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Air-Conditioning system For Electric Vehicles (i-MiEV)

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1. Introducing “i-MiEV” (1)

Mitsubishi Motors Corporation (MMC) recently developed “i-MiEV” as an electric vehicle utilizing the ultimate eco-friendly zero-emission driving based on the “i” mini car.

“i-MiEV” is the reconstructed electric vehicle adopting revolutionary technology such as high-performance lithium-ion batteries and compact high performance motors.

Fig. 1.1 Mitsubishi “i-MiEV”

“i-MiEV” vehicles are currently in service throughout Japan via joint MMC - Power Company cooperative fleet testing.

1. Introducing “i-MiEV” (2)

Basic configuration and major specifications of the vehicle are shown as follows.

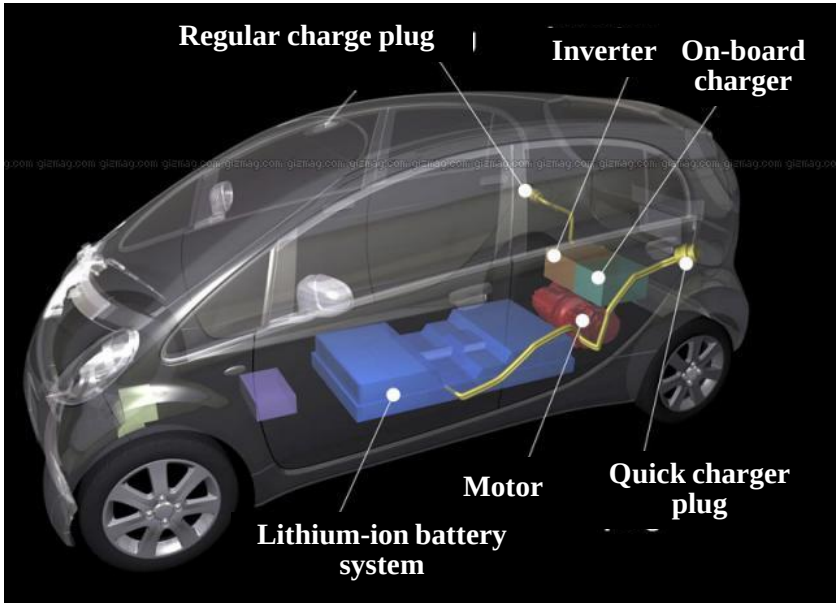


Fig. 1.2 Vehicle configuration

The vehicle has sufficient driving performance and cruising range for normal customer usage (160km/100mile).

Table 1.1 Major specifications of i-MiEV

*L * W * H*	*3,395 * 1,475 * 1,600 (mm)*
Wheelbase	*2,550 mm*
Mass	*1,080 kg*
N of Passengers	*4*
Max Speed	*130 km/h*
Range/charge	*160 km (100mile)*
Motor	*47kW, 180Nm*
Drive	*Rear Wheel Drive*
Battery	*Lithium-ion, 330V, 16Wh*

Table 1.2 Charging performance

	Power source	*Charge duration*
Quick charge	*3 phase 200V 50kW*	*within 30 min.*
Regular charge	*200V (15A)*	*about 7 hrs*
	100V (15A)	*about 14 hrs*

1. Introducing “i-MiEV” (3)

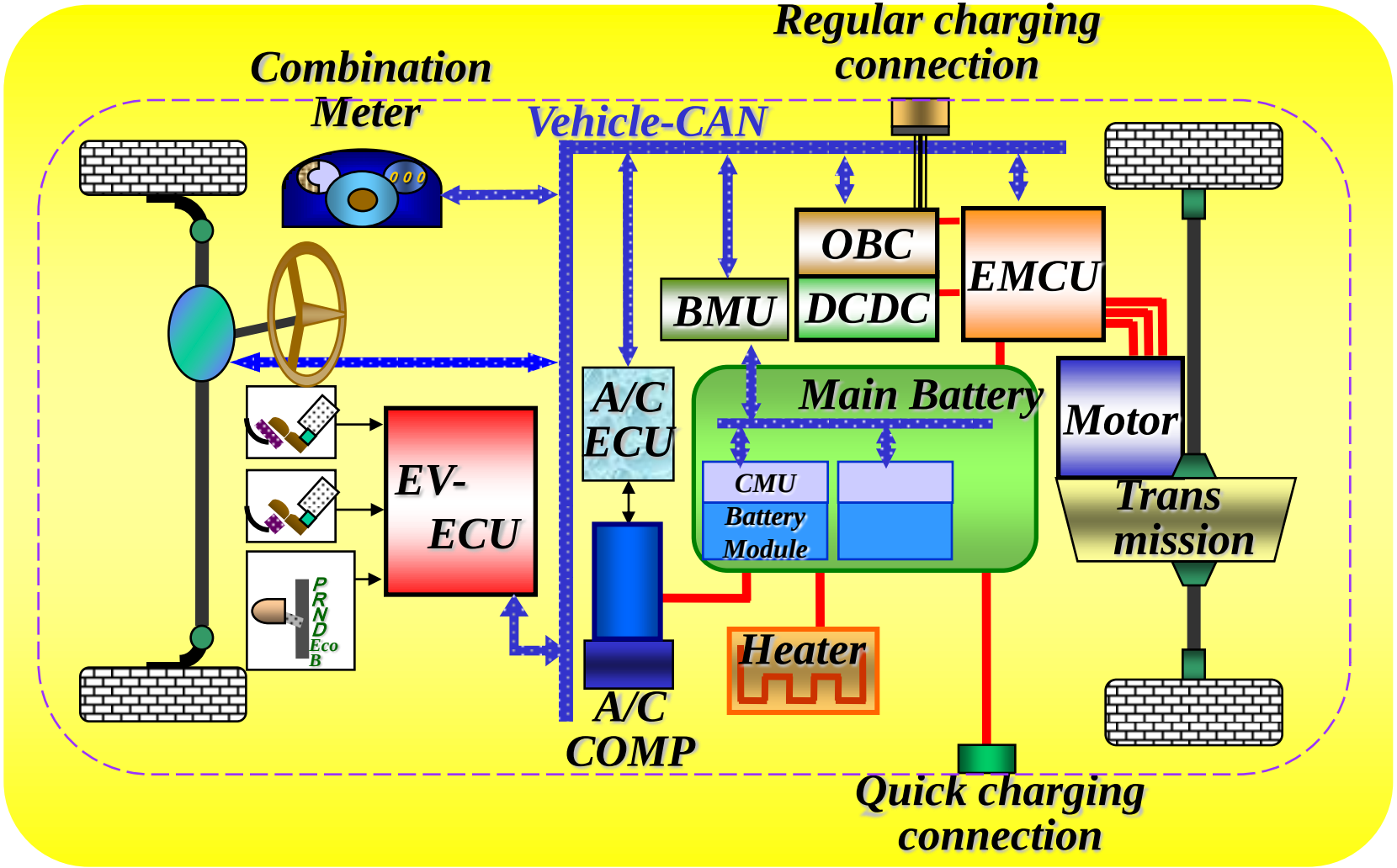


Fig. 1.3 Vehicle system configuration

2. Outline of the AC system (1)

2.1 Concept of the system

Basic concept of the AC system for "i-MiEV" is to appropriate original vehicle's system to the vehicle due to cost reduction in both development and parts.

Features:

The system has a refrigerant cycle with a Electric driven compressor for cooling and a coolant cycle with a PTC Heater for heating.

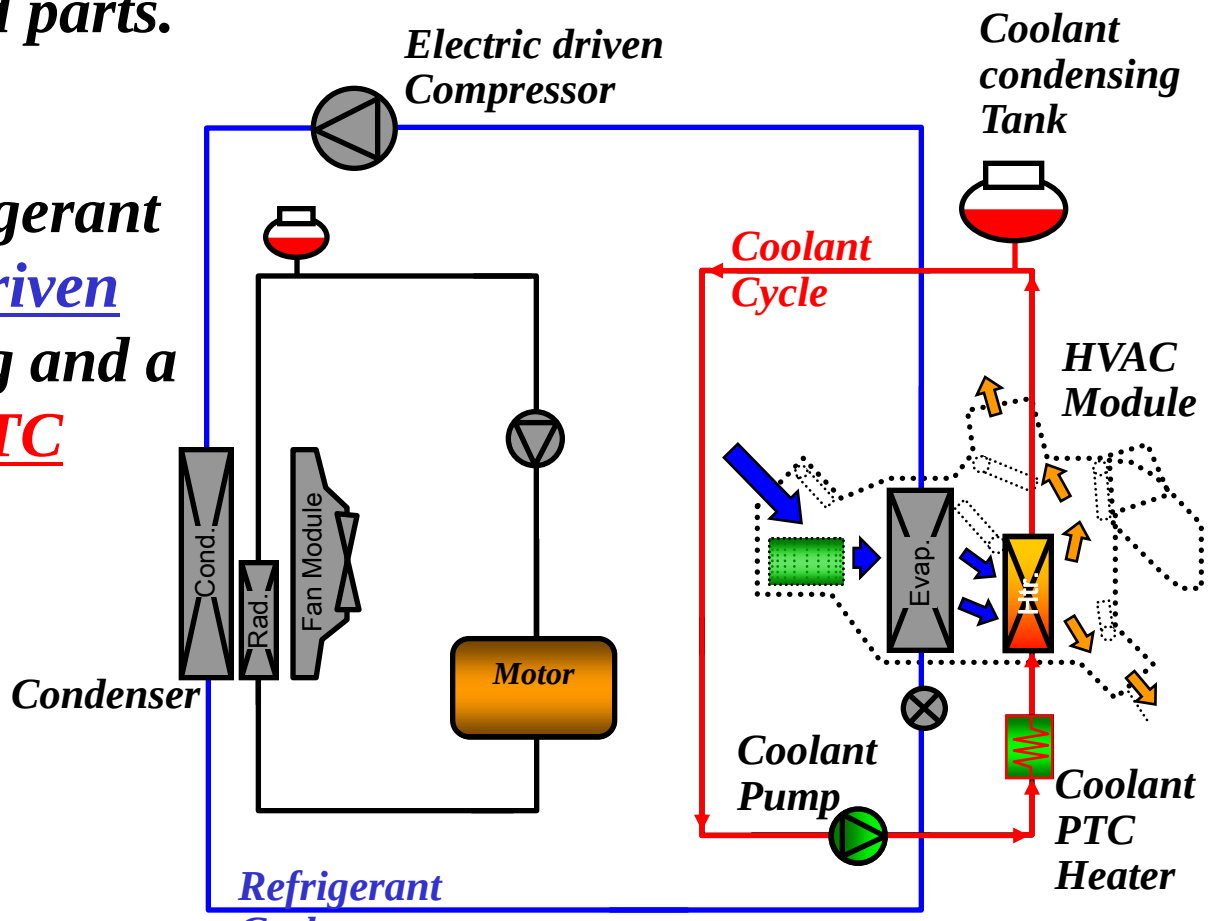


Fig. 2.1 AC system configuration

2. Outline of the AC system (2)

2.2 Actual Configuration of the system

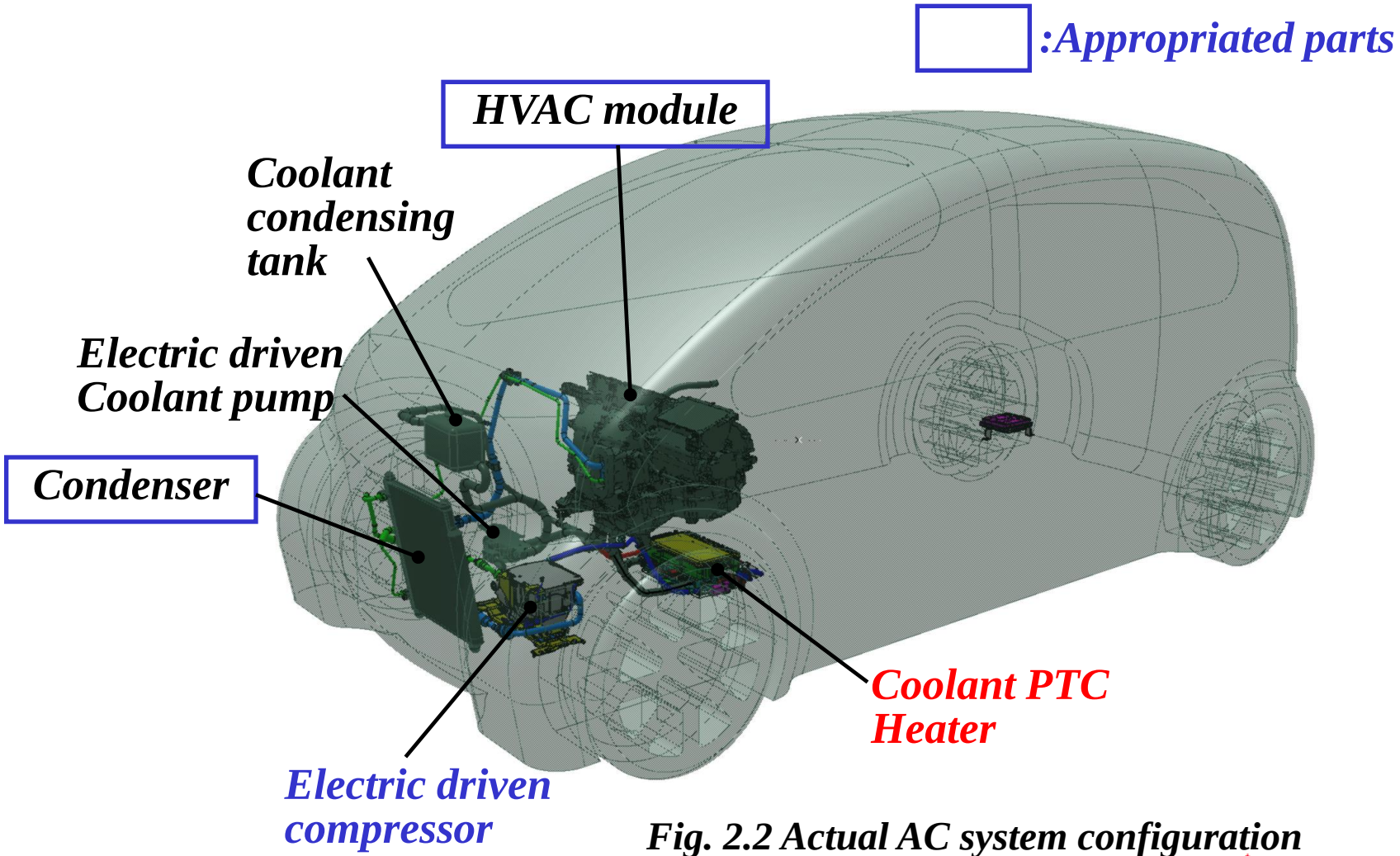


Fig. 2.2 Actual AC system configuration

2. Outline of the AC system (3)

2.3 Specification of key components

(1) Electric driven compressor

Table 2.1 Electric driven compressor spec.

L * W * H	291 * 162 * 157 (mm)
Mass	10.2kg (with Bracket)
Compressor type	Scroll with rare earth metal motor
Displacement	30 cc/rev.
Inverter	Integrated, suction ref. cooling
Max. rev.	6000 rpm
High Voltage range	DC 220 ~ 400 V
Low Voltage range	DC 8 ~ 16 V
Max. power	4.5 kW
Max. input current	20.5 A (@DC 220V)
Refrigerant	HFC-134a
Ref. Lubricant	POE oil

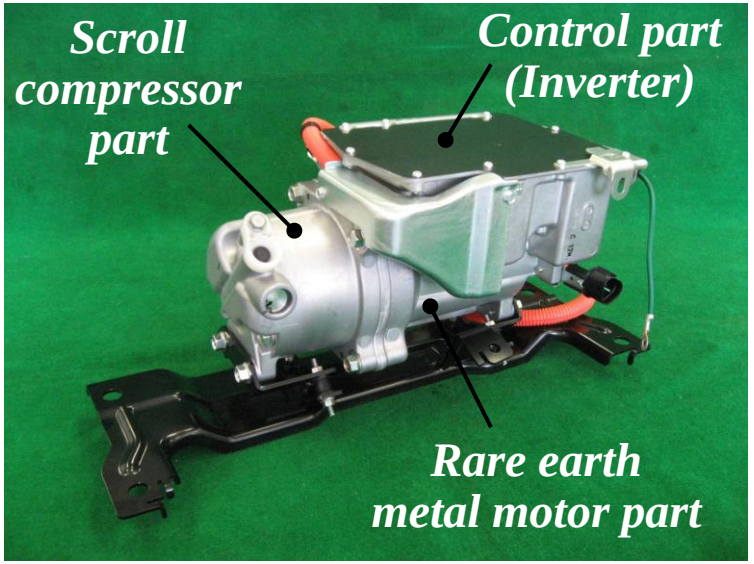


Fig. 2.3 Electric driven compressor

Oil separator is integrated due to improvement of both ref cycle capacity and efficiency.

2. Outline of the AC system (4)

(2)-1 Coolant PTC Heater

Table 2.2 Coolant PTC Heater spec.

L * W * H	290 * 160 * 100 (mm)
Mass	7.4 kg (dry)
Heating devices	PTC heating elements
Heating Capacity	5.0 kW (@ 6L/min., 25 deg C)
Coolant press. Drop	2 kPa (@ 6L/min., 80 deg C)
Capacity control	On/Off cycling (8 steps)
High Voltage range	DC 220 ~ 400 V
Low Voltage range	DC 8 ~ 16 V

PTC: Positive Temperature Coefficient

Fig. 2.4 Coolant PTC Heater

The heater is installed in vehicle under hood area. Therefore the high voltage cable doesn't need to be leaded into the cabin.

2. Outline of the AC system (5)

(2)-2 Coolant PTC Heater

This heater is basically 4 layer structure; control board part, upper coolant passage part, PTC elements part, and lower coolant passage part.

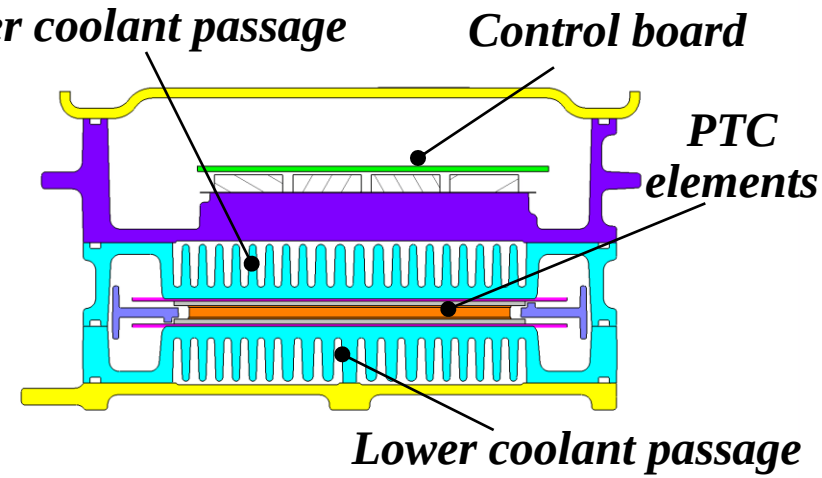


Fig. 2.5 Coolant PTC Heater (cross section)

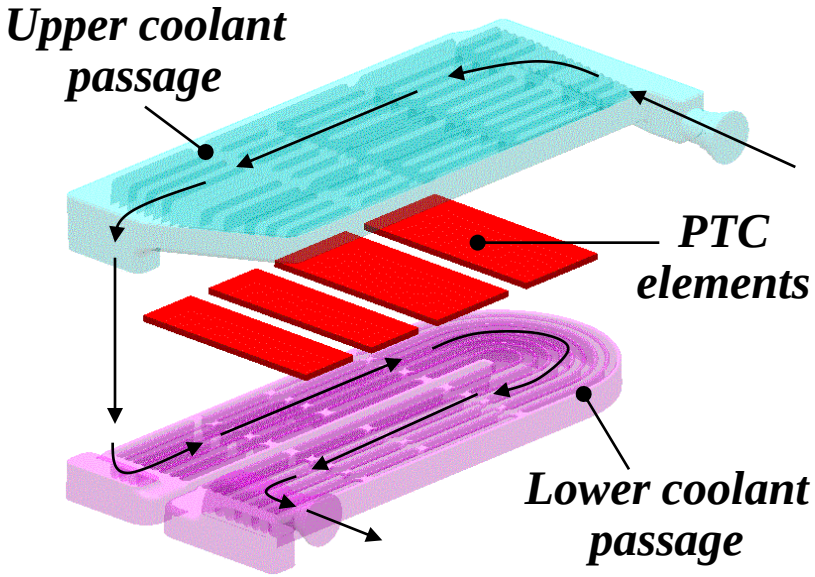


Fig. 2.6 Coolant PTC Heater (coolant passages)

The heater has 3-dimensional coolant flow passages for efficient thermal conduction from PTC elements to coolant.

2. Outline of the AC system (6)

2.4 Control specification

(1) Temperature control

There are 6 positions of "Cool",6 positions of "Hot", and "Ventilation" position. This control decrease the situation in which both the compressor and the PTC heater are operated simultaneously.

(2) MAX switch (SW)

MAX SW ON:

The system is operated under maximum capacity.

MAX SW OFF:

Fan speed and coolant temp are limited.

⇒ Usually "OFF"

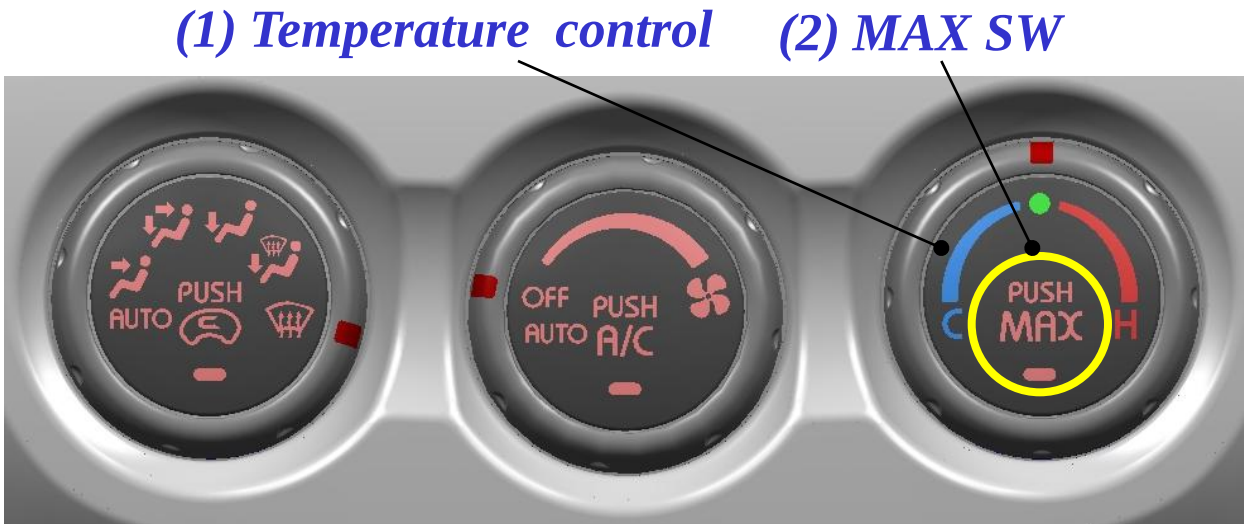


Fig. 2.7 Control Panel (1)

2. Outline of the AC system (7)

(3) Fan auto control

Fan speed is controlled automatically to keep comfort temp in the cabin.

(4) Ventilation position

Both the compressor and the PTC heater are off. Only fan is operated for ventilation.

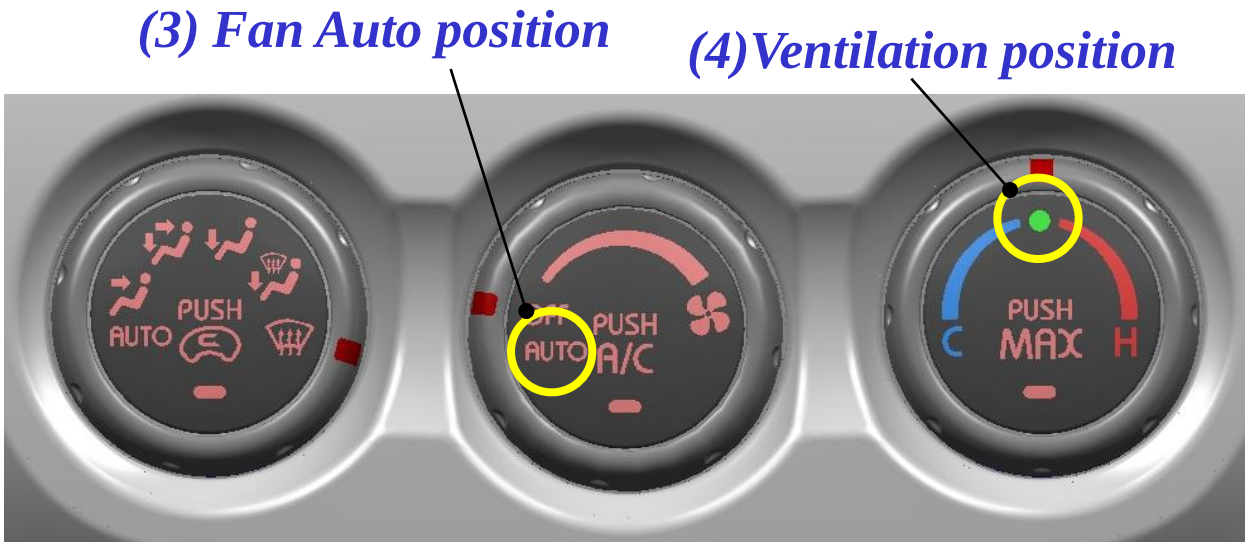


Fig. 2.7 Control Panel (2)

3. Performance (1)

3.1 Vehicle test results (Cooling performance)

The cooling performance of "i-MiEV" is slightly better than that of the baseline vehicle "i".

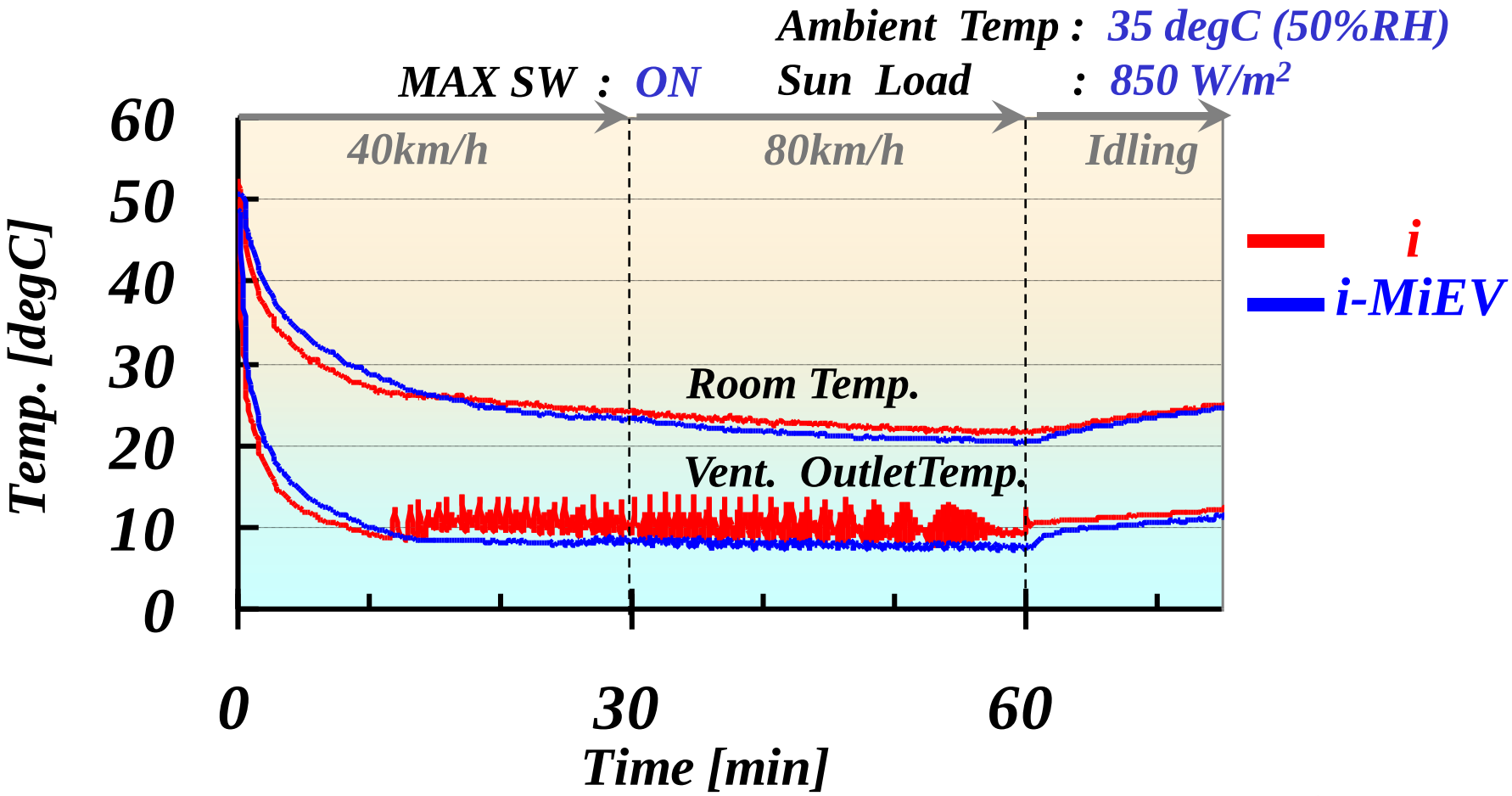


Fig. 3.1 Cooling Performance

3. Performance (2)

3.2 Vehicle test results (Heating performance)

The heating performance is better that of the baseline vehicle, especially under warming up and Idling conditions.

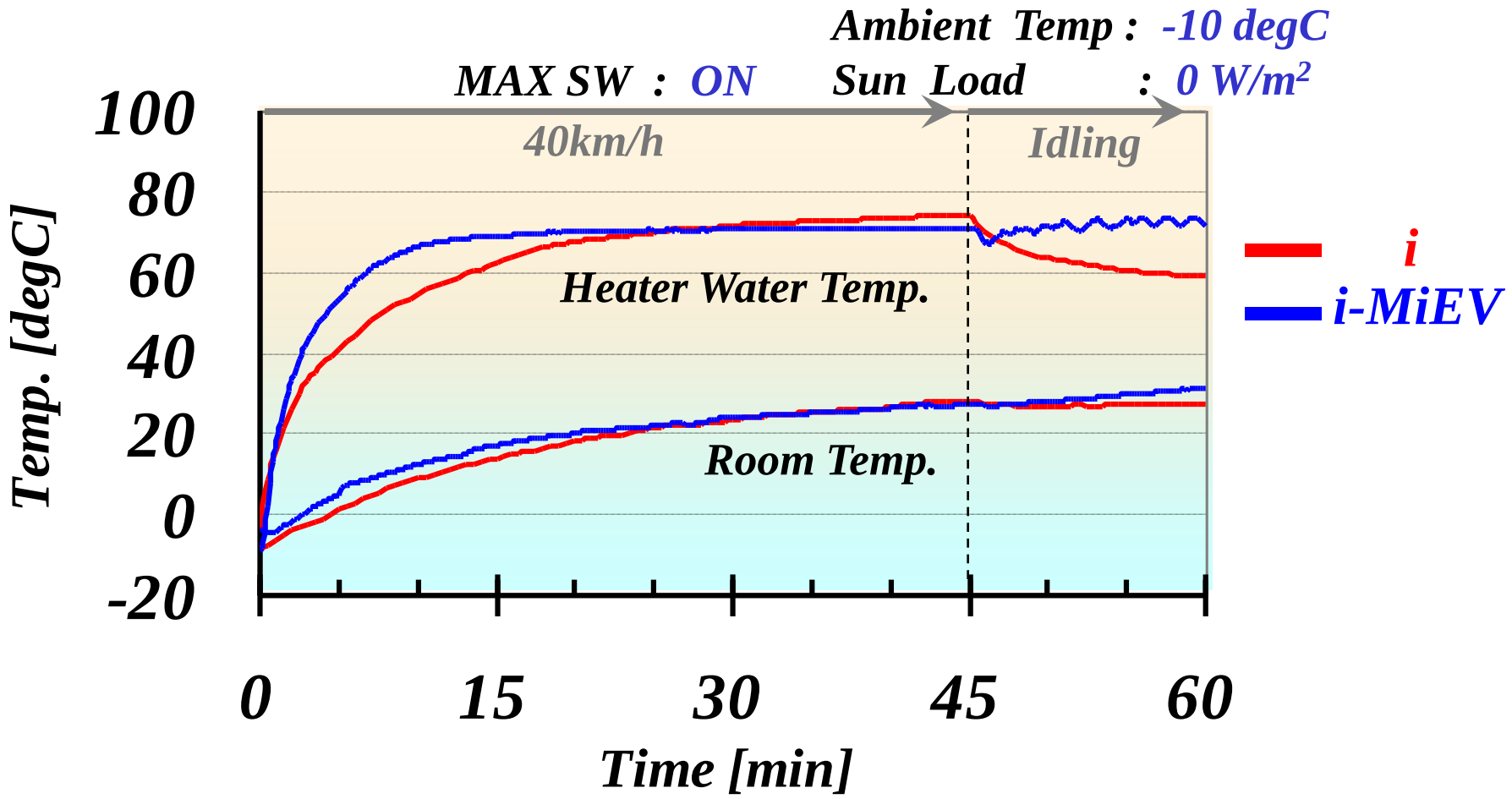


Fig. 3.2 Heating Performance

3. Performance (3)

3.3 Electric Power consumption

(1) Power consumption

Large electric power is necessary when heater is operated.

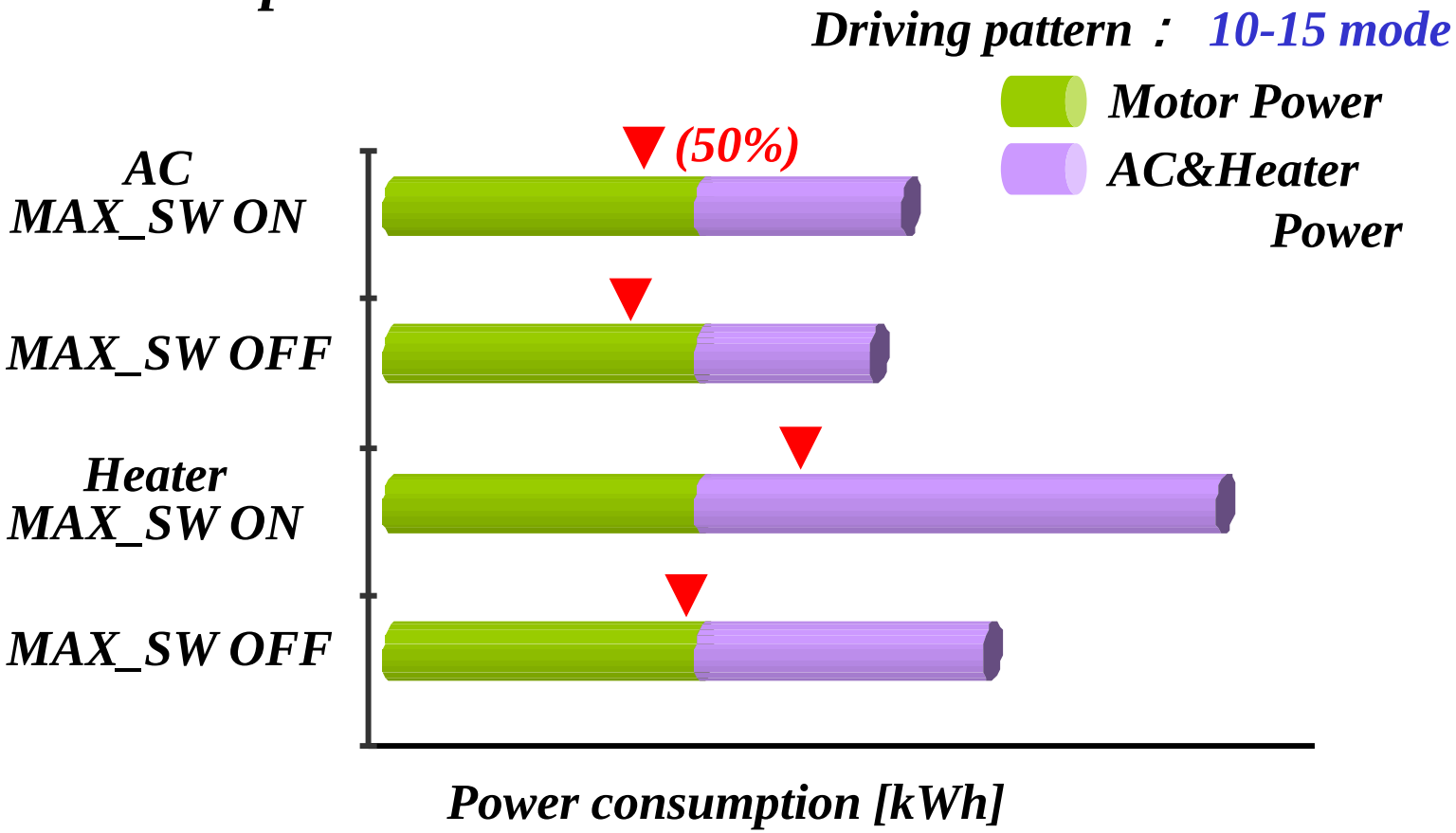


Fig. 3.3 Power consumption

3. Performance (4)

(2) Cruising range

The cruising range decreases when AC and Heater are operated.

Driving pattern ： 10-15 mode

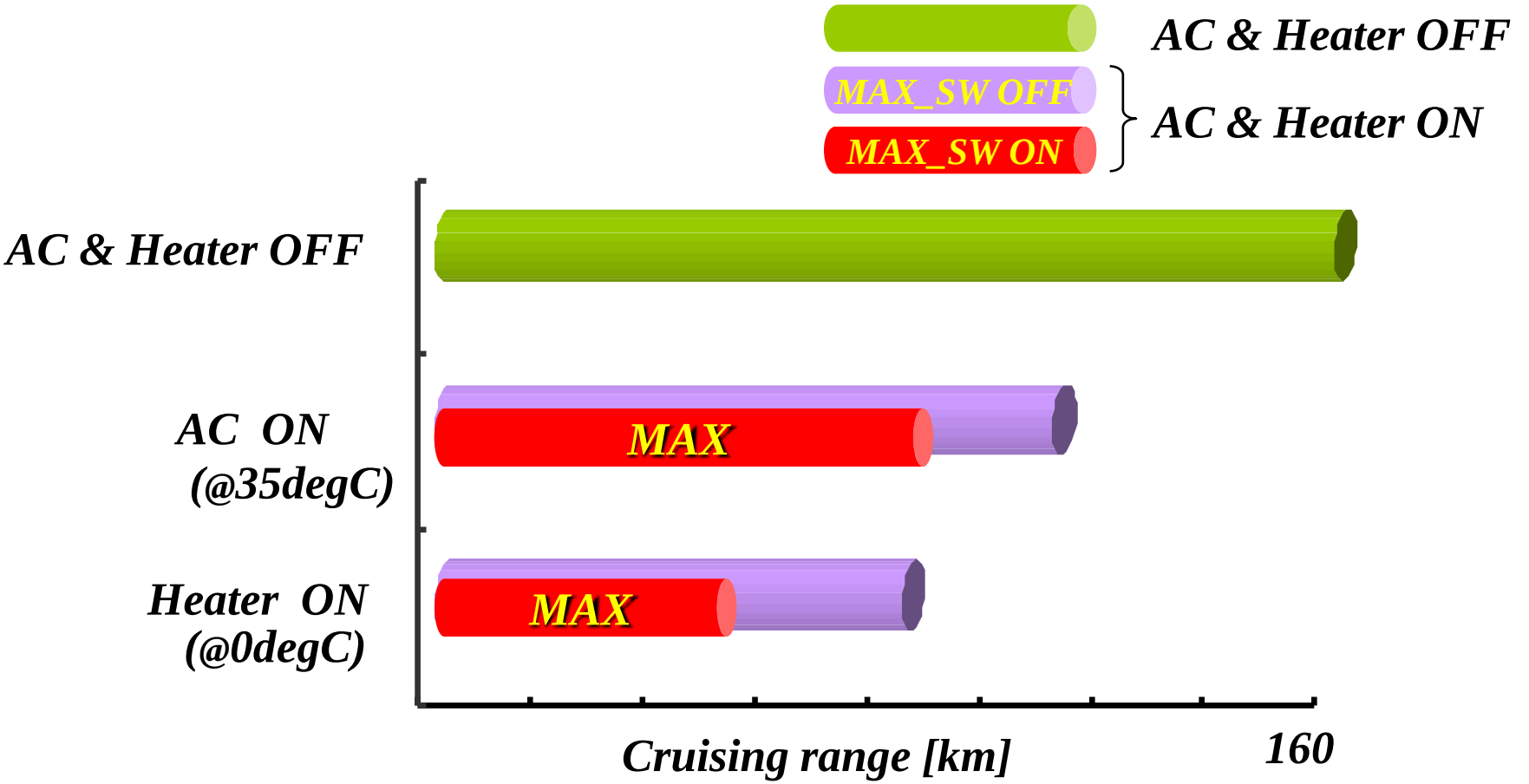


Fig. 3.4 Cruising range

4. Summary

- ***Mitsubishi Motors have developed the Air-Conditioning system for Electric Vehicle "i-MiEV" with a electric driven compressor and coolant PTC heater as key components.***
- ***The cooling/heating performance of the vehicle is almost equal to the baseline "i", which is a conventional engine vehicle, under normal usage conditions.***
- ***Operating the AC system have influence on the cruising rage of the vehicle, especially under heating mode.***

5. Next Step – future development (1)

- ***Improve cruising range by decreasing AC system power consumption during vehicle driving.***
  - ***– Decreasing vehicle thermal load (including "Pre AC" during charging)***
  - ***– Improving the efficiency of the AC system***

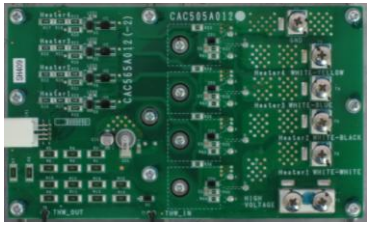
  etc.

- ***Improve power consumption of coolant PTC heater, especially.***
  - ***– Reducing size and mass***
  - ***–Improving control and efficiency***

5. Next Step – future development (2)

- ***Improvement of coolant PTC Heater***

We should pursue downsizing (small & light weight), and controllability (smooth capacity control & communication to the vehicle).



Power circuit board

Power/Control circuit board

Gen1 *Current Product*

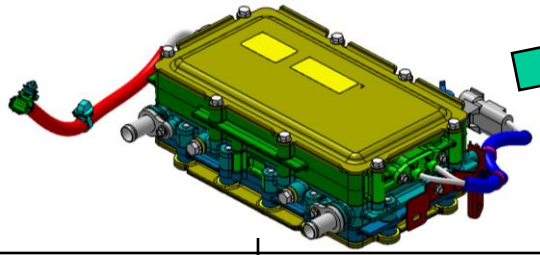
On-Off step control
by a external controller
On-Off signal line
Volume : 100% (Baseline)
Mass : 100% (Baseline)

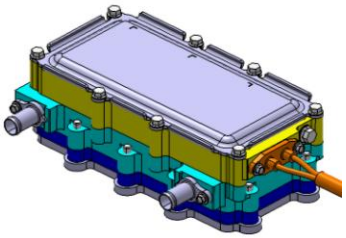
Gen2 *Development*

Integrated control circuit
PWM control (or On-Off step)
CAN or Local communication
Volume:70% (compared with Gen1)
Mass :70% (compared with Gen1)

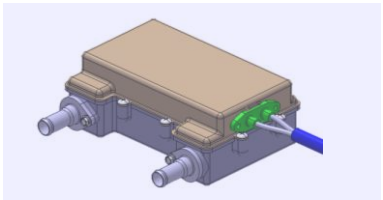
Gen3 *Future Target*

Integrated control circuit
PWM control (or On-Off step)
CAN or Local communication
Volume:50% (compared with Gen1)
Mass :50% (compared with Gen1)





Same structure as Gen 1



Brand-new structure

2009~ *Around 2011* *Around 2013*

END

Thank you for your attention.