BMS Project Lit Review

Source: **Battery Management System and its Applications by Xiaojun Tan**

Important Definitions:

SOC (State of Charge): A percentage of a remaining charge capacity within the battery

SOH (State of Health): The quantification of degradation of the battery, normally a calculation based on capacity and power

SOP (State of Power): The power provided by the battery pack to various electrical loads

such as the motor at a specific moment

SOE (State of Energy): The rest energy of the battery, which can be expressed by percentage (%) or as a unit of energy (J)

Coulomb Counting: Method for calculating State of Charge by integrating net current flowing into or out of the battery over time

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Notes:

1) **Microcontroller Based BMS**
    - 5 Battery Input Parameters:
        - Current Drawn
        - Terminal Voltage
        - Temperature
        - Internal Resistance
        - Time
    - Book uses Neuro Fuzzy Model
        - Takes in Inputs Above
        - Model utilizes Neural Networks & Fuzzy Logic
            - Fuzzy Logic utilizes if…then logic, not just 0 & 1s
    - Weights Array determine estimations
    - Diagram:

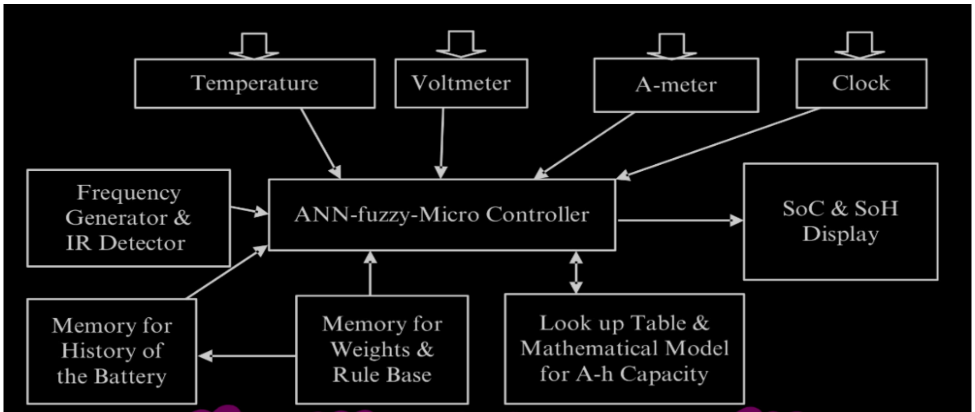

Figure 1.4 Block diagram of a microcontroller based BMS implementation.

2) Battery Voltage Monitoring

- Primarliy about High Voltage DC Systems
- Important to switch between each individual cell to monitor
  - Methods include switching between Relay Switch (offers high voltage isolation) & Differential Amplifier (gets rid of common mode Voltage issues)
- Different Schemes to monitor Voltage

Table 8.1 Comparison of voltage monitoring methods.

Voltage monitoring method	Acquisition accuracy	Circuit complexity	Leakage current	Resistance matching	Cost
Scheme based on precision resistance divider	Lower	Simple	Larger	Yes	Low
Scheme based on photocoupler relay switch array	Higher	Complicated switch array circuit	Smaller	No	Higher
Scheme based on differential operational amplifier	Higher	Complicated power circuit for operational amplifier	Smaller	Yes	High
Scheme based on special integrated chip	High	Simple	Larger	No	Depending on the chip

- An important note: SOC error % needs to be determined by the battery type and voltage measuring system used
  - Solution to problem: Including an Isolation Zone, which just sets a cap and a min for both Upper Charge Limit & Lower Discharge Limit

3) Battery Current Monitoring

- System that includes battery cells in series means that we need to monitor total current after each series connection with a few sampling channels
- High Current Sampling frequency is higher because of impact on SOC calculations
- Accuracy Index should be determined for:
  - Safety - threshold for charge and discharge currents (consider capacitive and inductive loads
  - Instrument Display – make sure error margin is considered for specific operation
  - SOC estimation Demand – Columb Counting depends on the integration of current over a time, so error in measurement will show in integration
- CURRENT MONITORING SCHEMES
  - *SERIES RESITANCE SCHEME*
    - Convert the current signal into a voltage signal, so we can use an A/D chip for the microcontroller

        - Add small shunt resistance to the circuit path to measure voltage drop before powering the load
    - Problems
        - Shunt needs to be small compared to the load resistance to minimize loss (LOSS STILL MATTERS)
        - Isolation circuit becomes more complex because of this shunt resistance, so cost advantage of shunt is not as obvious with EVs
    - *HALL SENSOR SCHEME*
        - Typically has 3 pins E+ & E- of the operational amplifier and a Vout
        - Electromagnetic voltage is typically very small (in mV), hence why there needs to be amplification
        - Problems
            - Non-linearities exist, the line of Vout vs Current will have a curve and Vout = 0 will not correspond to Current = 0

4) **Battery Temperature Monitoring**

- Battery is sensitive to its operating temperature
    - IF TEMP HIGH, then it can cause shell breakage, electrolyte leakage, explosion, and other safety accidents
    - IF TEMP LOW, then it can cause electrolyte solidification and failure to charge or discharge the battery
- Battery Temp significance on SOC
    - Cold temperatures reduce the voltage (known as sagging)
    - Available charge capacity is reduced in colder temperatures
    - High Temperatures accelerate the chemical reaction rates in the cell
        - Self-discharge in the cell increases meaning less available charge
- ***TEMP SCHEMES***
    - Thermistor (temperature dependent resistor)
    - Temp Sensor
    - Integrated Chip