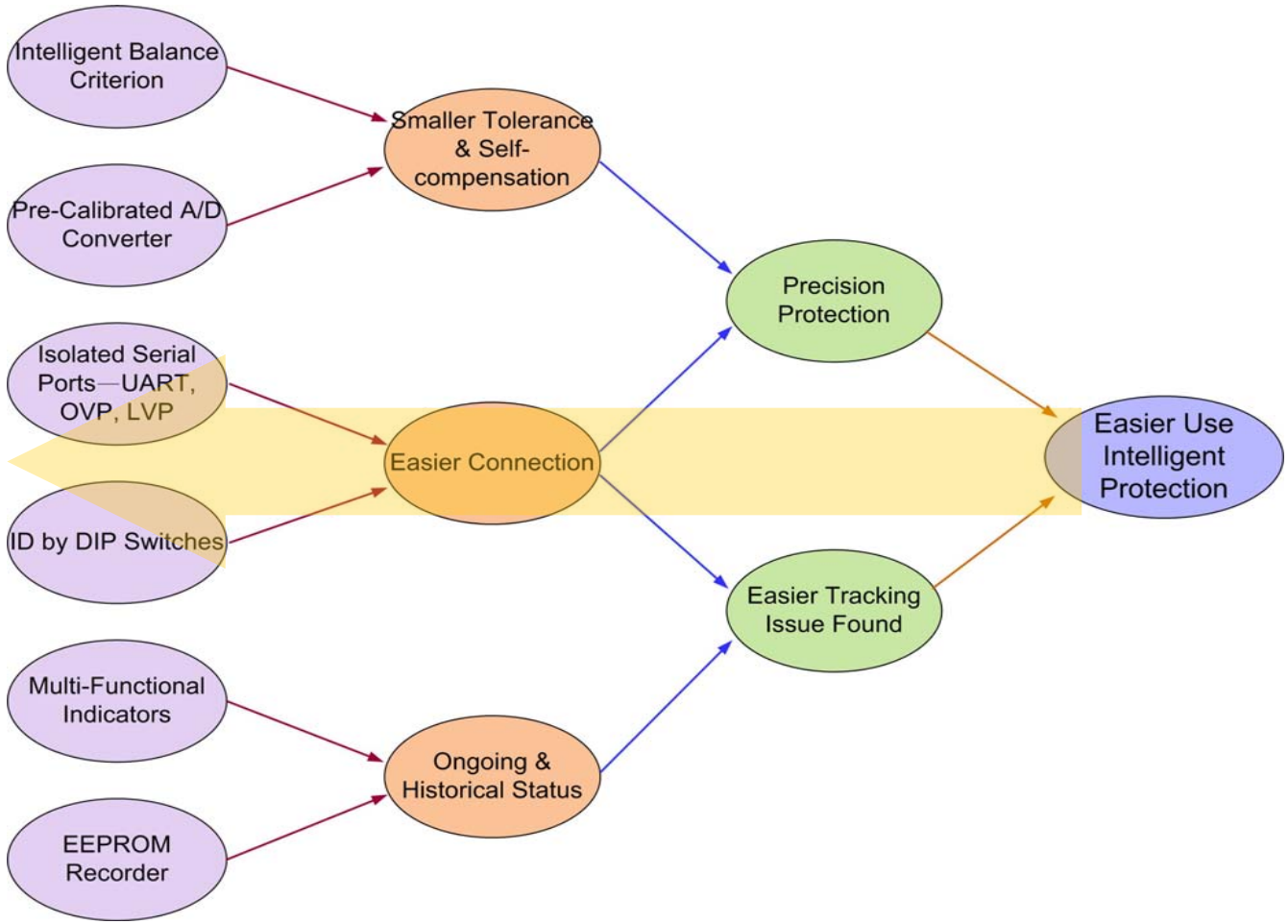
Impact of Self-discharge and Rush Discharge

6P7S Sanyo 18650Y (Almost free from initial capacity variation)

•Self-discharge and rush discharge (pulse discharge) will be accumulated in cycle use, therefore such capacity degradation is the first topic of the balance.

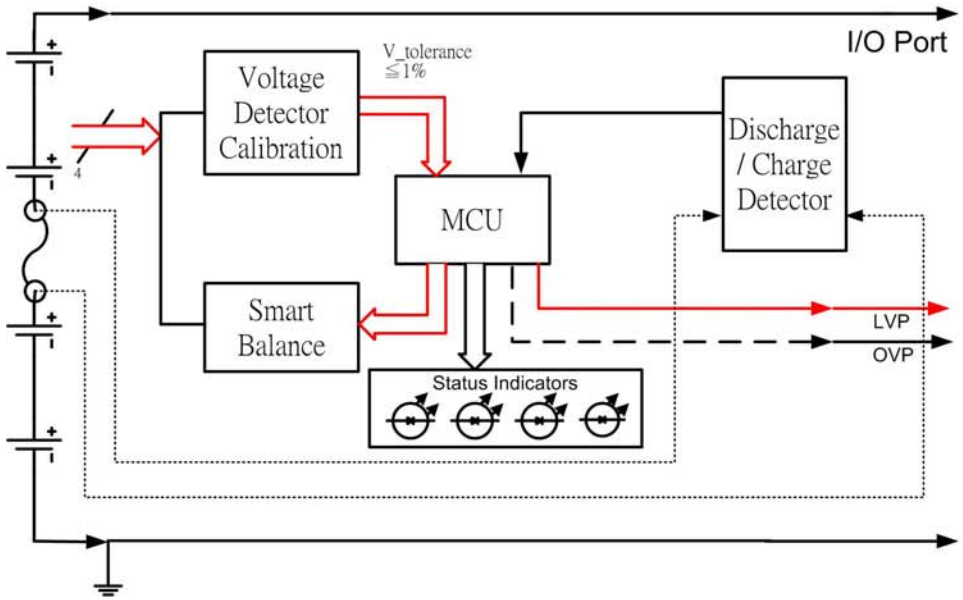


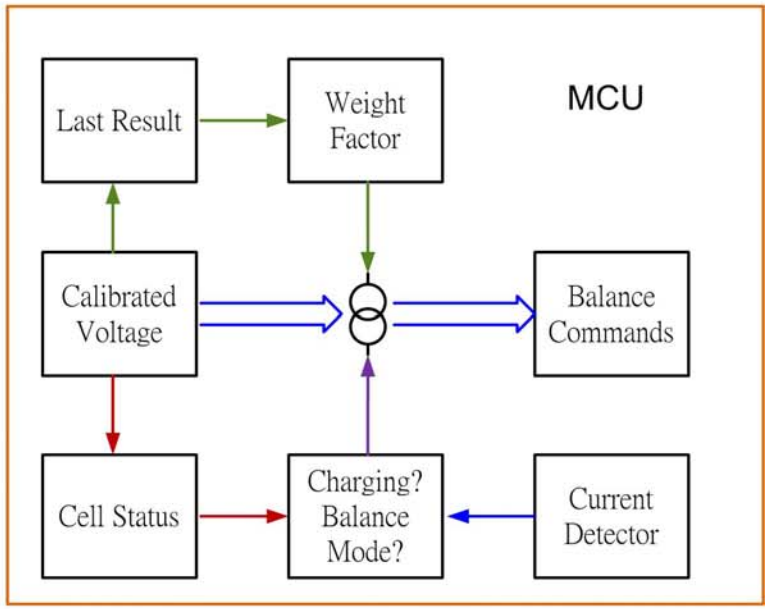
Unfolding Design Criteria



Design Block

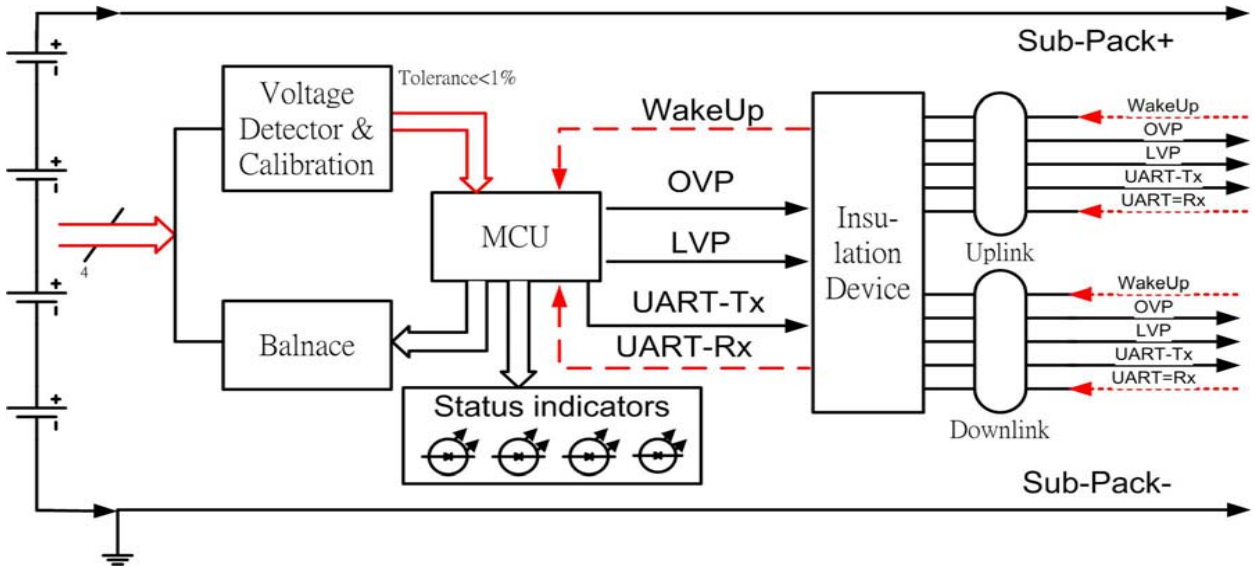
Design Criterion of the VMS for 4S1P Li-iron Battery Pack





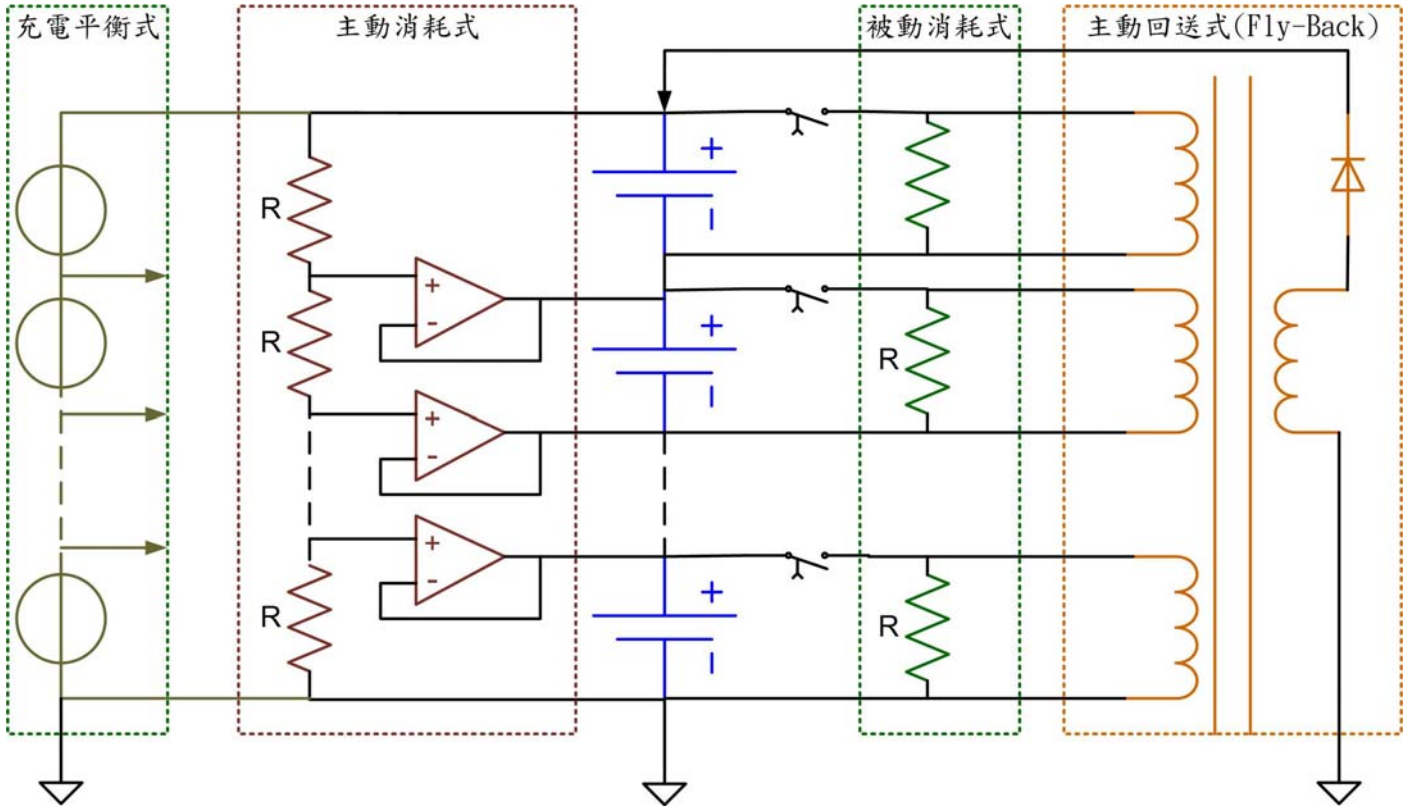
Because the ascent of voltage vs. capacitor (0.2V↔80%) is much smaller than other lithium battery (0.6V↔70%), simple equalizing criterion is enough for $LiFePO_4$ battery.

Design Block with Digital Interface



- As considering the added cost timing delay possibility and direct connection, without multi-paths or star connection, we select the Universal Asynchronous Receive/Transmit protocol.
- Because all of MCU are embedded this UART port, no further cost for VMS. What the power system needs to be implemented is a protocol converter, such as UART→RS232/RS485/RS422, UART→USB, and UART→CAN.

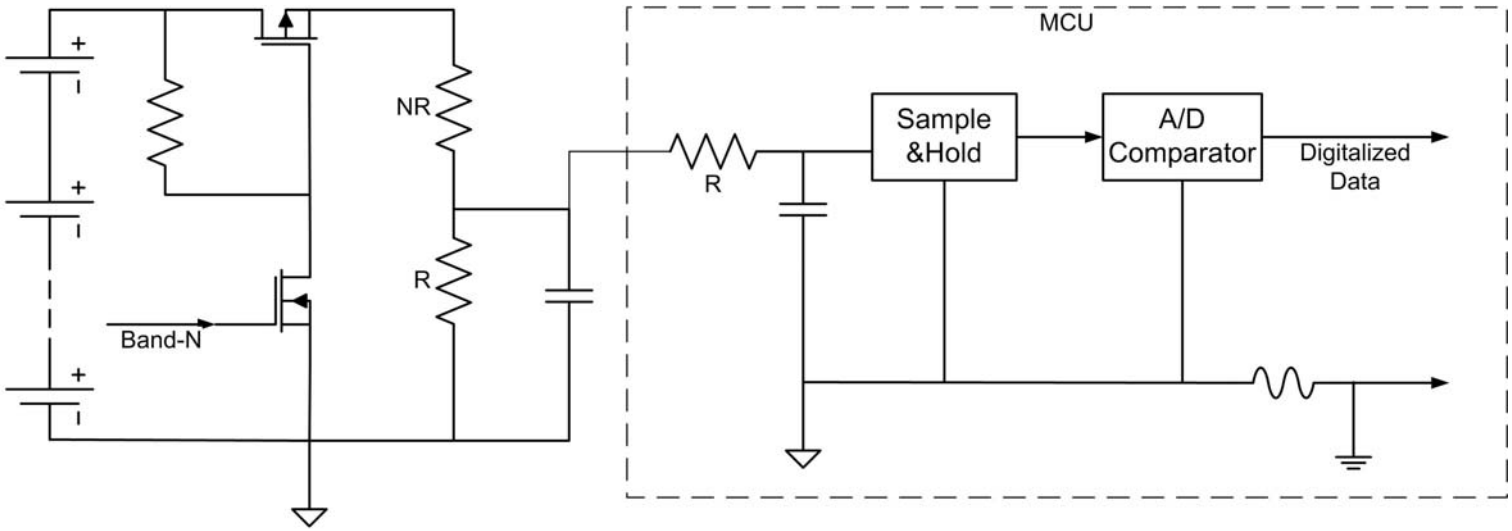
平實而可靠的平衡電路

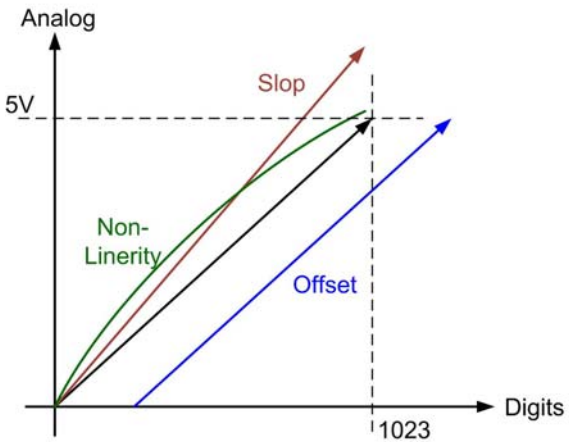


- 被動消耗式, 沒有專利問題, 沒有高頻切換雜訊, 及平衡中電壓快速變化問題, 忠實而可靠, 適用於多串架構, 雖然佔用面積較大, 只能在充電中啟動平衡, 但仍是日系保護晶片唯一採用的方式.

謹慎考慮的數位類比轉換器

啟用自動補償設計, 減少可能誤差





A/D Error

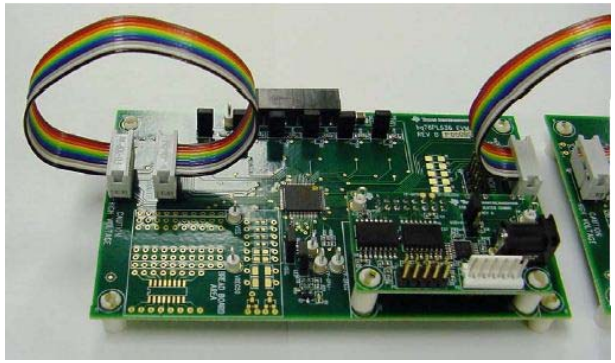
1. Slop: 由於分壓電阻誤差, 參考電源(+5V)誤差, 或是MCU內部的Sample & Hold, 及多串級此較器造成的斜率偏移, 這一類的誤差多是由電阻之類的元件所造成, 也代表這一類的誤差多有溫度偏移的效應. MCU內部的電阻多是由Poly Trace 所製成.

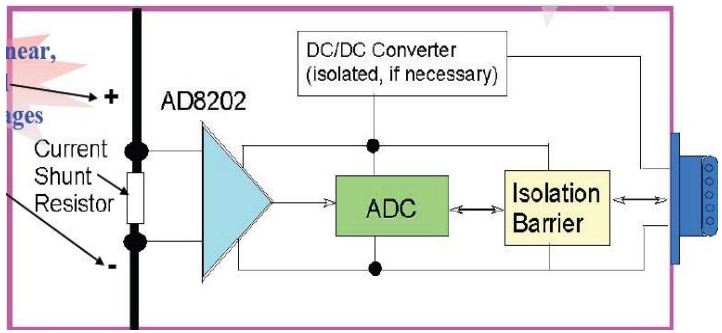
2. Offset: 是MCU內部的Sample & Hold, 及多串級此較器造成的斜率偏移, 這一類的誤差量來自MCU的類比電路中的偏壓電路的可靠性有關,.

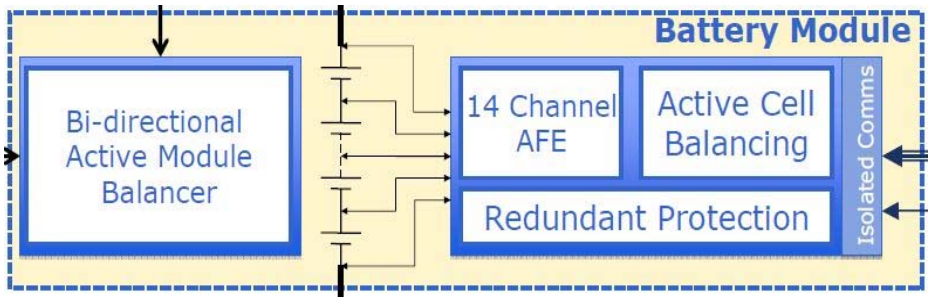
3. Non-linearlty: 這部份的誤差多是由於電阻的非理想性所造成, 也就是電壓--電流的比例不是一個常數(定值), 但由於A/D內部的電阻必然採用對稱性佈局, 外部的金屬皮膜電阻, 或是晶片電阻(銀膜+陶瓷)的非線性係數也低.

World Trend--Modular Design

Concept Copy?!





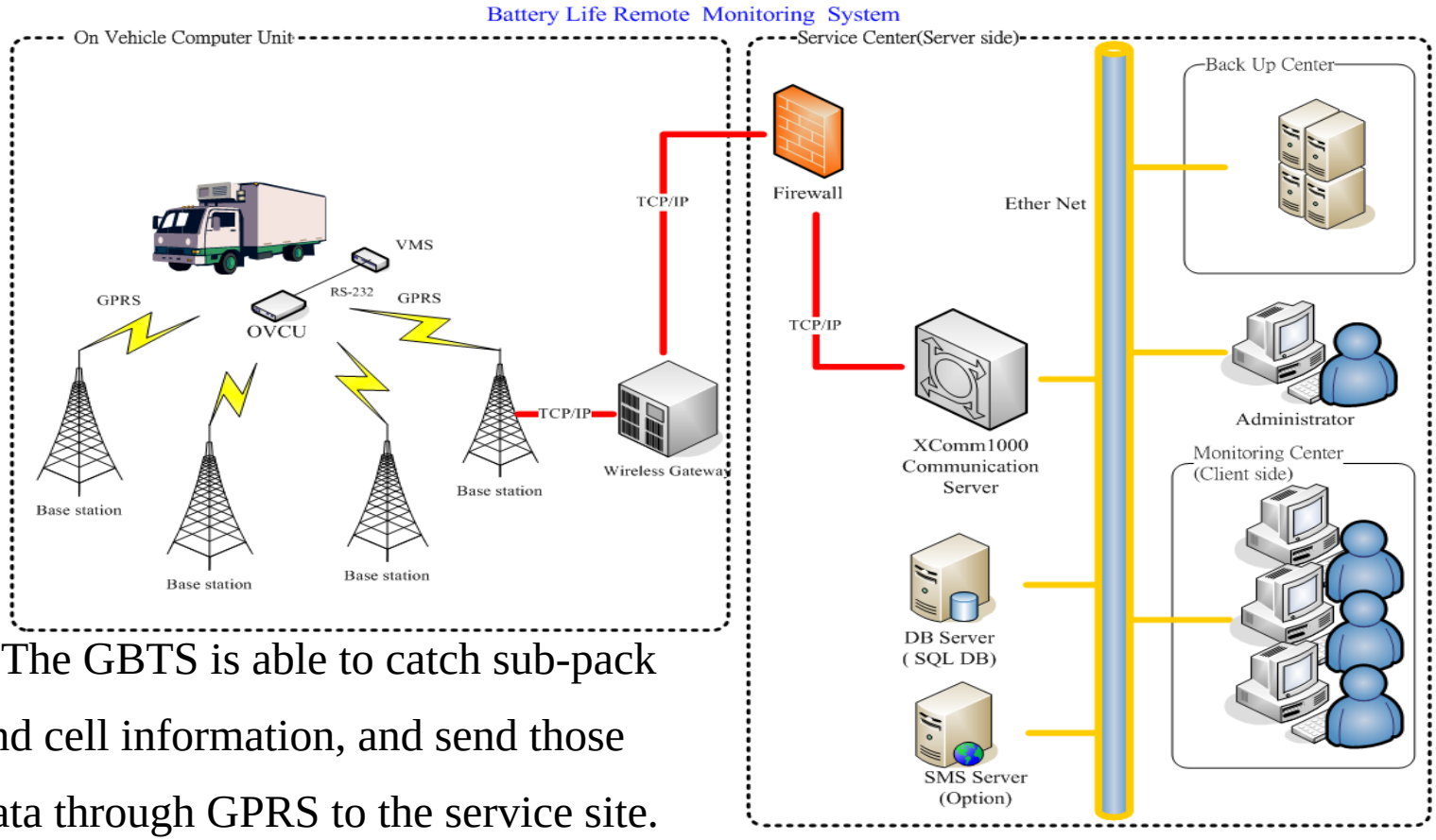


Nanophosphate™ Lithium Ion Prismatic Module

for Electric Vehicles and Range-extended Electric Vehicles

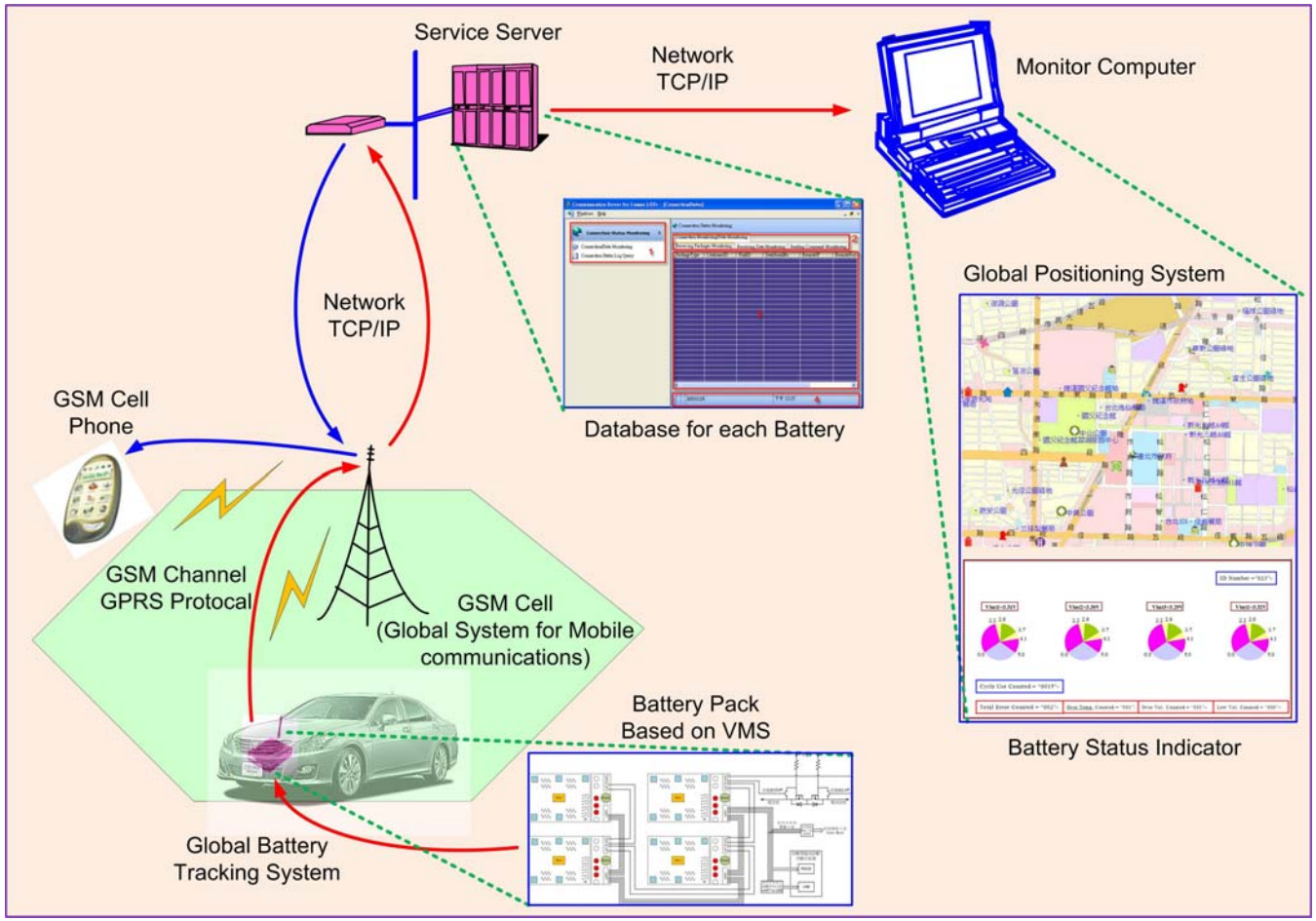
VMS Application--GBTS

Global Battery Tracking System



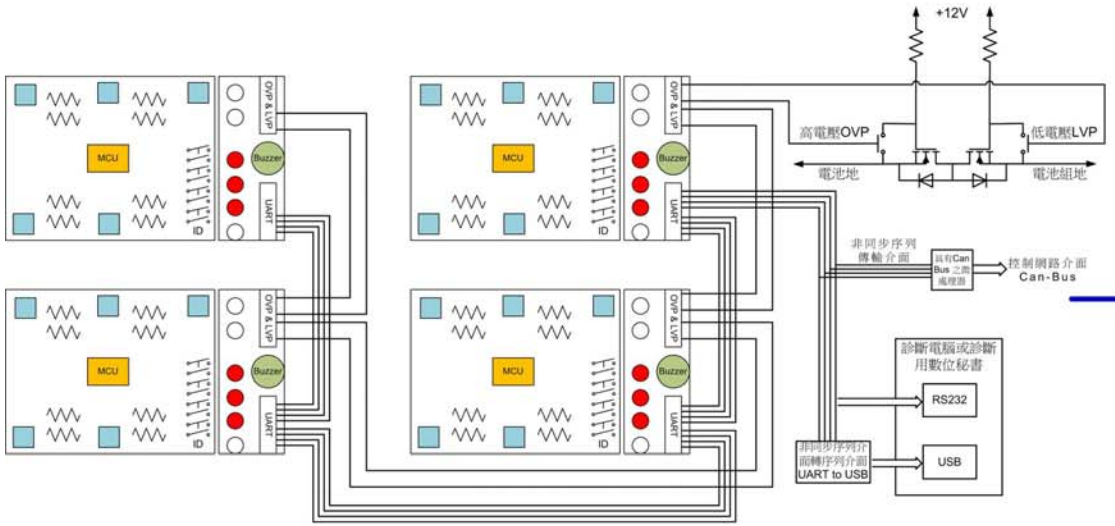
- The GBTS is able to catch sub-pack and cell information, and send those data through GPRS to the service site.
- GPRS: General Packet Radio Service, digital band of GSM.

GBTS Service



方便而功能完整的保護板

使用維護方便, 功能完整而確實, 方便電動車進入實用市場

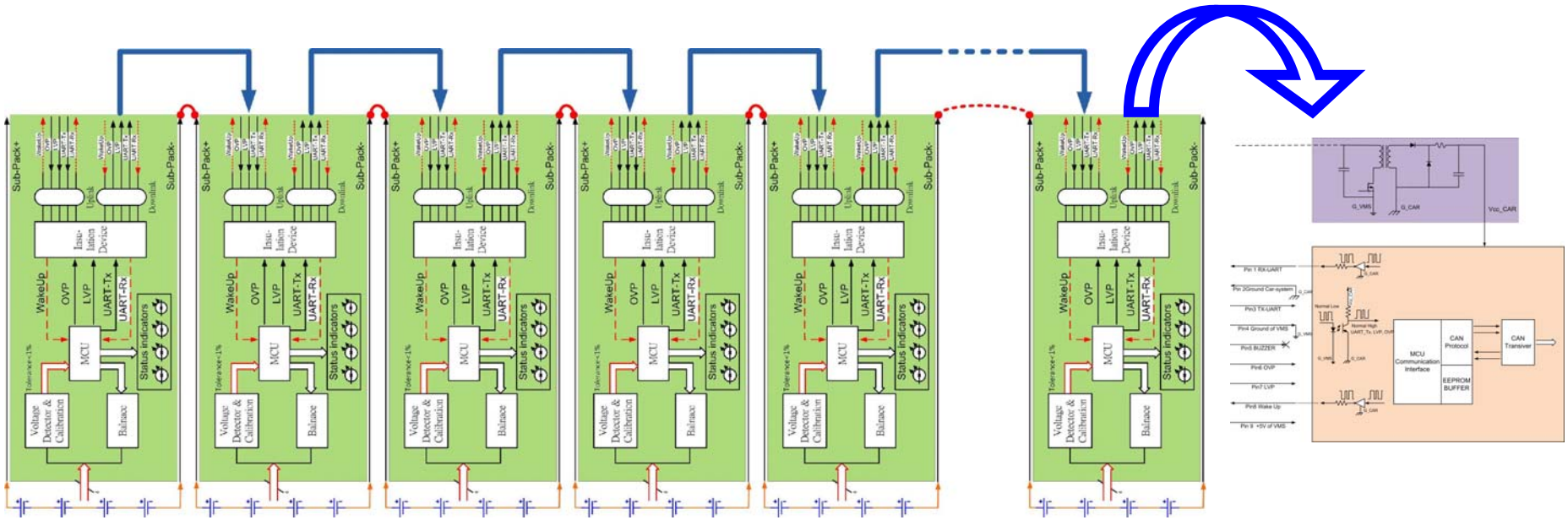


深受客戶喜愛的數位訊號串接介面具有

- 可自由串接的非同步通用序列傳輸介面，監控訊號線不會隨著電池數量的增加而增加，使用於需要大電力的電動汽車或電動機車上，更顯優勢。
- 加裝簡單的開關模組，可使鋰鐵電池取代傳統鉛酸電池，市場大而易於接受。鋰鐵電池的長效安全性，從此成為太陽能儲能設備、備援電力的最佳選擇。
- 標準模組設計概念，大大降低電池組裝及維修的成本。

系統設計應用—UART→CAN Bus

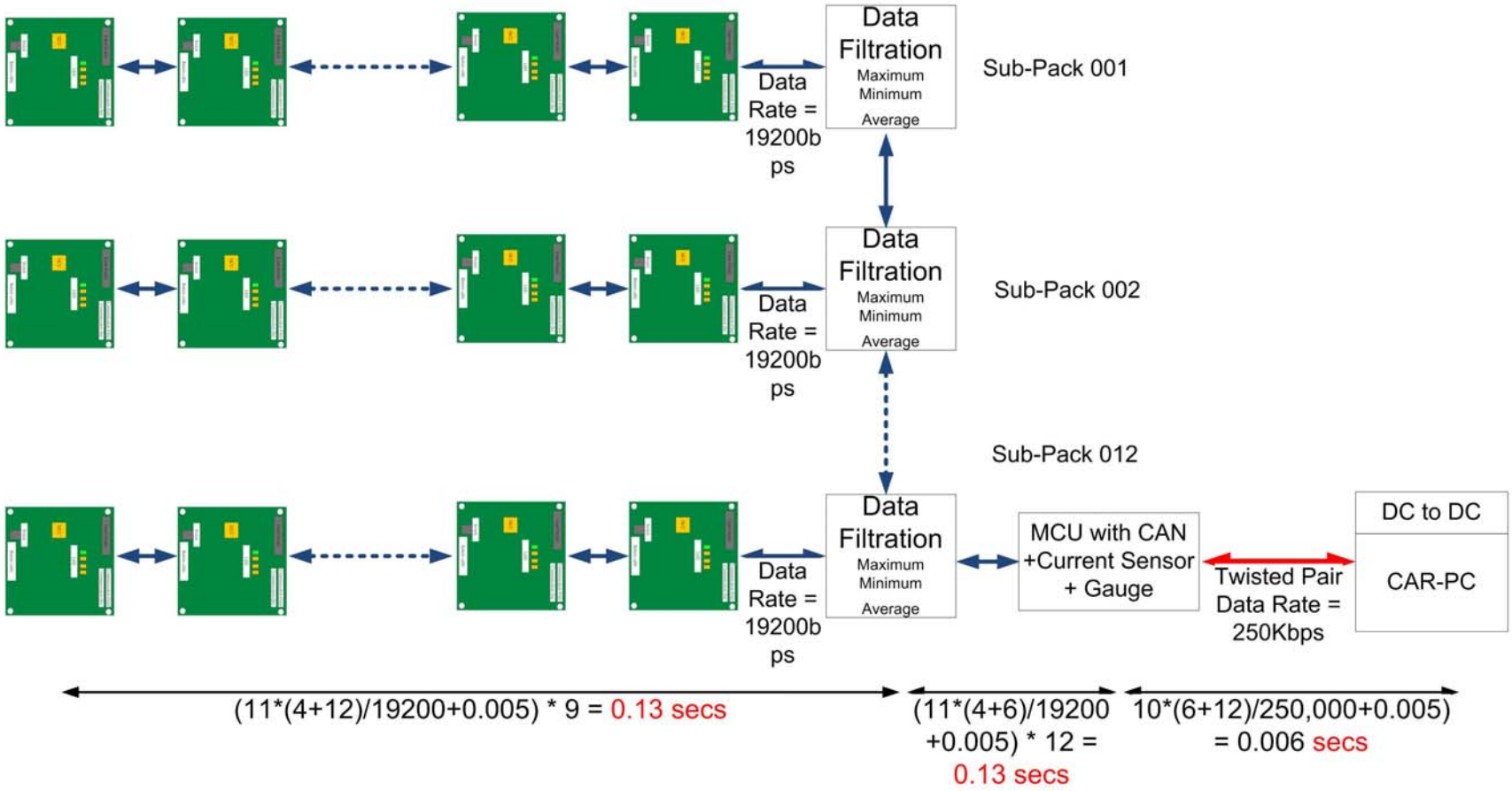
for Simple Power System



系統設計應用—分層管理系統

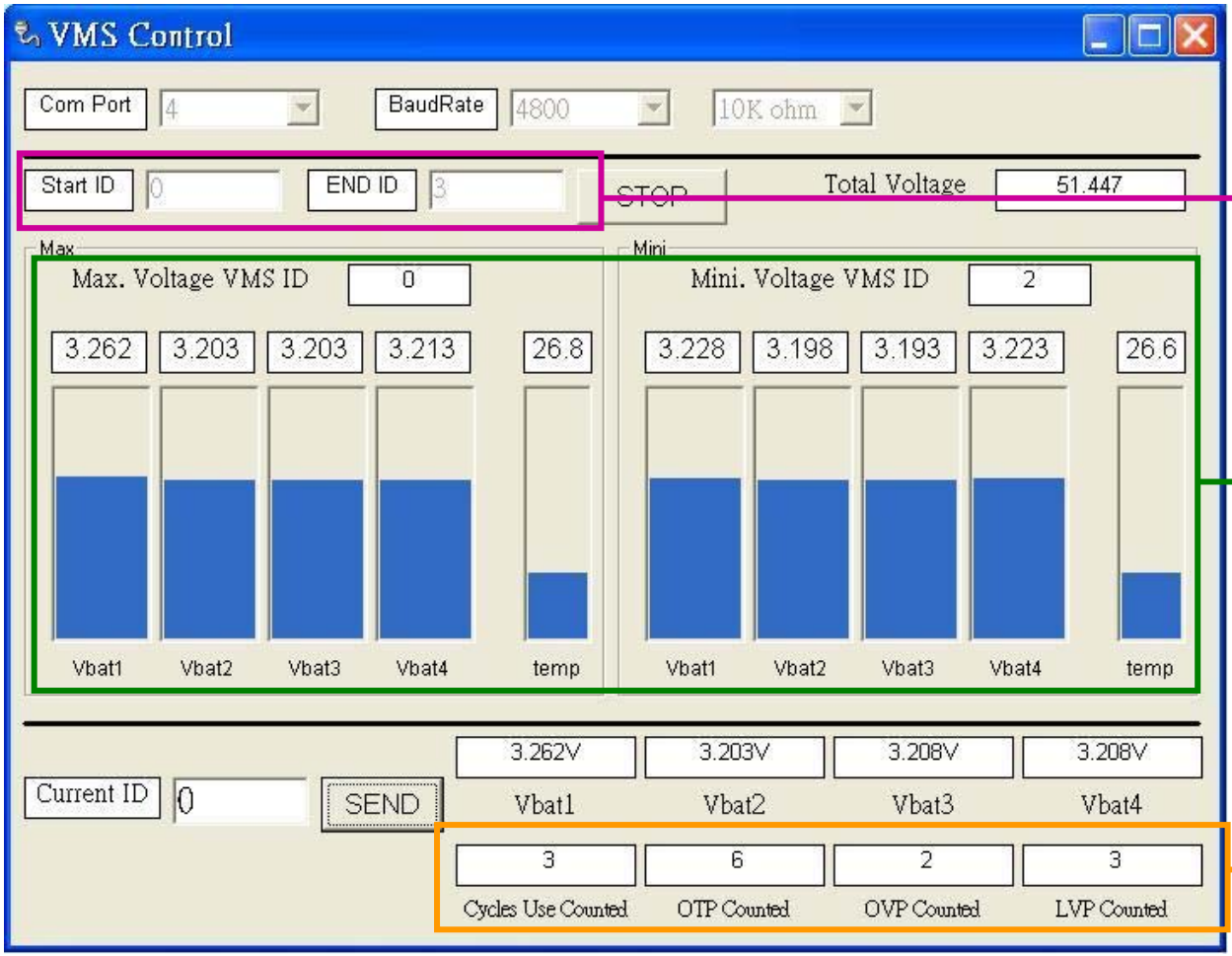
for Large Power System with Multi-sections

1. Hierarchical Solution: Faster (0.266 Secs), Complicated, Dedicated for special power system, extensible to 255 x 255 VMS



VMS Application-- Diagnostic Program

Simple tool to Monitor battery (not in 3.2V, but 12V)



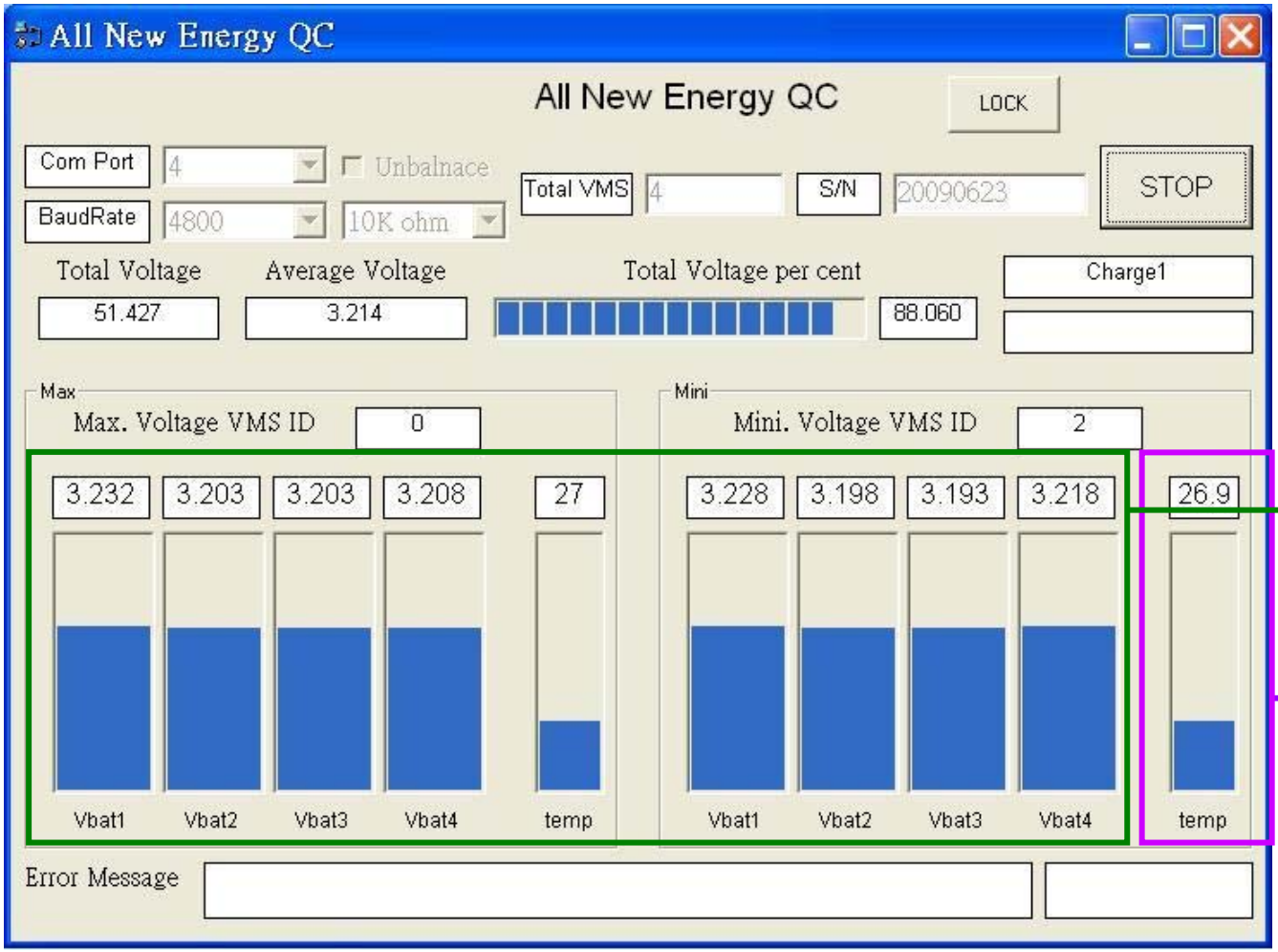
VMS ID Setting area

Voltage display area

Counter status area

VMS Application-- Cycle Tester

Simple Tool to Quality Check (not in 3.2V, but 12V)



Cell Voltages

Cell Temps

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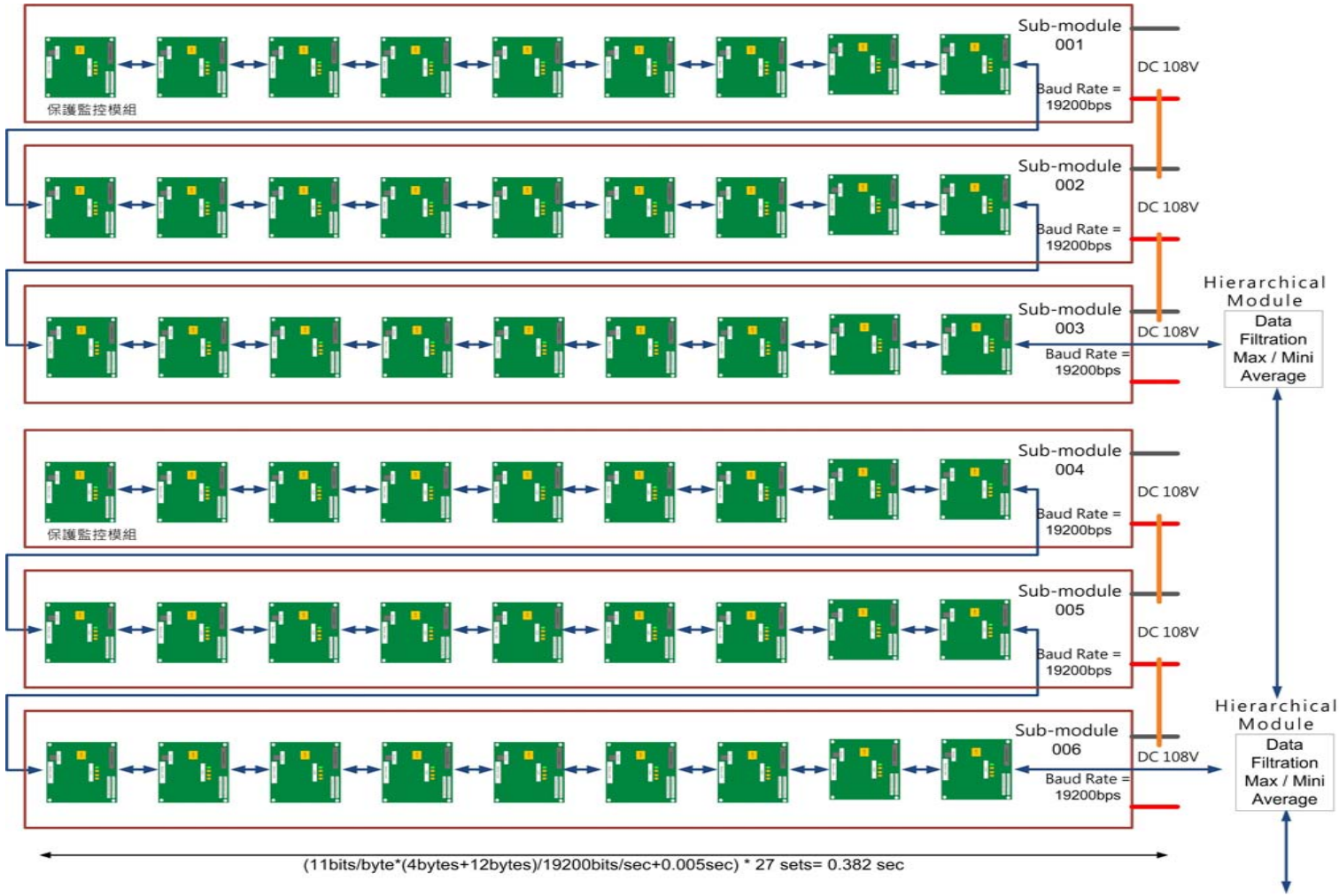
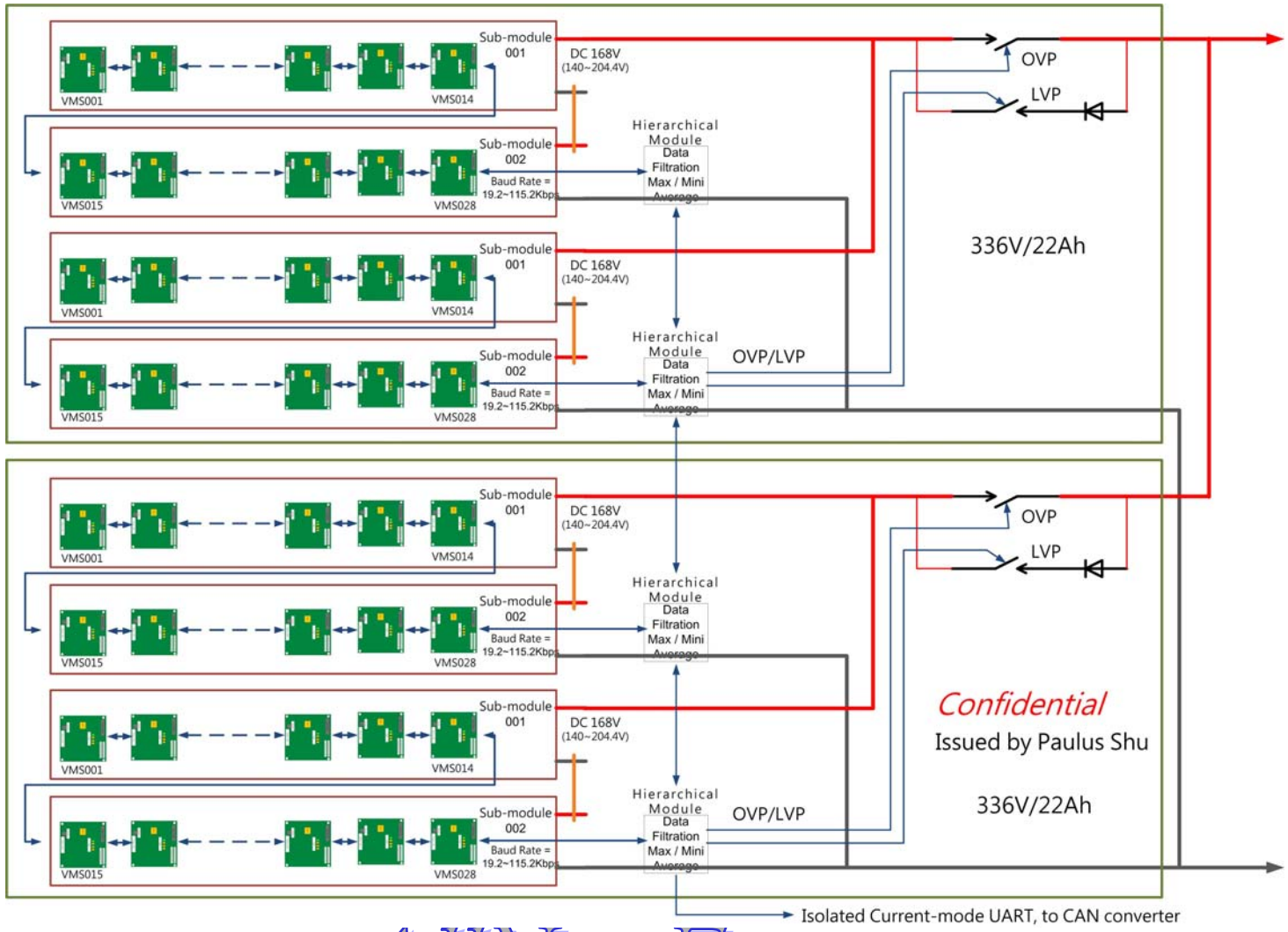
系統使用方式

Parallel processing & Data compression make fast, efficient, and flexible



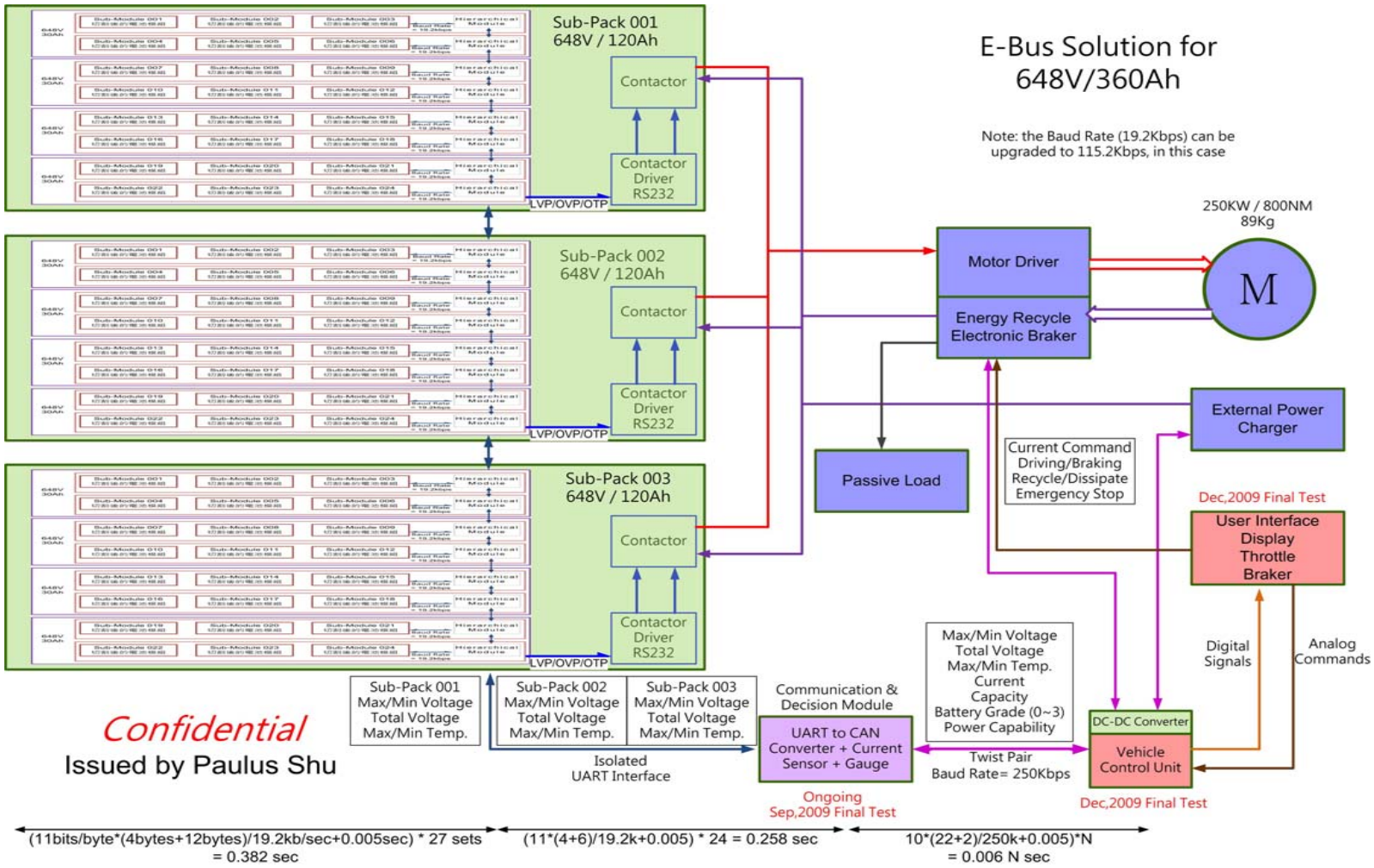
系統建置(System Integration)-I

LEV and Power Bank Solution



系統建置(System Integration)-II

E-Bus / Power Bank Solution, ready before next year



Confidential

Issued by Paulus Shu

簡報完畢

Thanks for Your Attentions