Battery Monitoring System

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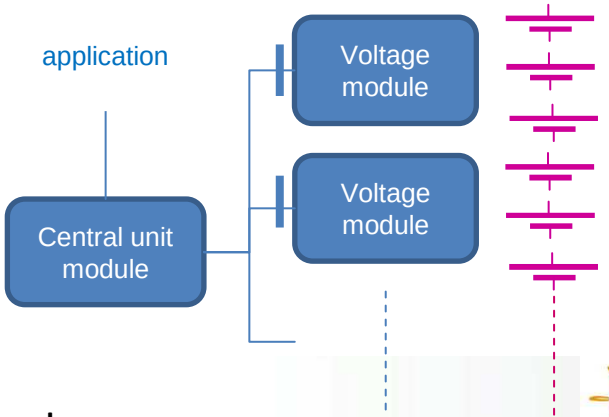
CEA LETI&LITEN

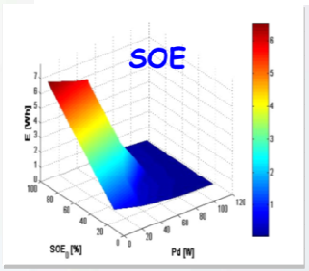
BMS – rôle et fonctions

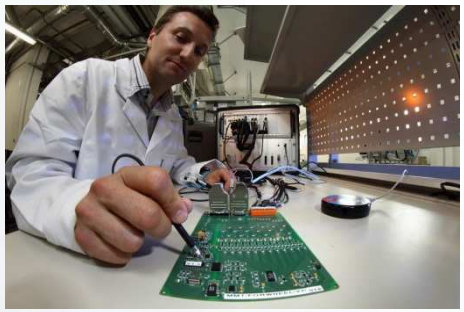
- BMS = Battery Management System
- Fonctions principales
  - Assurer le fonctionnement de la batterie dans des conditions sécurisées
    - Monitoring des tensions, de température
  - Permettre un fonctionnement performant
    - Équilibrage des cellules pour optimiser l'énergie disponible
    - Fournir l'état de charge de la batterie
- Autres fonctions
  - Pilotage des organes de sécurité
    - Information ou contrôle de l'ouverture du circuit de puissance
  - Estimateurs d'états spécifiques
    - État de santé de la batterie (ou vieillissement)
    - État d'énergie de la batterie
    - Courant ou puissance maximale disponible
  - Contrôle de l'isolement du pack batterie
  - Gestion du management thermique (exemple : pilotage de ventilateurs …)
  - Isolation d'un accumulateur défectueux

Modular BMS

- Sensors characterization
- Expert on Li-ion BMS
  - Voltage measurements module
    - Passive cells balancing
  - Central unit module
    - High precision current measurement
    - Algorithms and electrochemical indicators embedded
  - CAN protocole communication
- BMS protoypes based on proven concepts





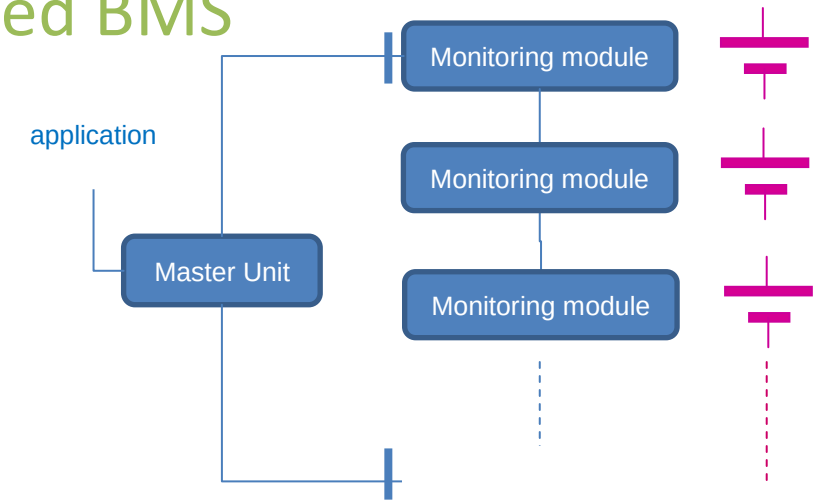


8 projects
10 to 80 kWh
< 50 000 km

transferred to industry

TRL 8

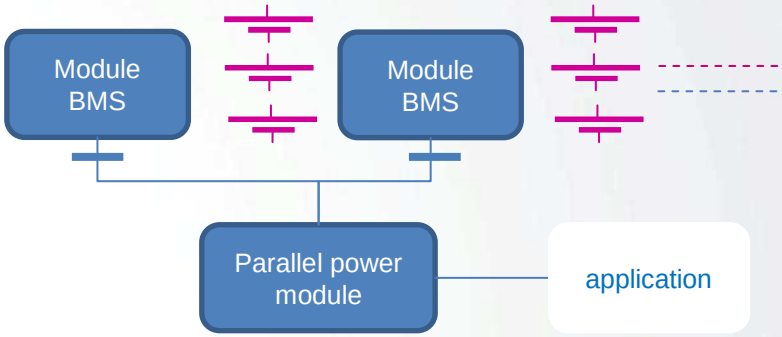
Chained BMS



- Simplified electronic
- Redondance optimization
  - Measurement
  - Communications
- Local balancing
- Local calculators
- Isolation optimization

TRL 4

Parallel plug BMS



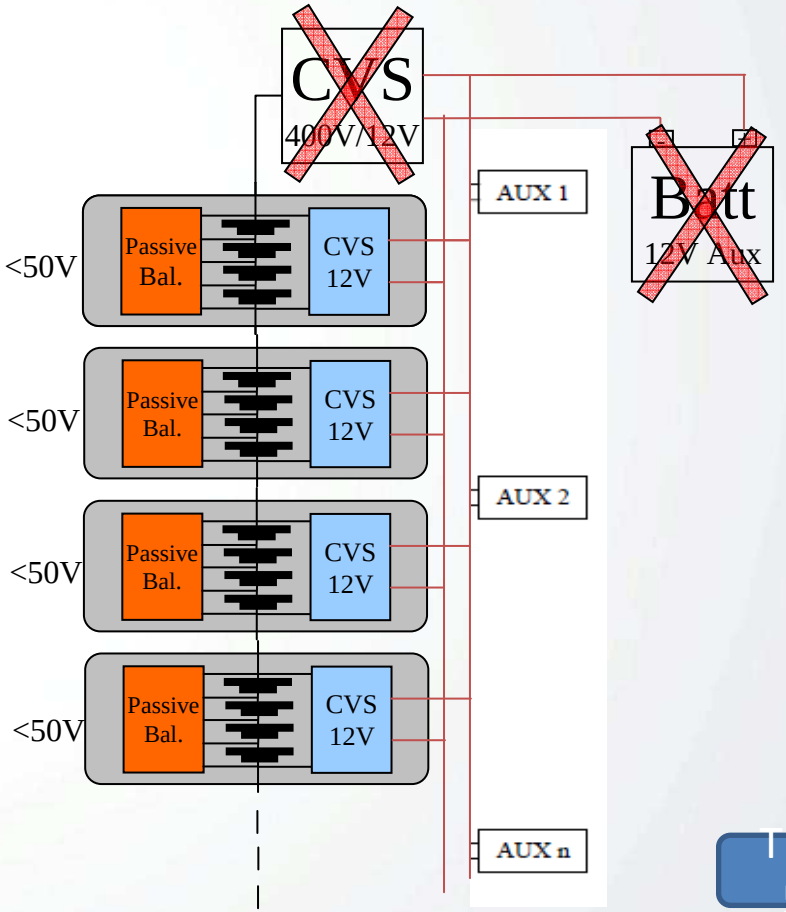
- Local BMS for module
  - Voltage module measurements
  - Passive cells balancing
  - Current module measurement
  - Algorithms and electrochemical indicators embedded
  - Internal and external communication
- Power module to parallel plug
  - Power current control strategy

TRL 7

Active balancing BMS

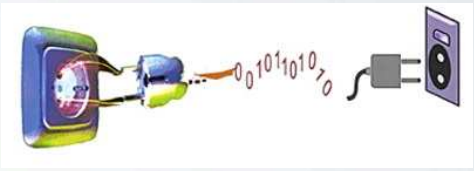
- High current
  - cell balancing
  - module balancing
- Modularity
- Safety
  - Modules voltage < 50 V
  - 12 CVS redundancy

Redistribution topologies
Cell-to-battery, battery-to-cell, bidirectional



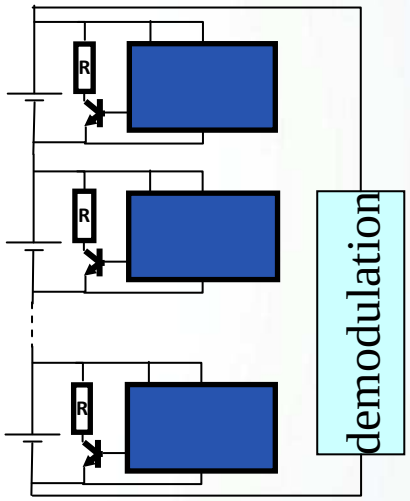
TRL 5

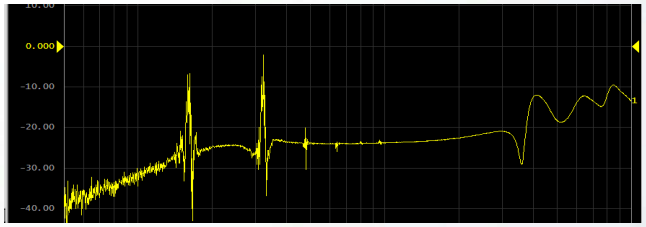
Communication means



- Power line current of energy sources
  - On battery cells
  - On PV
- Specific bus
  - High rate
  - redundant
- Simply analogic module
- Standard

Modulation /demodulation





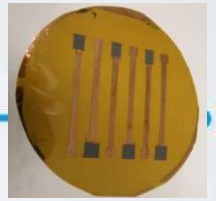
transferred to industry

TRL 8

Specific measurements

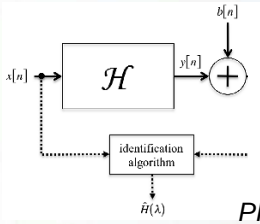
In collaboration with LETI/DCOS

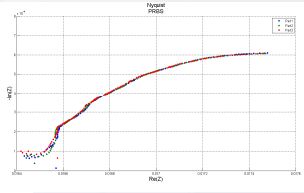
Active measurement



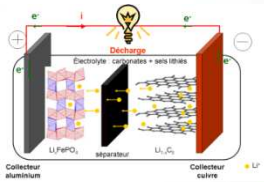
Reference electrode

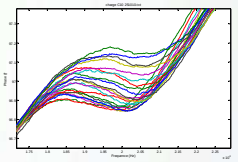
- Electric impedance measurement
- Mechanical impedence measurement
- Security battery measurements
  - Inside battery sensors
- Short circuit detection
- Electric arc measurement



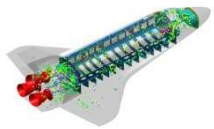


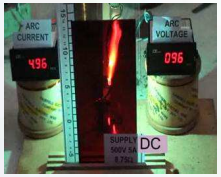
PRBS identification



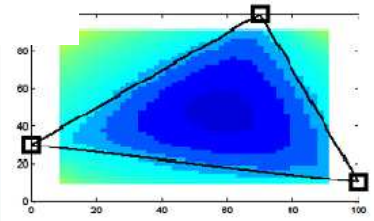


Inside mechanical impedance tracking

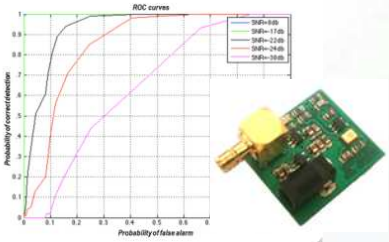


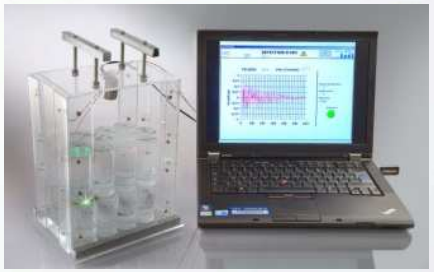


localization



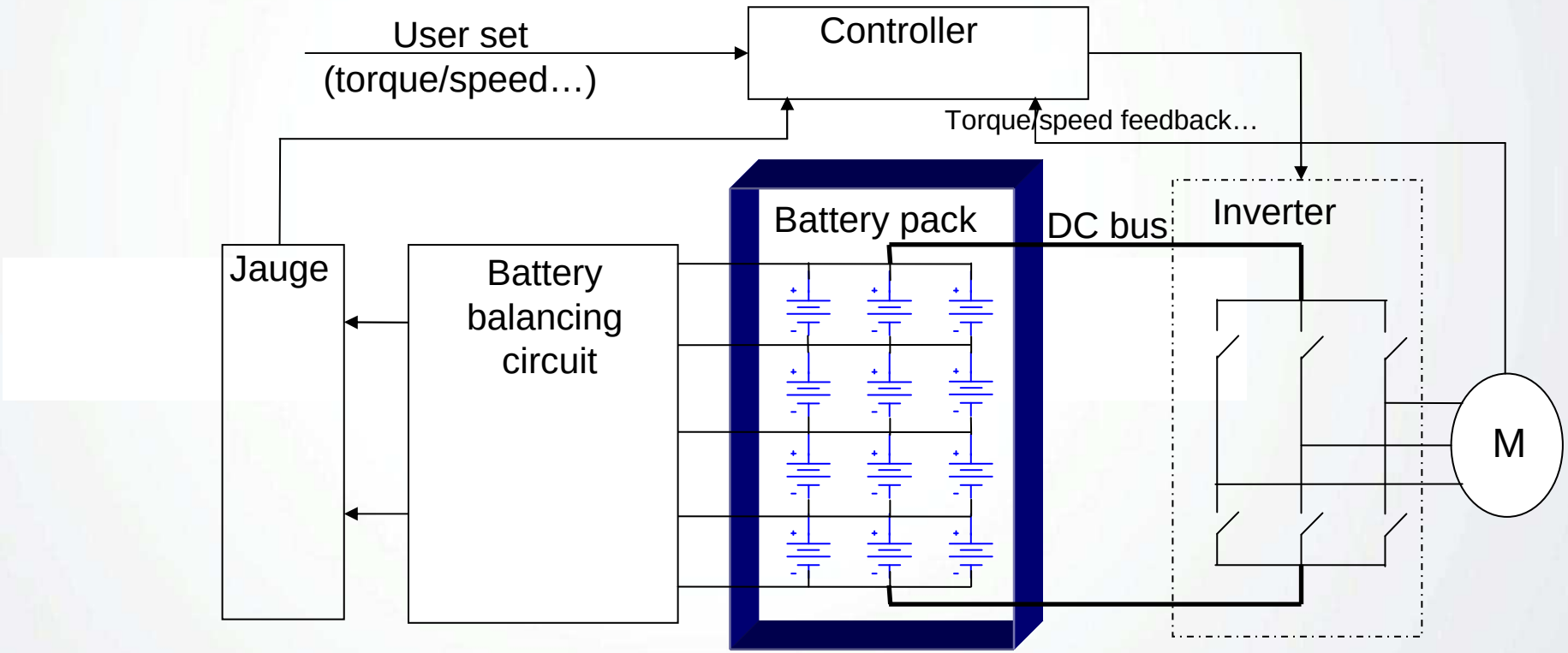
In situ detection





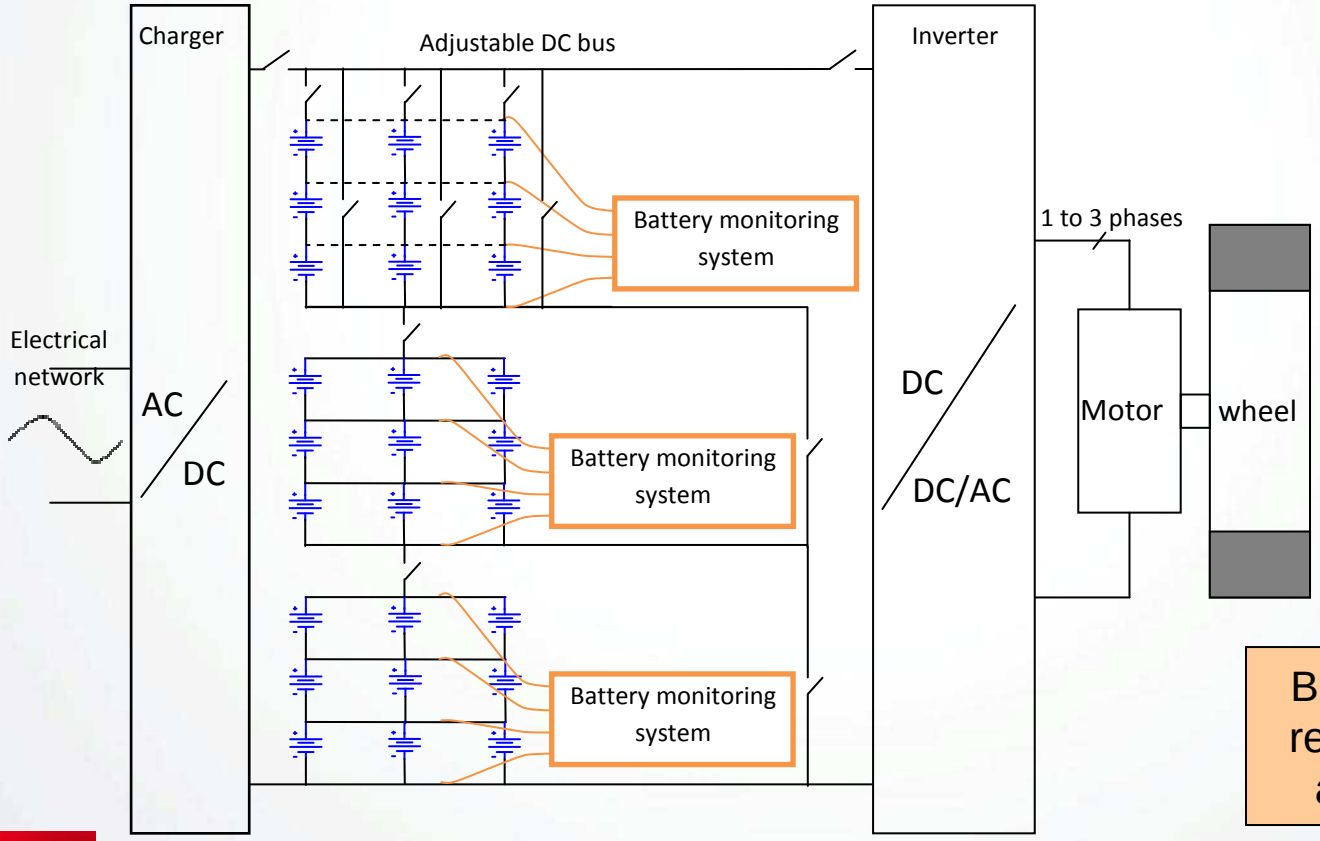
TRL 3-4

Actual electrical propulsion principle



How to overcome a battery cell failure

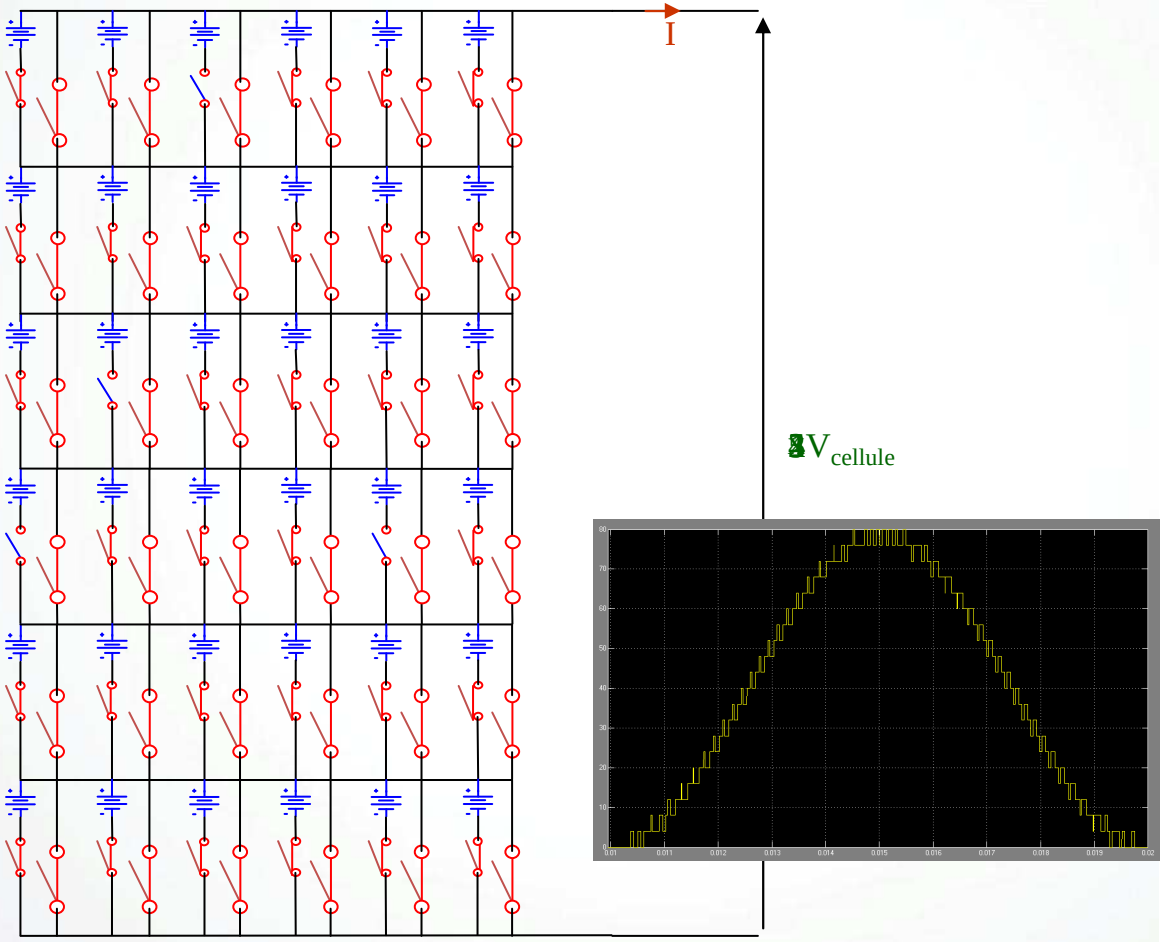
- Actually if one cell is failed, all the battery pack is impacted as all the battery cell are in serial
- One solution is to cut the battery pack in several disconnectables modules



- **Adjustable DC bus voltage**
- **As the current can be large (up to 300 A) several transistors in parallel are required -> each module can be cut in several columns at same cost**
- **As transistor cost is quite proportionnal to its voltage over 25 V, it is interesting to cut the battery pack in modules voltage of around 20 V (4 to 5 serial Li-ion cells)**

But that solution continues to require a charger, an inverter and a cell balancing circuit

Toward modules having only one serial cell

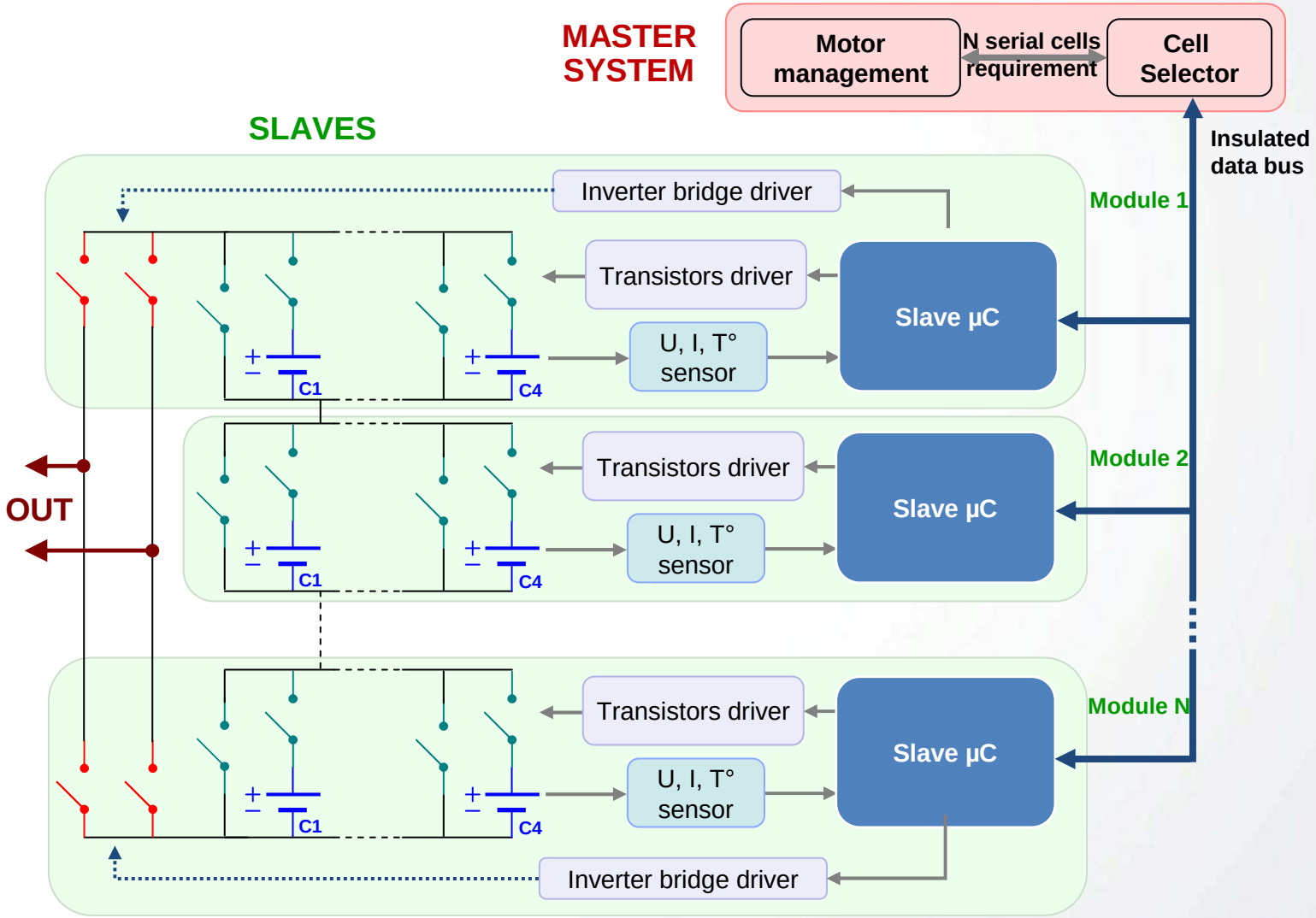


- Cell balancing in real time and with the full useful flowing current → no losses and no additional weight or cost for cell balancing
- No high frequency and high voltage switching → very low commutations losses
- Can work as well for charge or discharge
- Replace the inverter
- Replace the charger
- Replace the costly converter of high speed charger stations
- Improve the current and voltage waveforms applied to the electrical motor or get on the electrical network
- Can reduce by a factor five the losses compare to an embeddable inverter

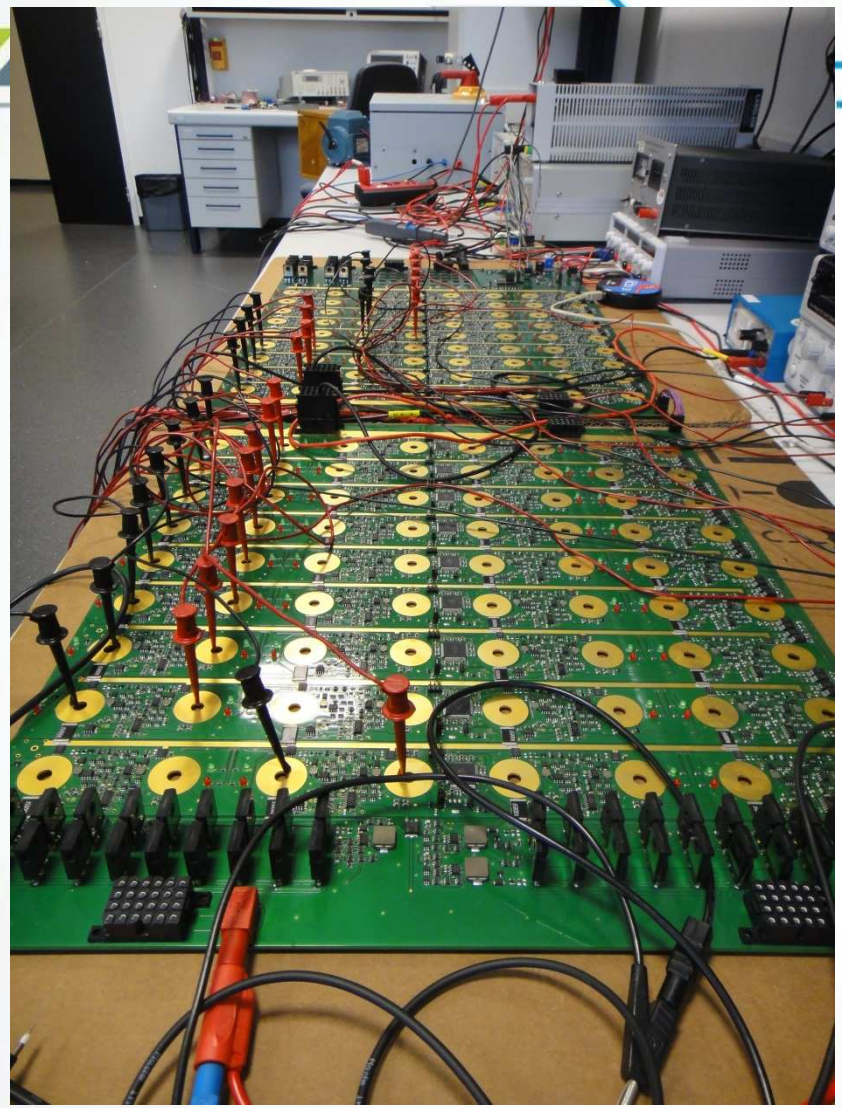
50 to 100€ of transistors cost per 10 kW to get an efficiency of 98,5%
(catalogue price → could be significantly reduced with quantities)

SERMA TECHNOLOGIES
Serma Group

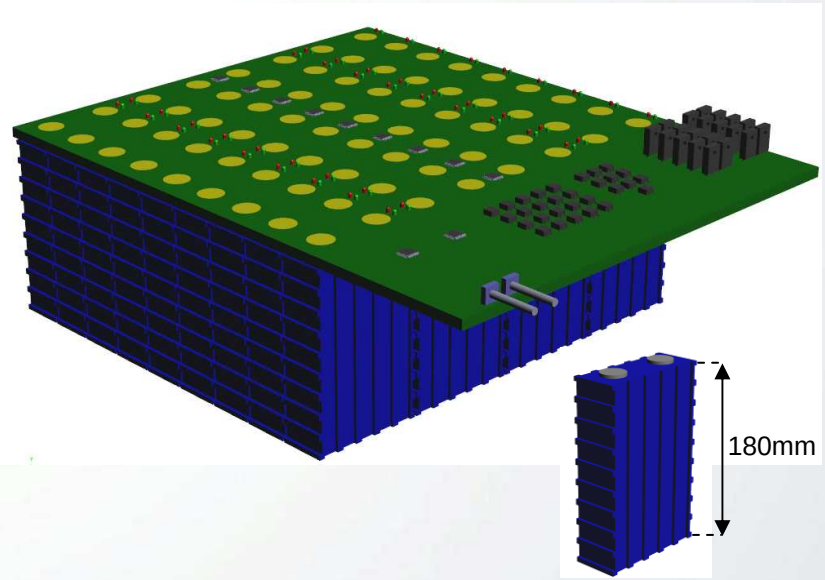
First prototype architecture



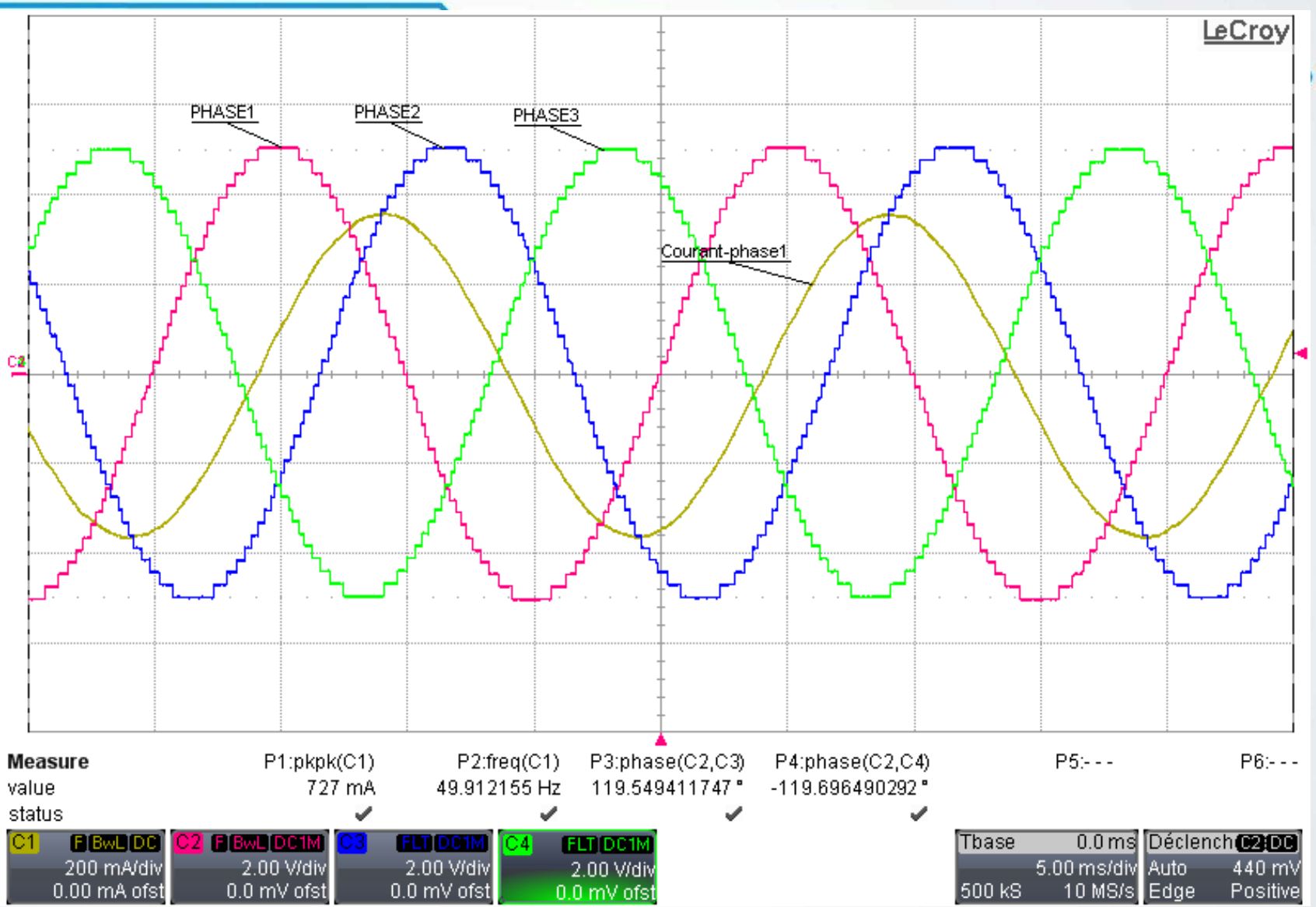
1st prototype fabrication



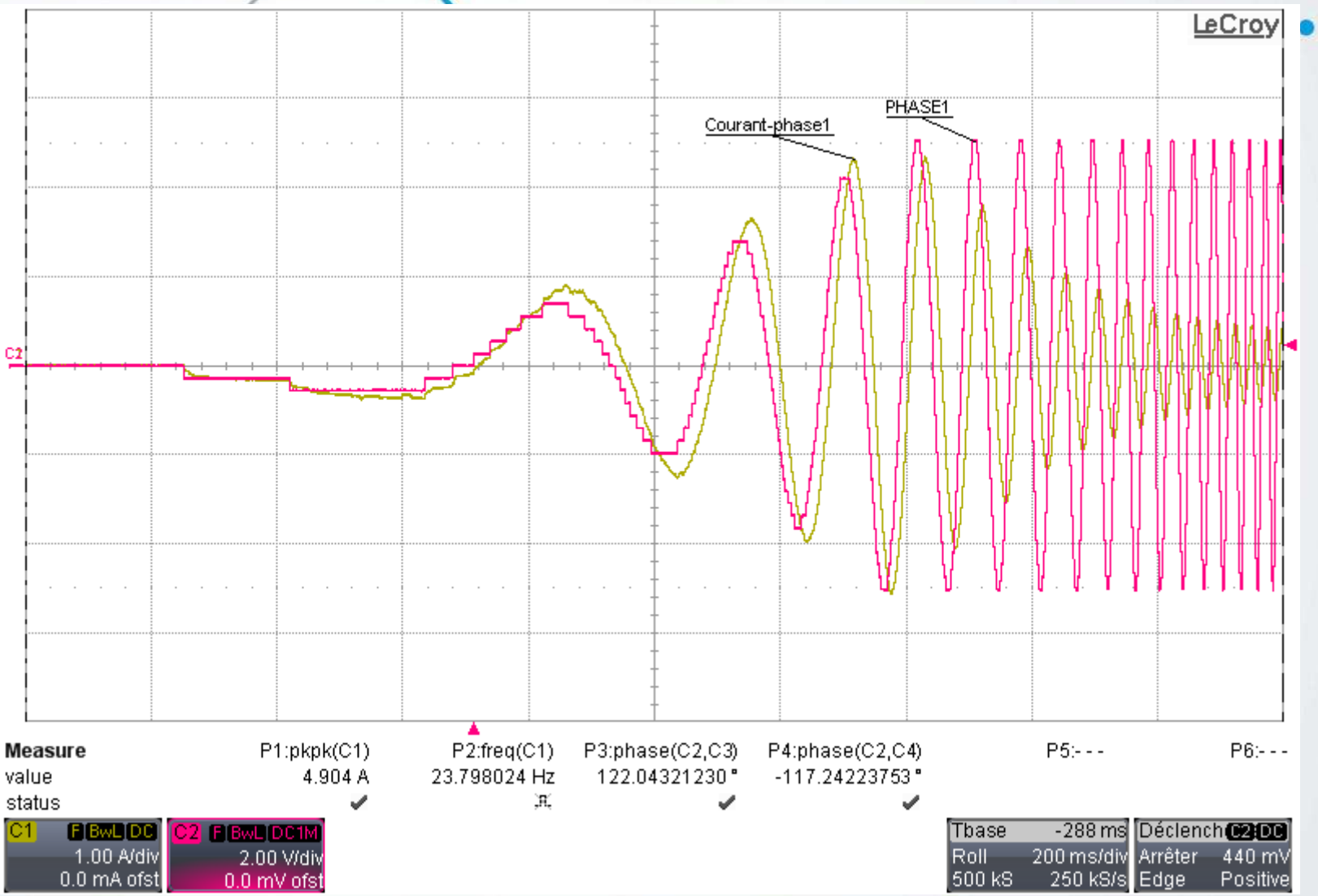
- 18 modules
- 4 cells of 40Ah per module
- Include an inverter to reverse the output voltage
- Permits to switch in serial/parallel two such systems



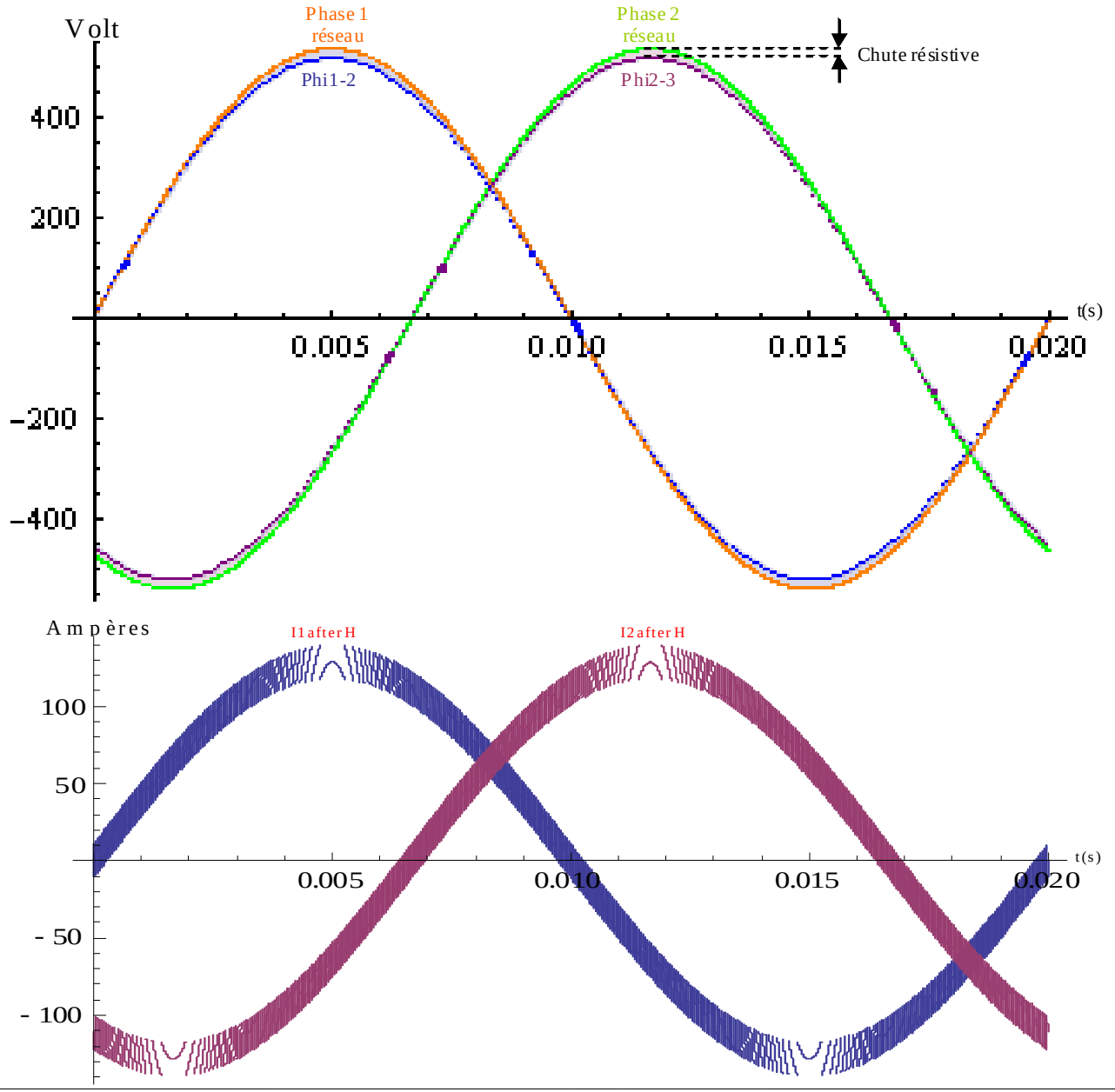
Electrical motor driving: continuous regime (measurement)



Electrical motor driving: transient regime (measurement)

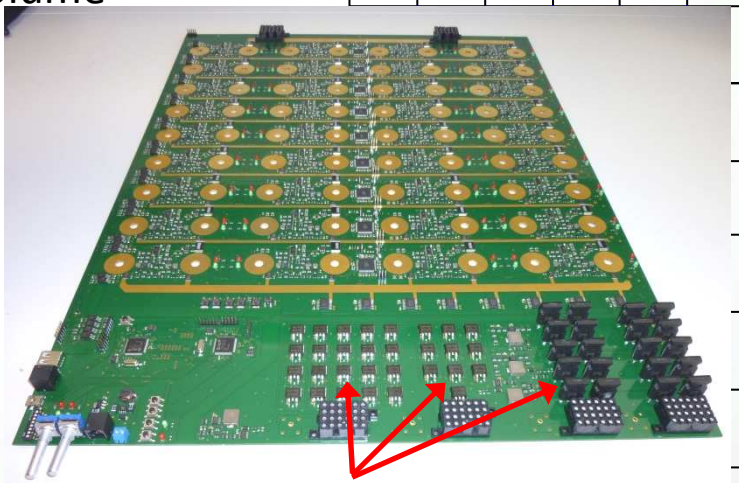


Under 380V electrical network recharge (simulation)

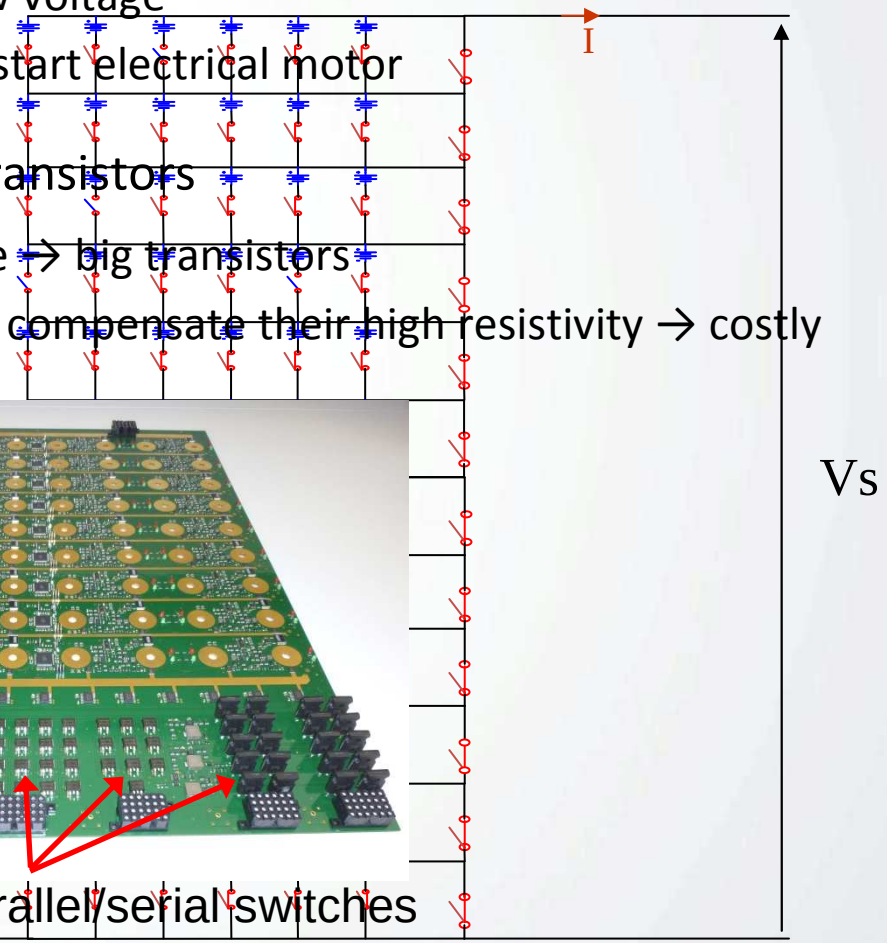


Output current capability adjustment

- Parallel/serial switching of batteries blocks
  - Lower resistive losses at low voltage
  - Higher available current to start electrical motor
- Inverter and serial/parallel transistors
  - Have to sustain high voltage → big transistors
  - Many parallel transistors to compensate their high resistivity → costly and high volume

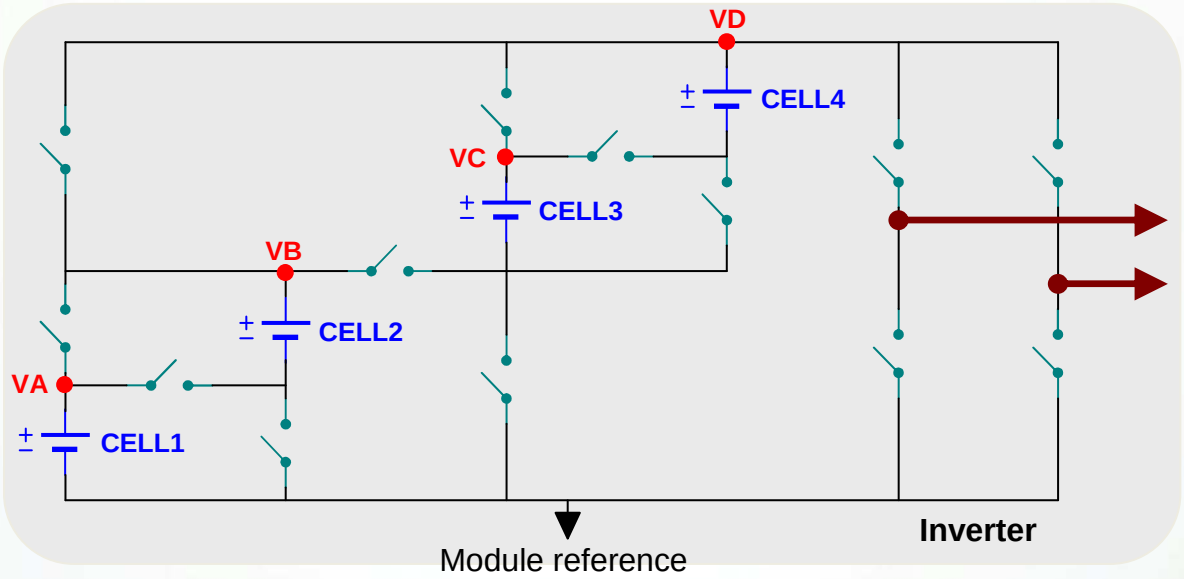


Inverter and parallel/serial switches



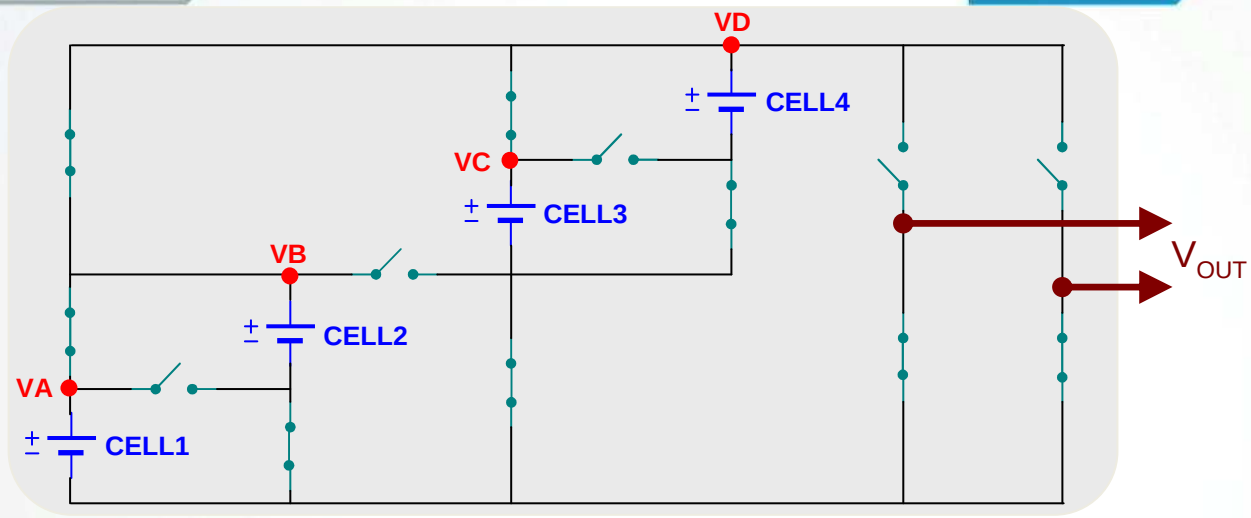
2d prototype: local switching design

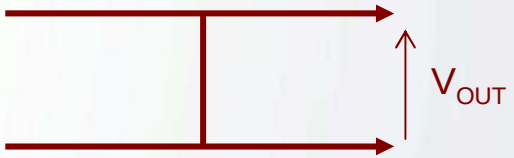
- Local inversion and serial/parallel switching
  - Under lower voltage → Smaller transistors
  - Easier to drive in synchronize the inverter

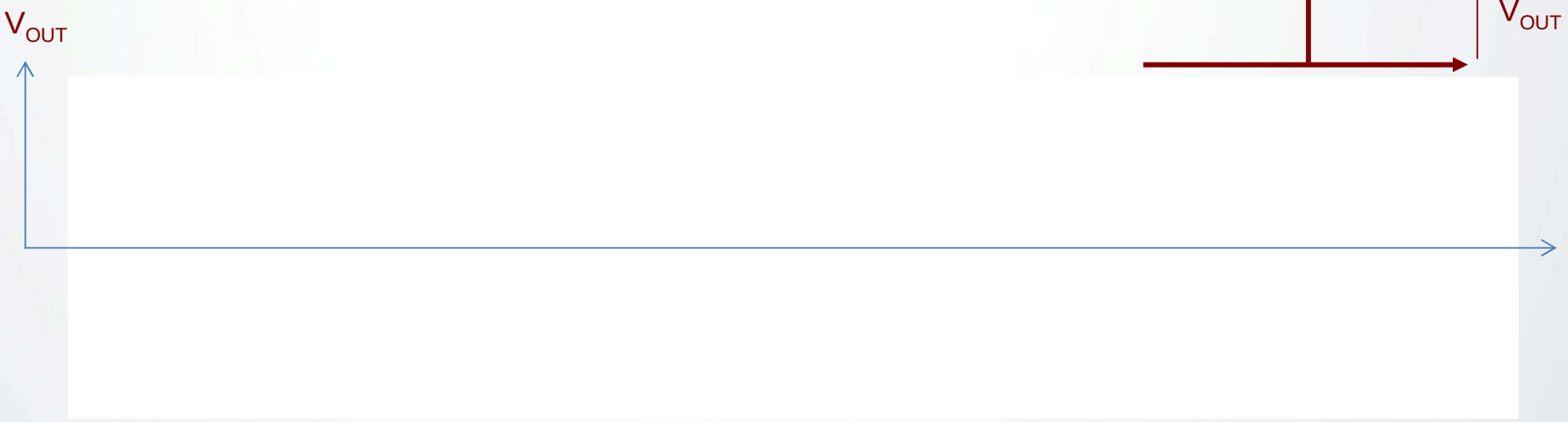


- Higher efficiency in low voltage: up to 4 cells in parallel

Le BMS commuté : l'architecture générique







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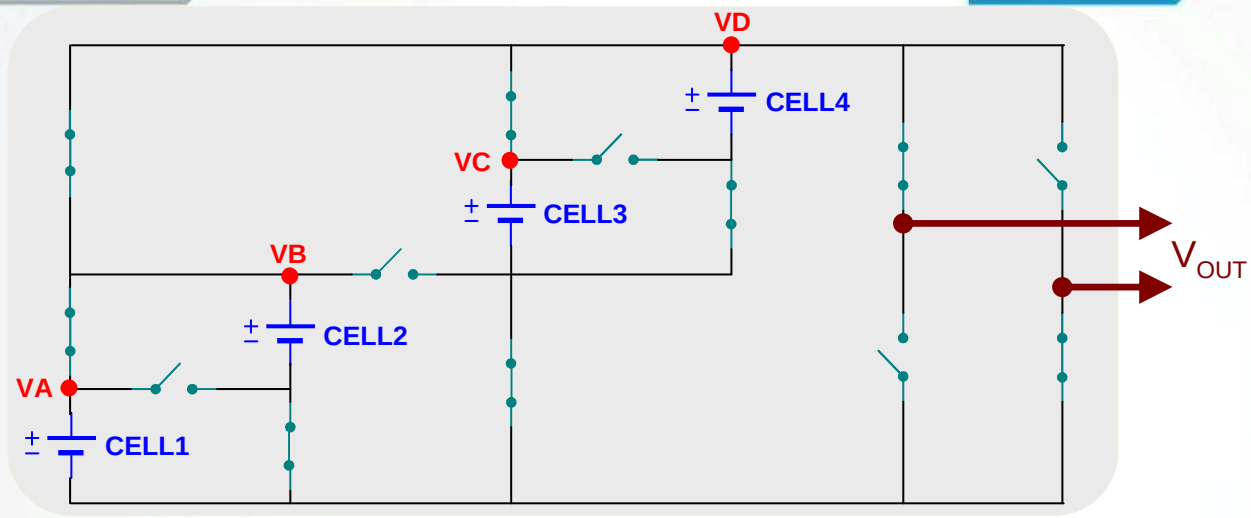

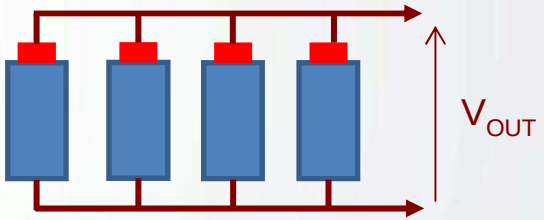

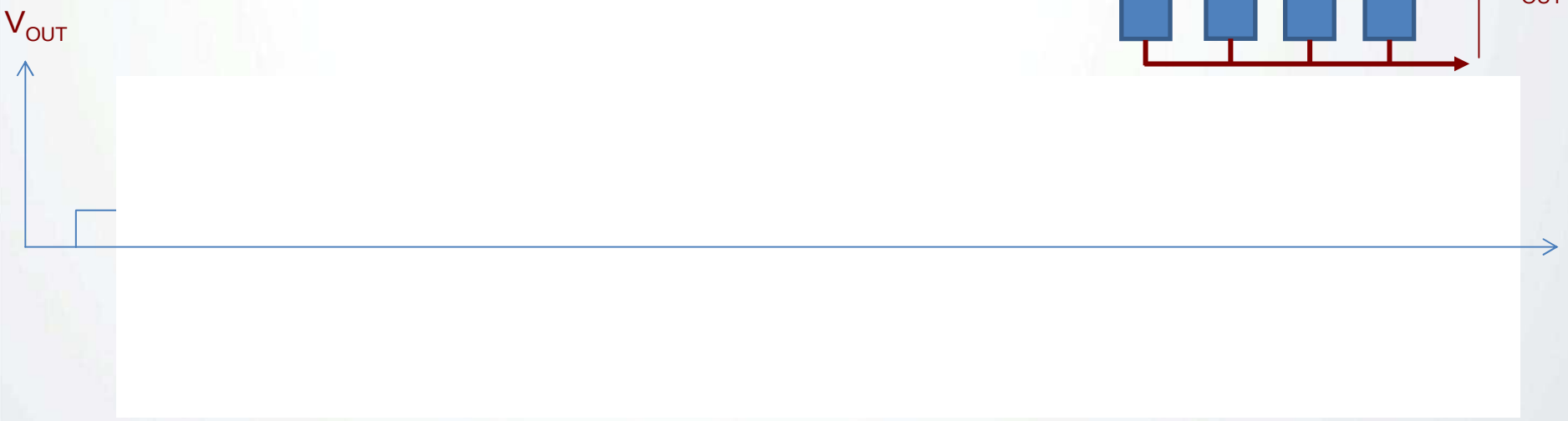

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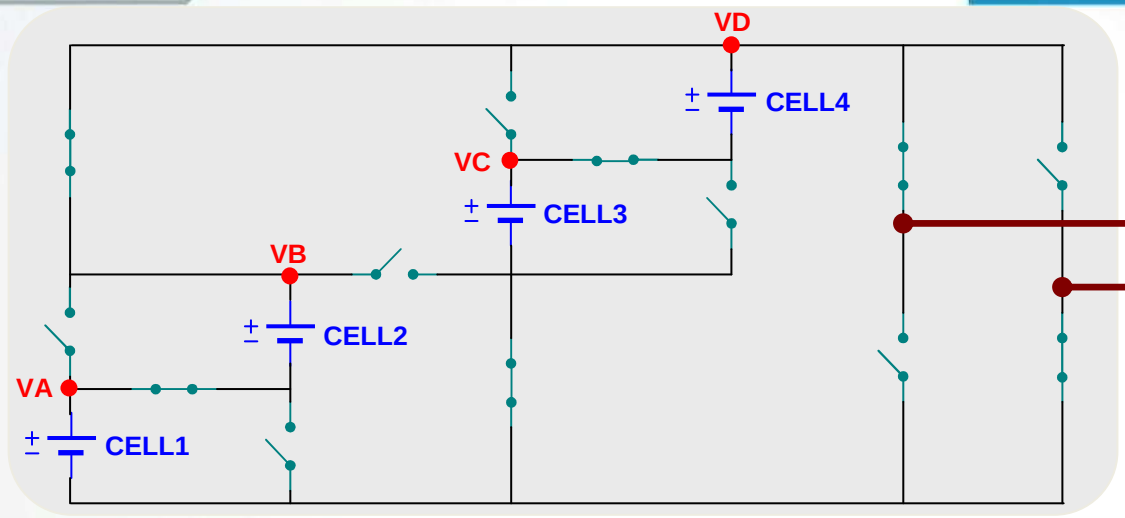

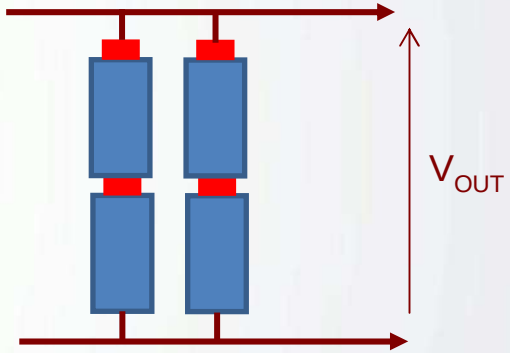

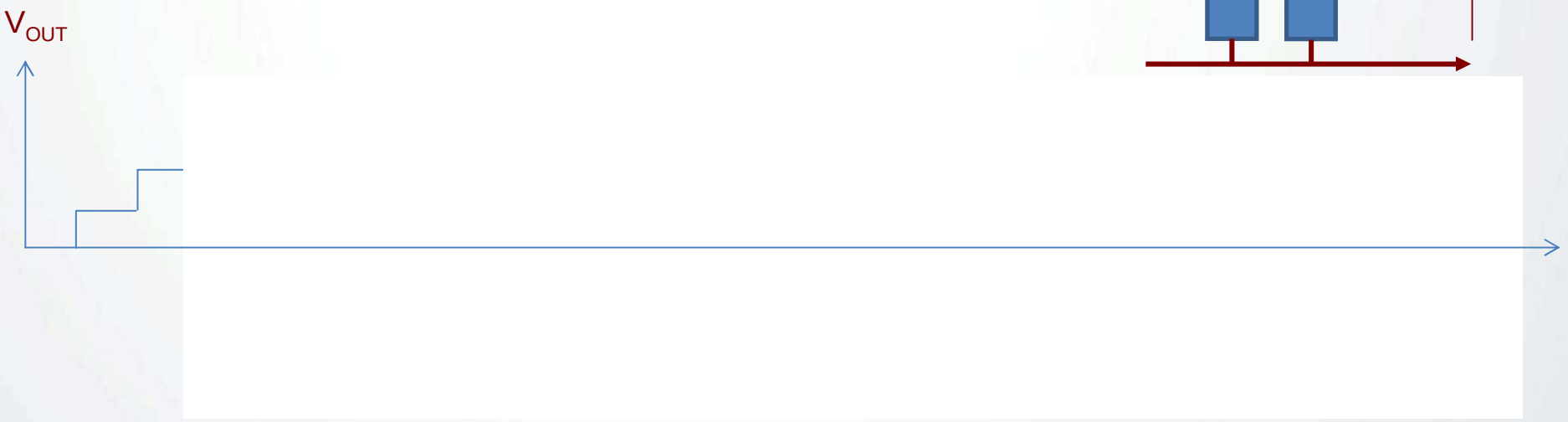

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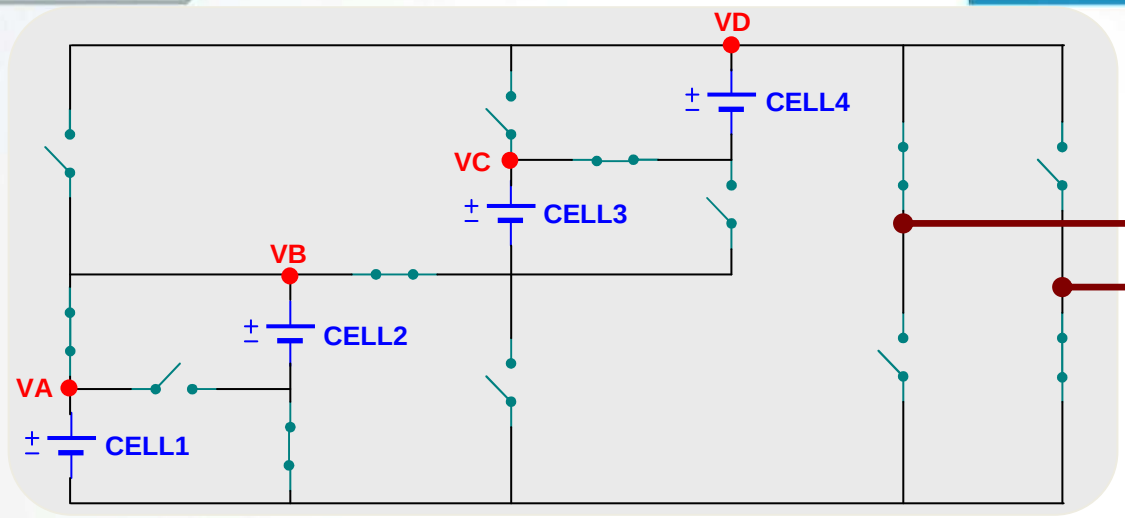

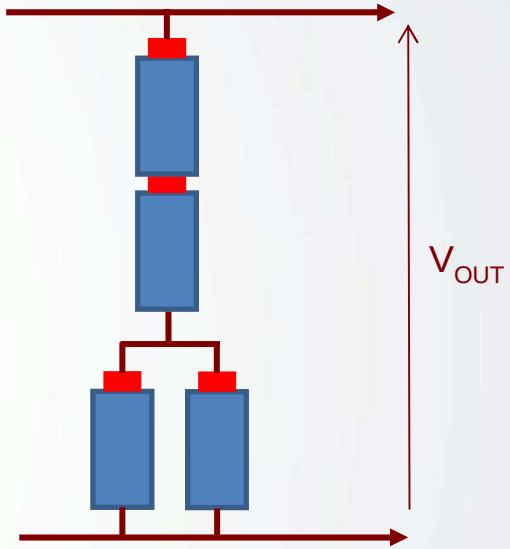

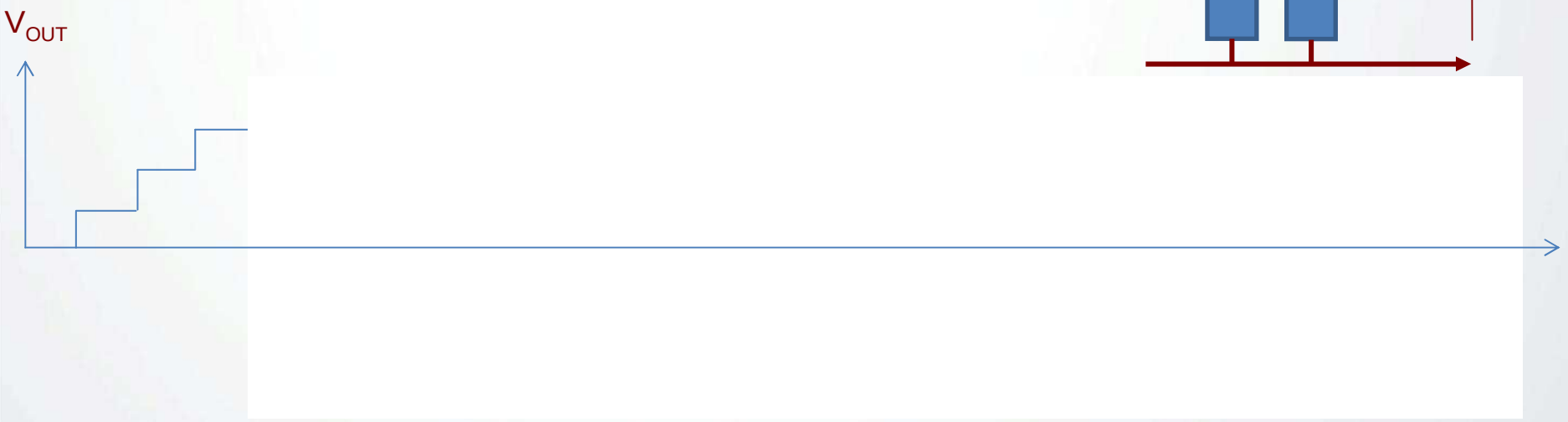

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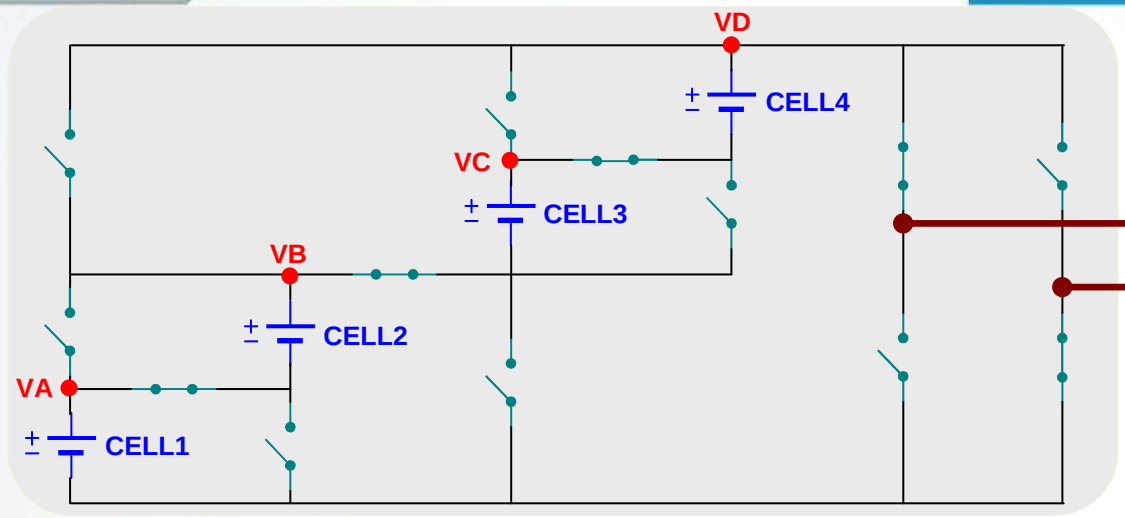

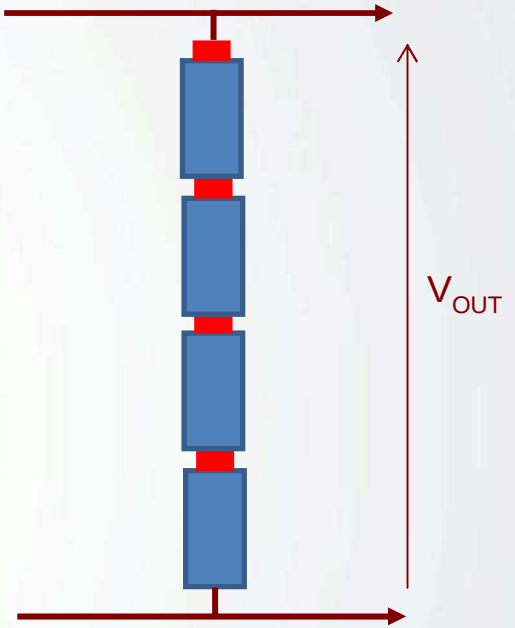

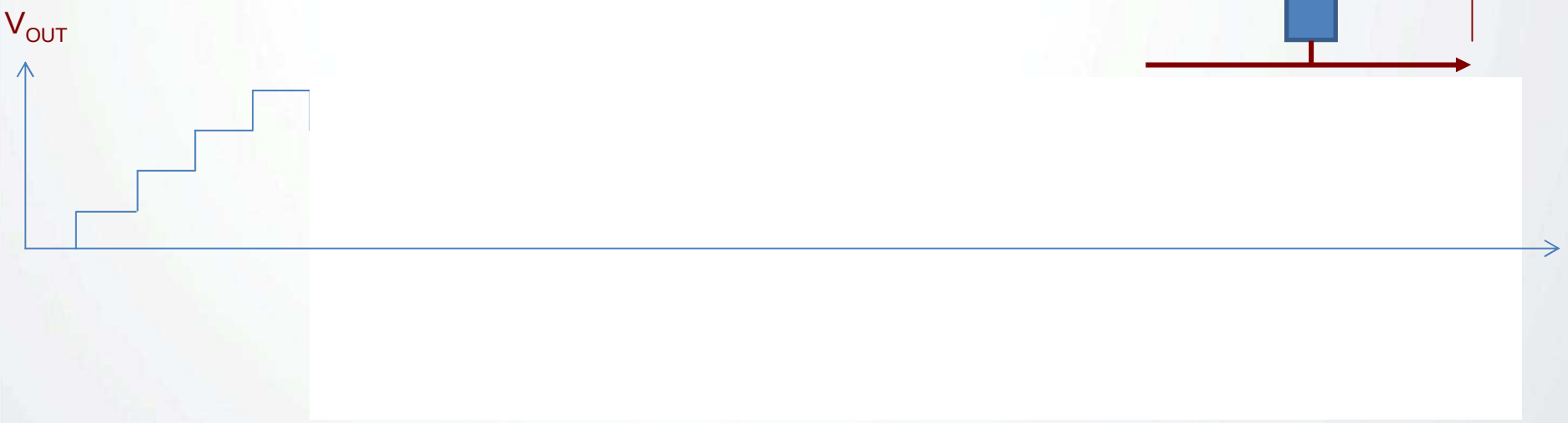

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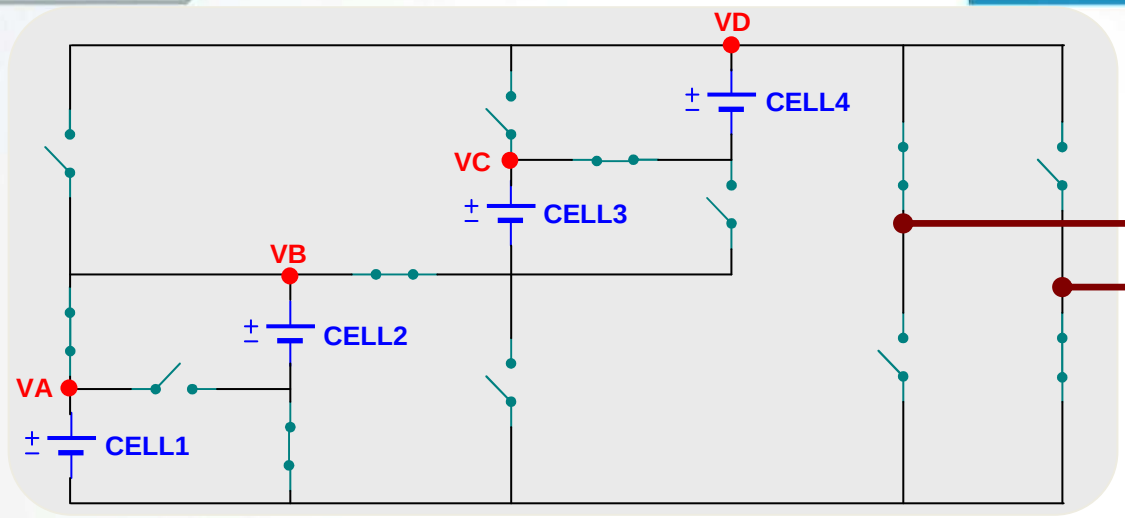

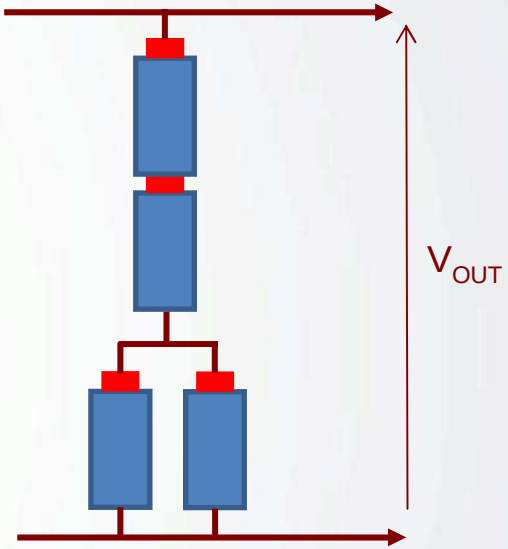

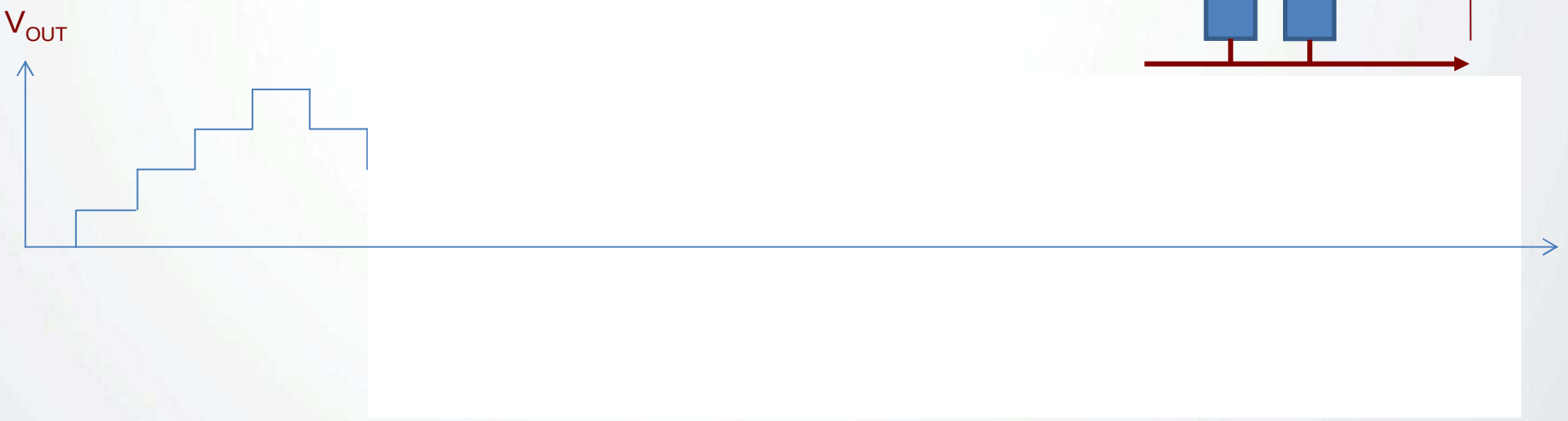

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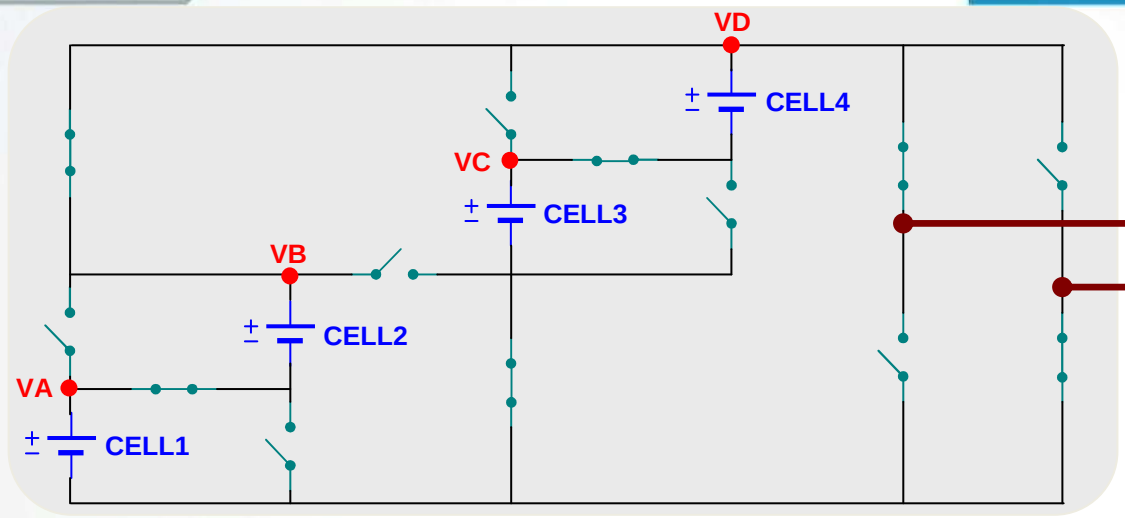
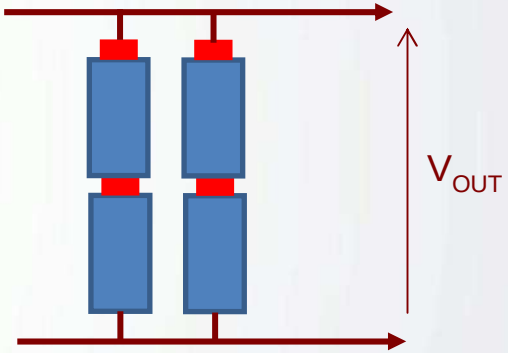
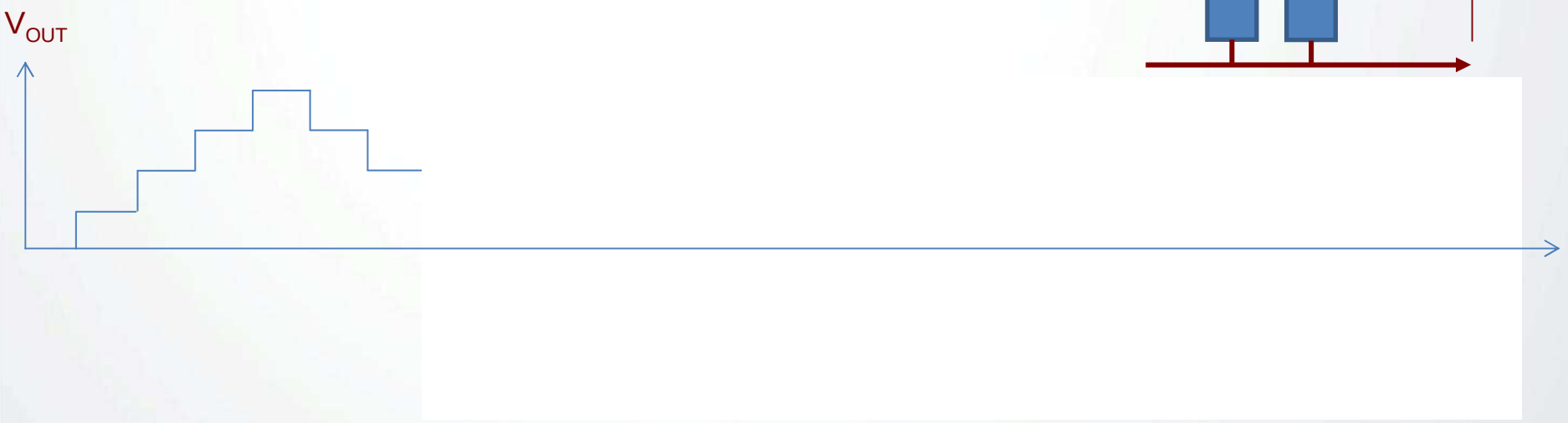
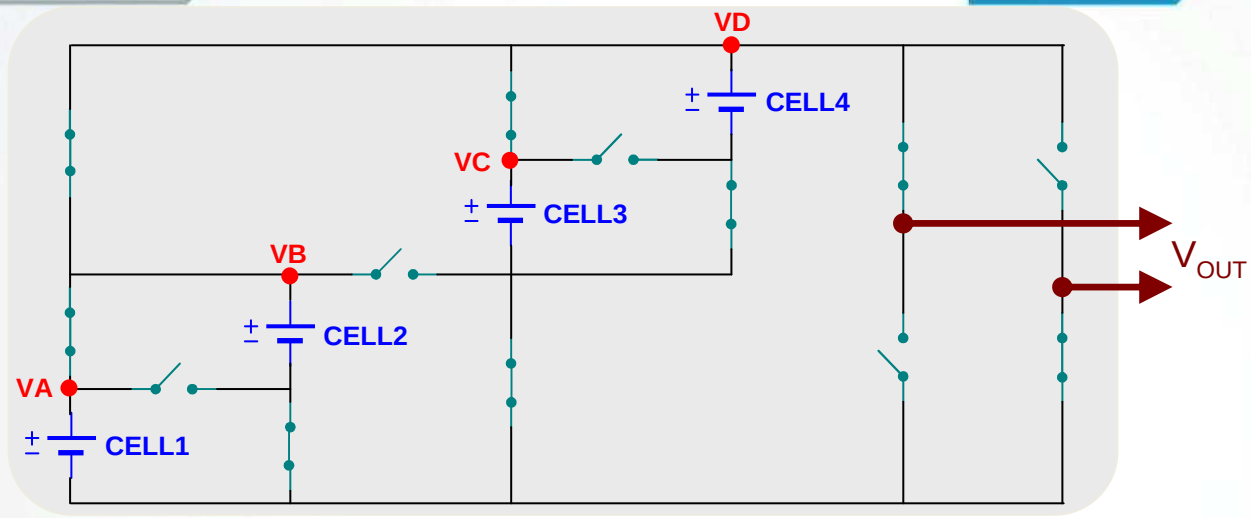
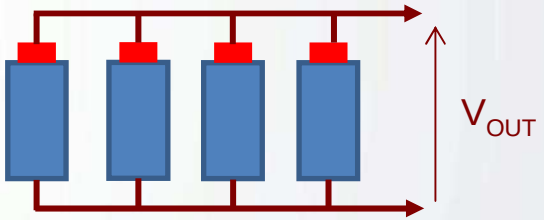


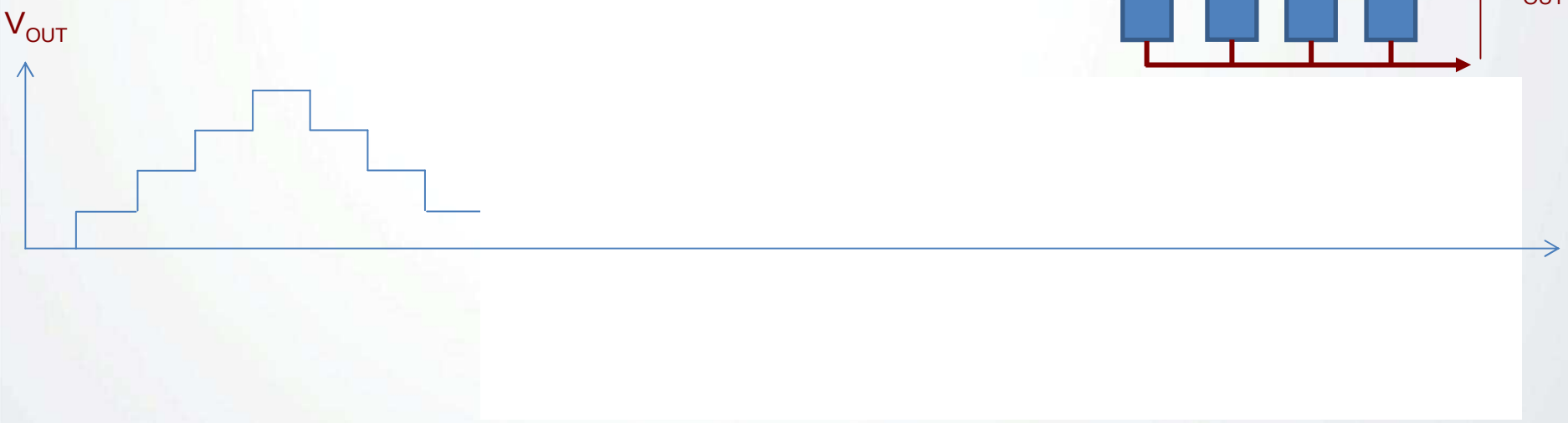




Le BMS commuté : l'architecture générique







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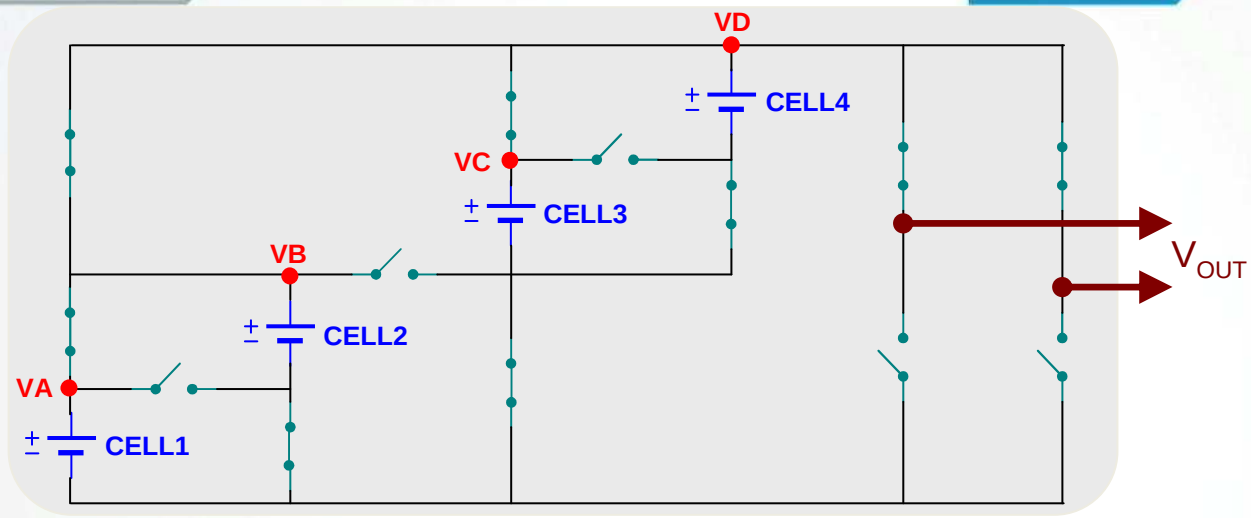

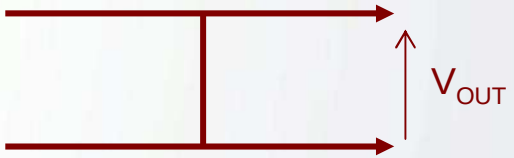

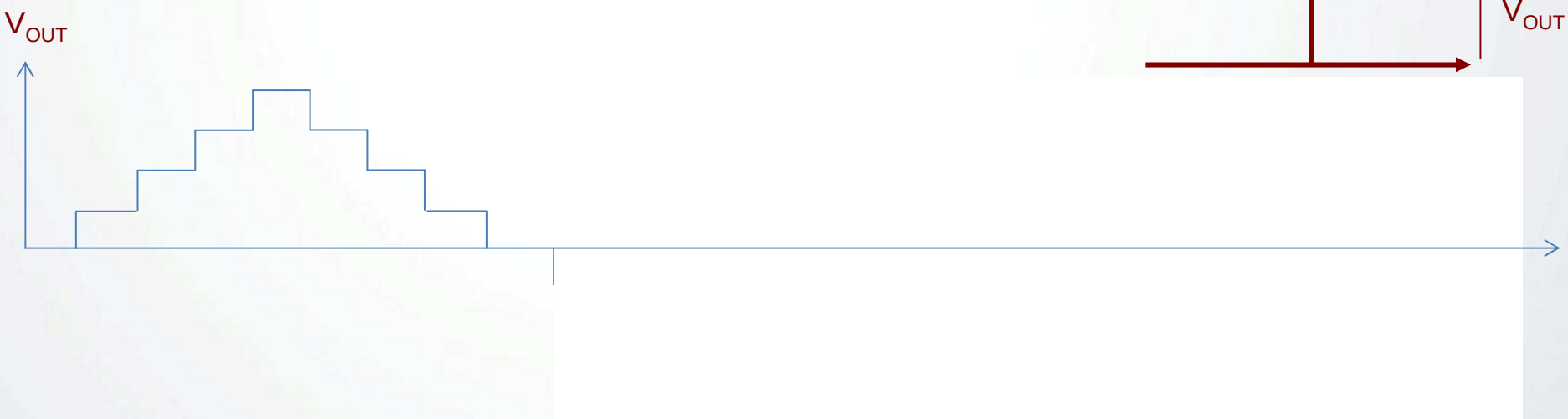

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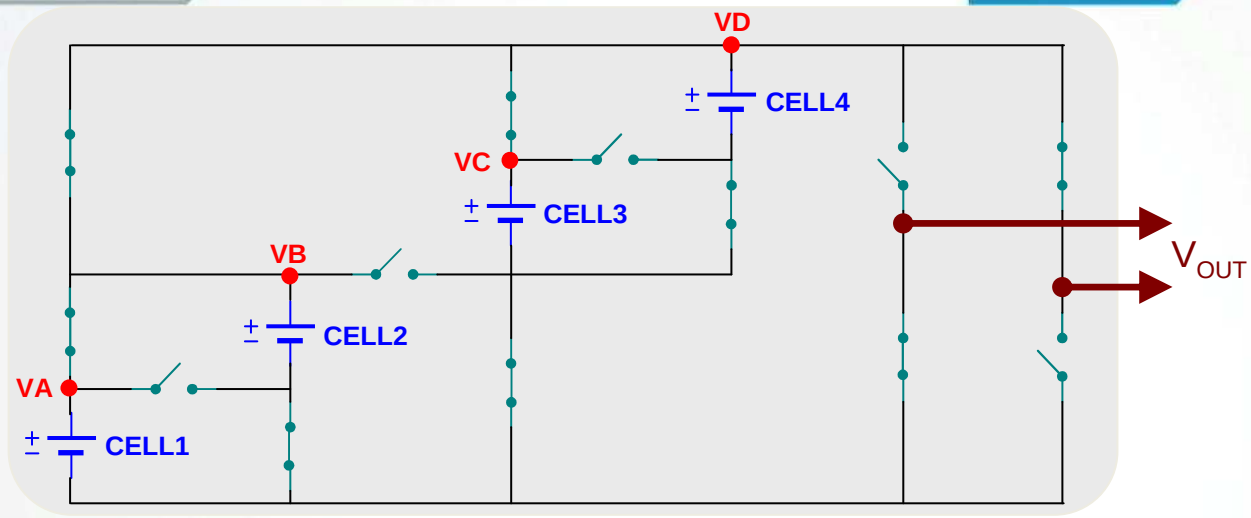

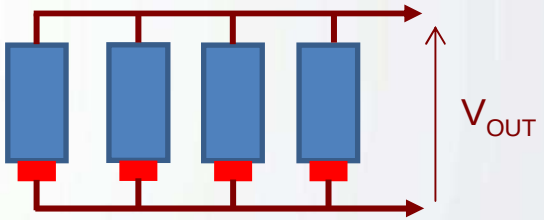

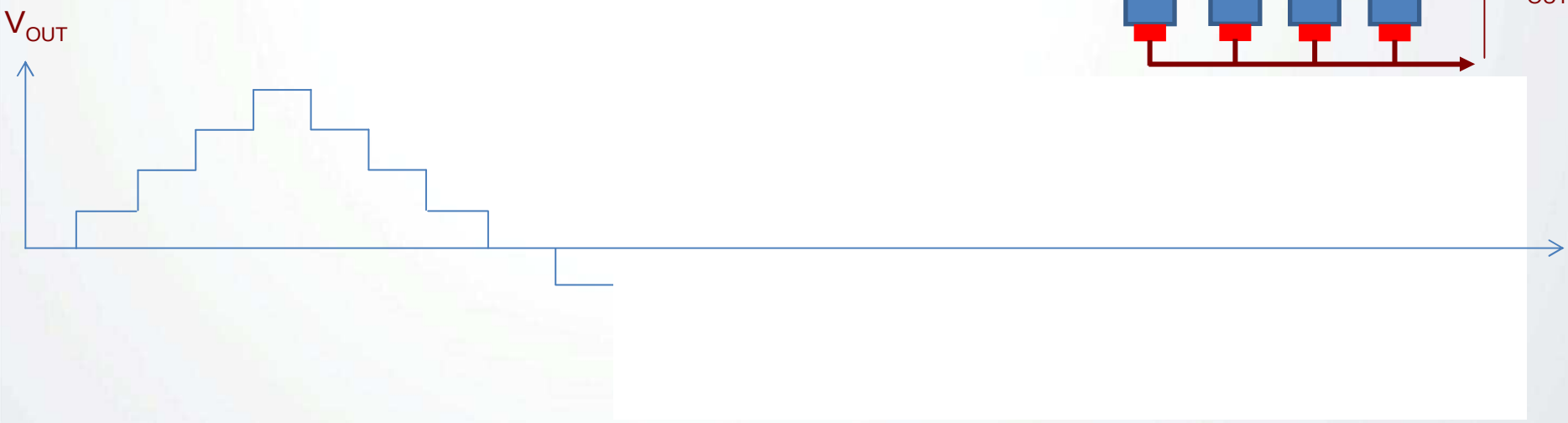

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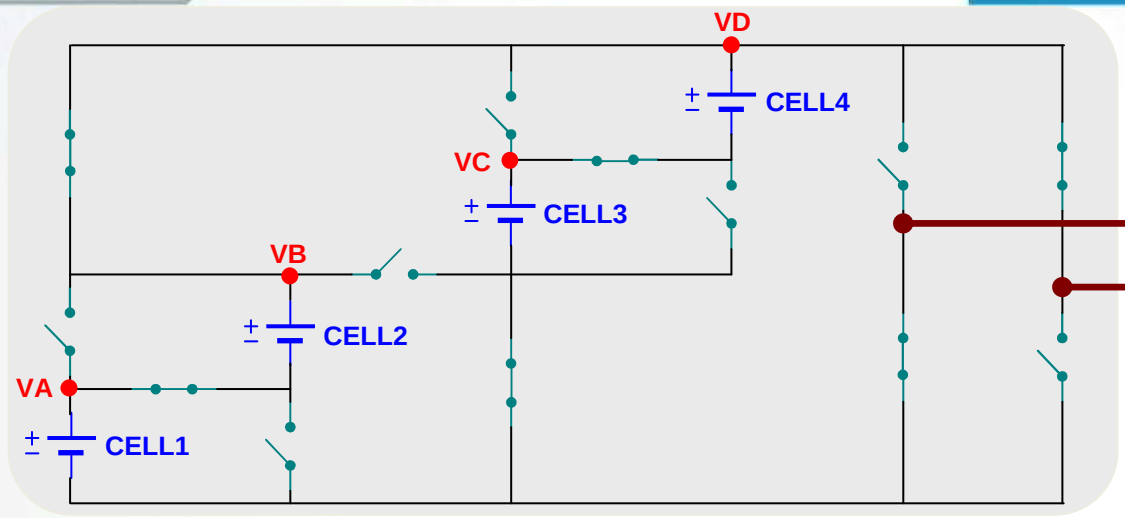

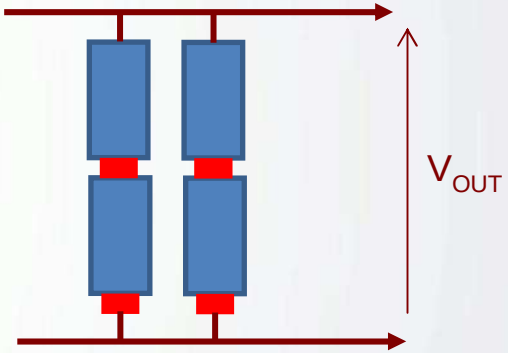

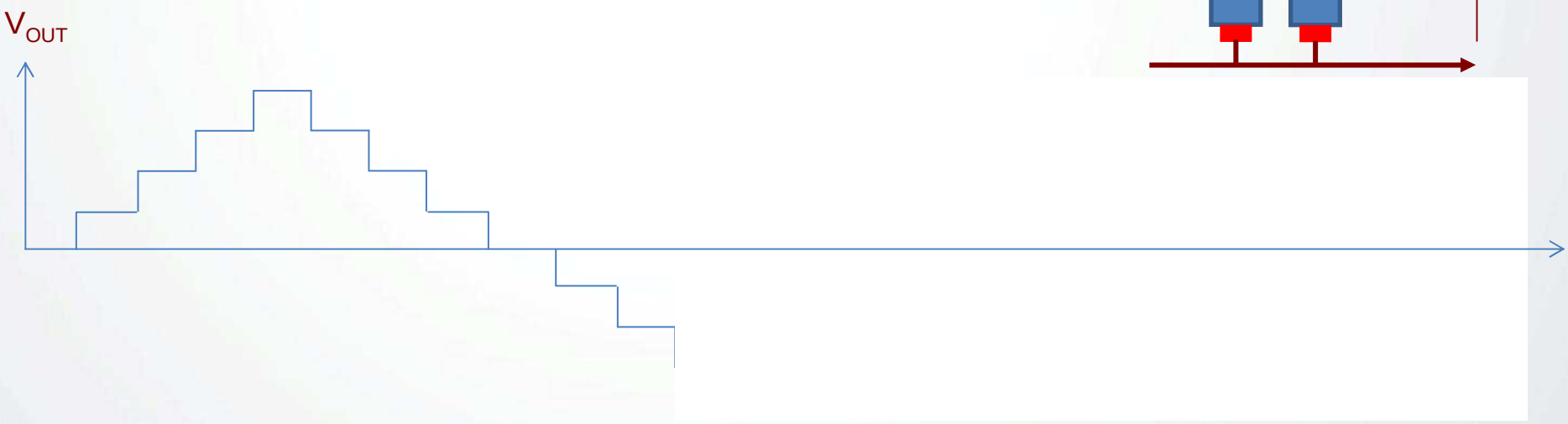

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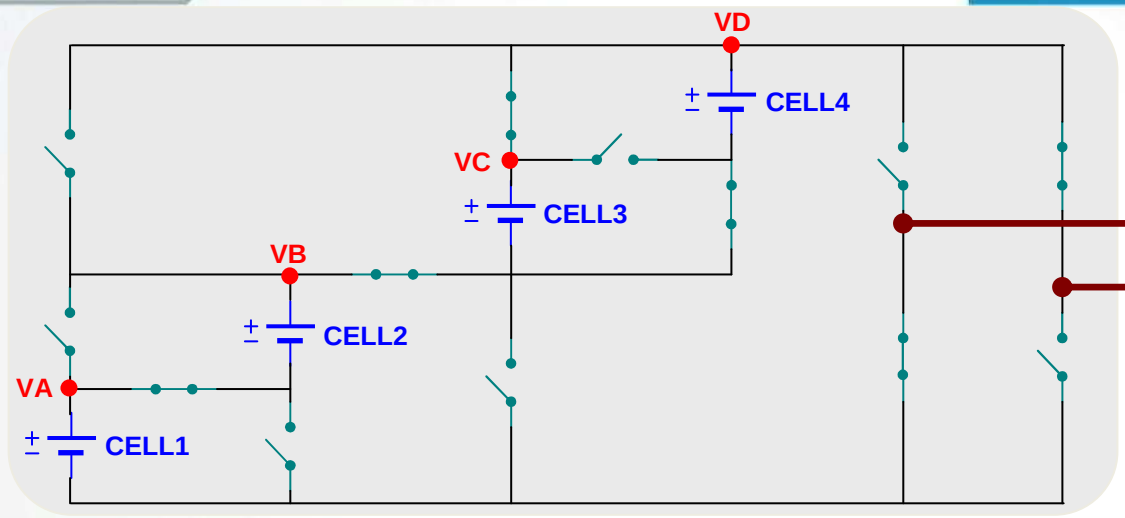
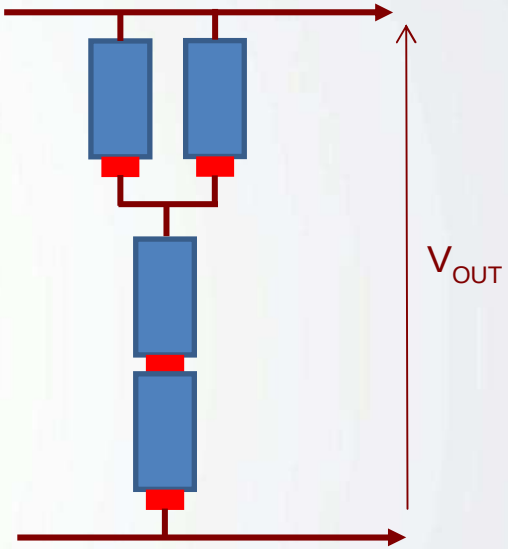
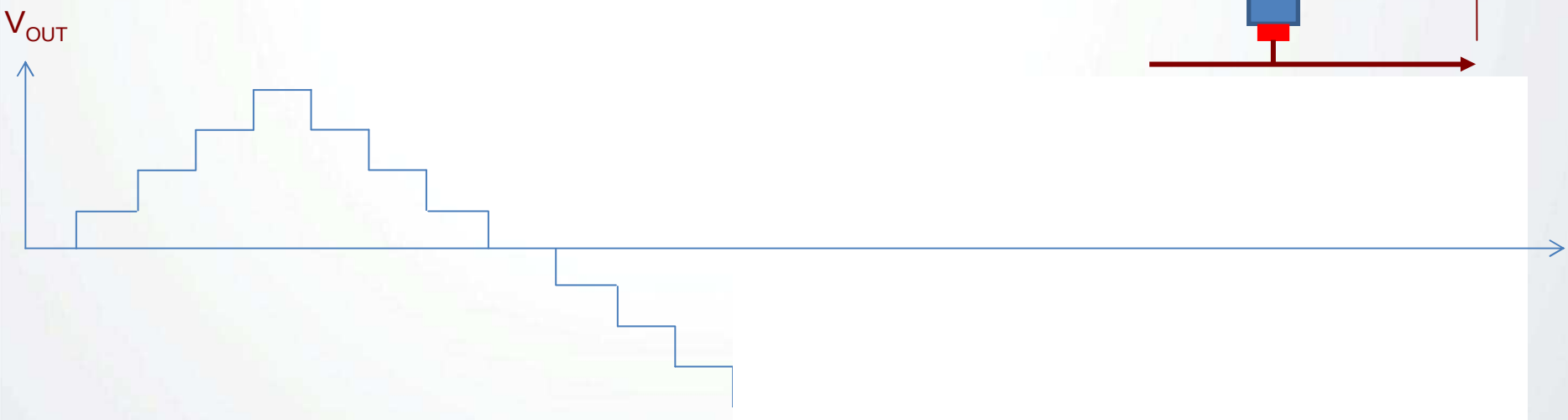
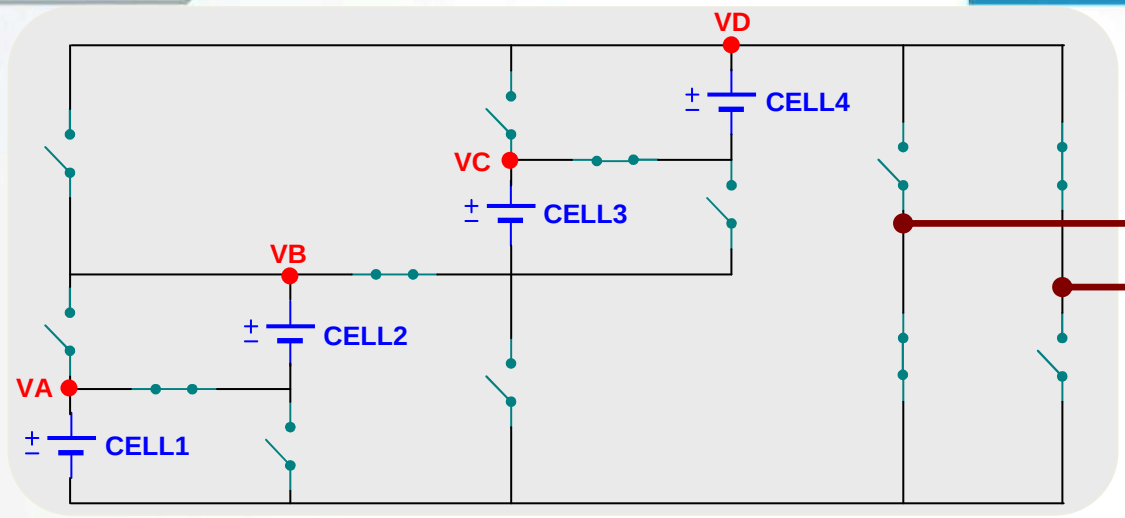
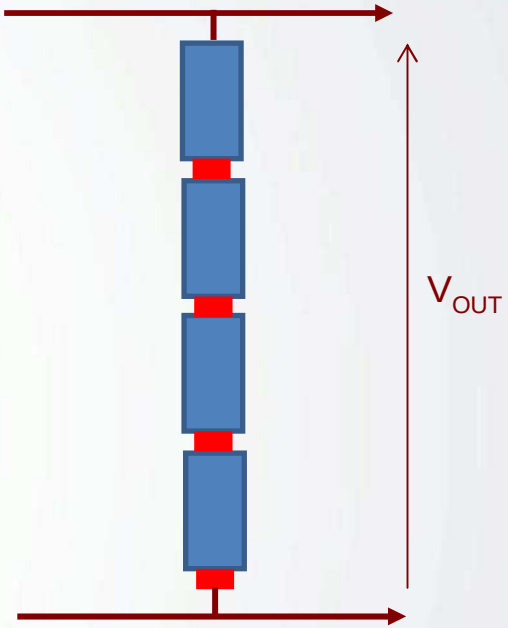


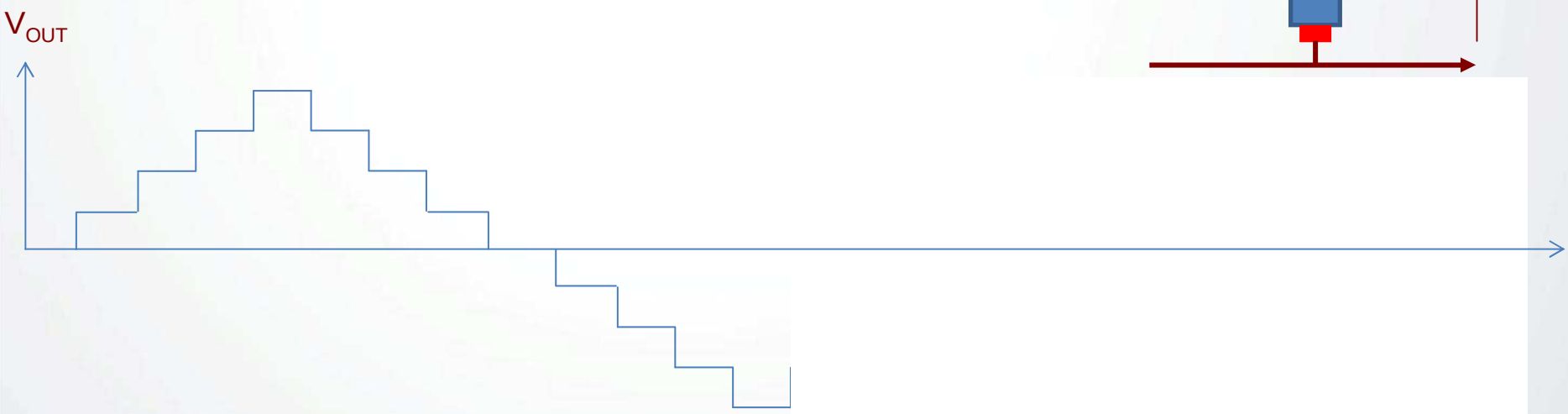




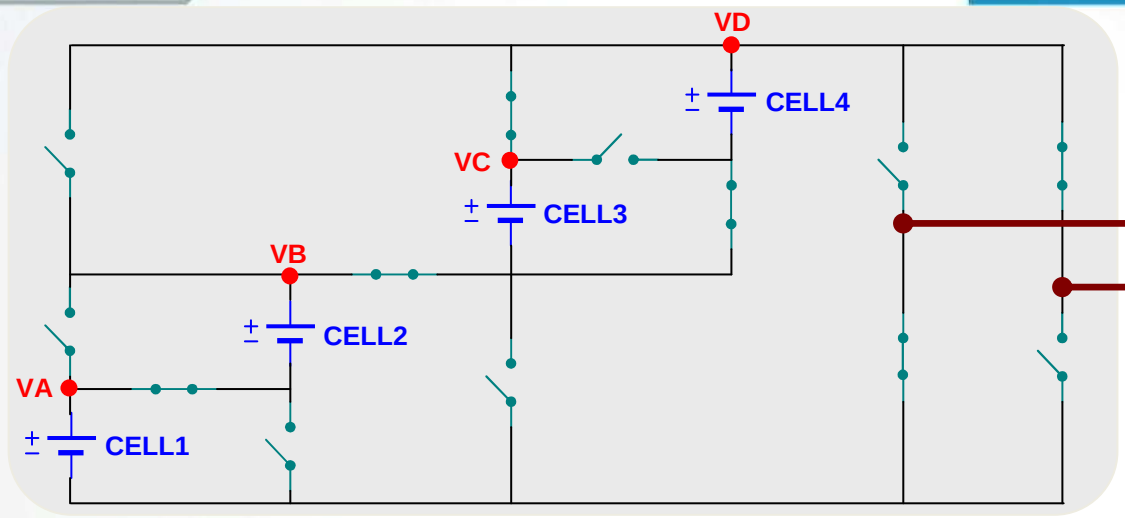
Le BMS commuté : l'architecture générique

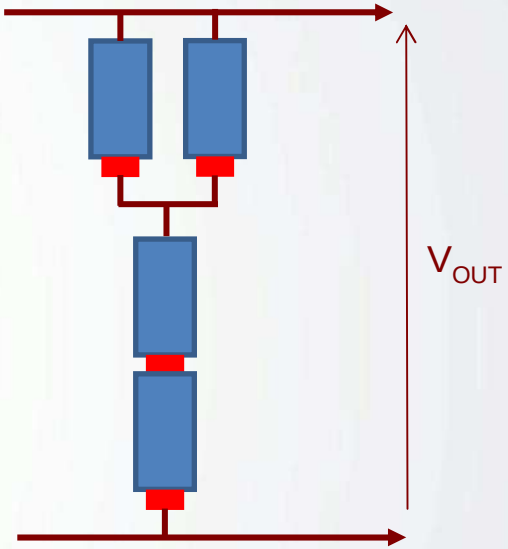


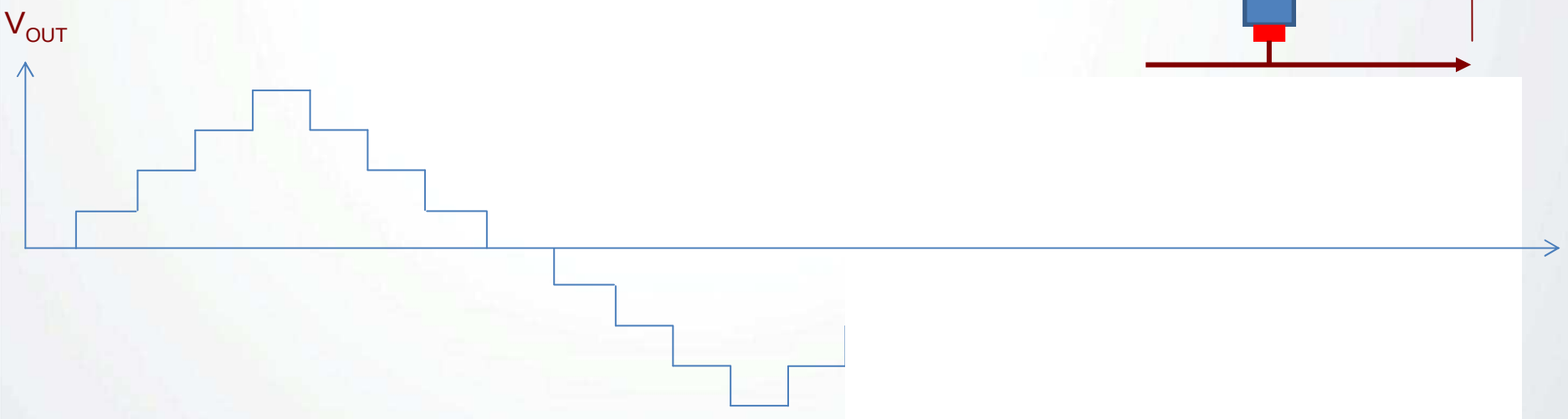




Le BMS commuté : l'architecture générique







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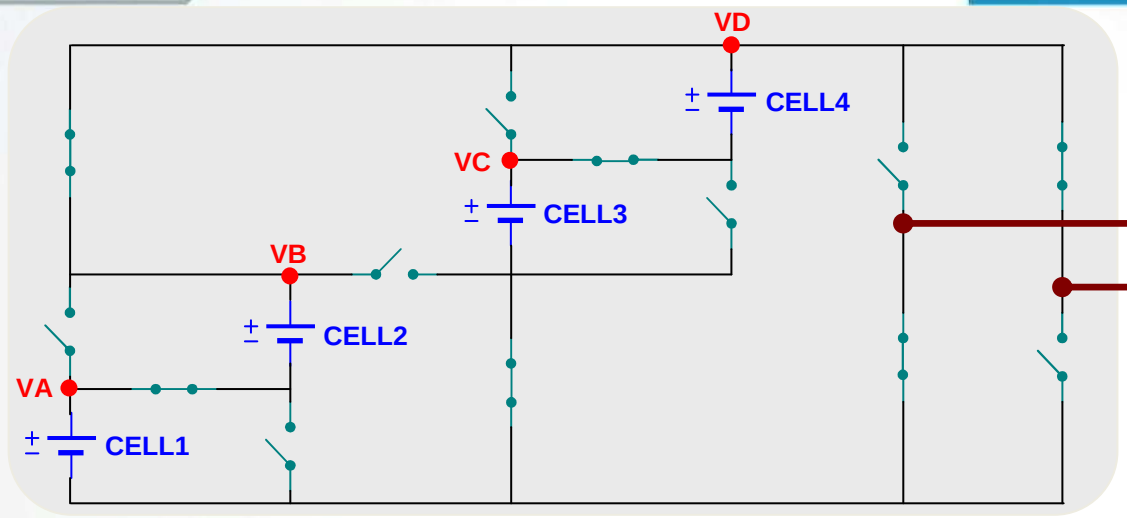

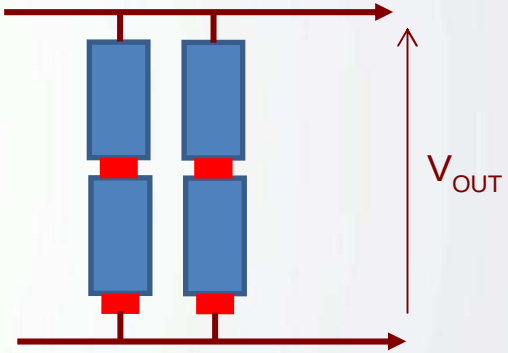

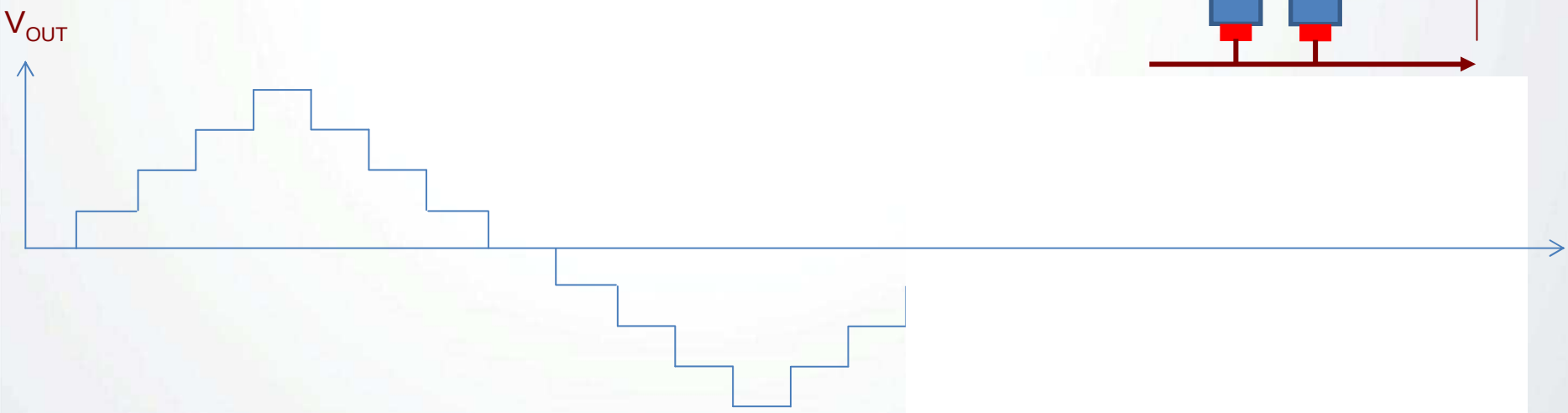

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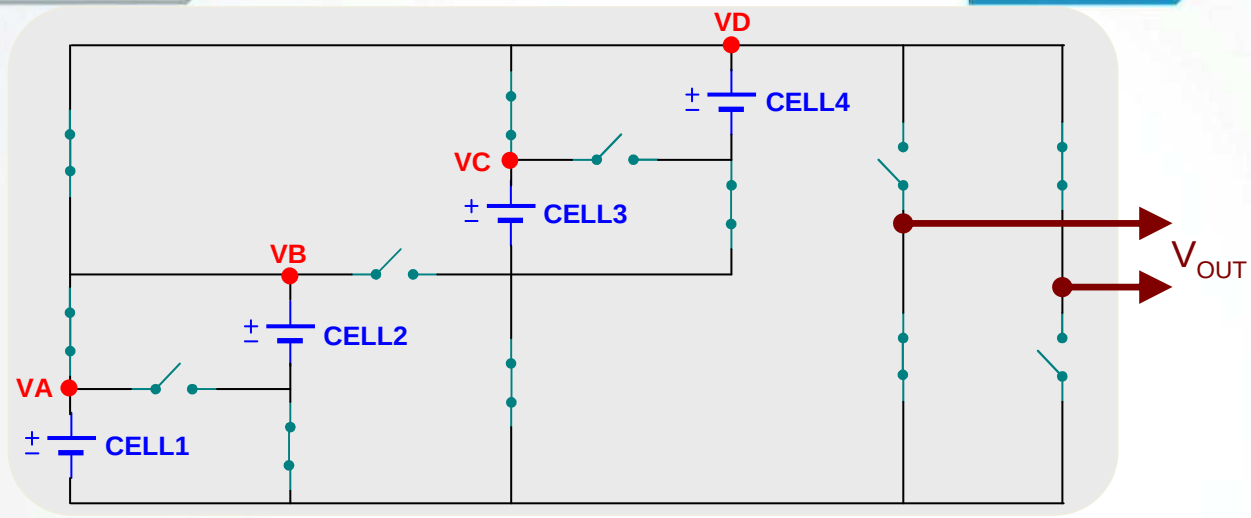

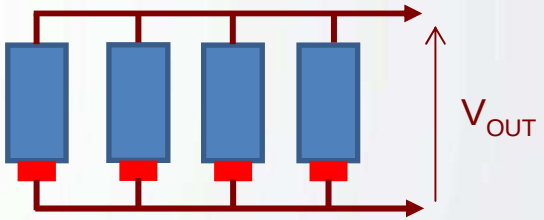

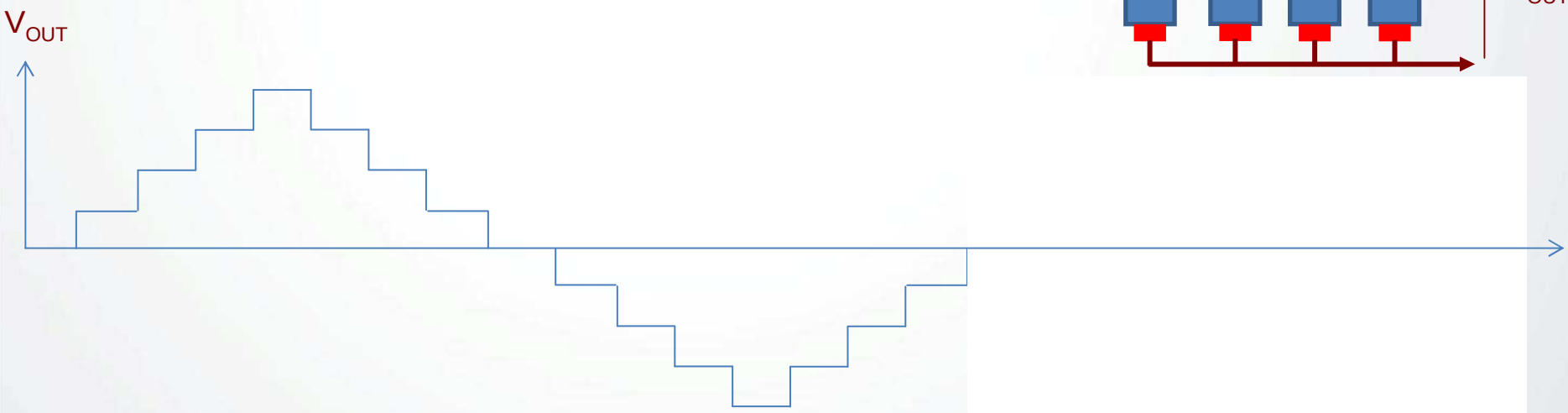

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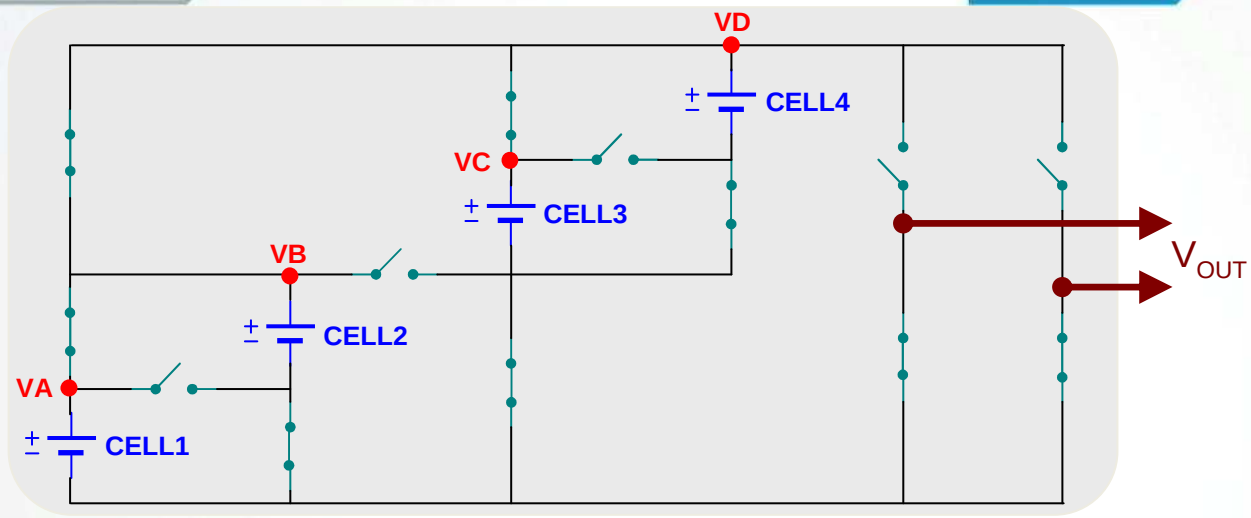
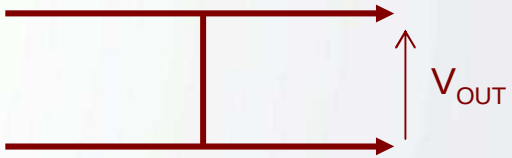
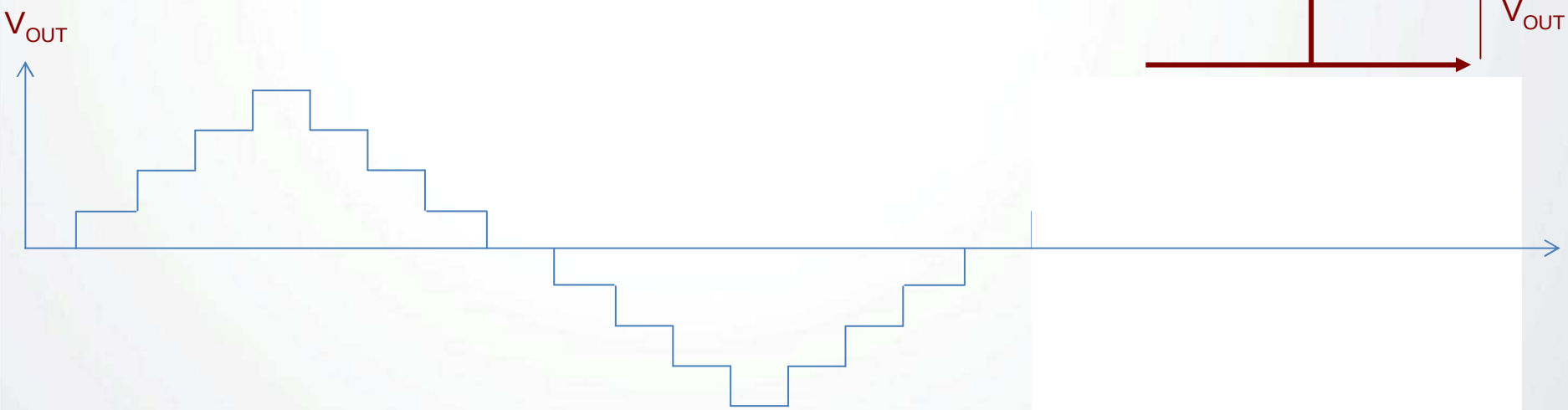
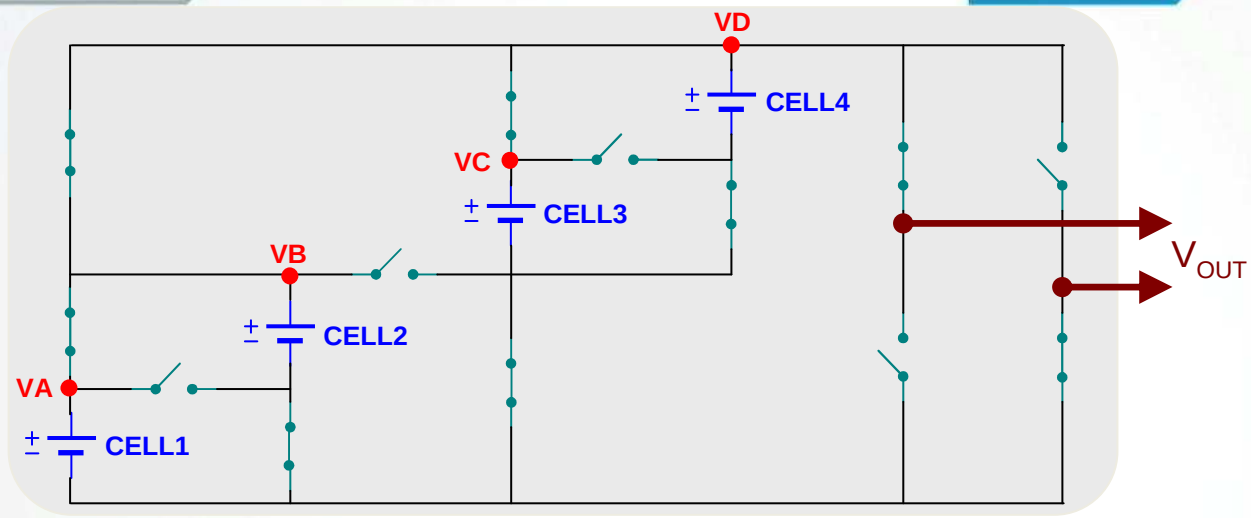
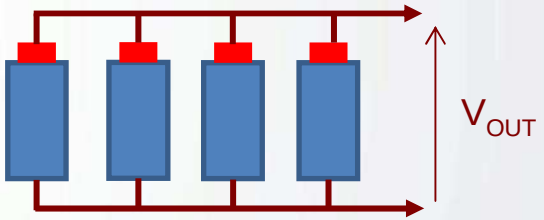


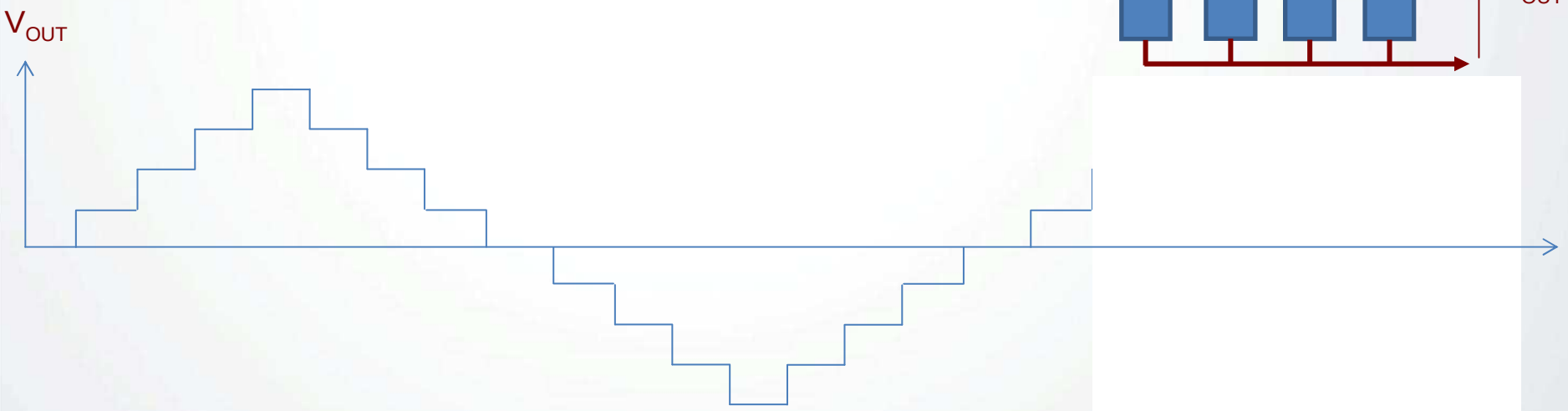




Le BMS commuté : l'architecture générique







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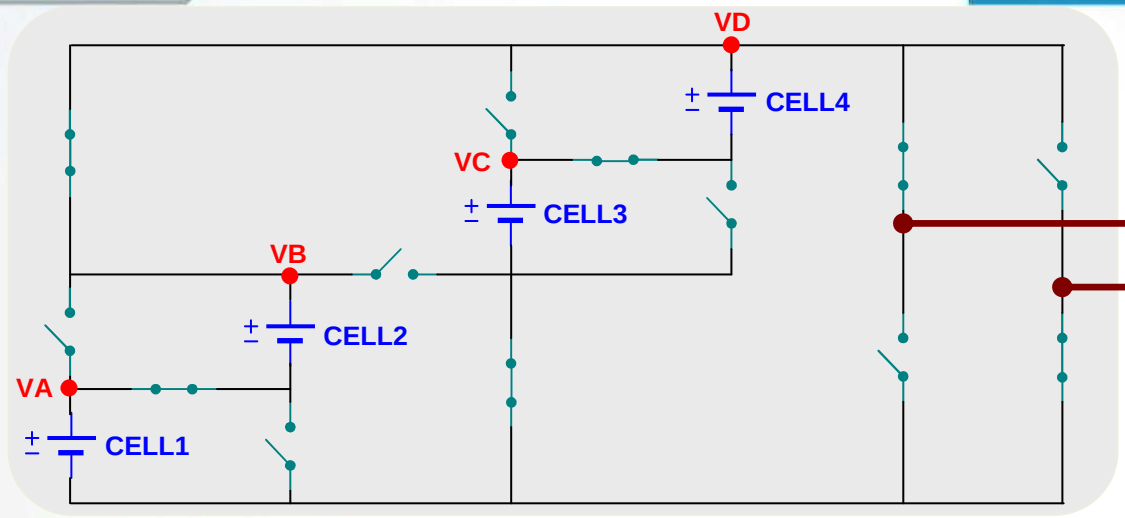

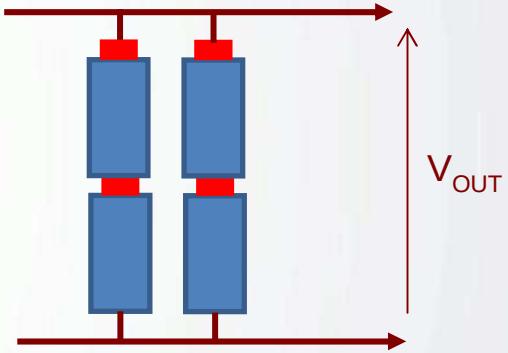

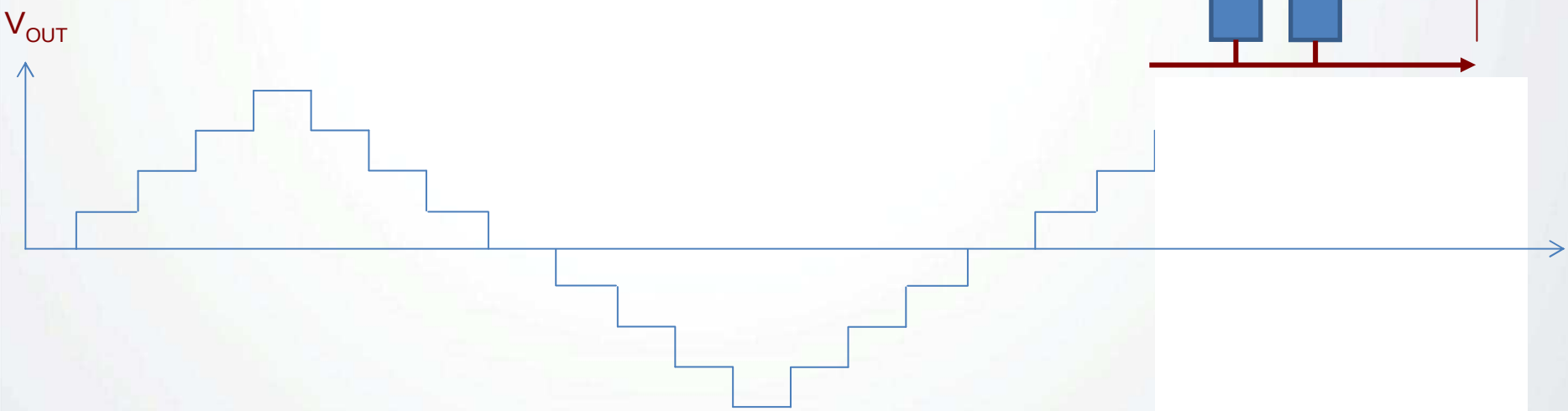

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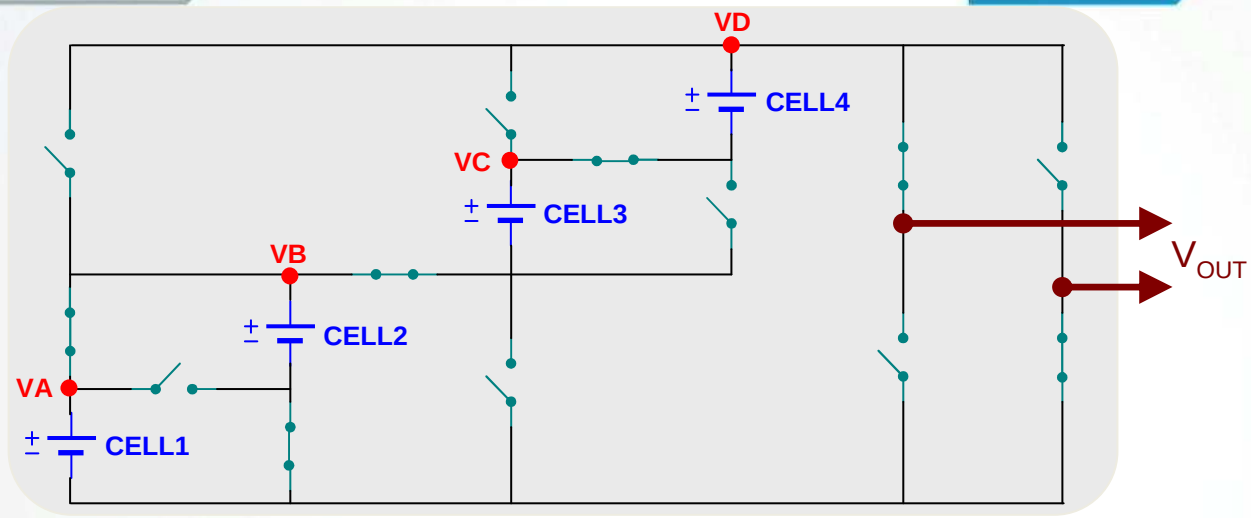
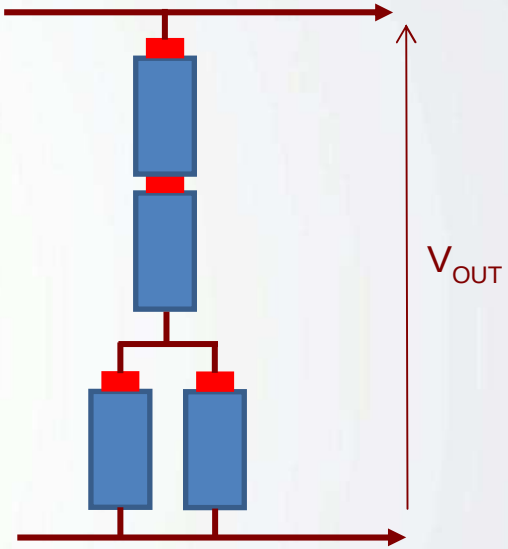
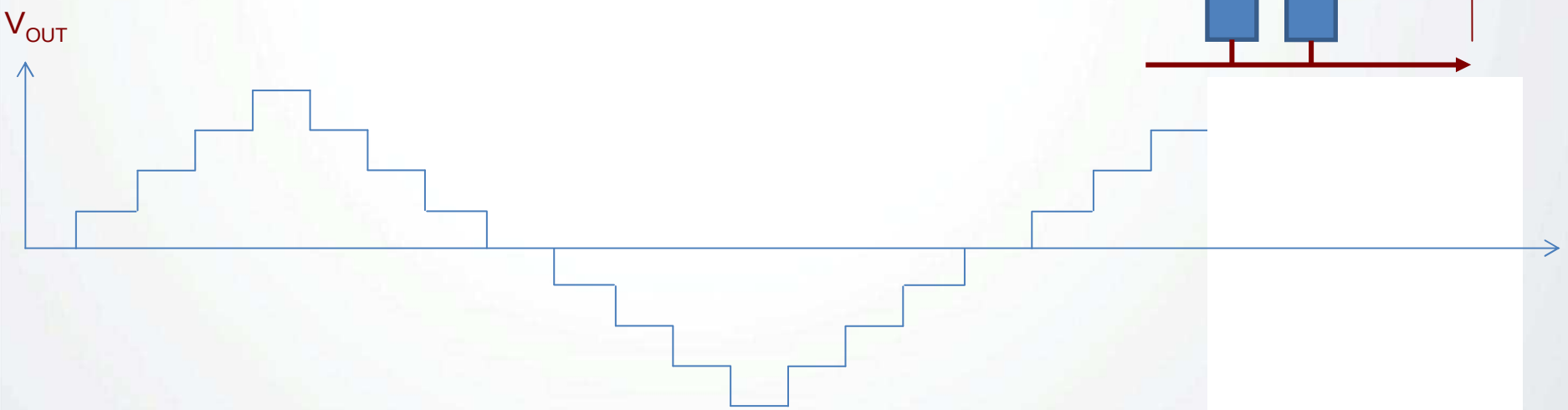
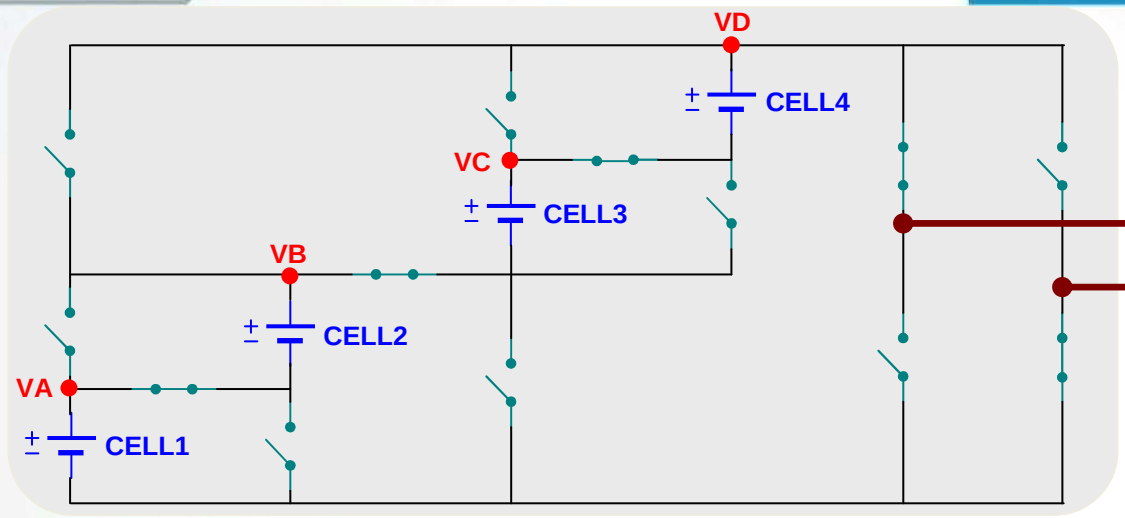
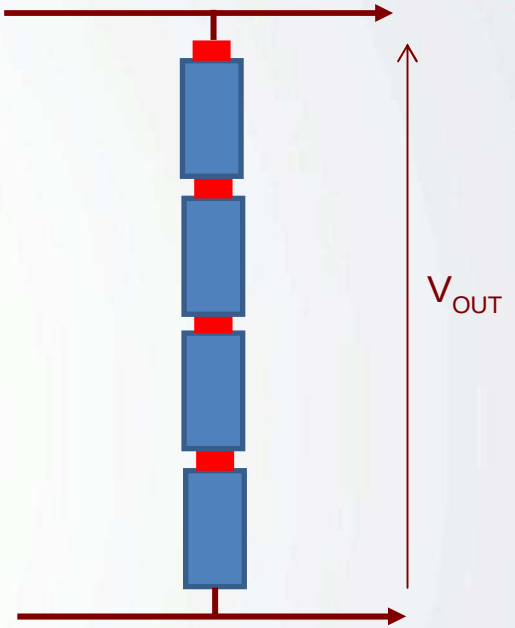


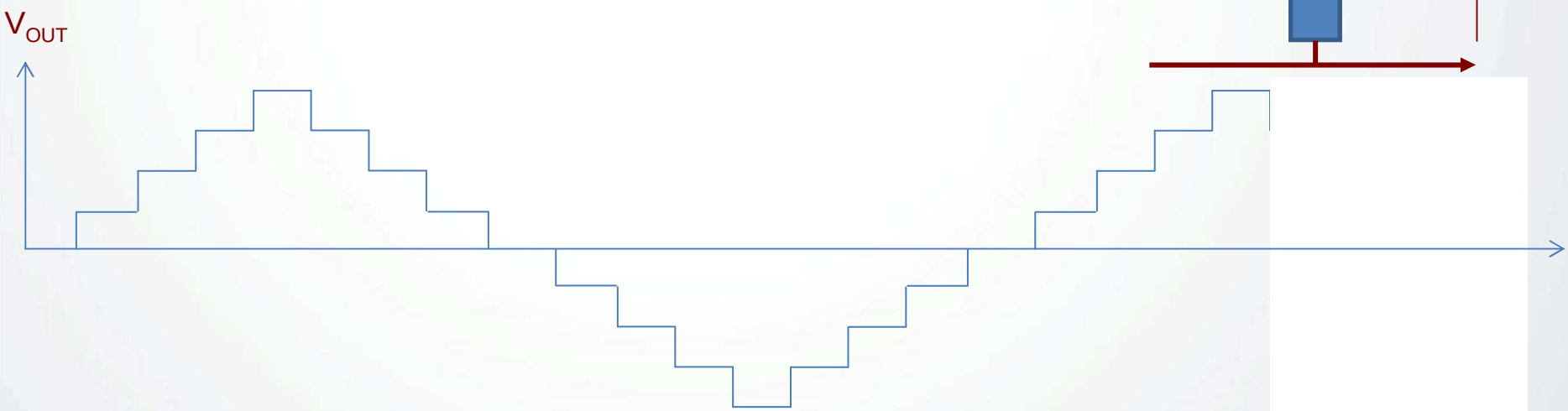




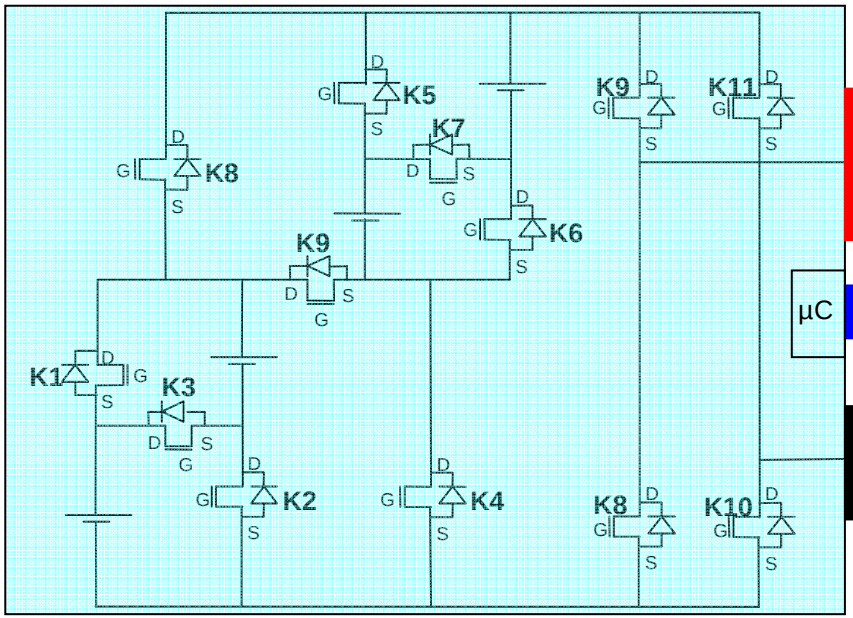
Le BMS commuté : l'architecture générique

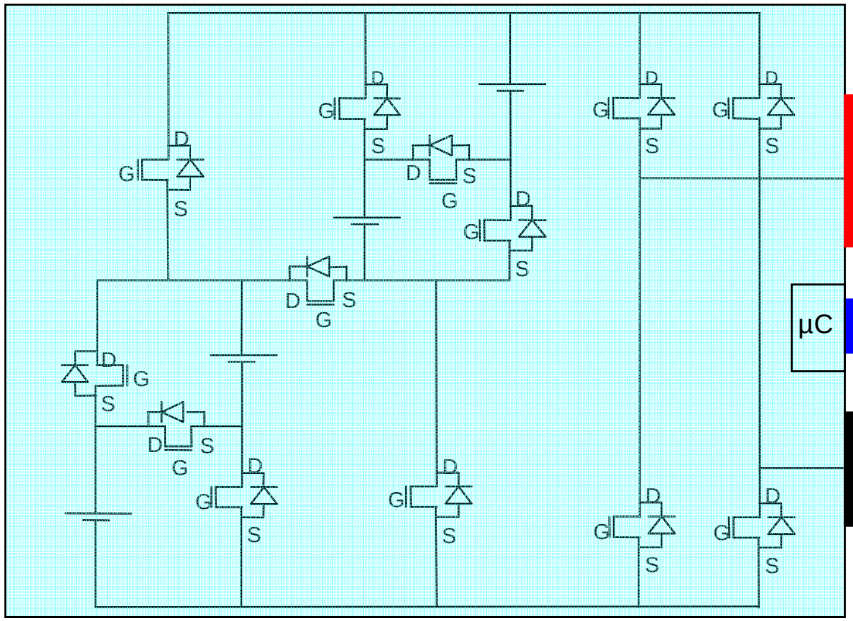






Le BMS commuté : l'architecture



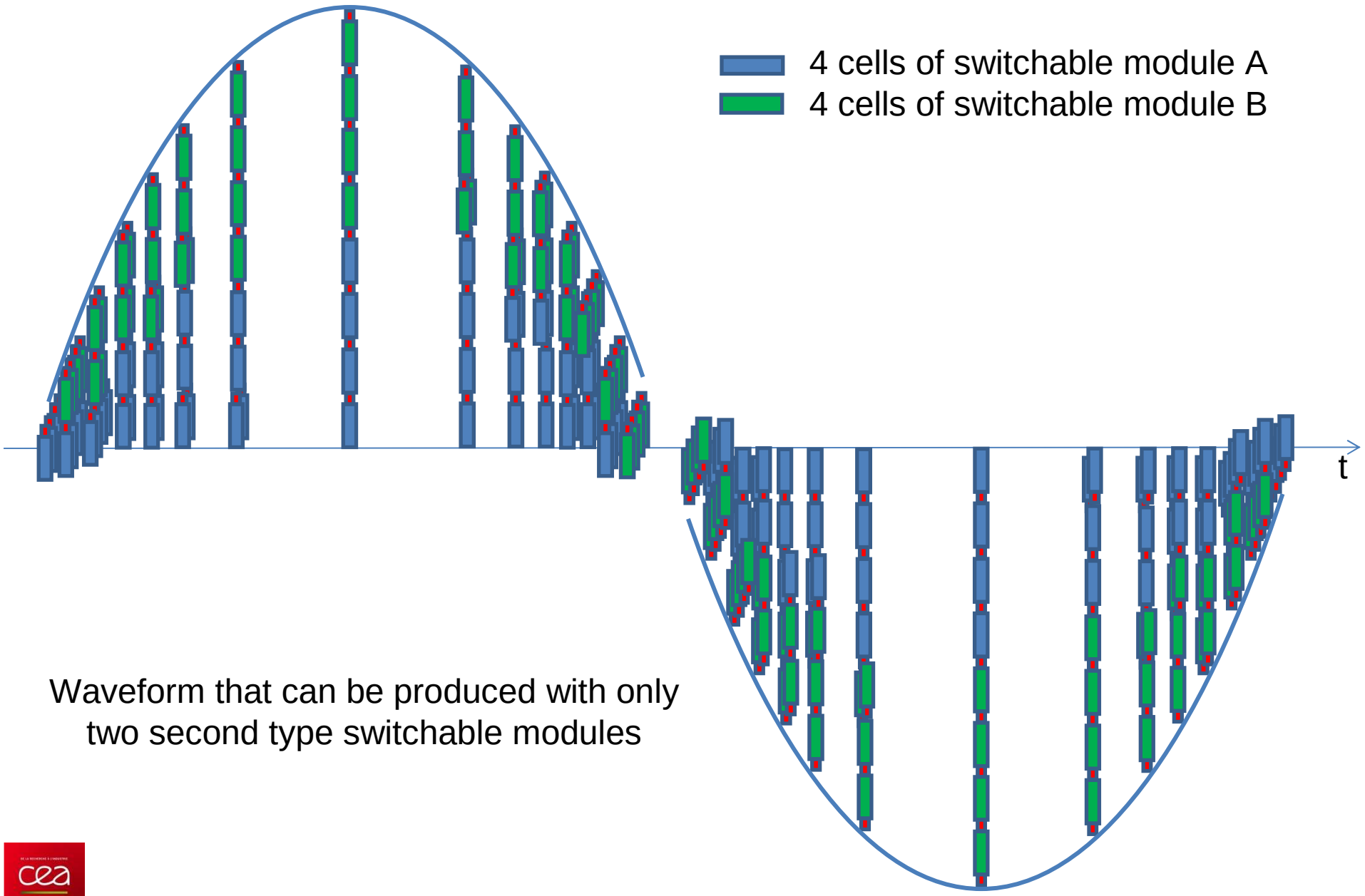


- **Highly modulable: each module never see a voltage higher than its one**
- **Security: no voltage on the module during the storage or in abnormal cases**
- **The module can manage its own recharge**

Power bus (serial connexion)

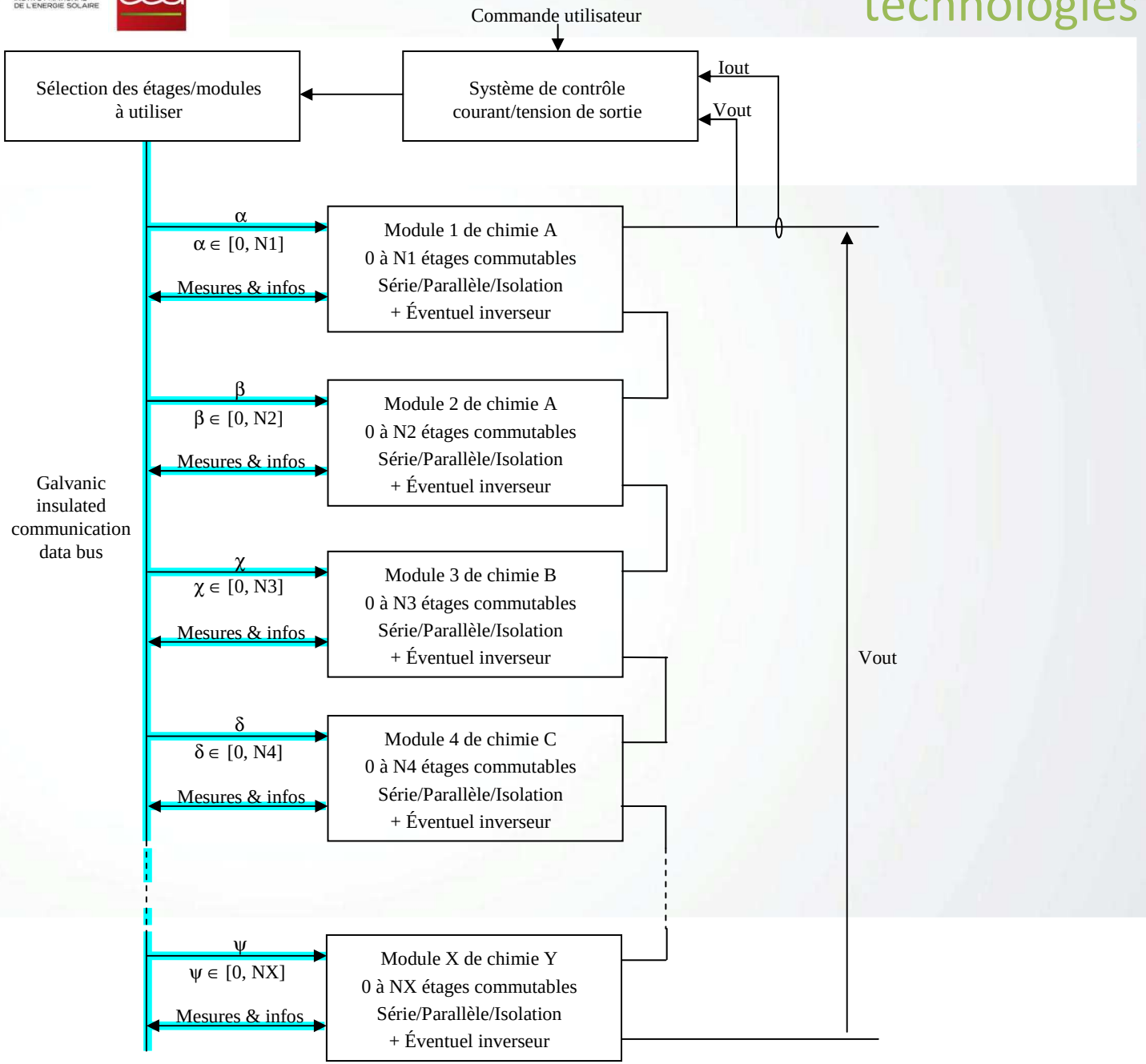
Insulated common data bus

2d prototype: principle



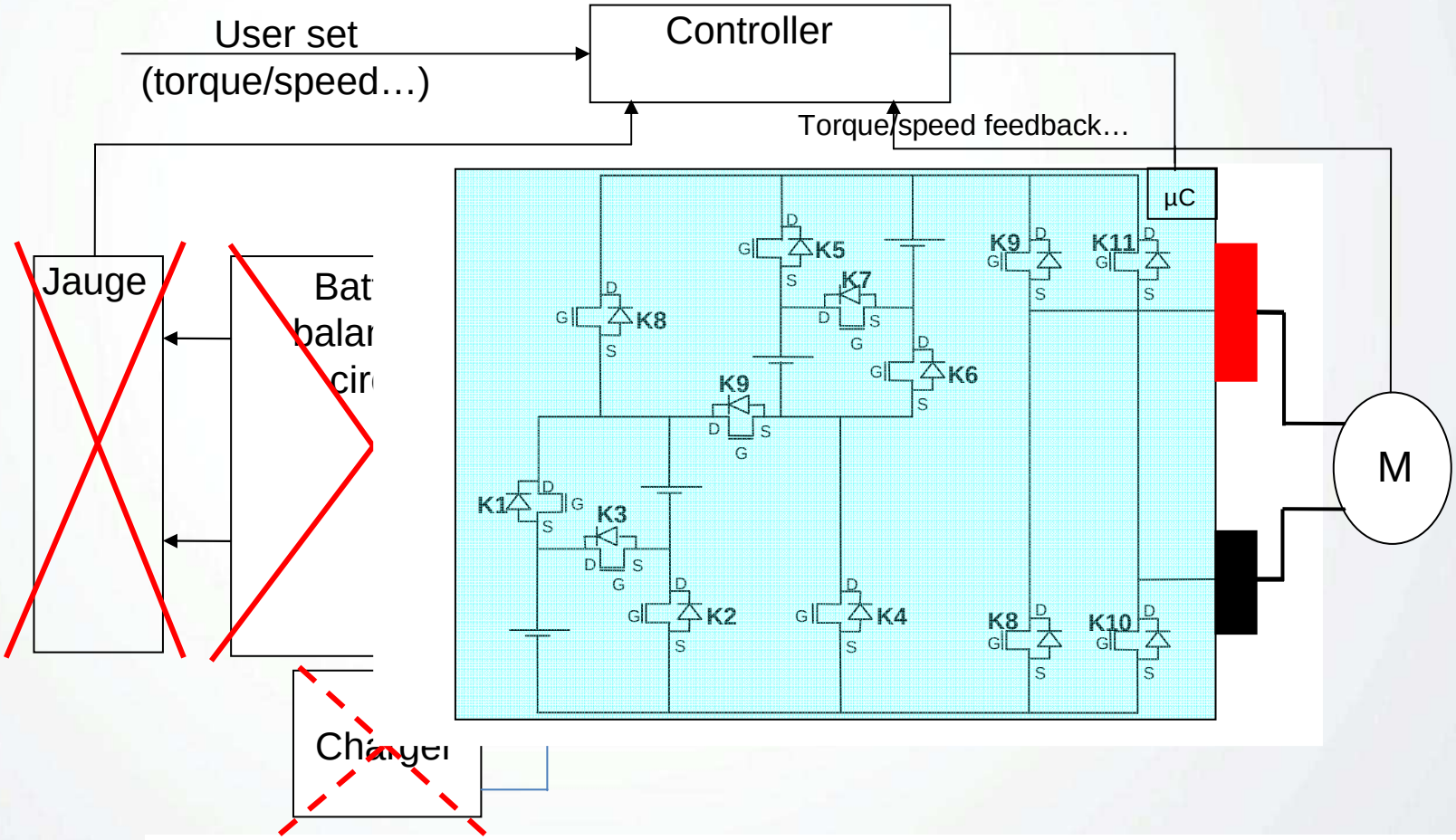
Waveform that can be produced with only two second type switchable modules

Possible to use various battery technologies



Le BMS commuté : l'architecture générique

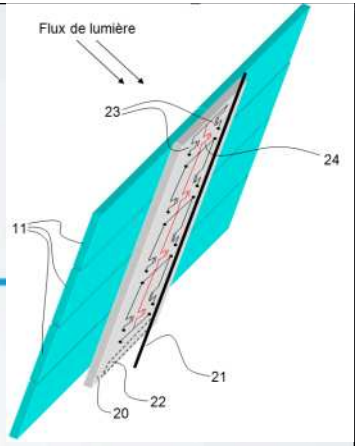
Classical architecture versus switching architecture



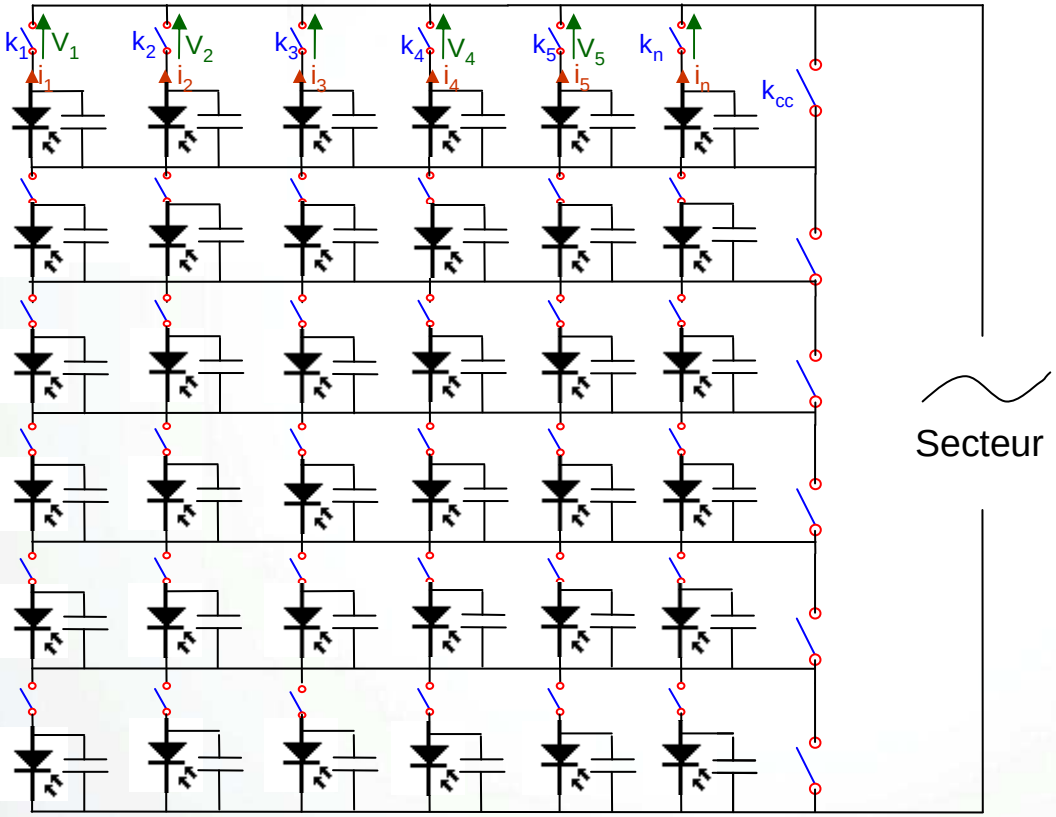
Exemple d'applications :

- Outils/objets électroportatifs
- Alimentation de secours (replacement groupes électrogènes)
- Eclairages de secours
- Systèmes de transport électriques (bus, voiture, scooter, vélo, bateau, trottinette, jouets…)
- Eclairages solaire avec stockage
- Stockage stationnaire
- Systèmes autonomes

Photovoltaic extension



- Direct connexion to the electrical network



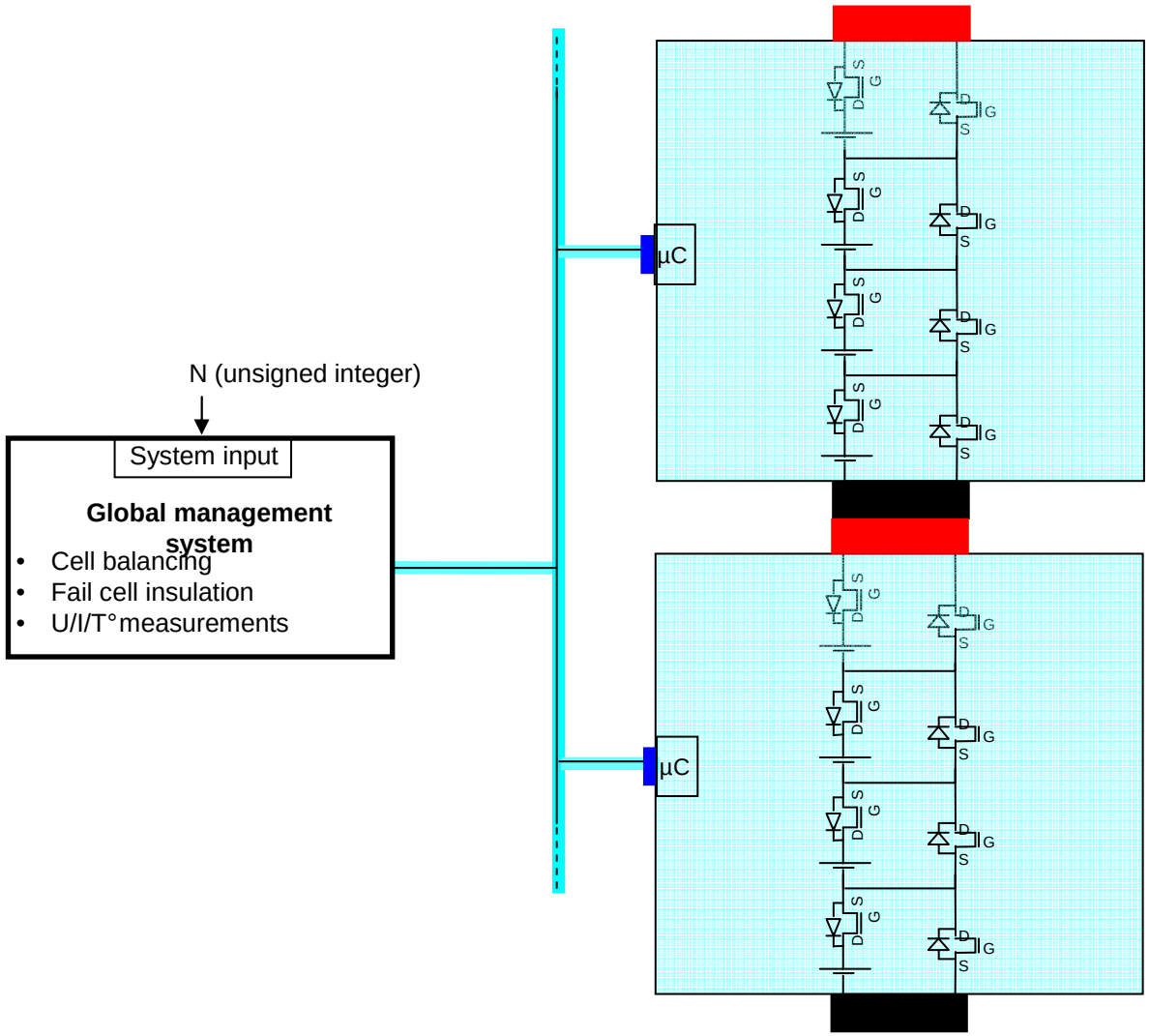
- Advantages
  - Remove the inverter
  - Local MPPT without any costly and heavy inductive converters
  - Disconnection of failed cells
  - Optimal operation even with some dark areas

Le BMS commuté : conclusions

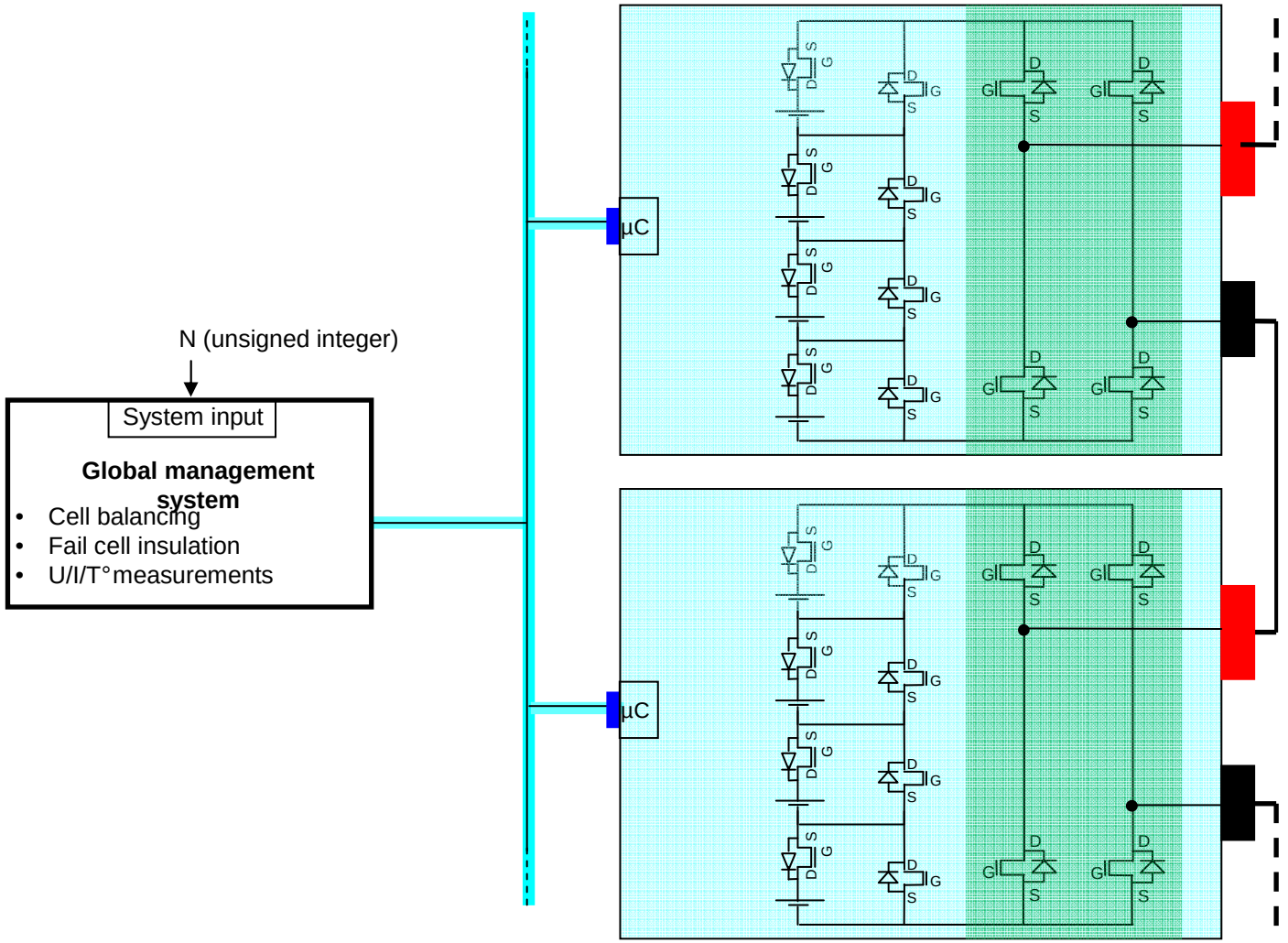
- Fonctions classiques
  - ☒ Monitoring des tensions et de température
  - ☒ Mesure du courant
  - ☒ Communication interne / externe
  - ☒ Estimation des indicateurs d'états (charge, santé, ou autres)
- Fonctions avancées
  - ☒ Équilibrage dynamique
  - ☒ Continuité de service en cas de défaut accumulateur
  - ☒ Régulation de la tension de sortie à la demande
    - Fonction d'écrêtage
    - Fonction de commande spécifique (exemple : contrôle moteur)
  - ☒ Optimisation de l'énergie embarquée
    - Par rapport au vieillissement
    - Par rapport à la thermique
  - ☒ Utilisation d'accumulateurs d'état de santé différent
  - ☒ Utilisation d'accumulateurs de chimie différente

Thank you for your attention

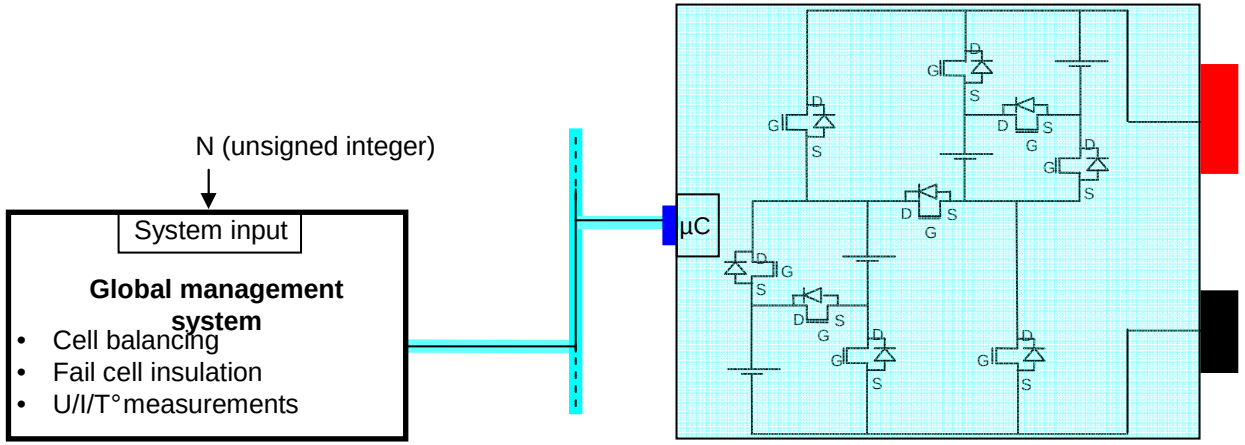
- Carte générique sans inversion de tension et sans mise en parallèle



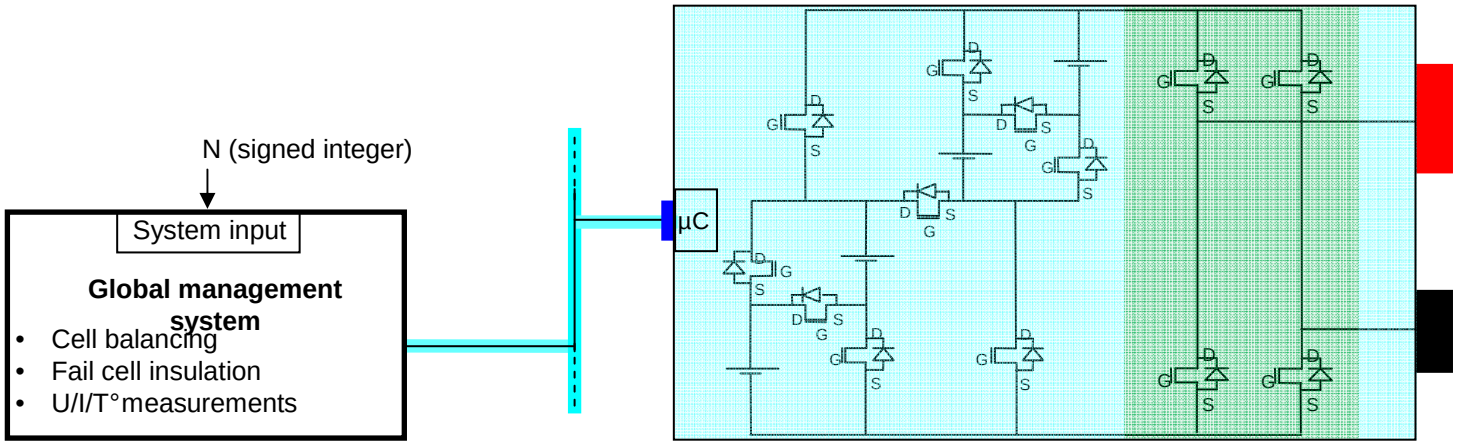
- Carte générique avec inversion de tension et sans mise en parallèle



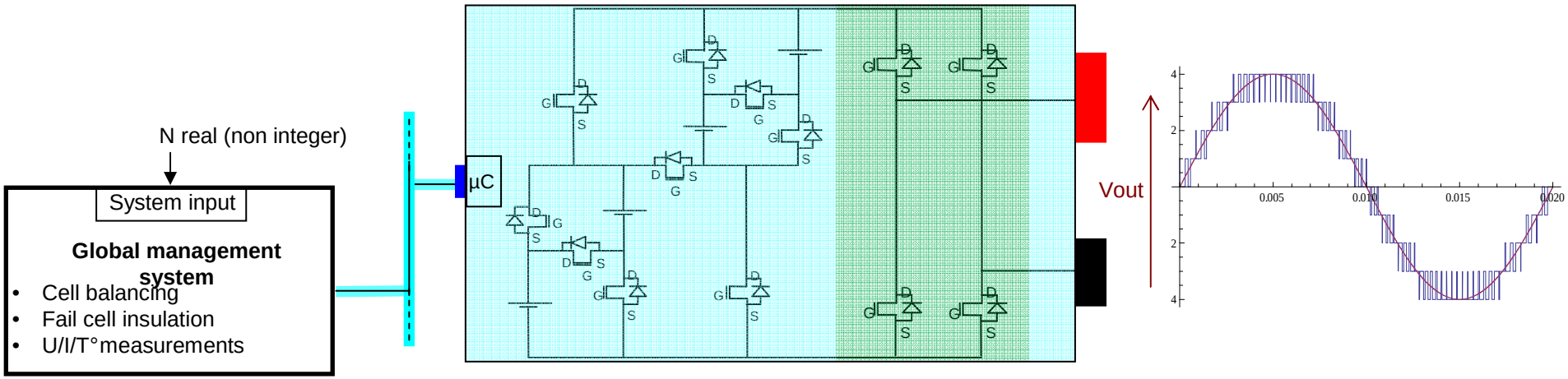
- Carte générique sans inversion de tension mais avec mise en parallèle



- Option 1 : avec inversion de tension et mise en parallèle



- Option 2 : avec niveaux intermédiaires (PWM inter-niveaux)



- Option 3 : avec pilotage system CEA