Auxiliary Inverter Charger (AIC)
– Concept & Experimental Results –

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Components in PHEV/EV

- Engine
- Electric compressor
- Motor & Generator
- Battery
- Electric power steering
- Inverter & Converter
- Charging port
- on-board charger

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Our Vision for future’s eco social system

HEMS: Home Energy Management System
BEMS: Building Energy Management System
FEMS: Factory Energy Management System
Concept of AIC (Auxiliary Inverter Charger)

Parking / Charging

Charging Station

Driving / Motor & Inverter

Integration & Shared Use

Battery
Charger
Motor & Inverter

Exclusively
Objectives

1. Create Circuit Topology to integrate inverter and charger
   - Maximize shared parts

2. Minimize electricity consumption
   - Limit wake up electric equipments while charging
   - Reduce electricity consumption for cooling charger

3. Select appropriate inverter for charging battery
   - Criteria
Schematic Figure of conventional Charger & Inverter

Charger
- Power Factor Correction circuit
- Step down circuit
- Cooling Fan
- Input filter

Motor & Inverter
Wiring of Power Line in Vehicle

Home

CCID

Inlet

Filter

AIC

Vehicle

Traction MG/Inverter

Main Battery

Load

AIC Relay

SMR

DC

DC

DC

DC

Load

DC

DC

DC

DC
Thermal Flow Model of AIC Cooling

AIC Heat Generation
Heat Generation at each IGBT
Thermally conductive grease

Heat Dissipation

Variable Thermal Resistance According to Cooling Fan

Engine Upper

Engine Bottom

AIC chassis

Engine Compartment

Atmosphere
## Selection of Inverter as charger

<table>
<thead>
<tr>
<th>Items</th>
<th>Stand alone</th>
<th>Inverter modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>On board Charger 3kW</td>
<td>Auxiliary Inverter 3-5kW</td>
</tr>
<tr>
<td>Safety/Durability</td>
<td>Independent from driving, braking, steering</td>
<td>Related with driving and braking</td>
</tr>
<tr>
<td>Loss (@3kW)</td>
<td>100W</td>
<td>300W (Large recovery current)</td>
</tr>
<tr>
<td>14V board net at charging</td>
<td>Only charger wakes</td>
<td>Only Auxiliary Part wakes</td>
</tr>
<tr>
<td>Additional Parts for charger</td>
<td>Input Filter 4leg, Reactor Relays Control ECU</td>
<td>Input Filter 1leg, Reactor Relays</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input Filter 1leg, Reactor Relays (Large capacity for MG cut)</td>
</tr>
</tbody>
</table>
Efficiency of AIC as Charger

Input: 240V, Output 300V

Efficiency (%)

- 96.3%

Power (W)

- 0 500 1000 1500 2000 2500 3000 3500
Harmonic Current

Harmonic Current (A)

IEC61000-3-2

Harmonic Order

Harmonic Current

IEC61000-3-2

Harmonic Order
Cooling Performance \((T_{\text{engine}} = 35 \text{ deg C})\)

- 240V-AC in, 300V-DC out, 2.7kW
- Limit: 125 deg C
- IGBT, Q5
- IGBT, Q1
- IGBT, Q7
- AIC chassis
- Engine Bottom
- Engine Upper
- Engine compartment
- Atmosphere

Operating rate: 0%

Fan: ON \rightarrow OFF

Time

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Cooling Performance  \((T_{\text{engine}} = 90 \text{ deg C})\)

240V-AC in, 300V-DC out, 2.7kW

Limit: 125 deg C

- IGBT, Q5
- IGBT, Q1
- IGBT, Q7
- AIC chassis
- Engine Bottom
- Engine Upper
- Engine compartment
- Atmosphere

Operating rate: 48%

2000s

Temperature \((\text{deg C})\)

Time

Fan

ON

OFF
Bi-directional Charging Performance

**Efficiency**

- Input: 288V, Output: 200V
- Efficiency vs. Power (W)

![Efficiency Graph]

**Waveform & Power Factor**

- Input: 280V, Output: 200V
- Power Factor: 0.994
- Waveform with current and voltage indicators

![Waveform & Power Factor Graph]
Conclusions

AIC offers the following merits:

1. **Volume and weight Reduction by integration of inverter and charger**
2. **Easy Installation with no additional cooling system**
3. **Available Bi-directional charge with high efficiency**
Thank you!