Safety Design of CHAdeMO Quick Charger and its impact on Power Grid

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TEPCO

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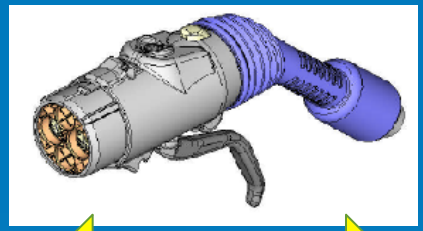
1. How safe is safe enough design?
2. Does quick charger degrade battery?
3. Is there negative impact on power grid?

Potential risk of high power



DC Level2

400V DC

AC Level3

400V 3φ

High power 3φAC and DC risk in the case of short circuit is substantially higher than low power 1φ.

Not only the connector but also total system design of charging infrastructure is important to handle high power 3φ and DC.

AC Level1&2

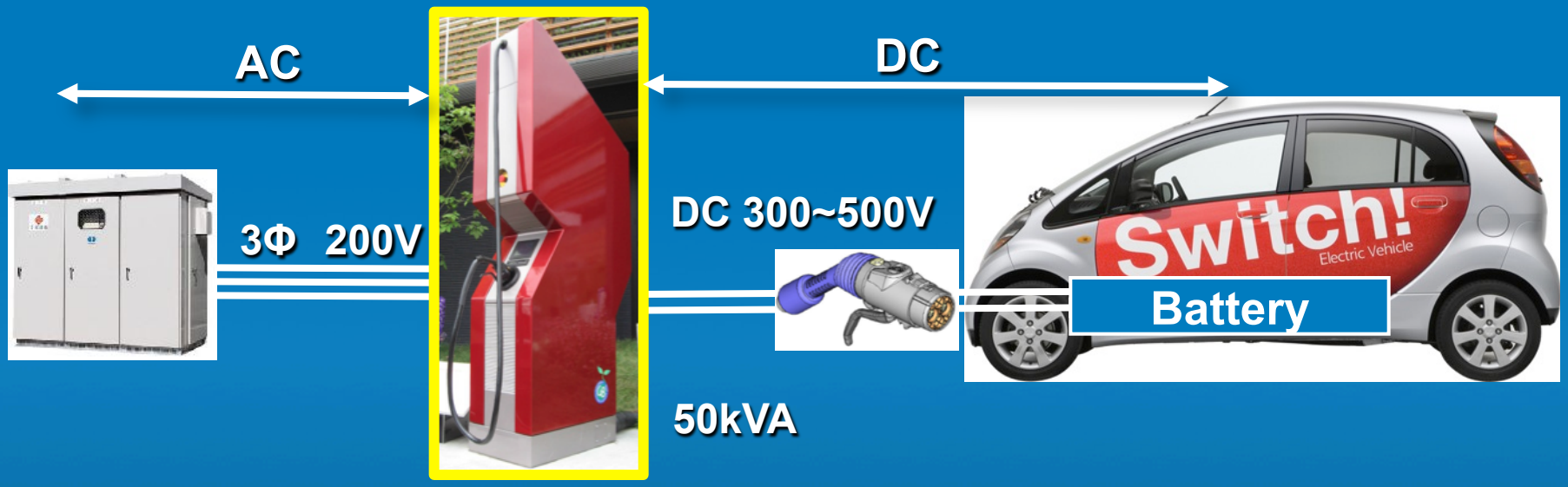
100~230V 1φ

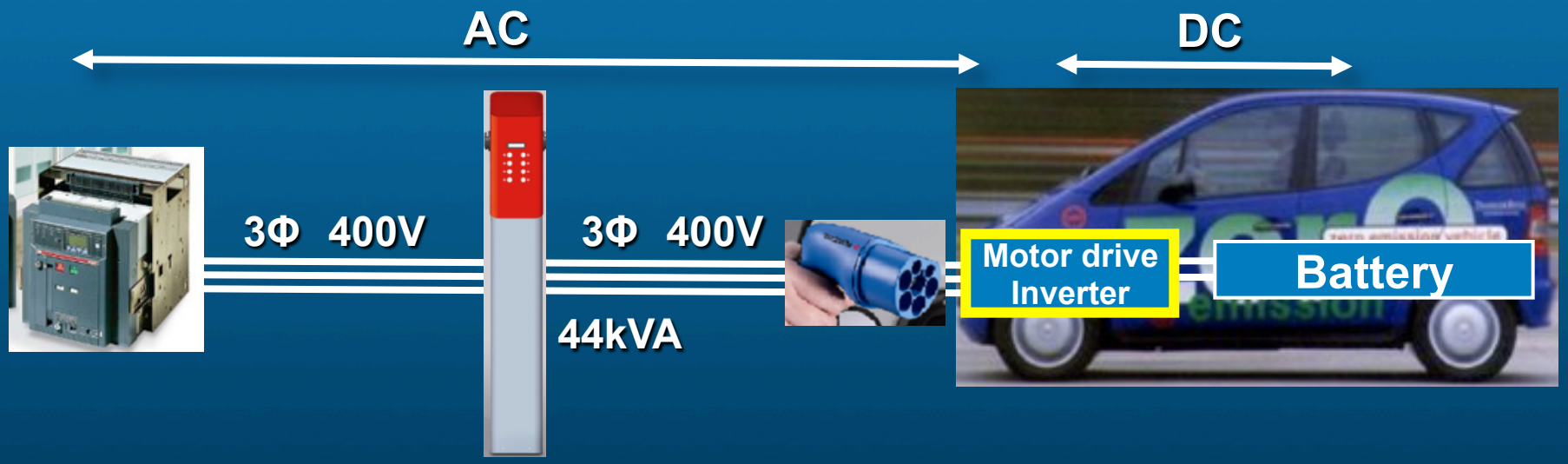
Potential Risk

0 10 20 30 40 50

Charger Output Power（kW）

Off-board Quick Charger vs. Motor Drive Inverter

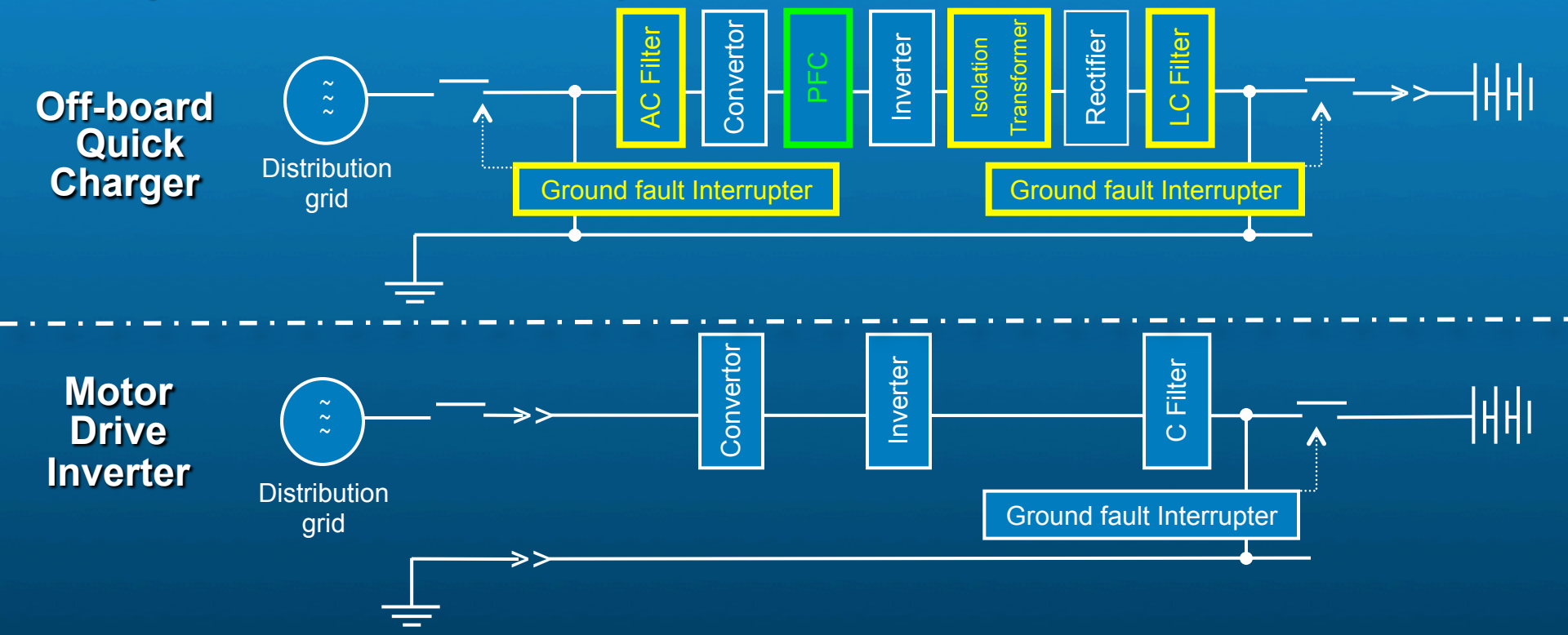




Safety elements in off-board quick charger

Element	Objectives
AC Filter	Remove higher harmonics distortion to protect distribution grid.
Power Fraction Corrector	Improve conversion efficiency.
Isolation Transformer	Separate battery circuit from grid for operator protection.
LC filter	Reduce ripple noise from output current to protect battery system.
Ground Fault Interrupter	Rapid response GFI to protect operator from electric shock.

Safety function **Performance improvement**



Size of off-board quick charger and motor drive inverter

Off-board quick charger

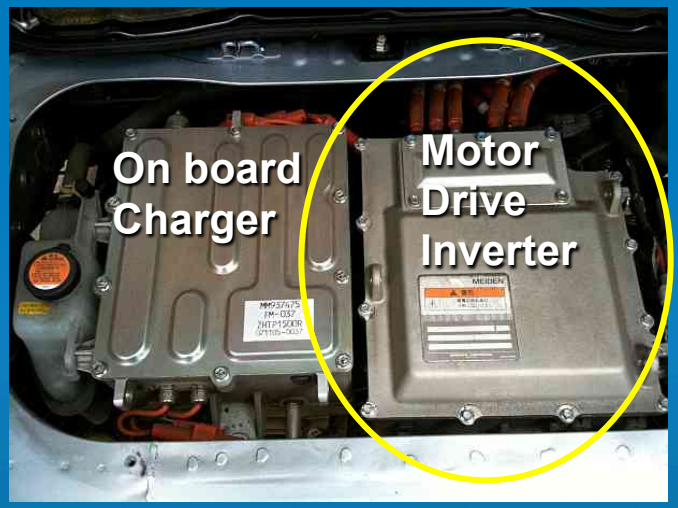
Isolation transformer

Ground Fault Interrupter

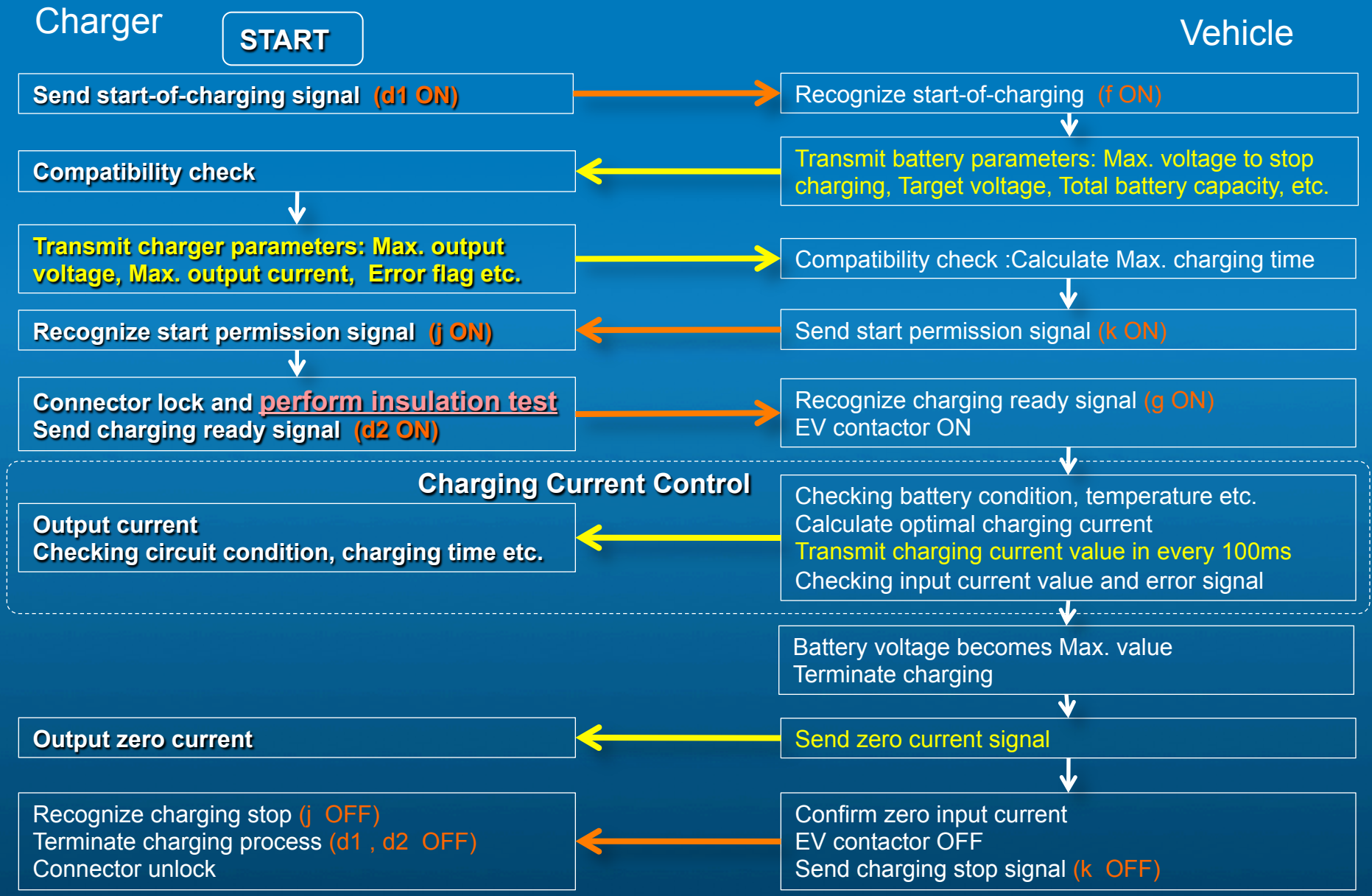
LC Filter

AC Filter

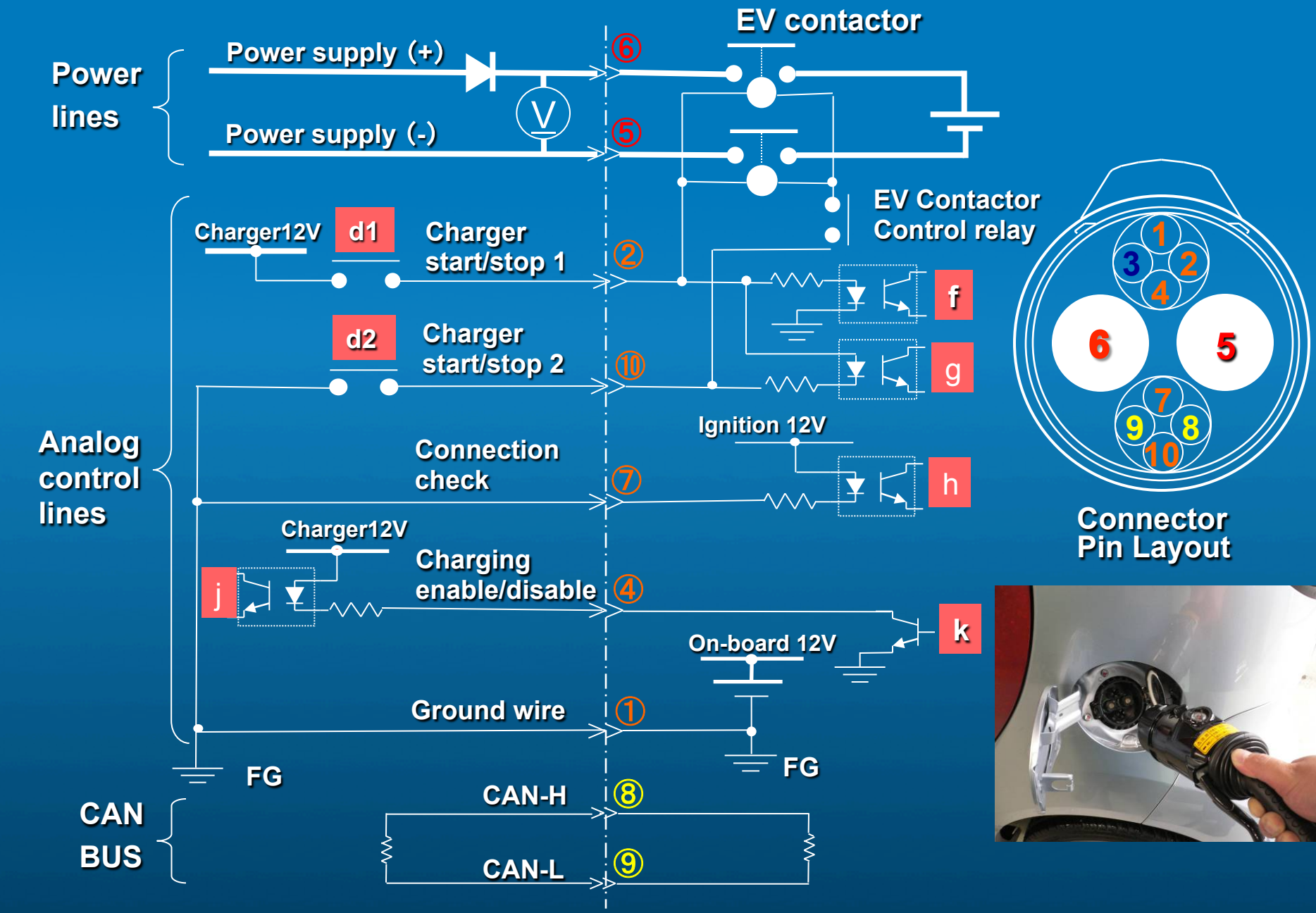
Motor drive inverter



Charging sequence flowchart

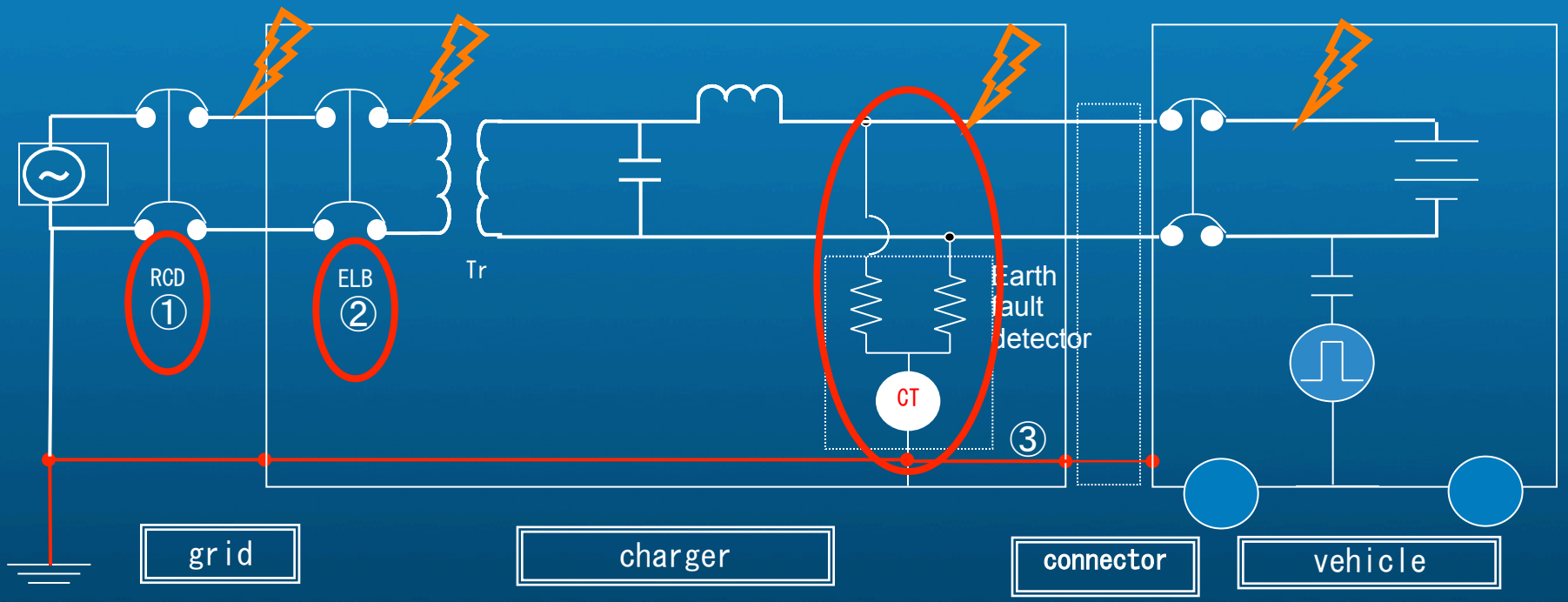


Connector interface



AC/DC and DC/DC converter isolation

- RCD(①) monitors between grid and ELB of charger.
- ELB(②) of charger monitors between ELB of charger and primary side of transformer.
- Earth fault detector(③) of charger monitors between secondary side of transformer and vehicle.



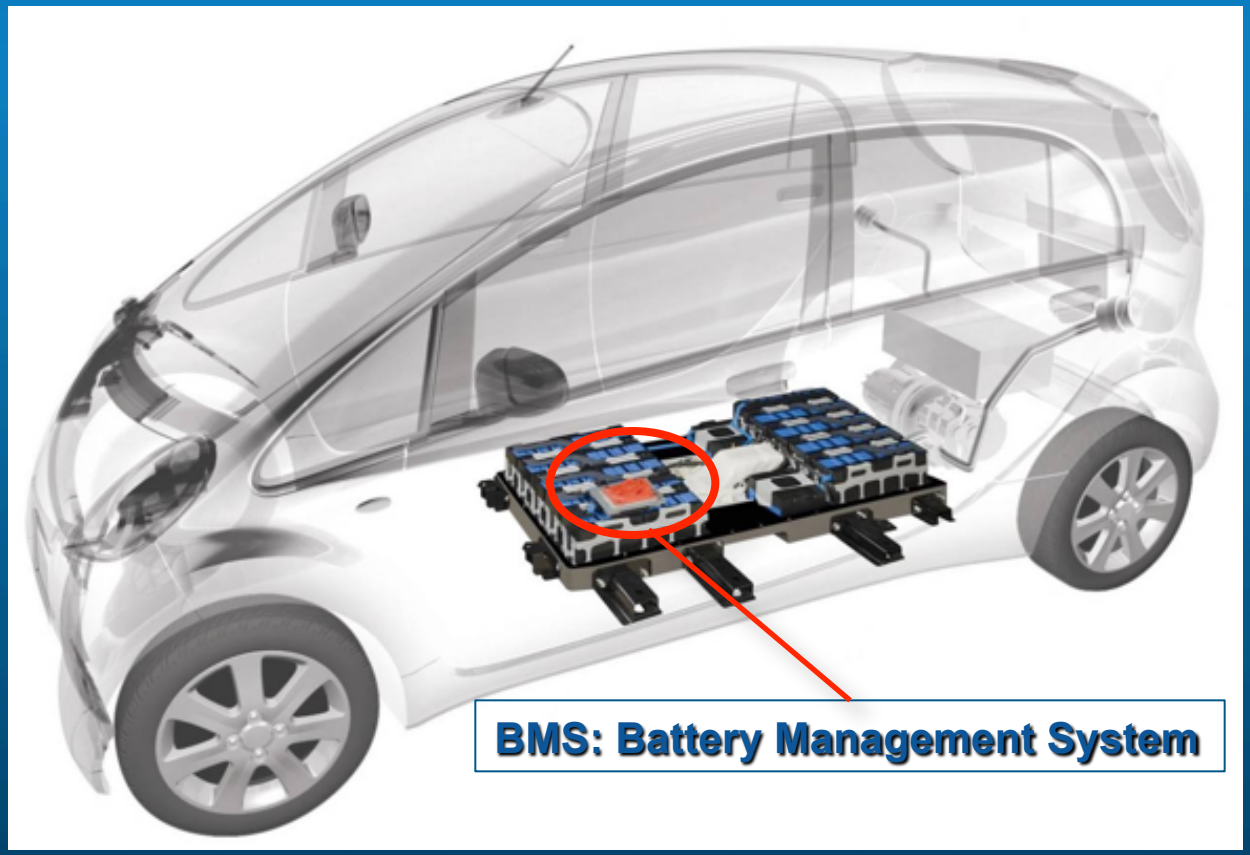
Summary

- Analog communication makes fail safe design.
- EV and charger redundantly watch charging condition.
- Isolation test prevents inadvertent short circuit.
- Connector is well designed to meet above functions.
- Isolation transformer prevents electrical shock.
- AC filter eliminates higher harmonic distortions.

1. How safe is safe enough design?
2. **Does quick charger degrade battery?**
3. Is there negative impact on power grid?

Optimal charging speed is different in each batteries

- Battery degradation is caused by over voltage and high temperature.
- Limit voltage and temperature depend on battery characteristics.
- On-board battery management system is watching the voltage and the temperature in real time.



Observing parameters
- Battery total voltage
- Cell voltage
- Battery temperature
- Input Current etc.

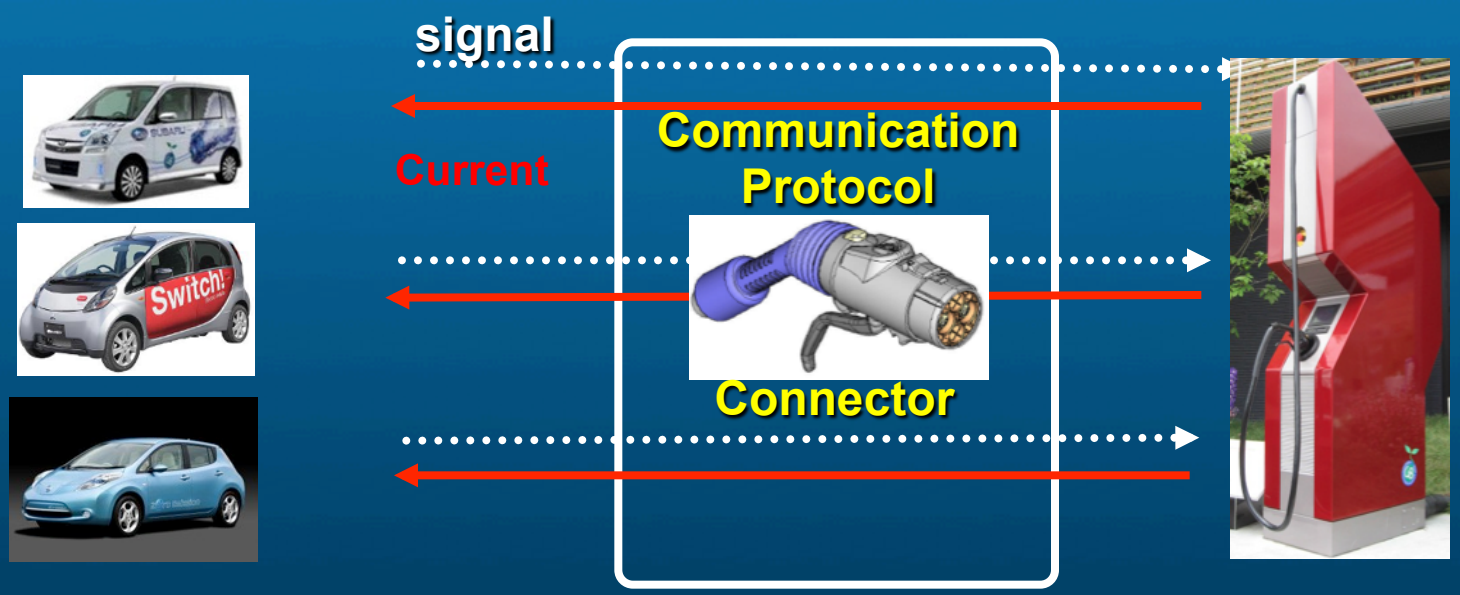
Charging process is controlled by EV in CHAdeMO

Problems:

- Battery improvement is so fast that it's difficult to catch up every batteries' data.
- Standardization to meet lowest speed battery disturbs battery improvement.

How CHAdeMO charger works:

- EV computer unit decides charging speed based on BMS observation.
- Charging current signal is sent to charger using CAN bus.
- Charger supplies DC current following the request from EV.



Does quick charger degrade battery?

- CHAdeMO quick charger can change charging speed to meet each batteries characteristics and condition.
- There is **no negative impact on battery system** by quick charging if charging speed is well controlled.
- Advanced battery which can absorb higher current can get higher power.

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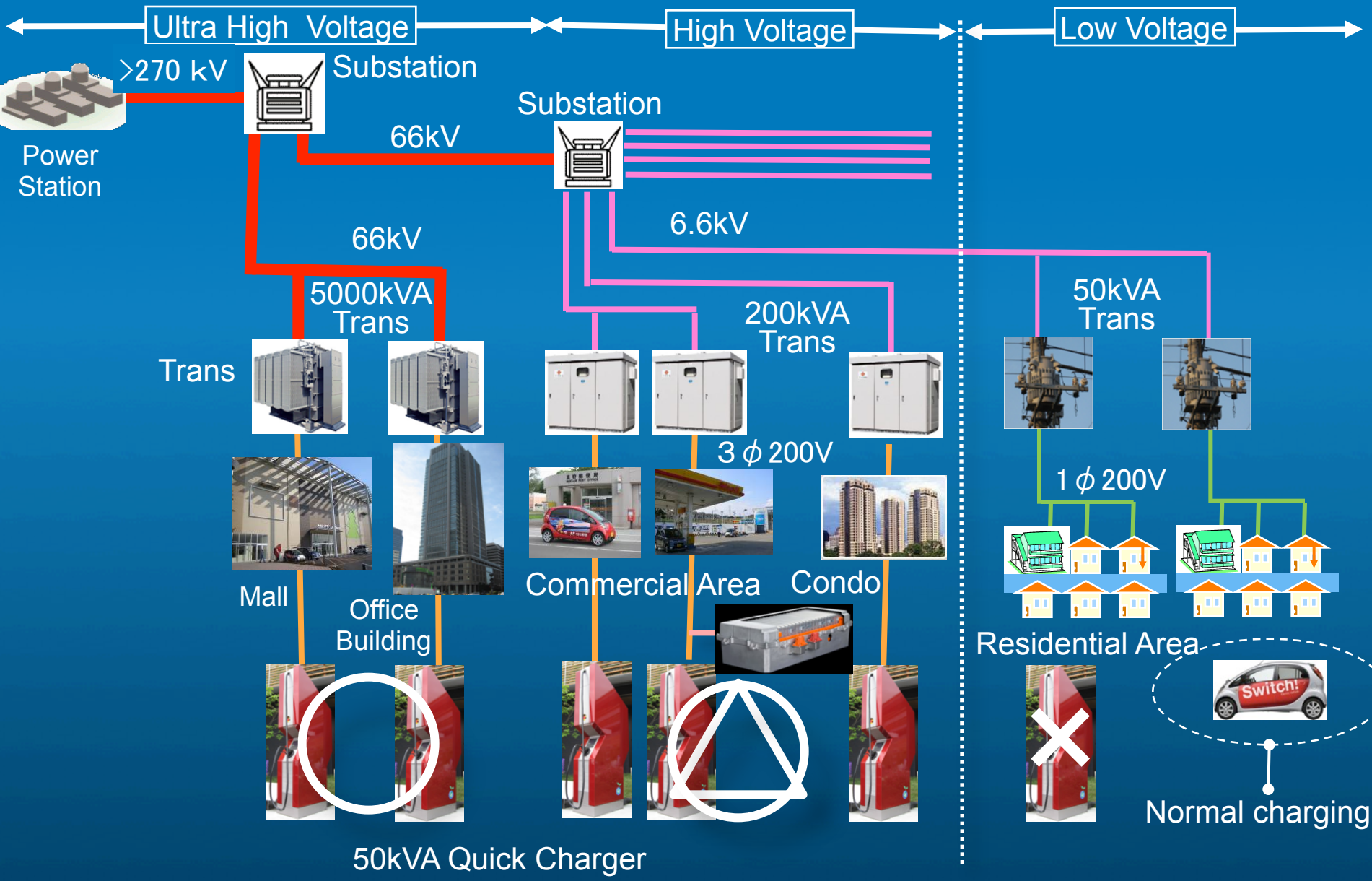
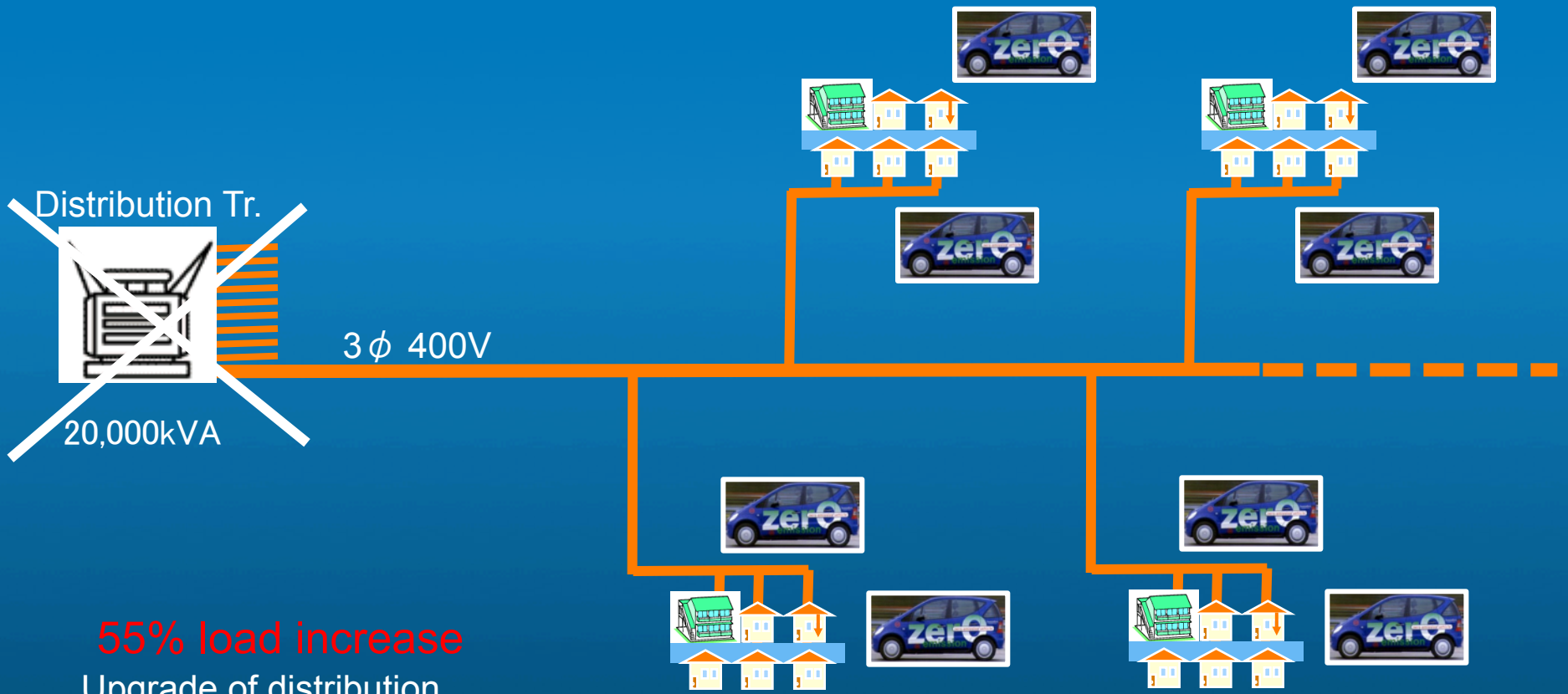
Location of quick chargers on power grid



Impact on distribution grid (20% dissemination rate)

16kVA X 1250 dwellings



55% load increase

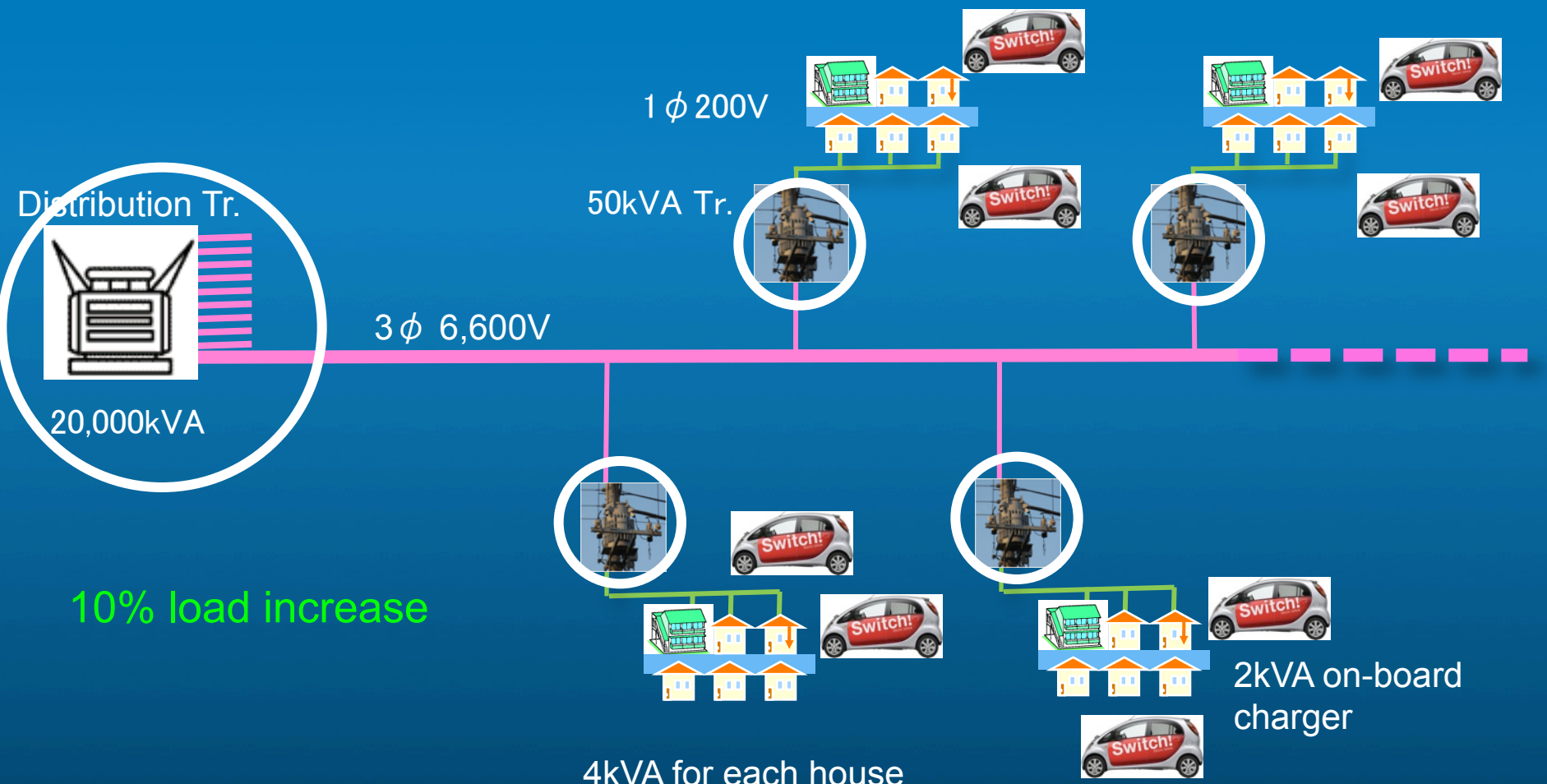
Upgrade of distribution transformer is necessary

16kVA for each house

44kVA on-board charger

Impact on distribution grid (20% dissemination rate)

4kVA X 5000 dwellings



Slow AC and fast DC combination

Fast

Charging Speed

Slow

Private/Office

Location

Public

Charging speed is most important.

Cost is most important since number of equipments is large.

People cannot wait for hours.

Is there negative impact on power grid?

- (Ultra) high voltage power grid can supply electricity to quick charger easily.
- Frequency to use quick charger is not often then impact on power grid is small.
- In order to minimize impact on distribution gird in residential area, on-board charger kW should be small.
- If there are moderate number of quick chargers in public area, drivers satisfy with small size on-board chargers.