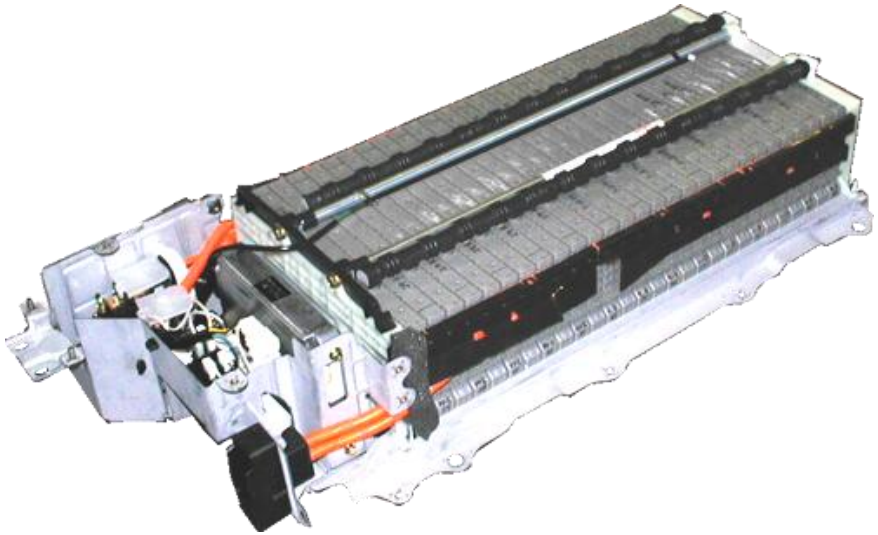
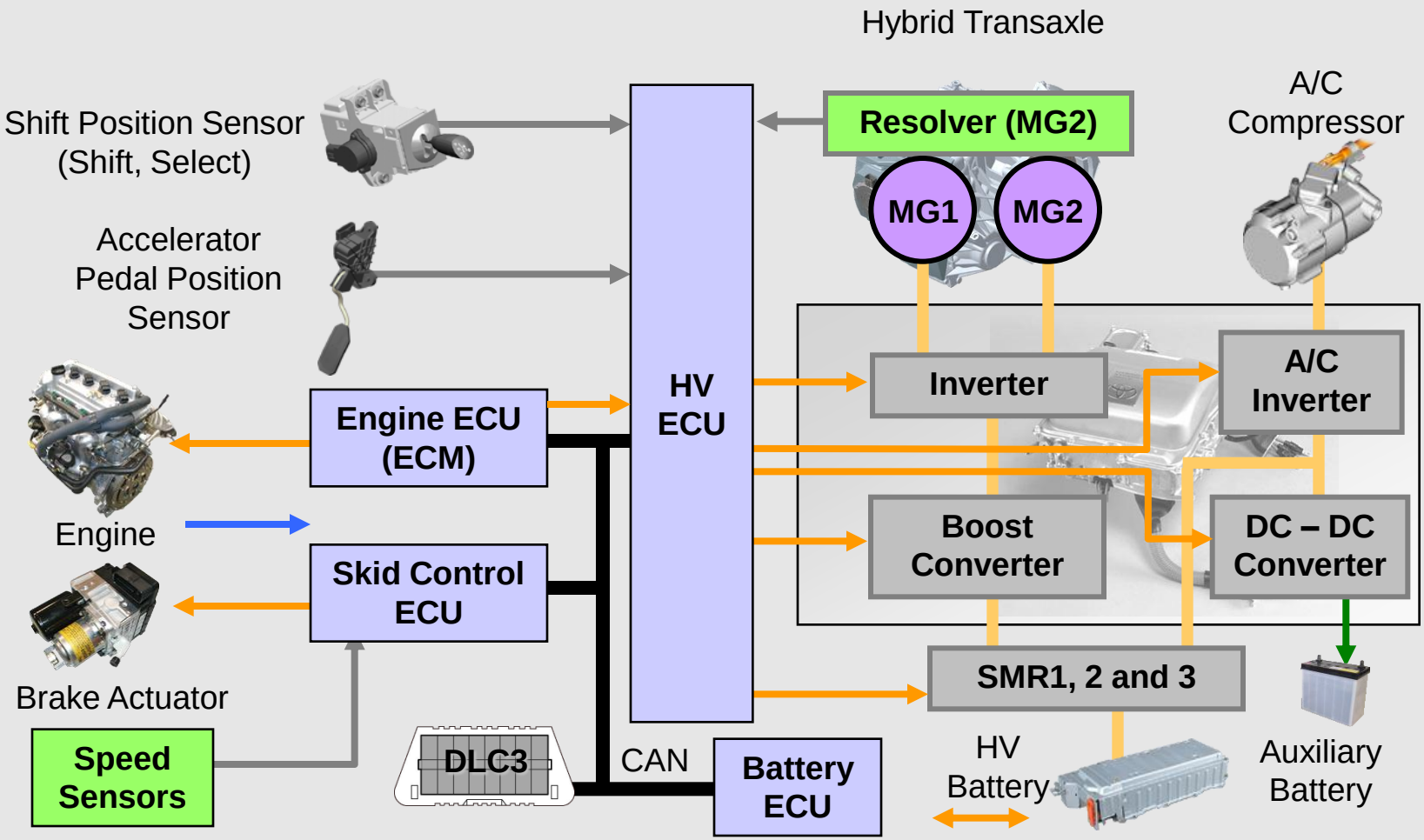


High Voltage System

System Diagram

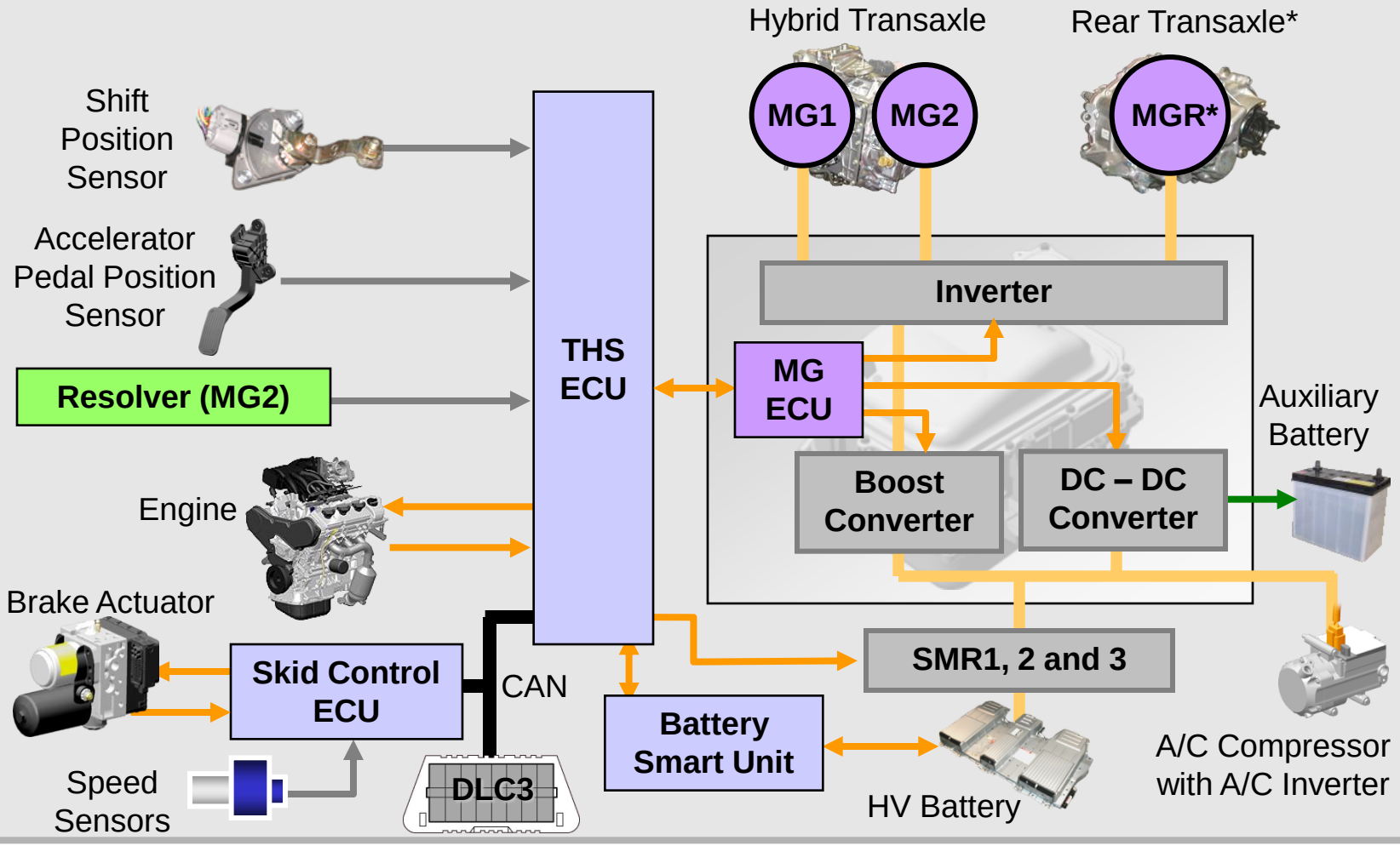
- System Diagram of Prius



TOYOTA

System Diagram

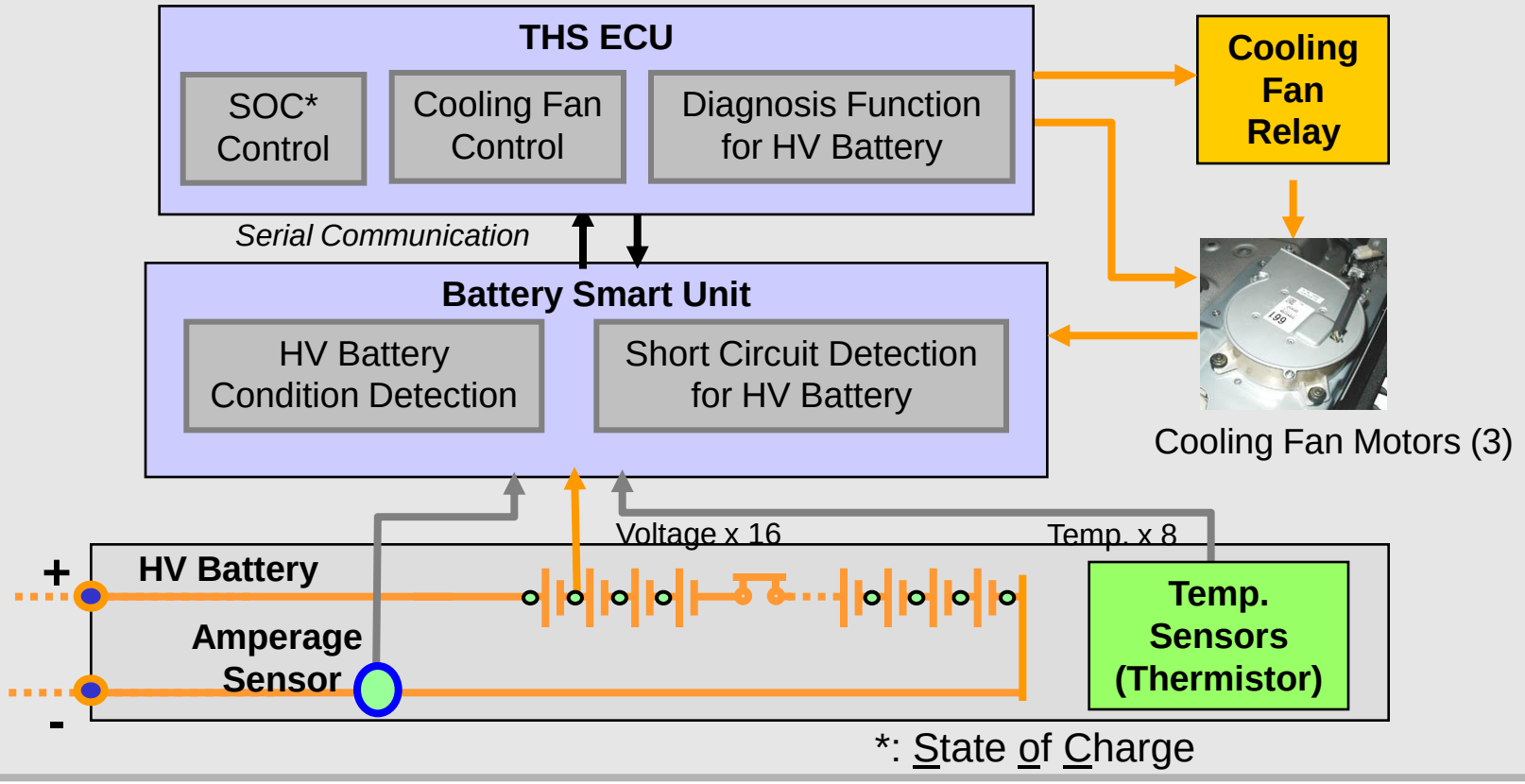
- System Diagram of RX400h



TOYOTA

HV Battery

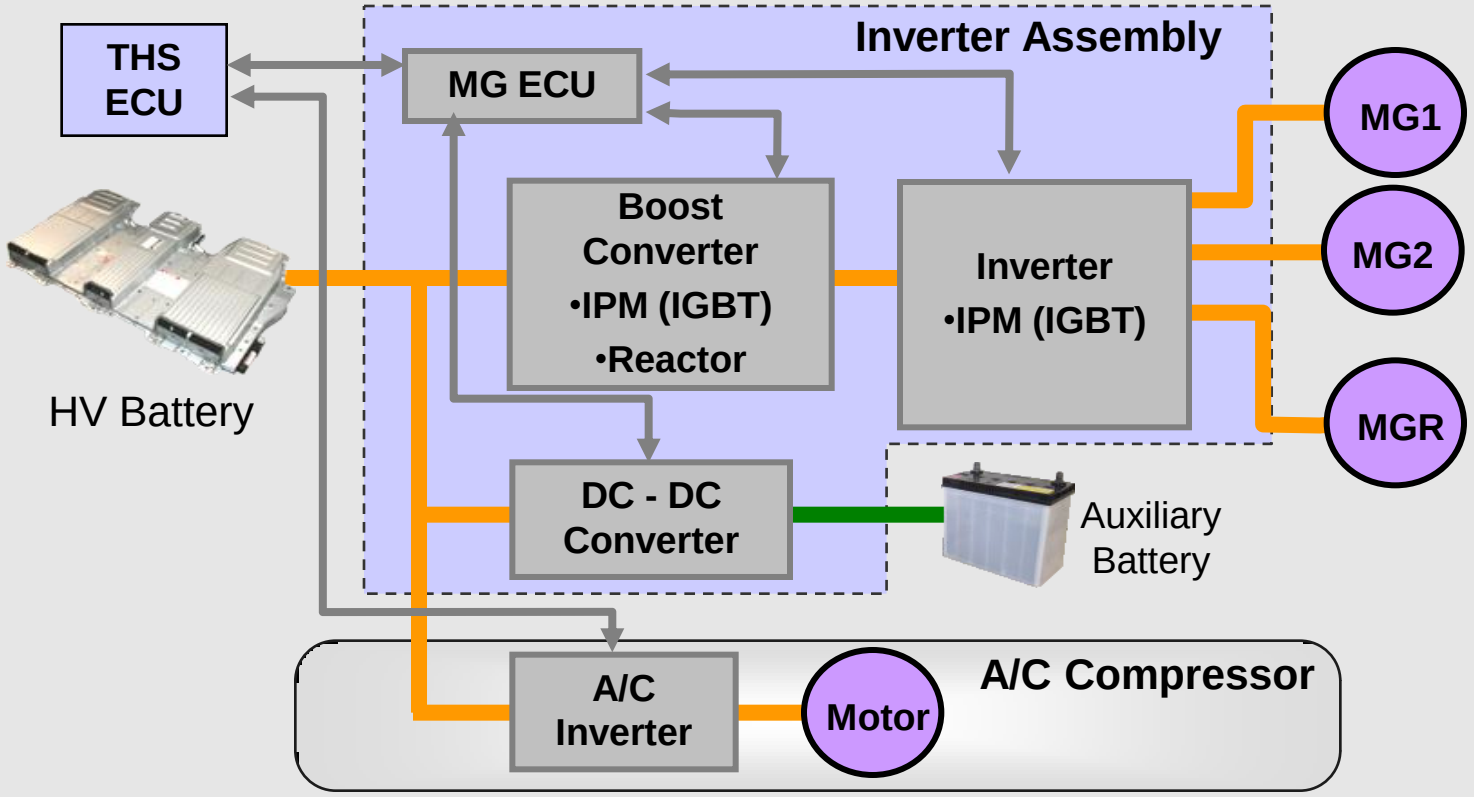
- Battery Smart Unit
  - Transmit the HV battery information to the THS ECU



TOYOTA

Inverter Assembly

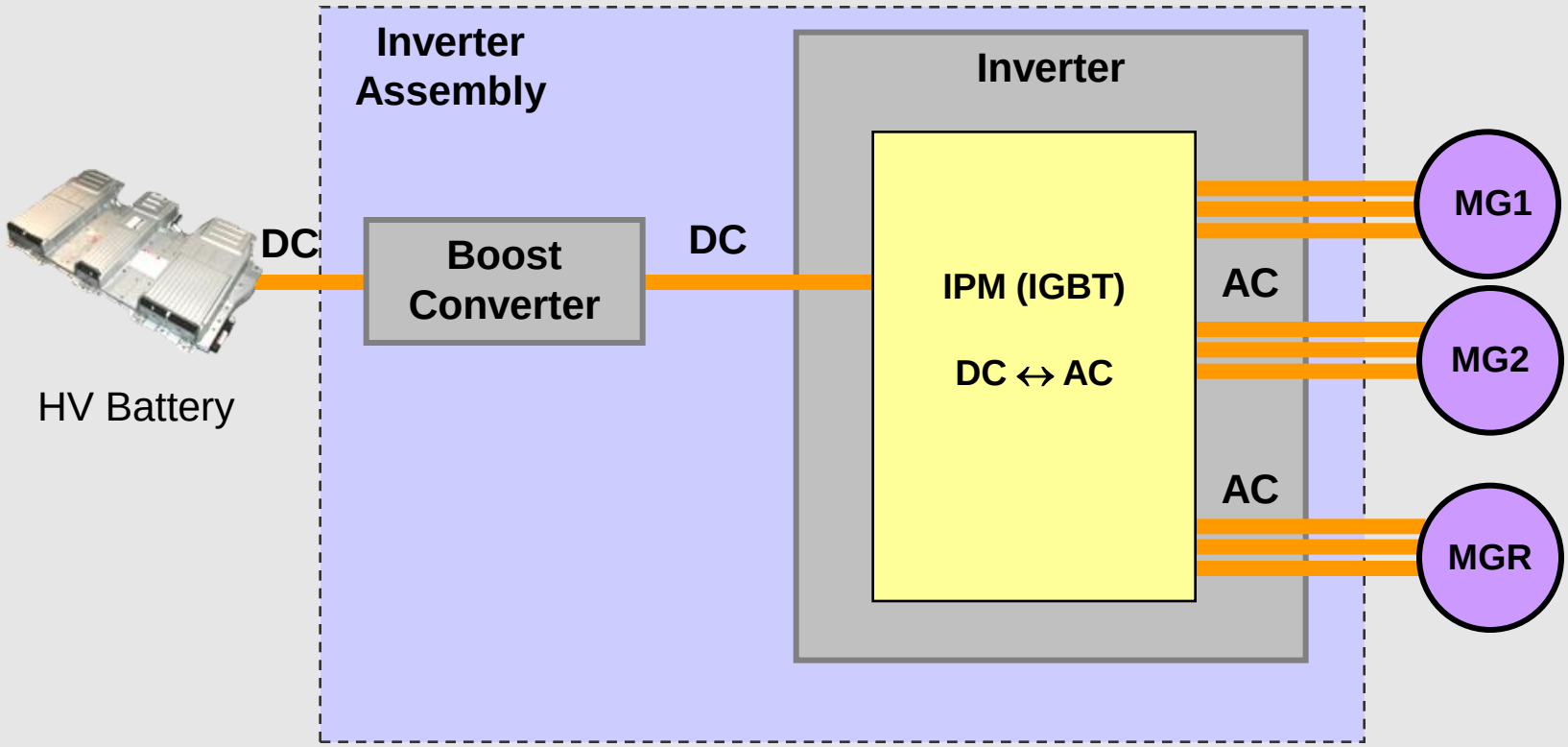
- System Diagram



TOYOTA

Inverter Assembly

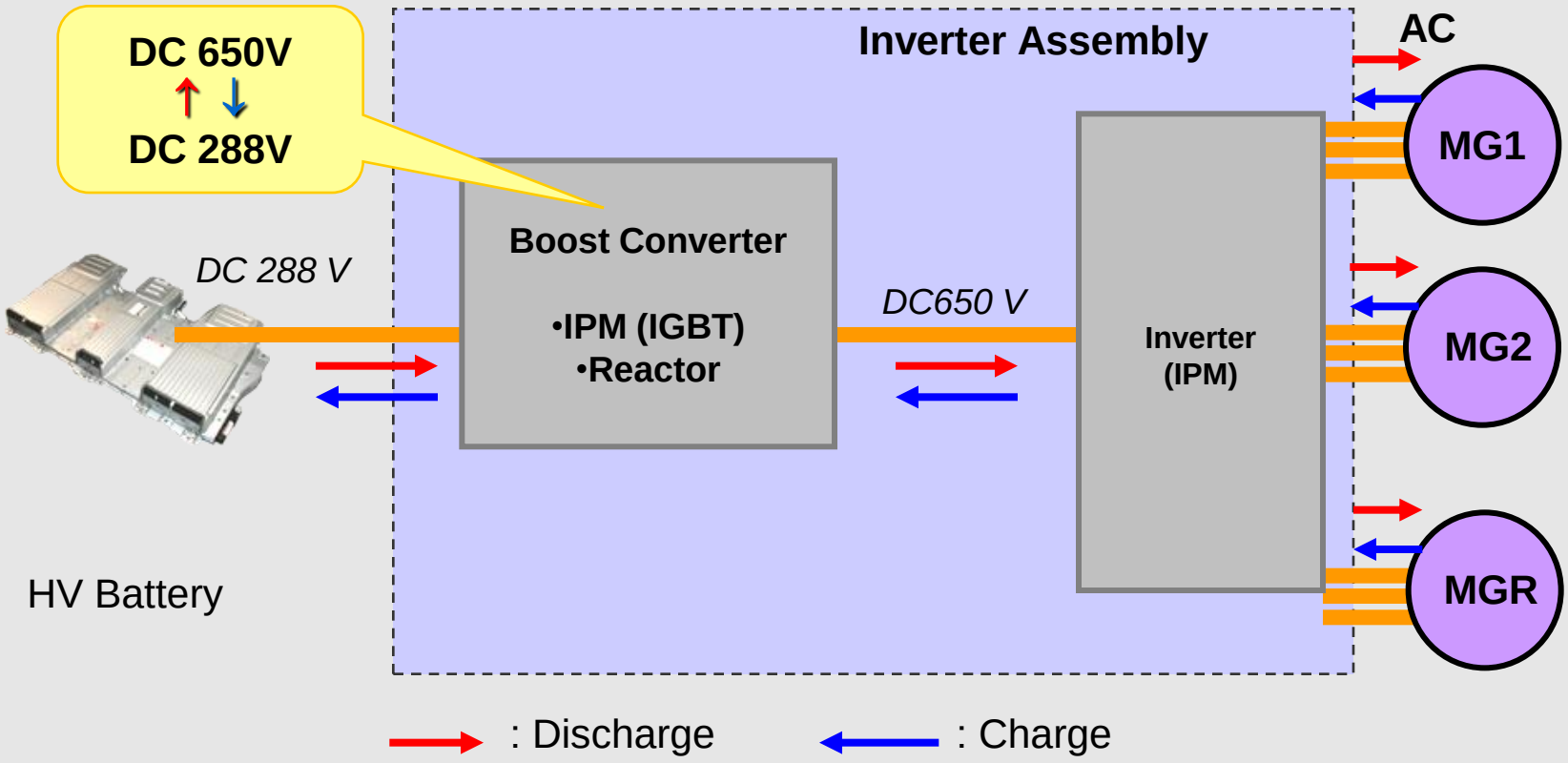
- Inverter
  - Converts DC ↔ AC



TOYOTA

Inverter Assembly

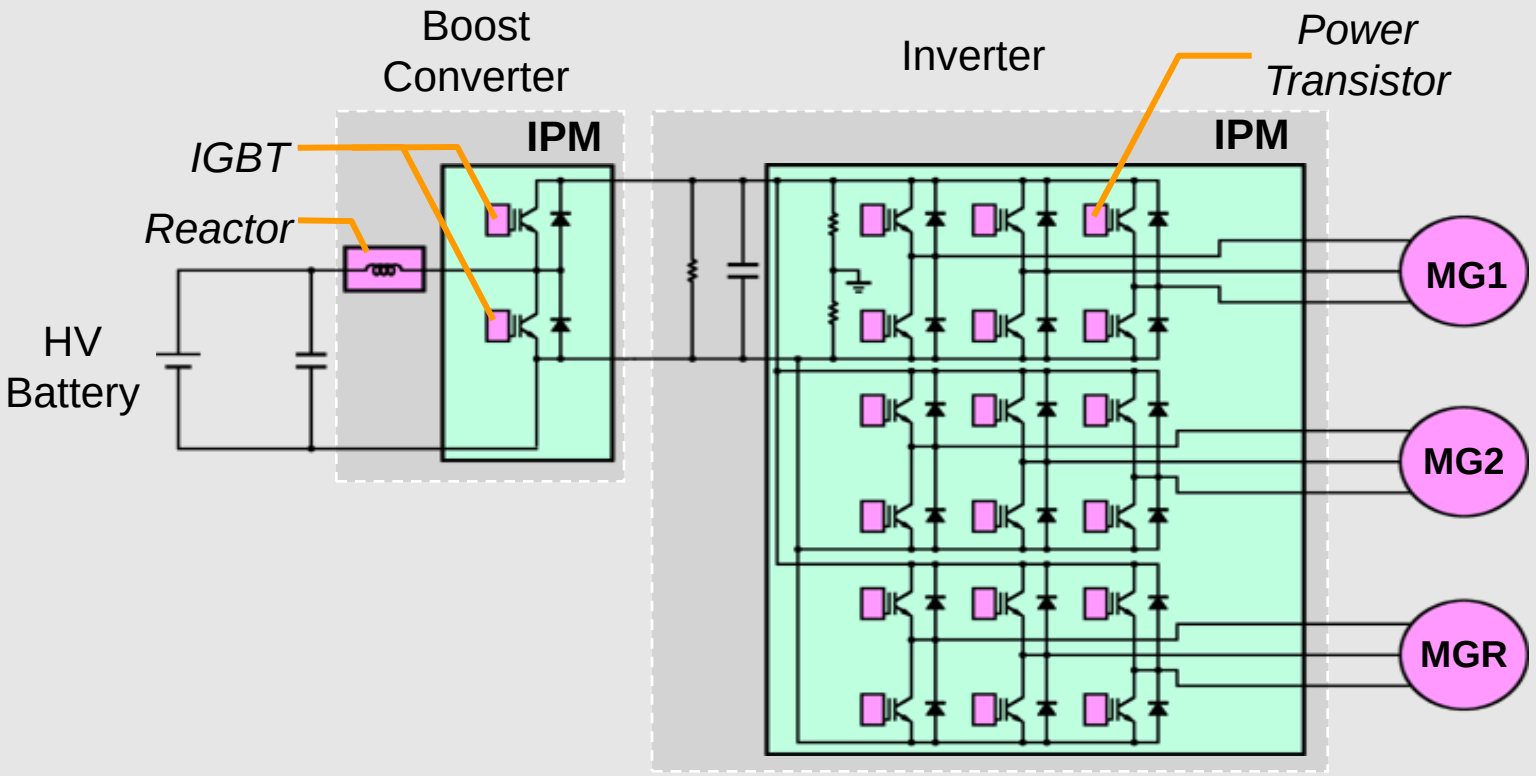
- Boost Converter (Variable-voltage System)
  - Converts DC 288V ↔ DC 650V



TOYOTA

Inverter Assembly

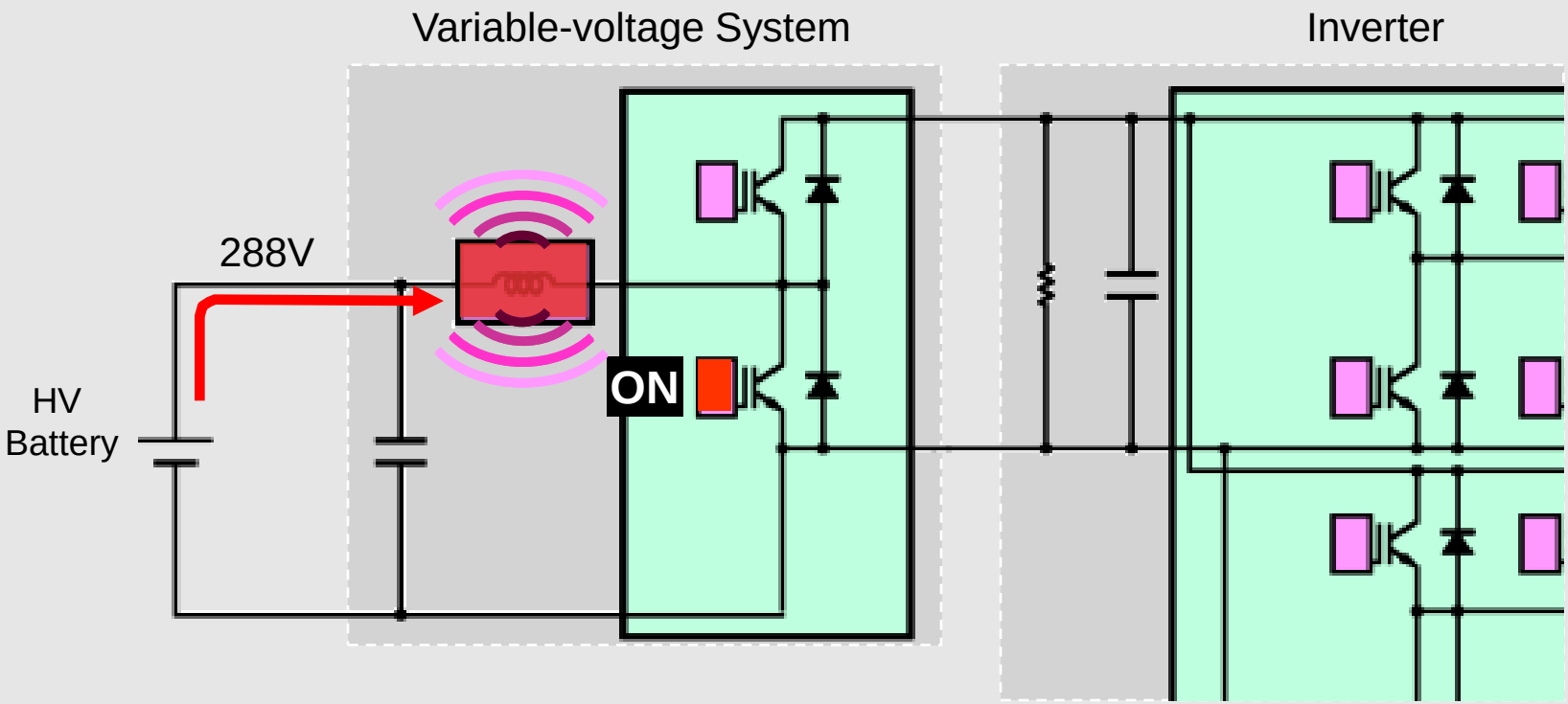
- Boost Converter (Variable-voltage System)
  - System Diagram



TOYOTA

Inverter Assembly

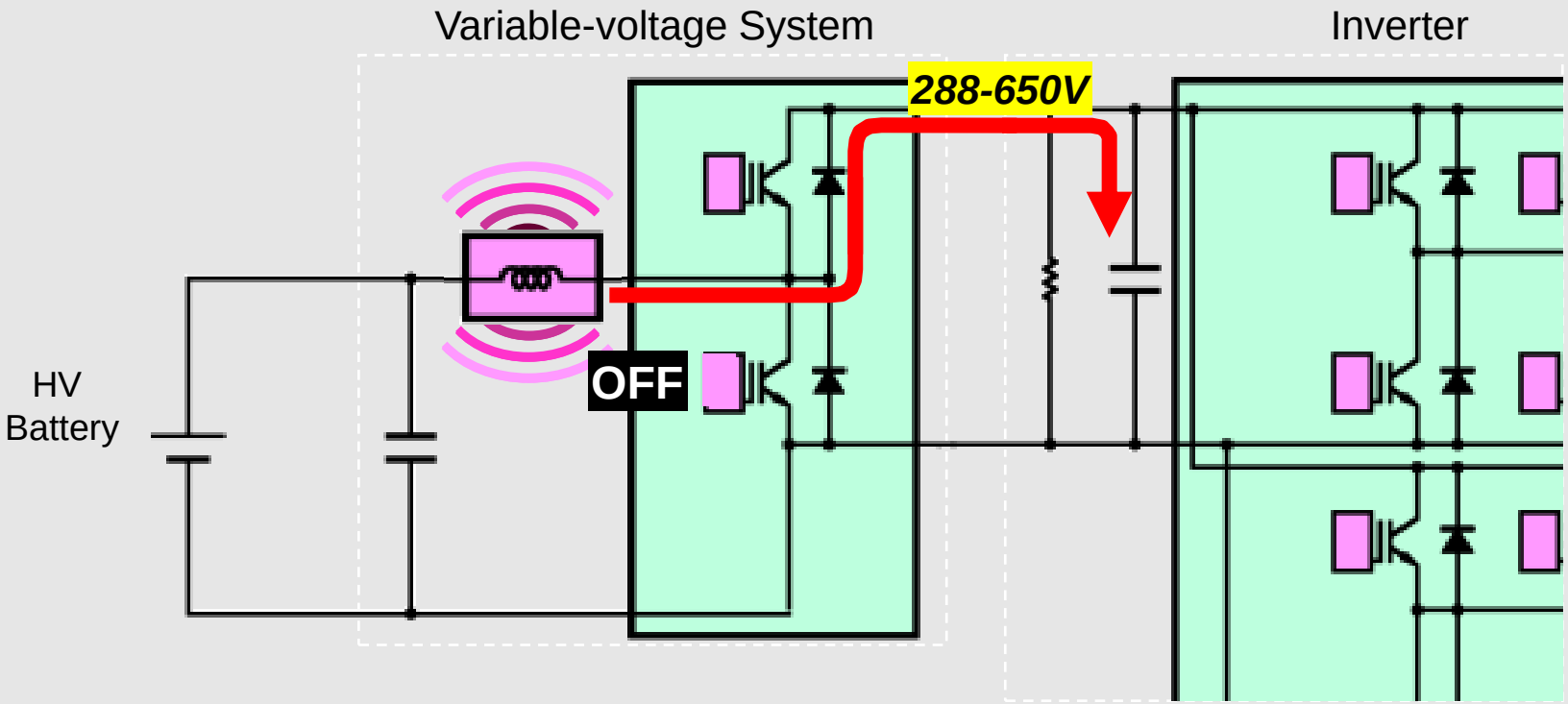
- Variable-voltage System
  - Voltage boost-up operation



TOYOTA

Inverter Assembly

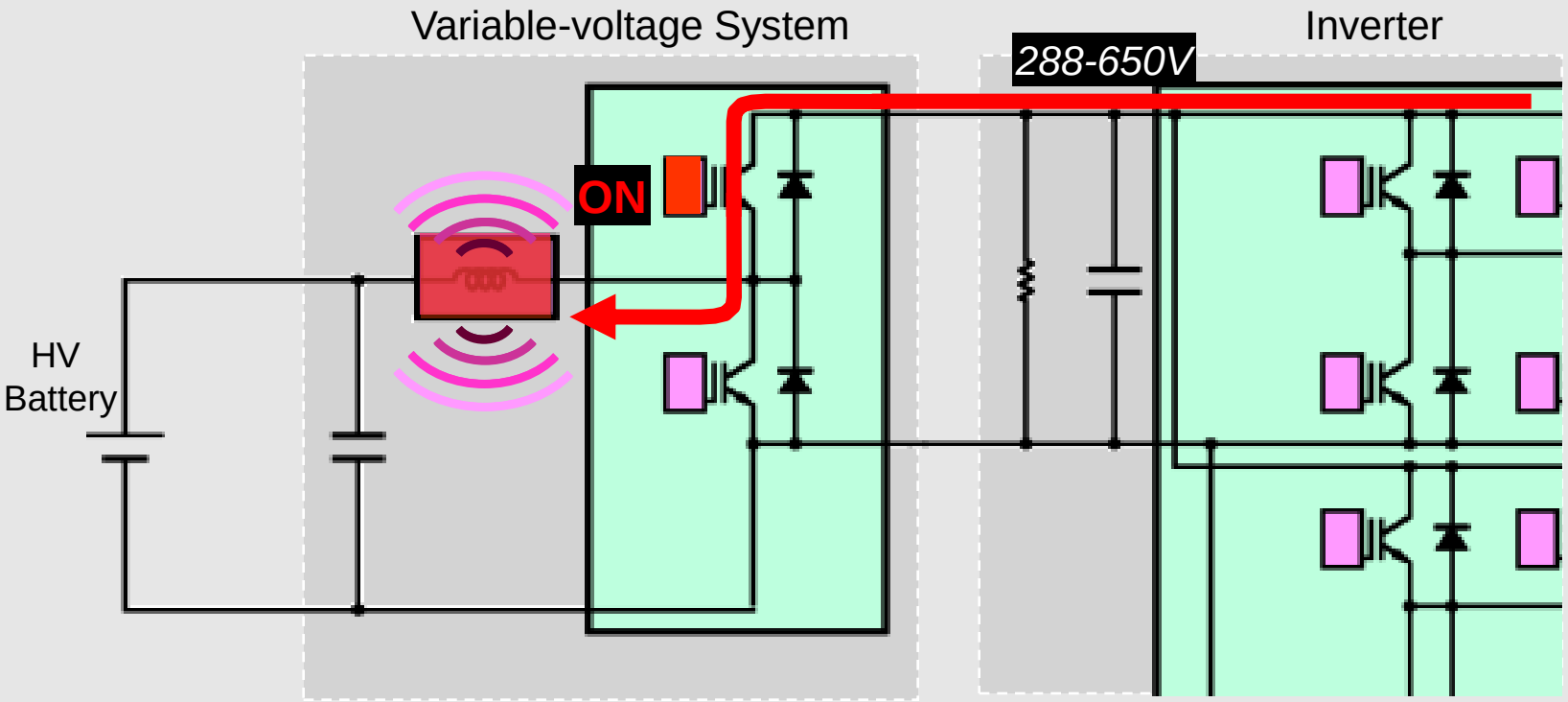
- Variable-voltage System
  - Voltage boost-up operation



TOYOTA

Inverter Assembly

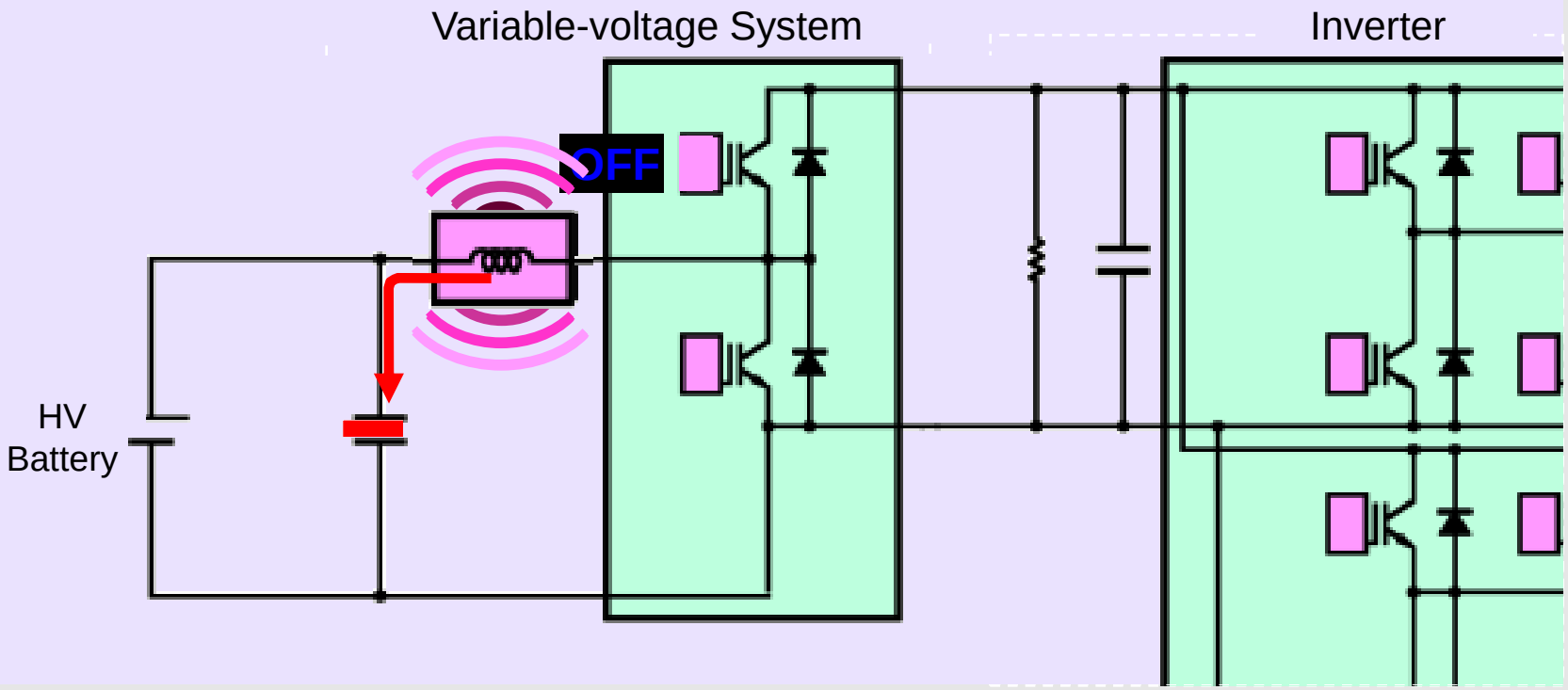
- Variable-voltage System
  - Voltage reduction operation (when charging)



TOYOTA

Inverter Assembly

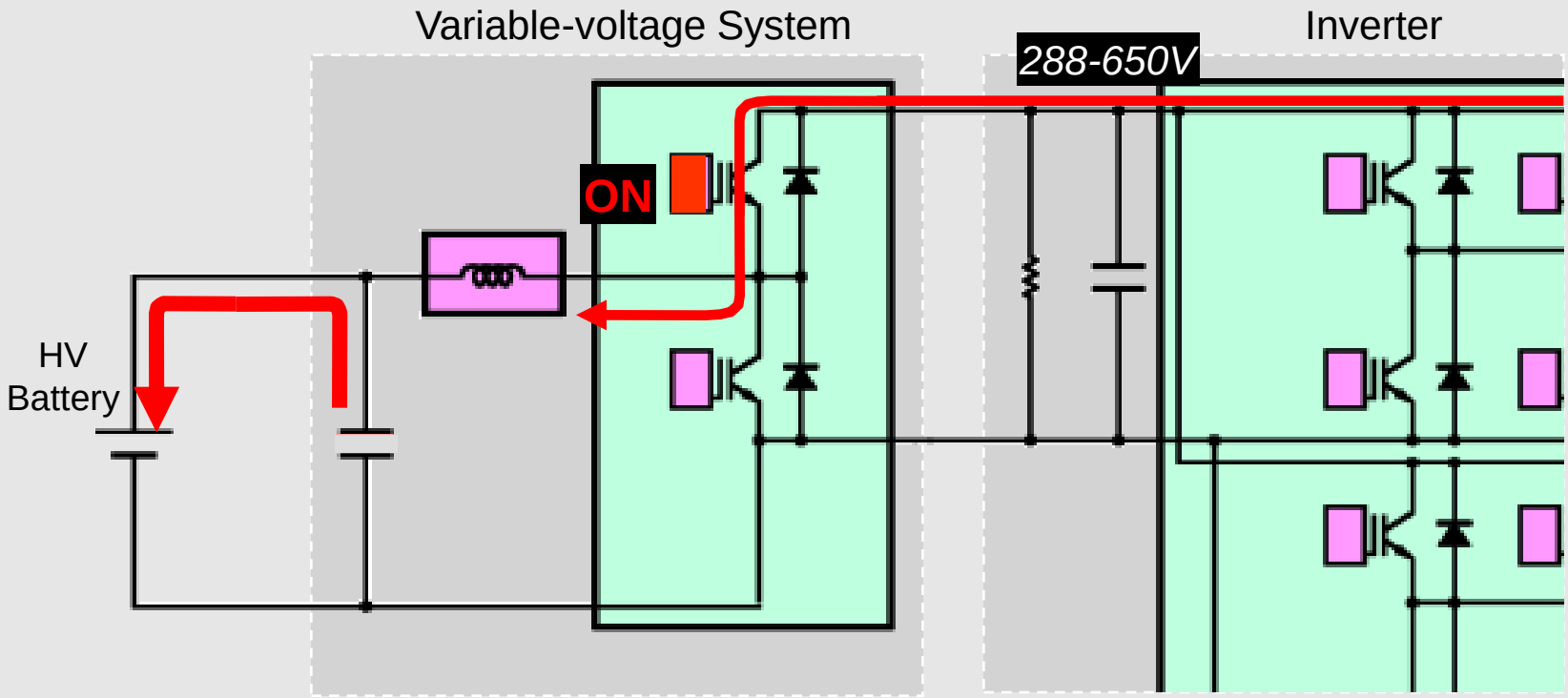
- Variable-voltage System
  - Voltage reduction operation (when charging)



TOYOTA

Inverter Assembly

- Variable-voltage System
  - Voltage reduction operation (when charging)



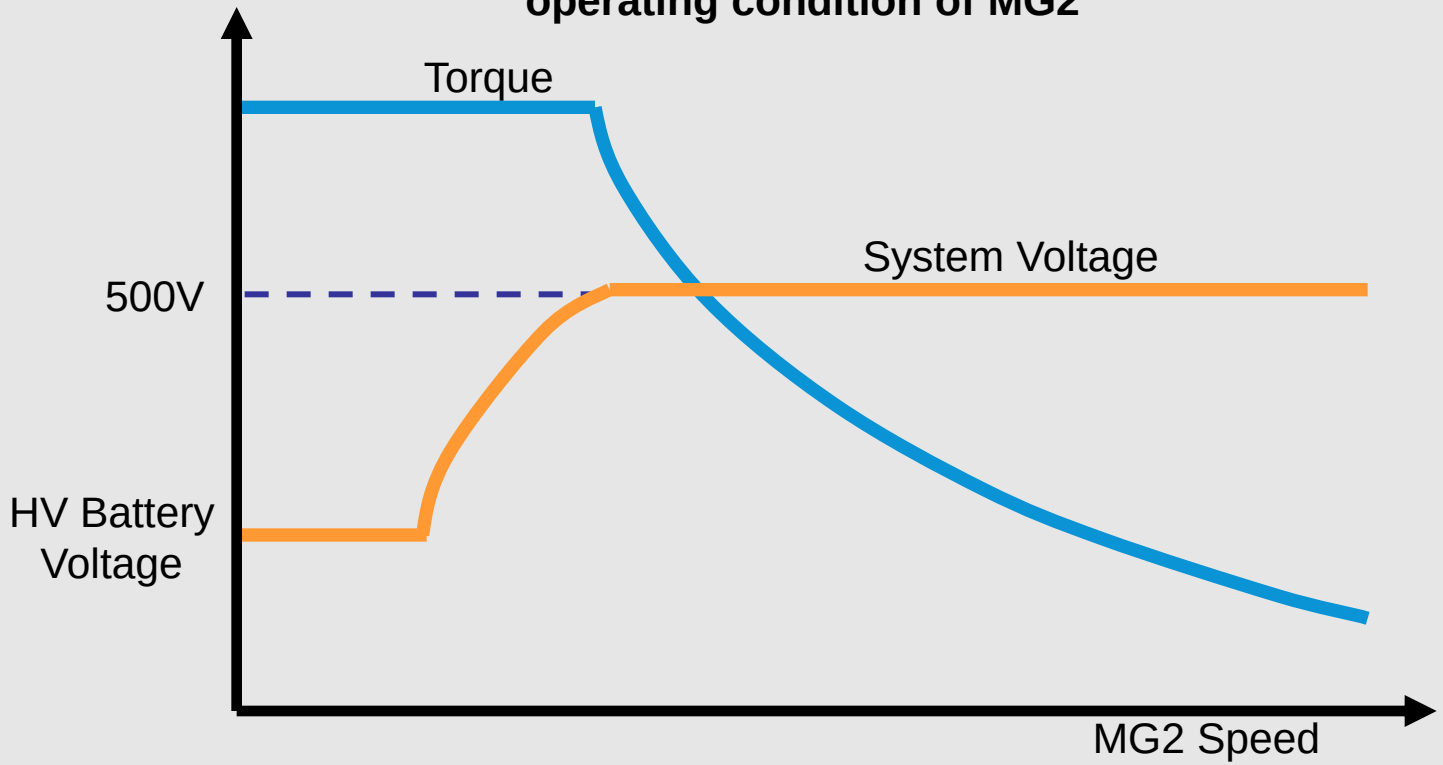
Voltage is regulated by IGBT duty

TOYOTA

Motor Control

- Variable Voltage Control

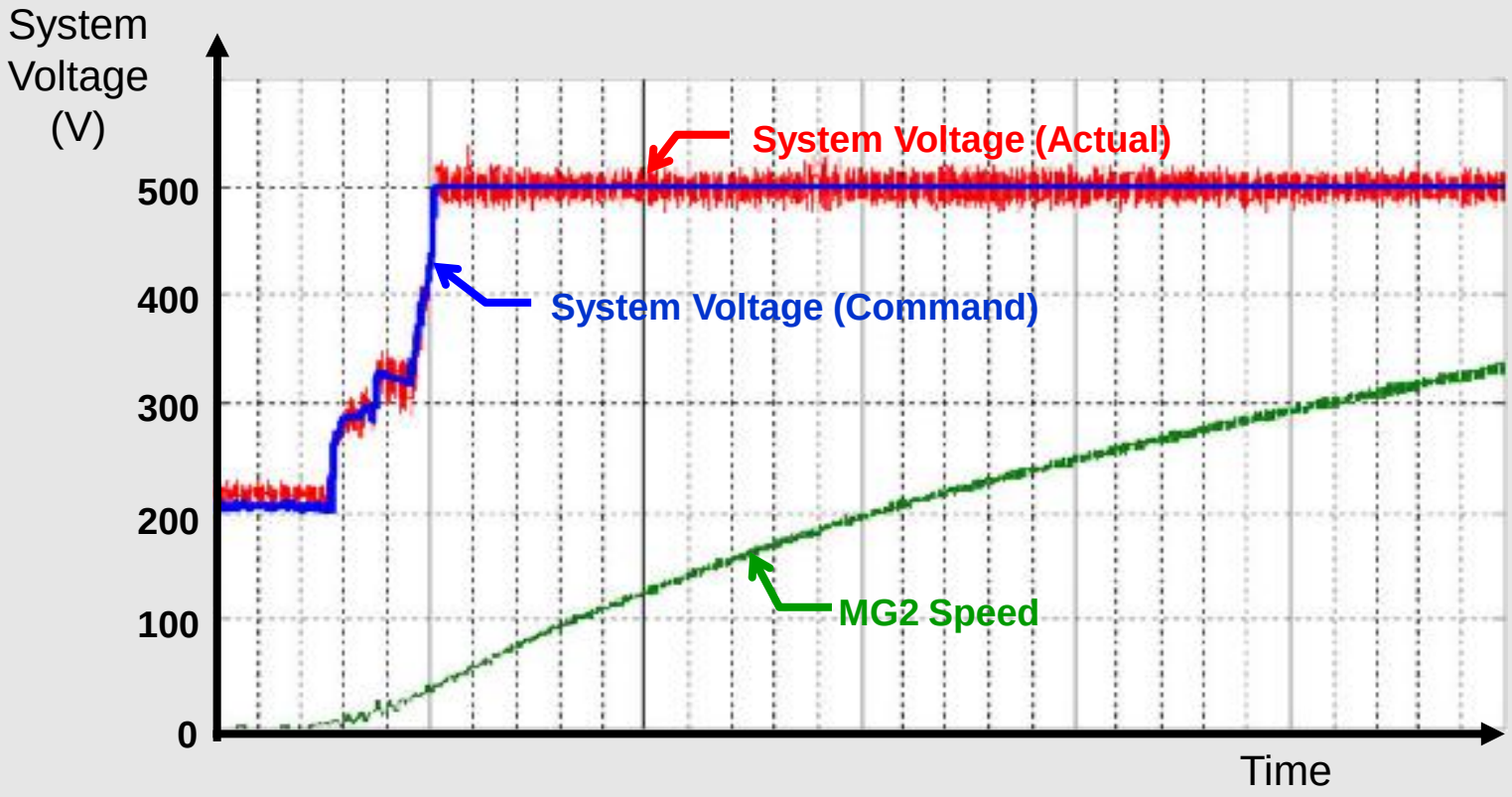
To minimize loss, the system voltage is controlled according to the operating condition of MG2



TOYOTA

Motor Control

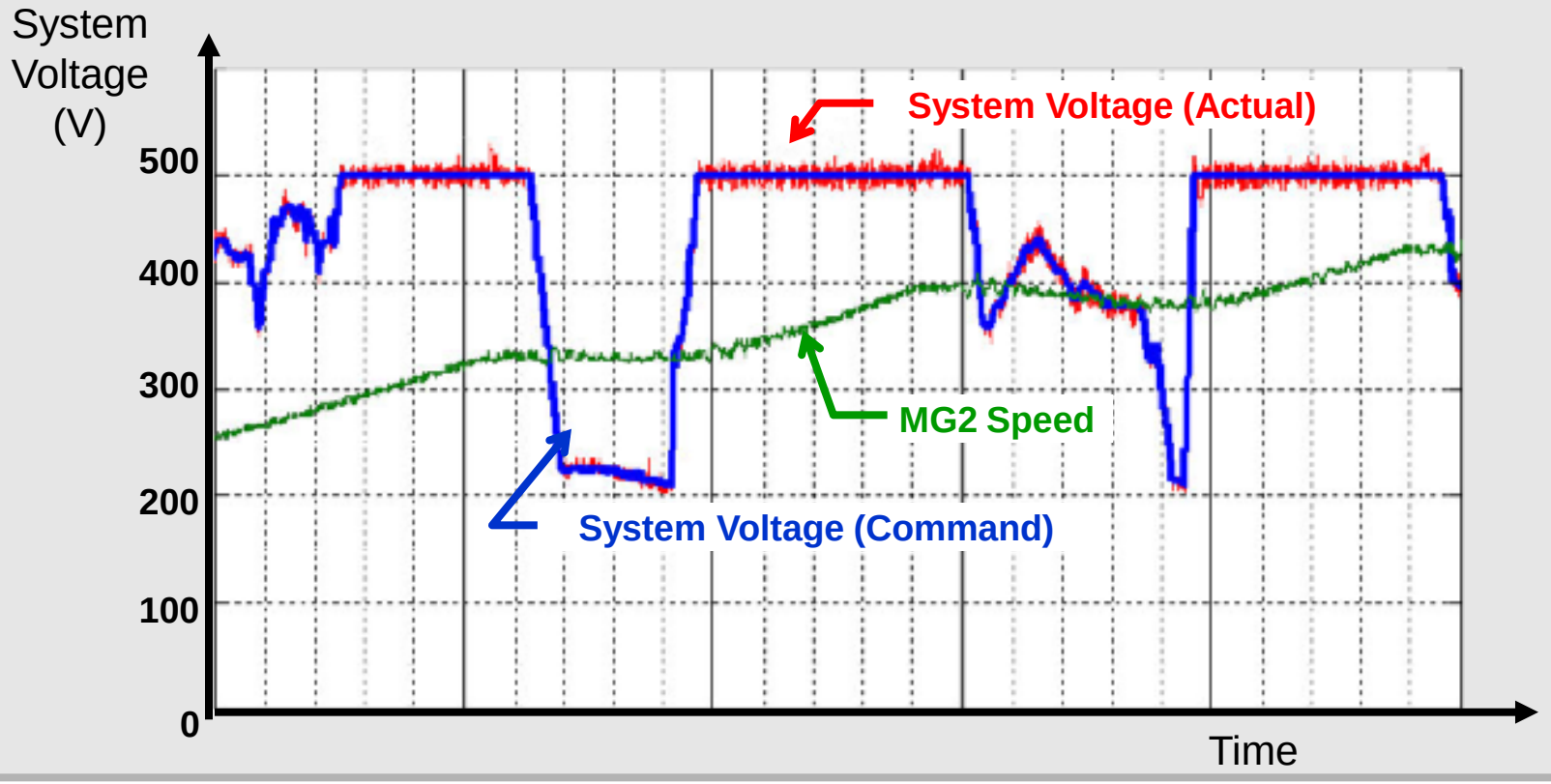
- Variable Voltage Control
  - Evaluation in vehicle (Full throttle)



TOYOTA

Motor Control

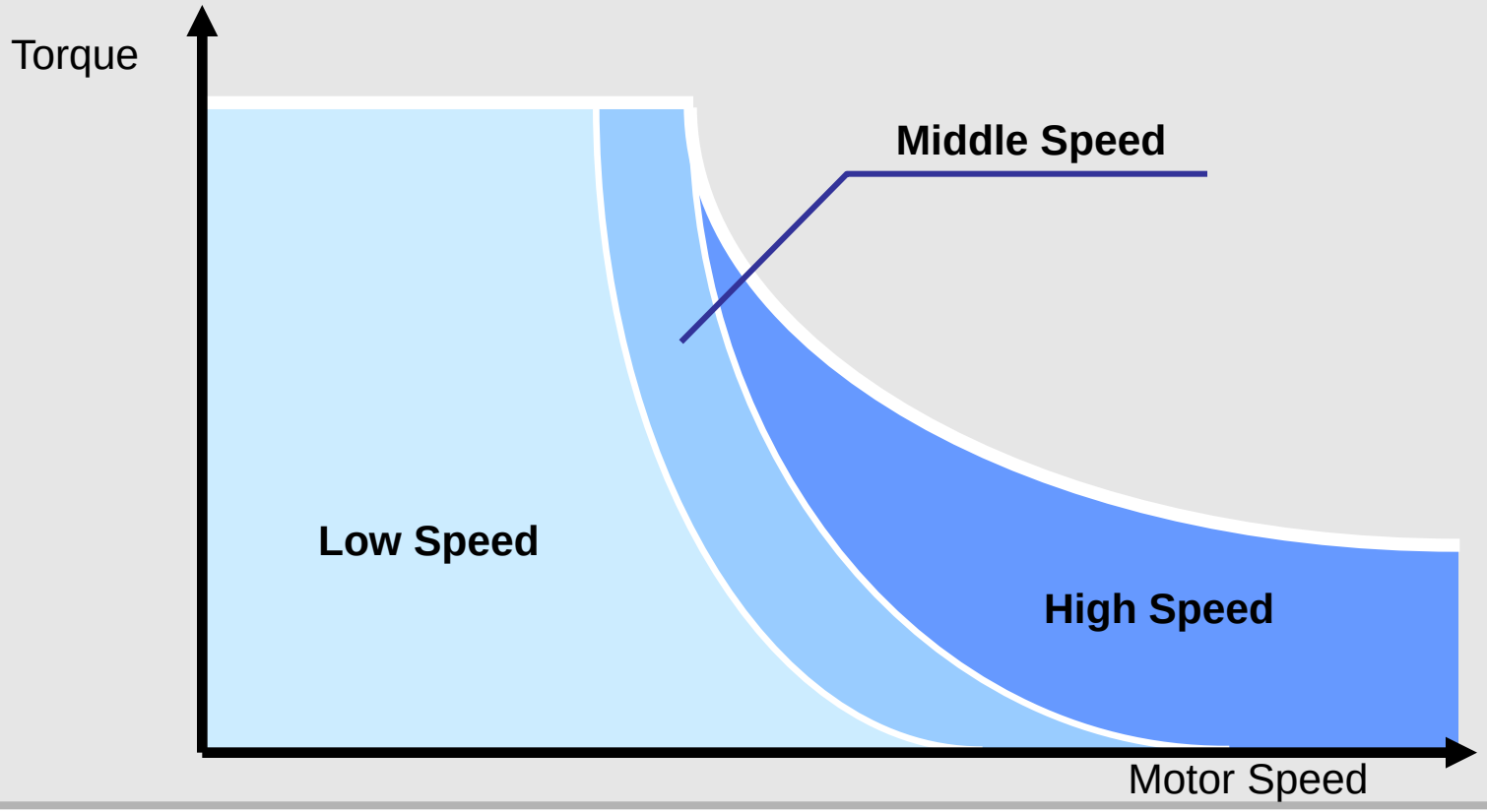
- Variable Voltage Control
  - Evaluation in vehicle (Accelerator pedal ON/OFF)



TOYOTA

Motor Control

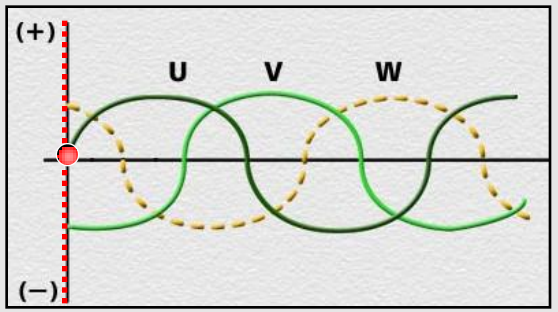
- Increase of Utilization Voltage
  - Control range of voltage control

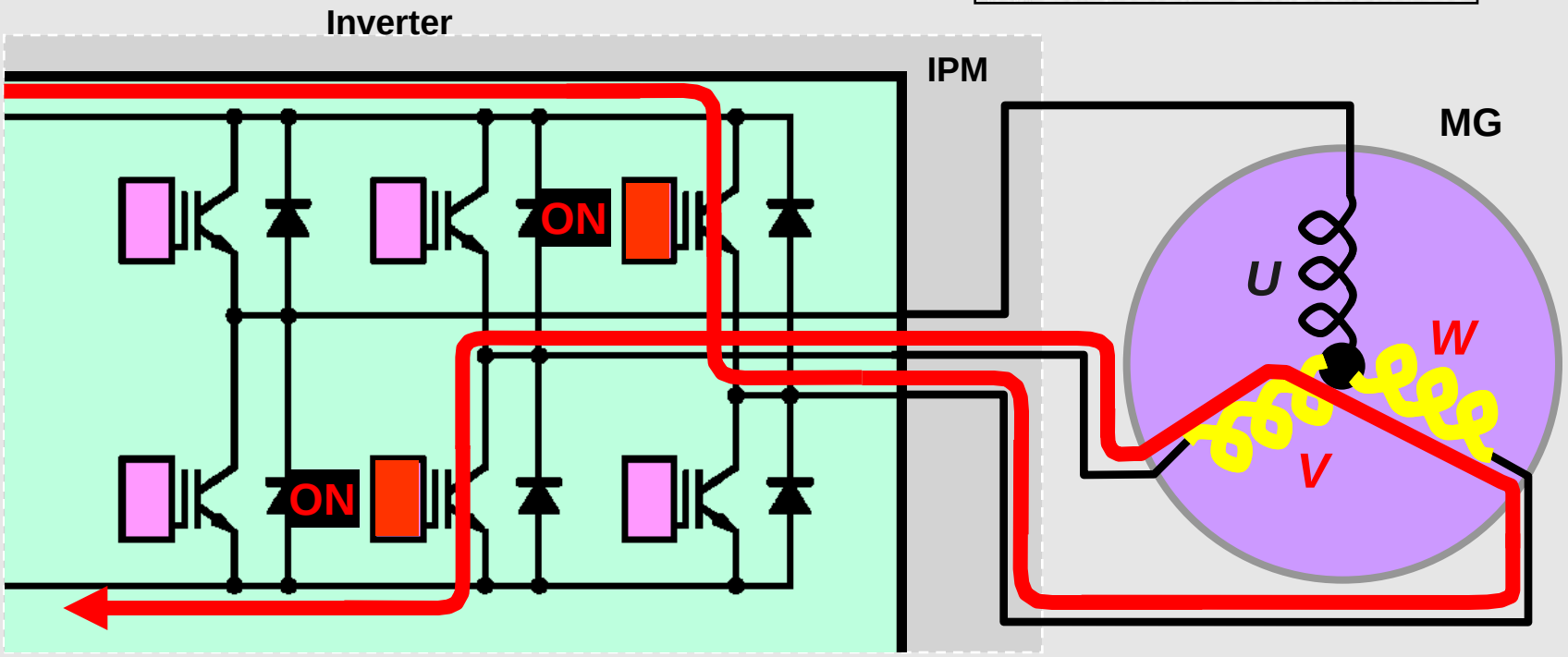


TOYOTA

Inverter Assembly

- Inverter Operation
  - Motor drive

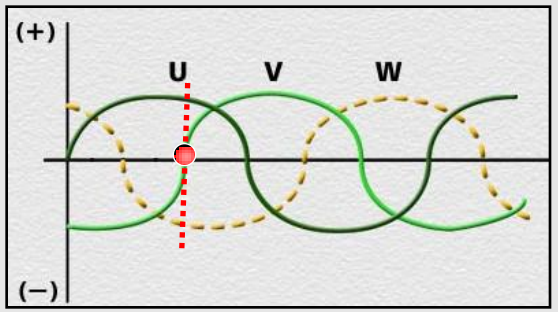


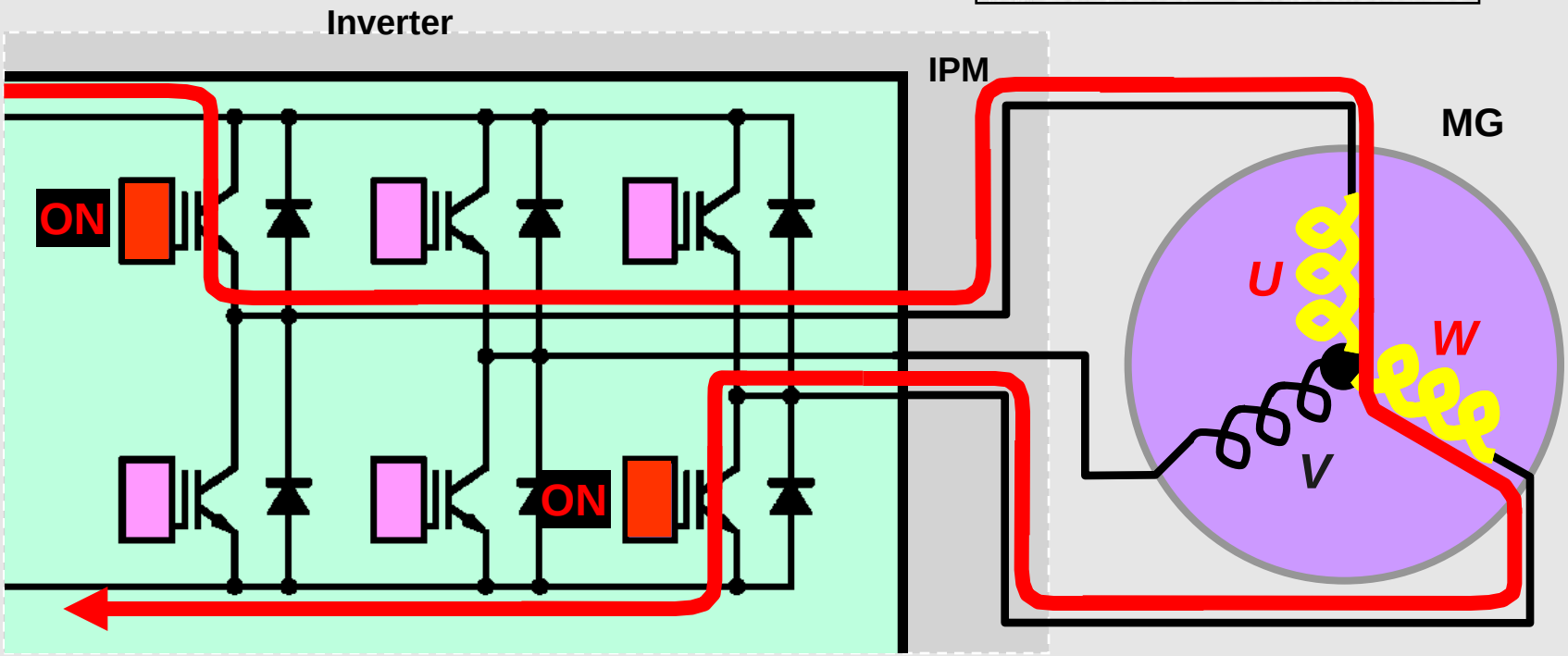


TOYOTA

Inverter Assembly

- Inverter Operation
  - Motor drive

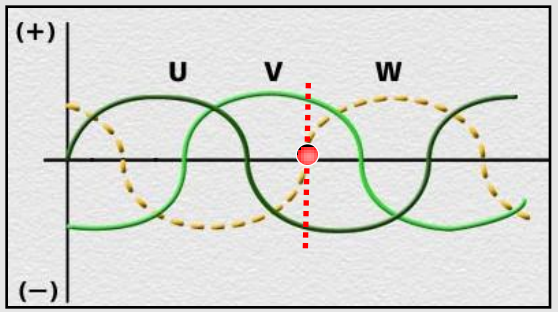


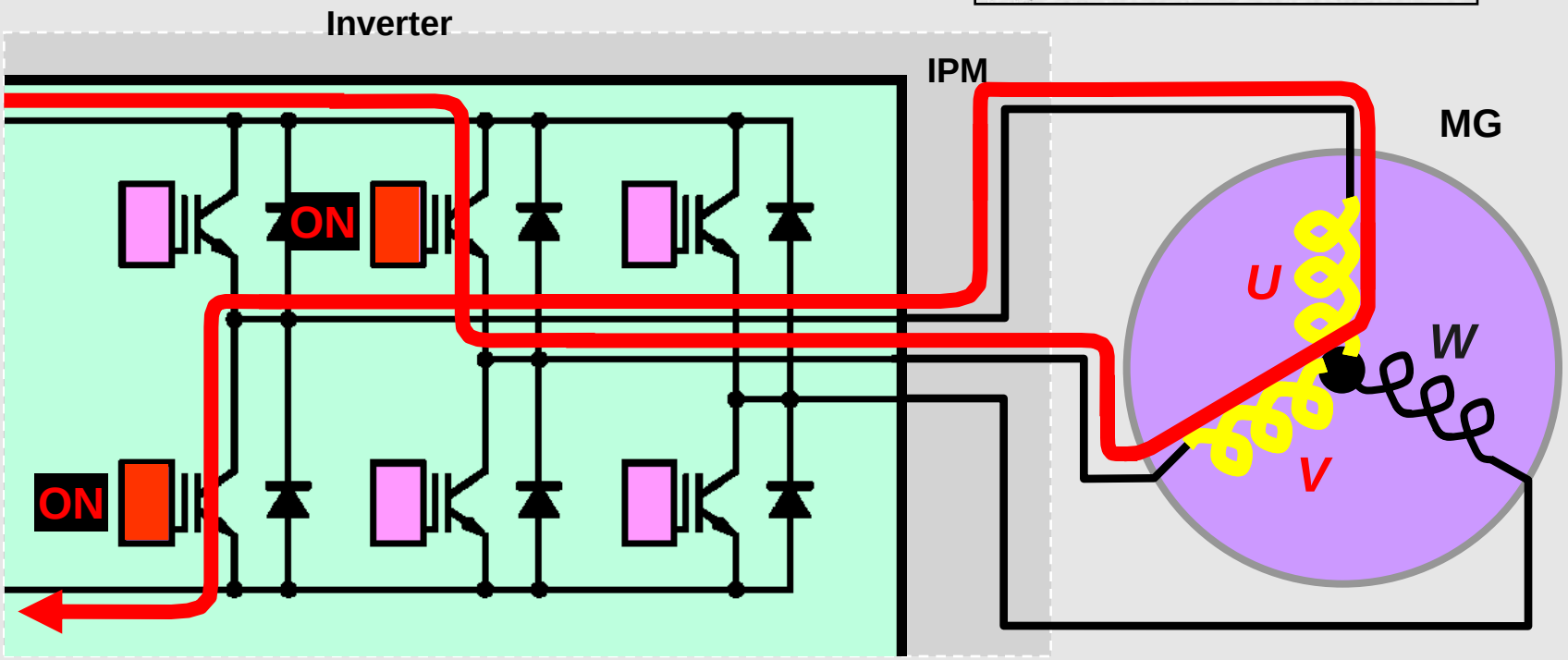


TOYOTA

Inverter Assembly

- Inverter Operation
  - Motor drive

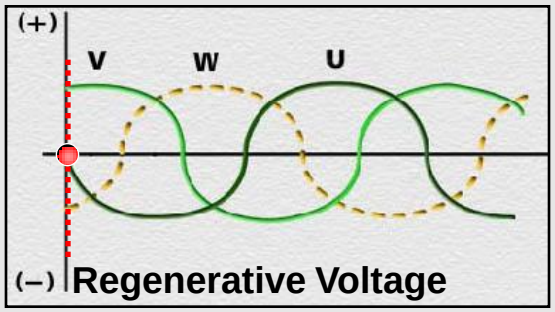


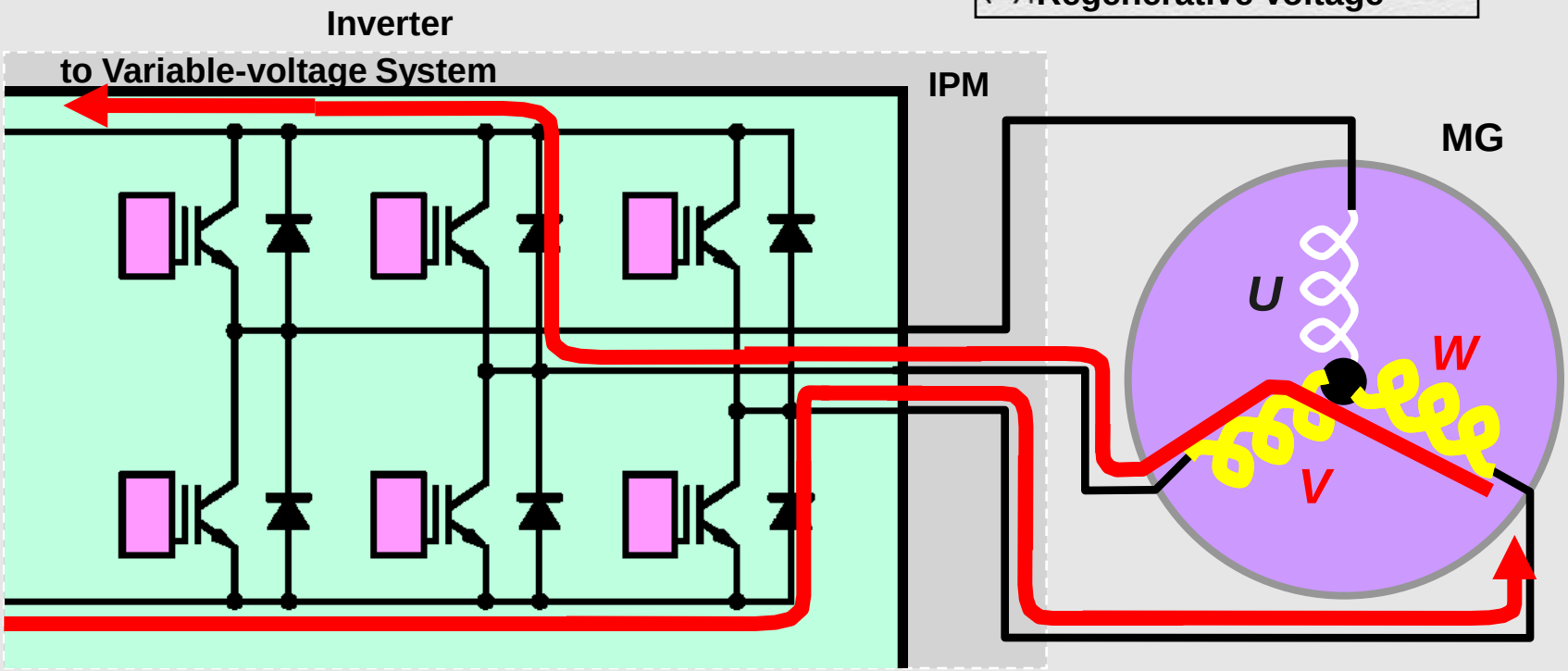


TOYOTA

Inverter Assembly

- Inverter Operation
  - Regeneration

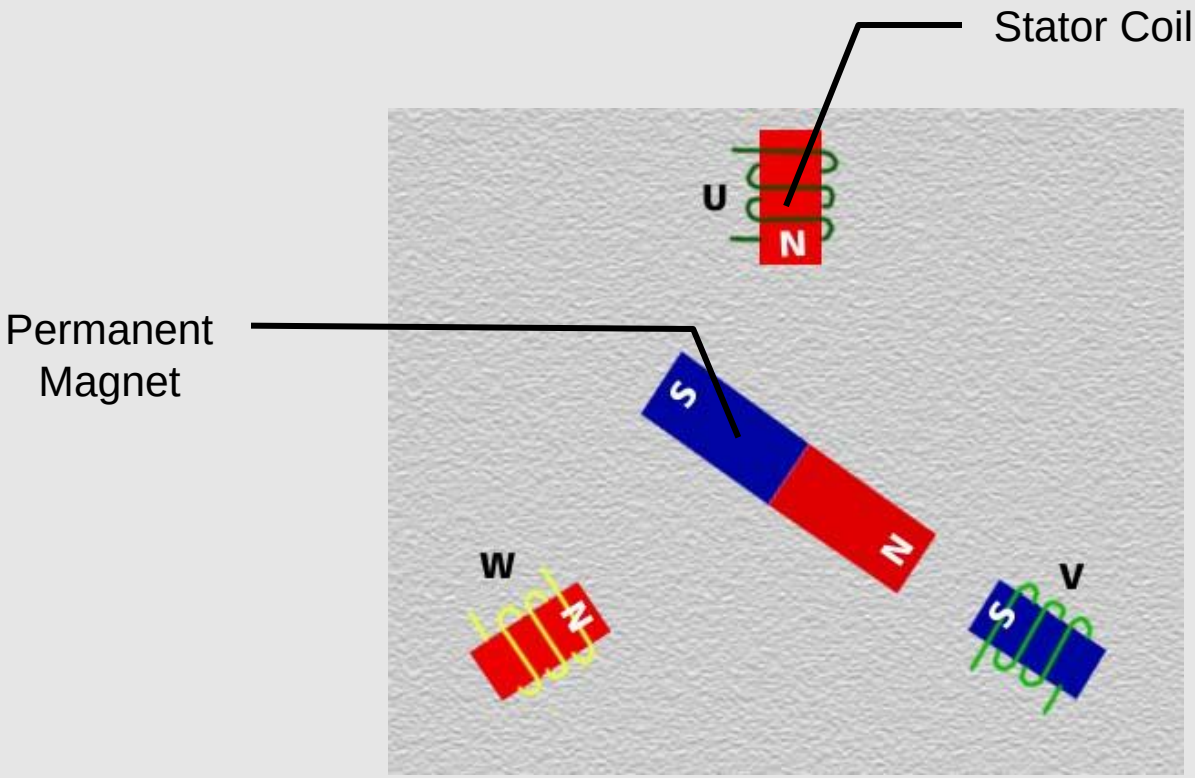




TOYOTA

Inverter Assembly

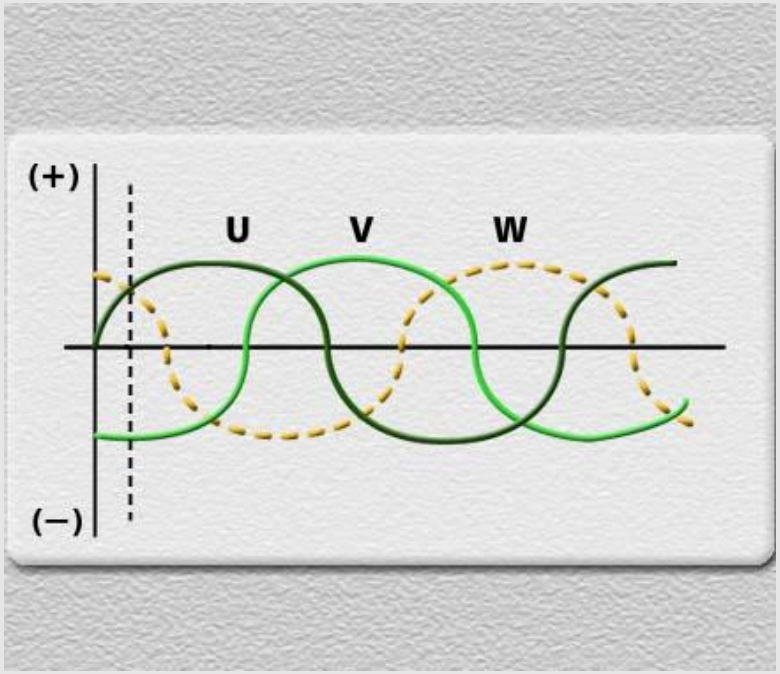
- Inverter operation

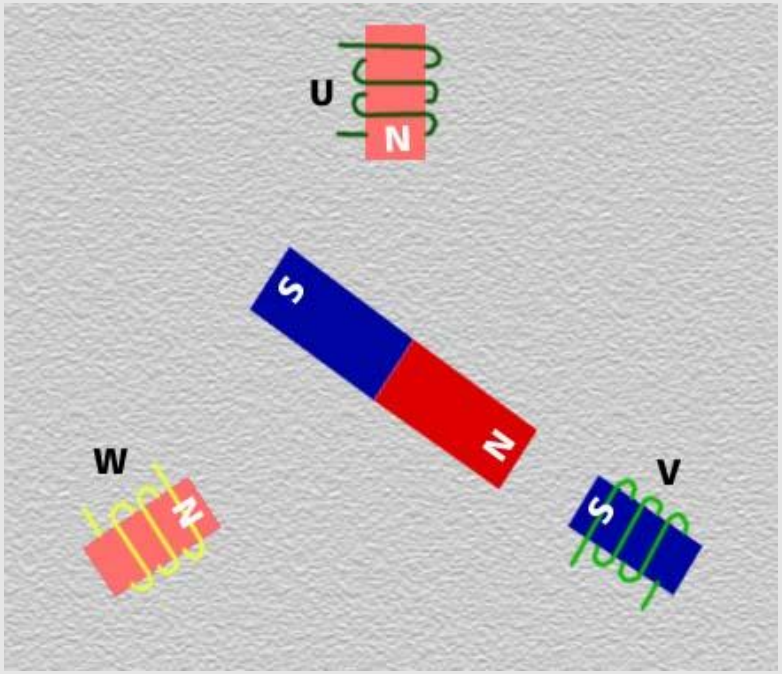


TOYOTA

Inverter Assembly

- MG1 / MG2
  - Stator coil polarity and magnetic strength changes moment by moment

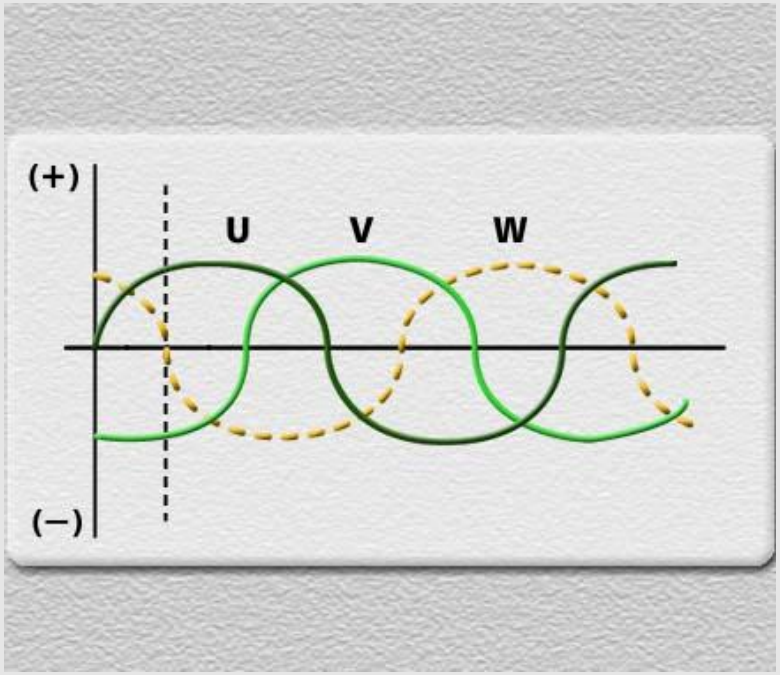


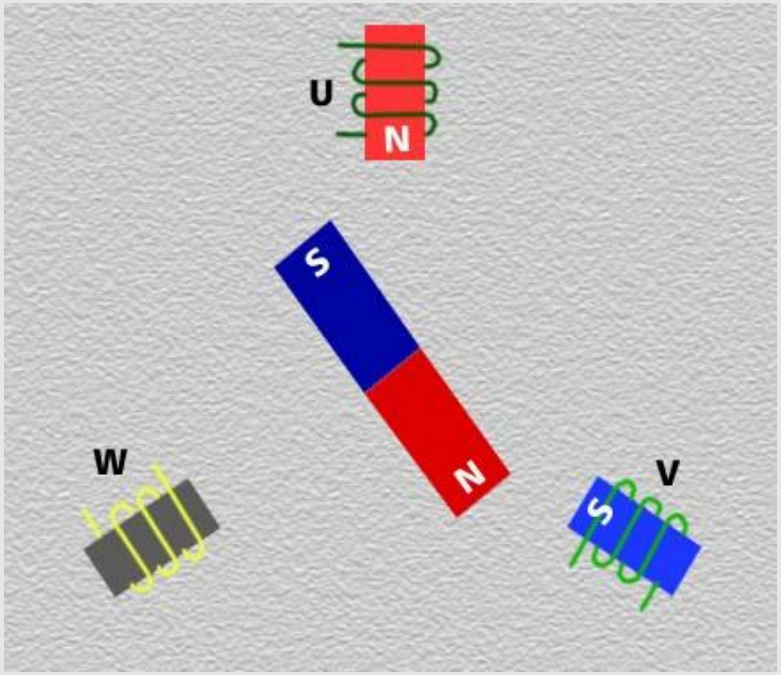


TOYOTA

Inverter Assembly

- MG1 / MG2
  - Rotor of permanent magnet is rotated via attraction / repulsion from stator coil

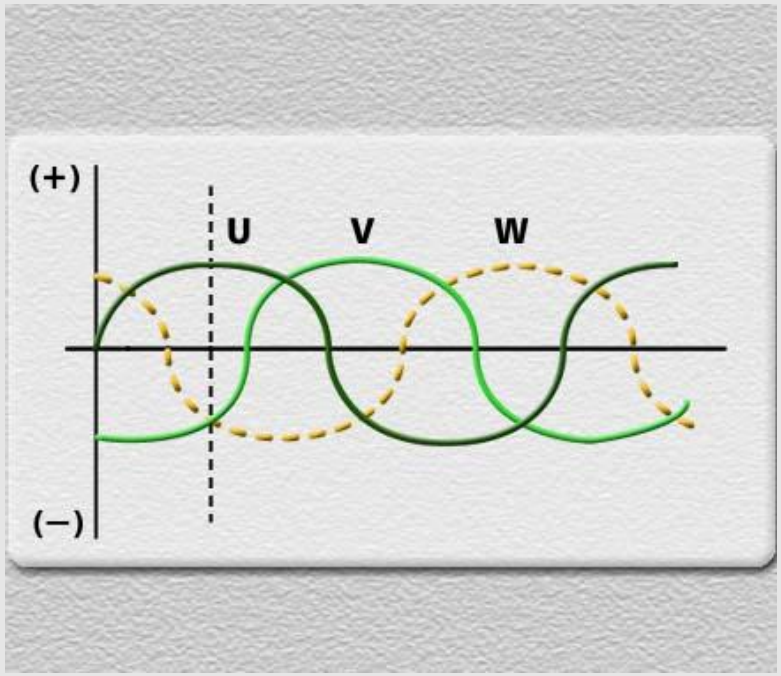


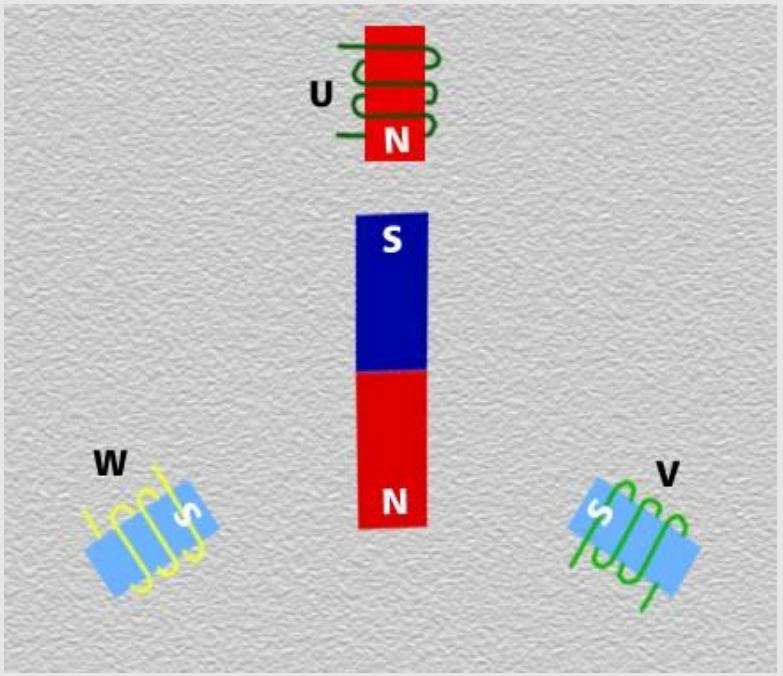


TOYOTA

Inverter Assembly

- MG1 / MG2

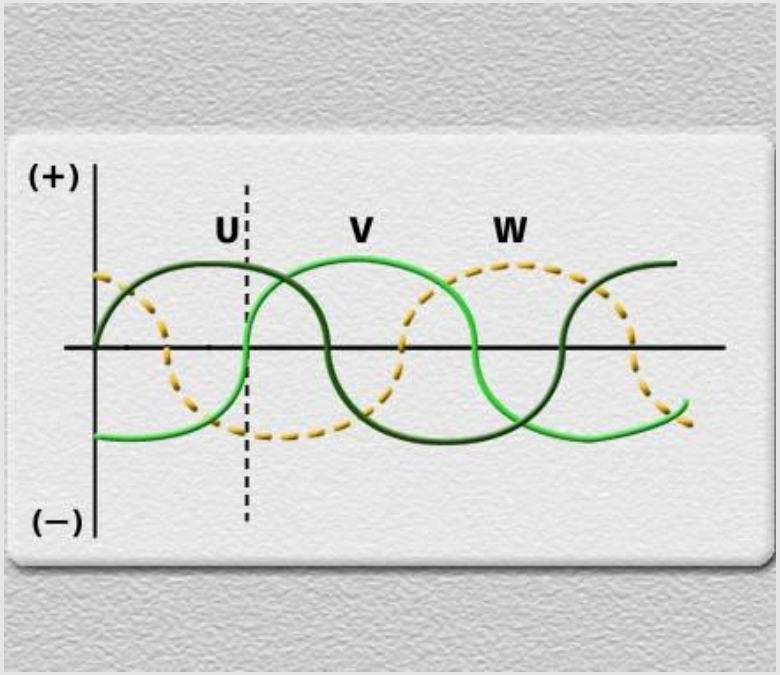


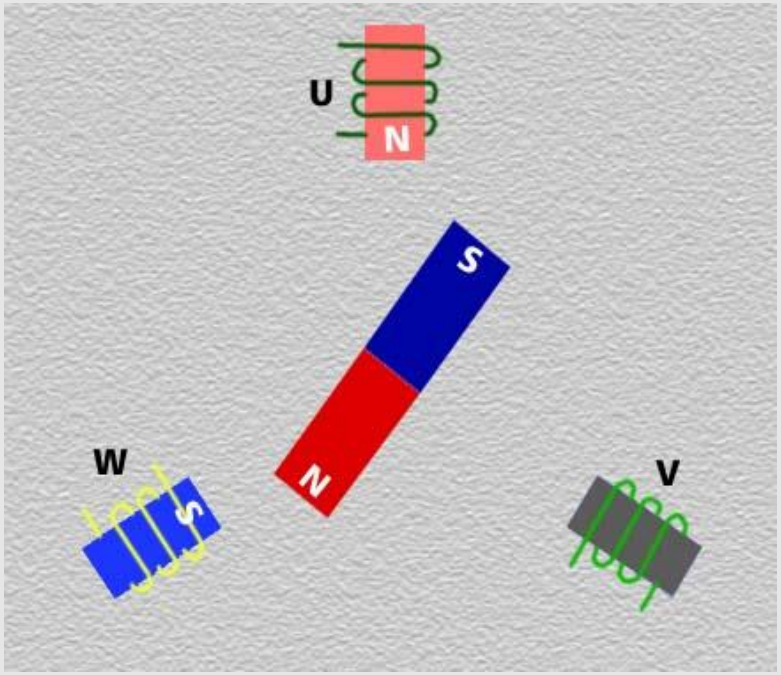


TOYOTA

Inverter Assembly

- MG1 / MG2





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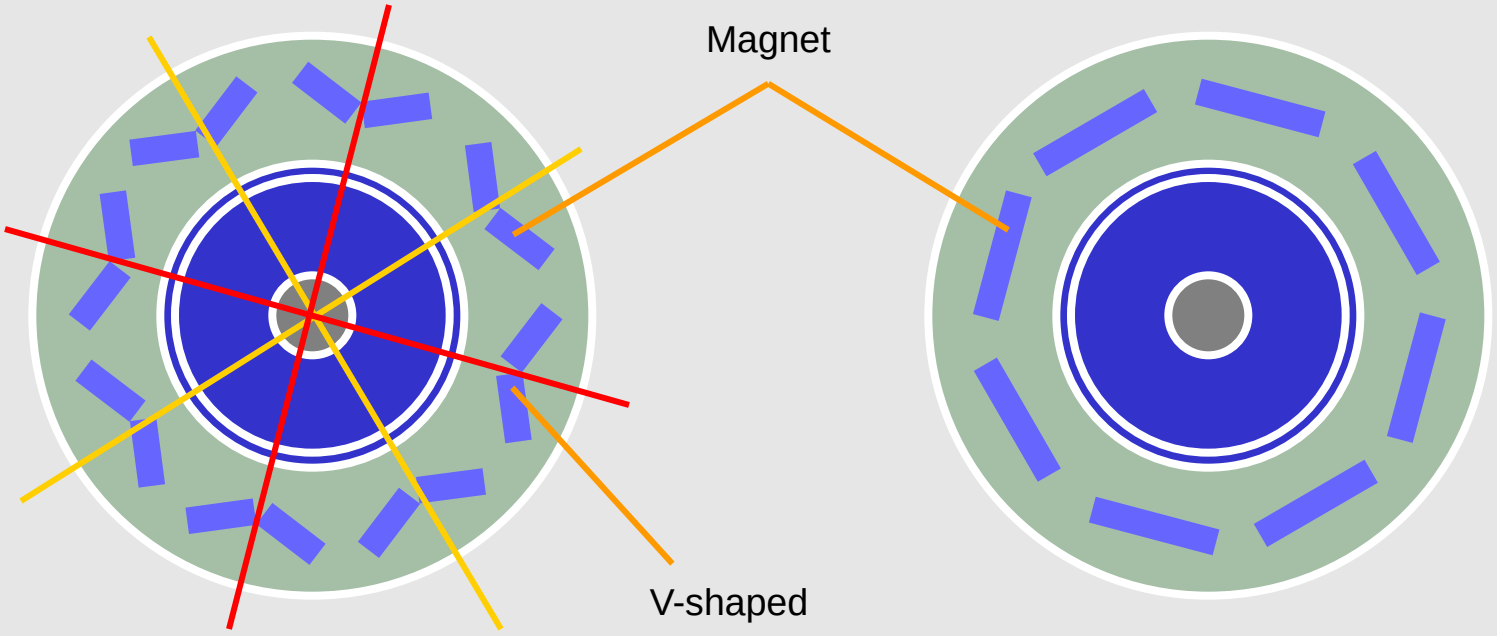
Motor Control

- Rotor magnets



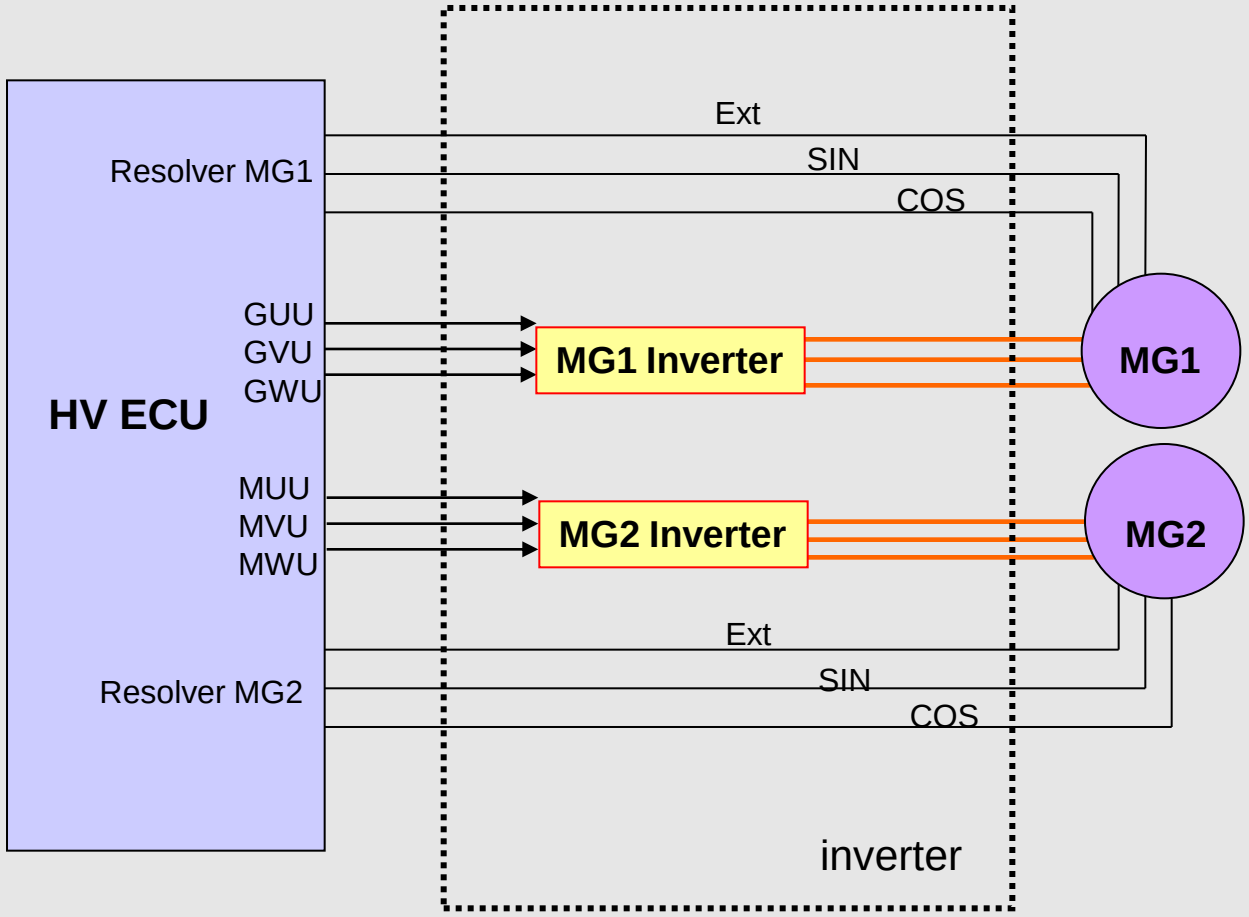
MG2 Rotor (’04 PRIUS)

MG2 Rotor (’03 PRIUS)

TOYOTA

Inverter Assembly

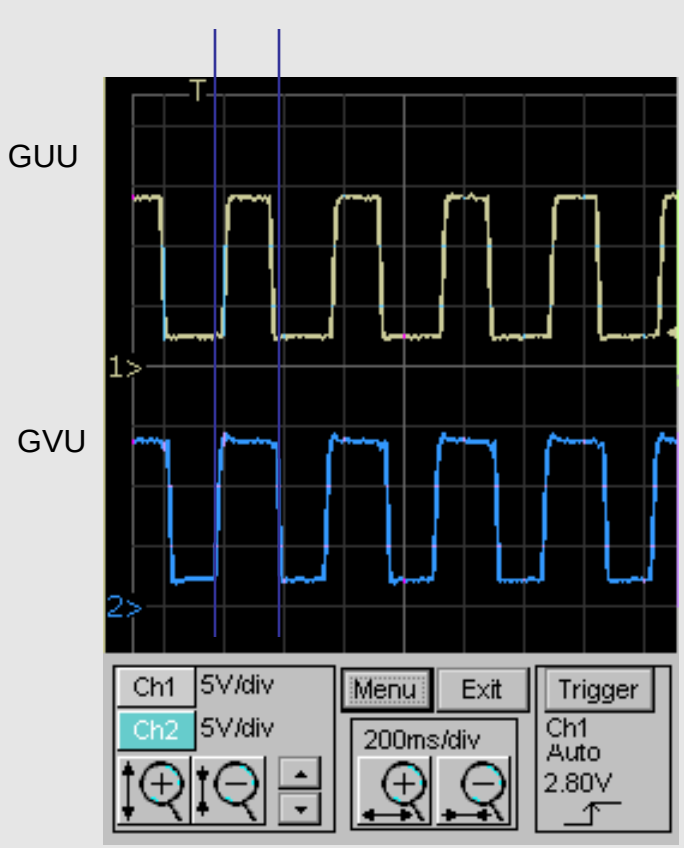
- Prius



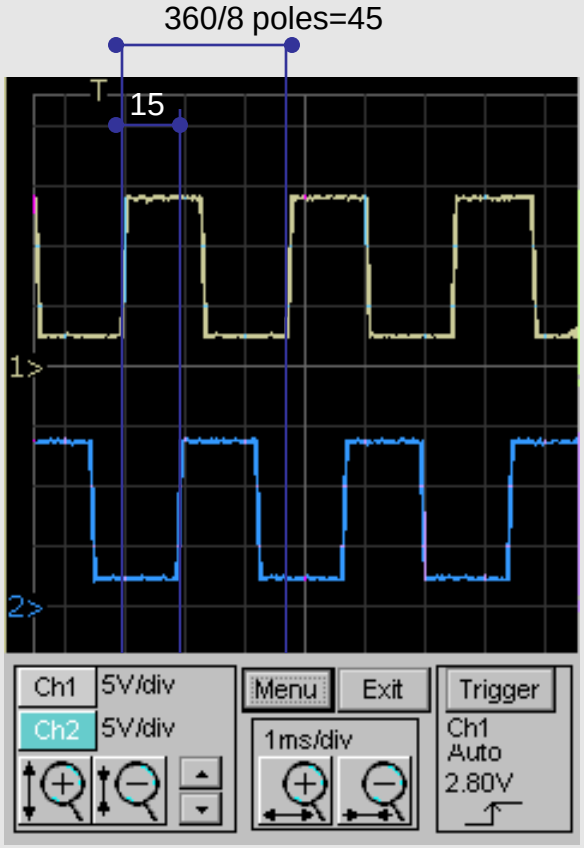
TOYOTA

Inverter Assembly

- GUU, GVU and GWU



IGN ON



Engine running

TOYOTA

Inverter Assembly

- Gate control of IGBT

GUU

PWM

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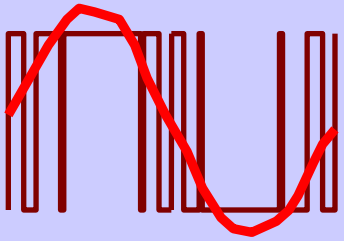
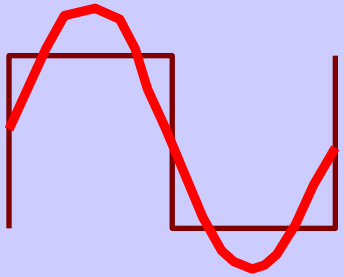
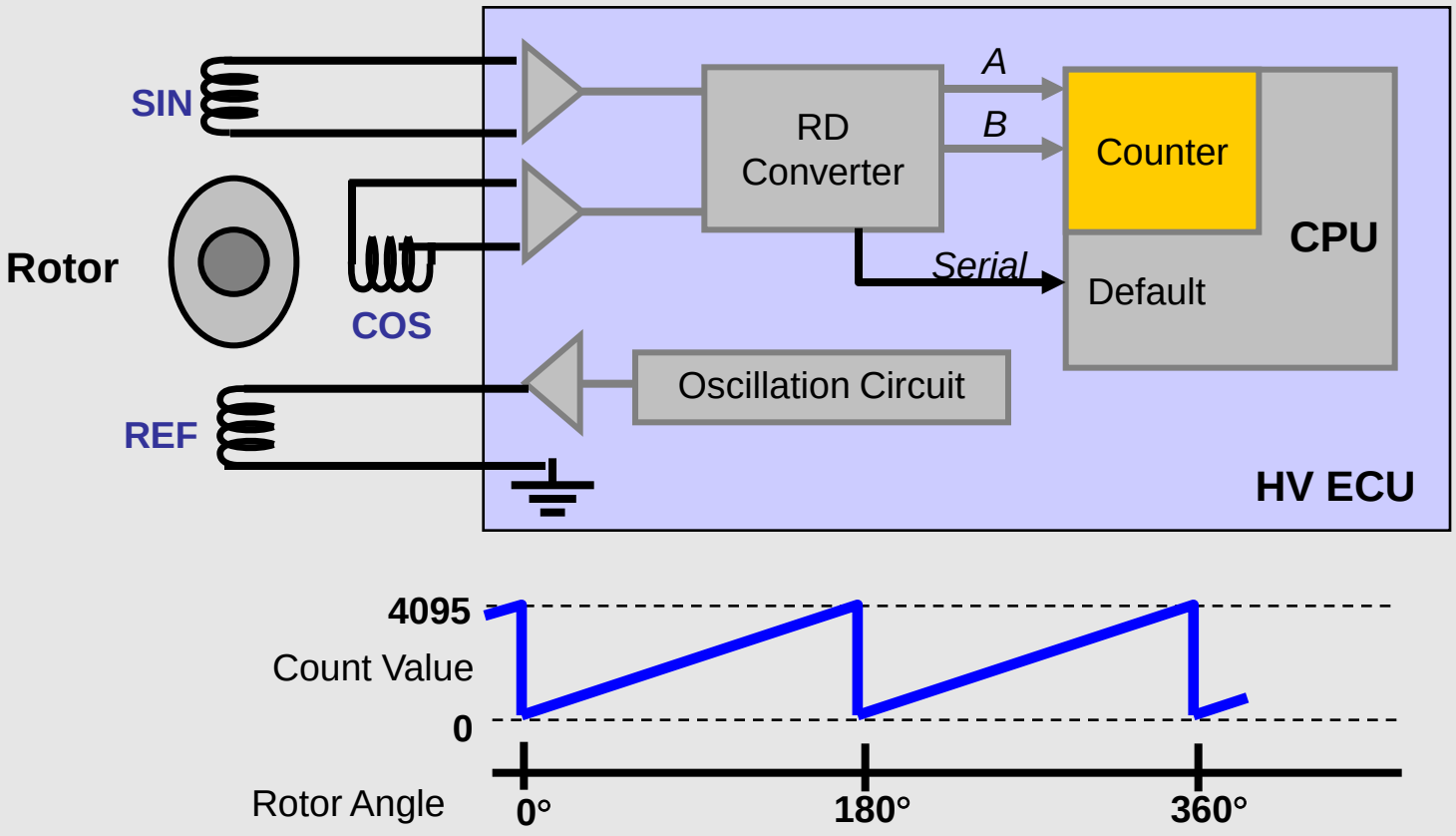
Motor Control

- Increase of Utilization Voltage
  - Kinds of voltage control

	Low Speed	Middle Speed	High Speed
Current Waveform			
Utilization Rate	0 – 0.61	0.61 – 0.78	0.78
Feature	Small Torque Fluctuation	Output Improvement	

Motor Control

- Resolver



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THS II

- Resolver operation

Resolver_A.ppt

Resolver_M.ppt

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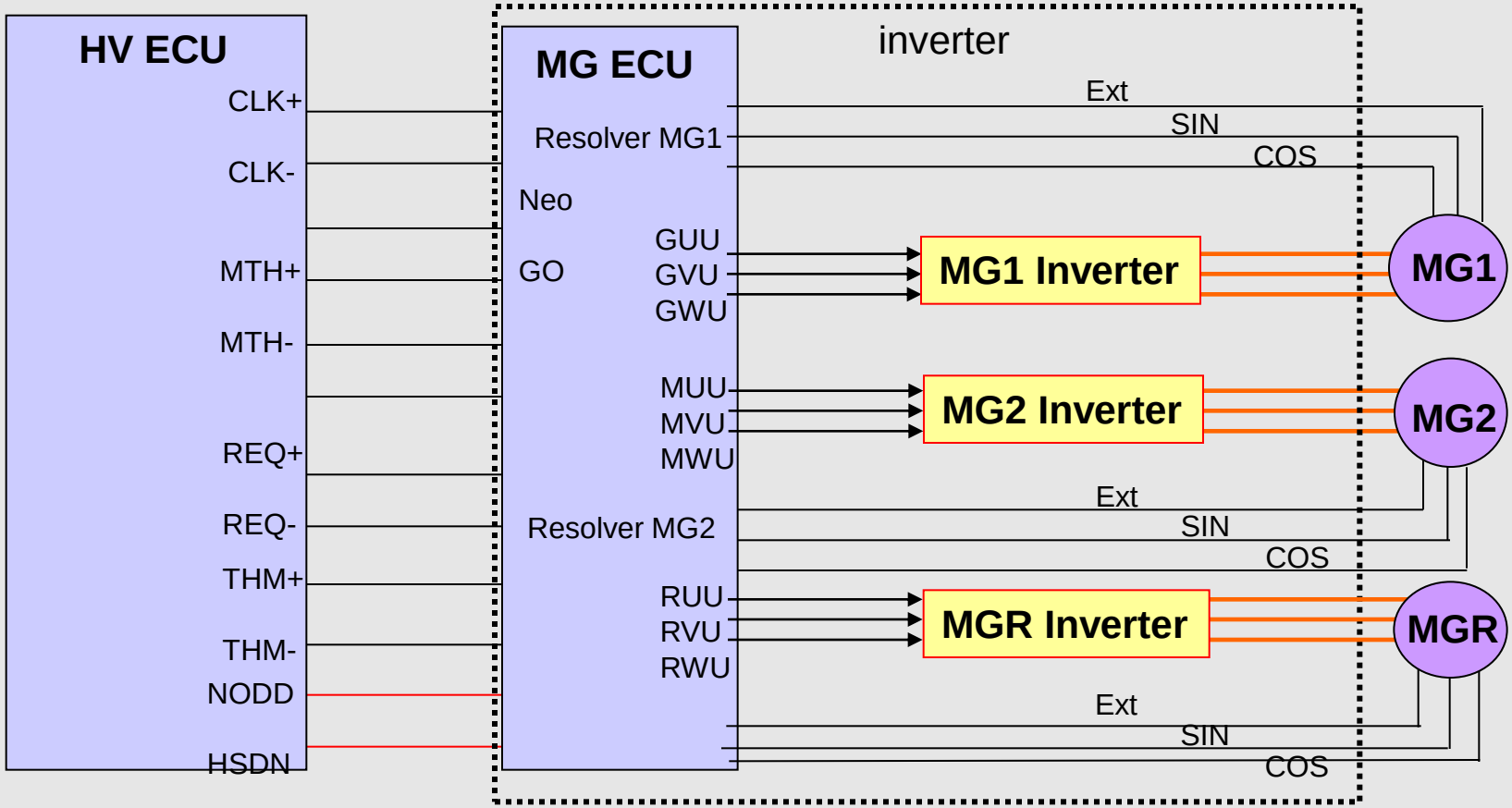
Inverter Assembly

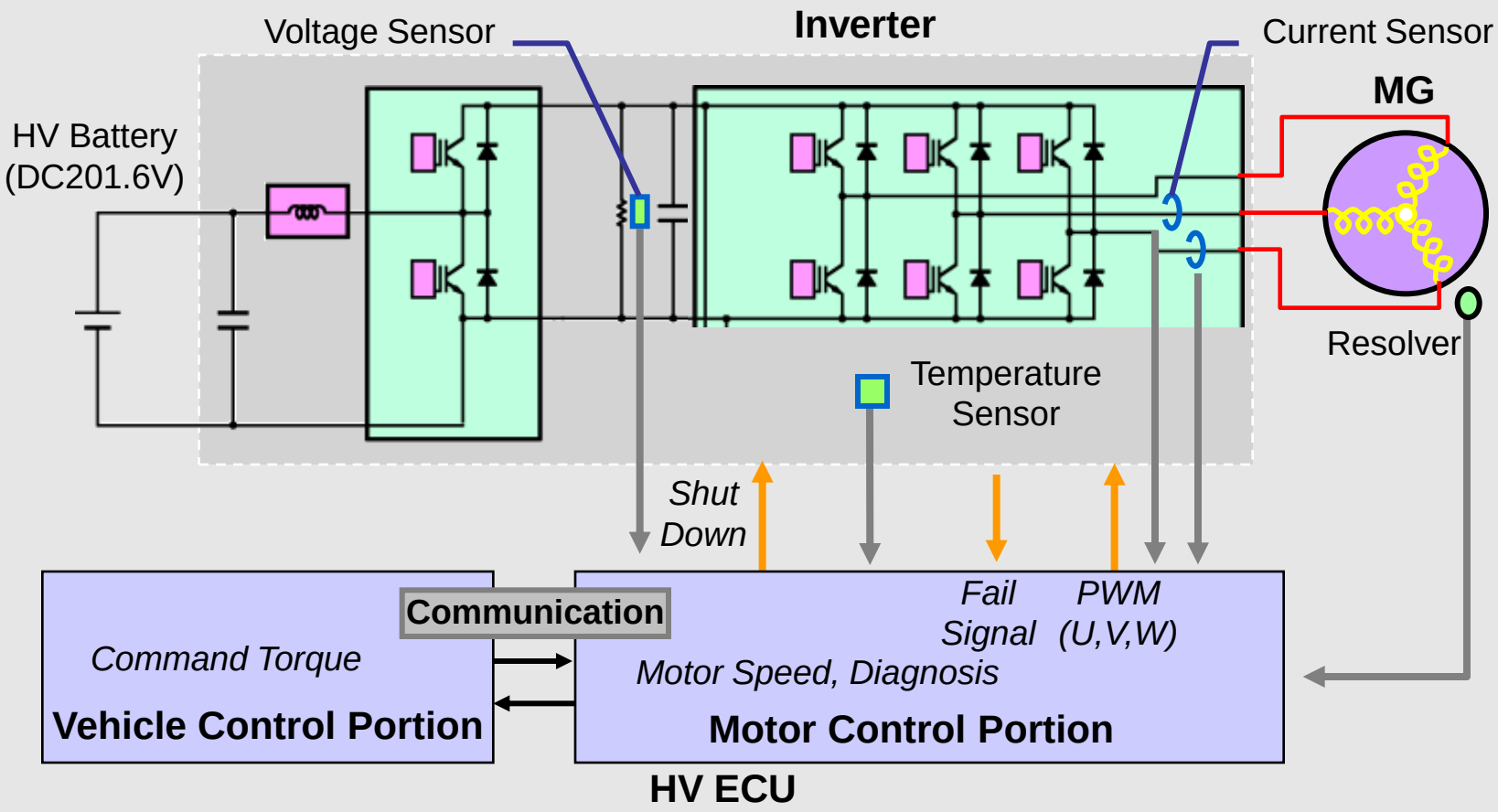
- RX400h



TOYOTA

Motor Control

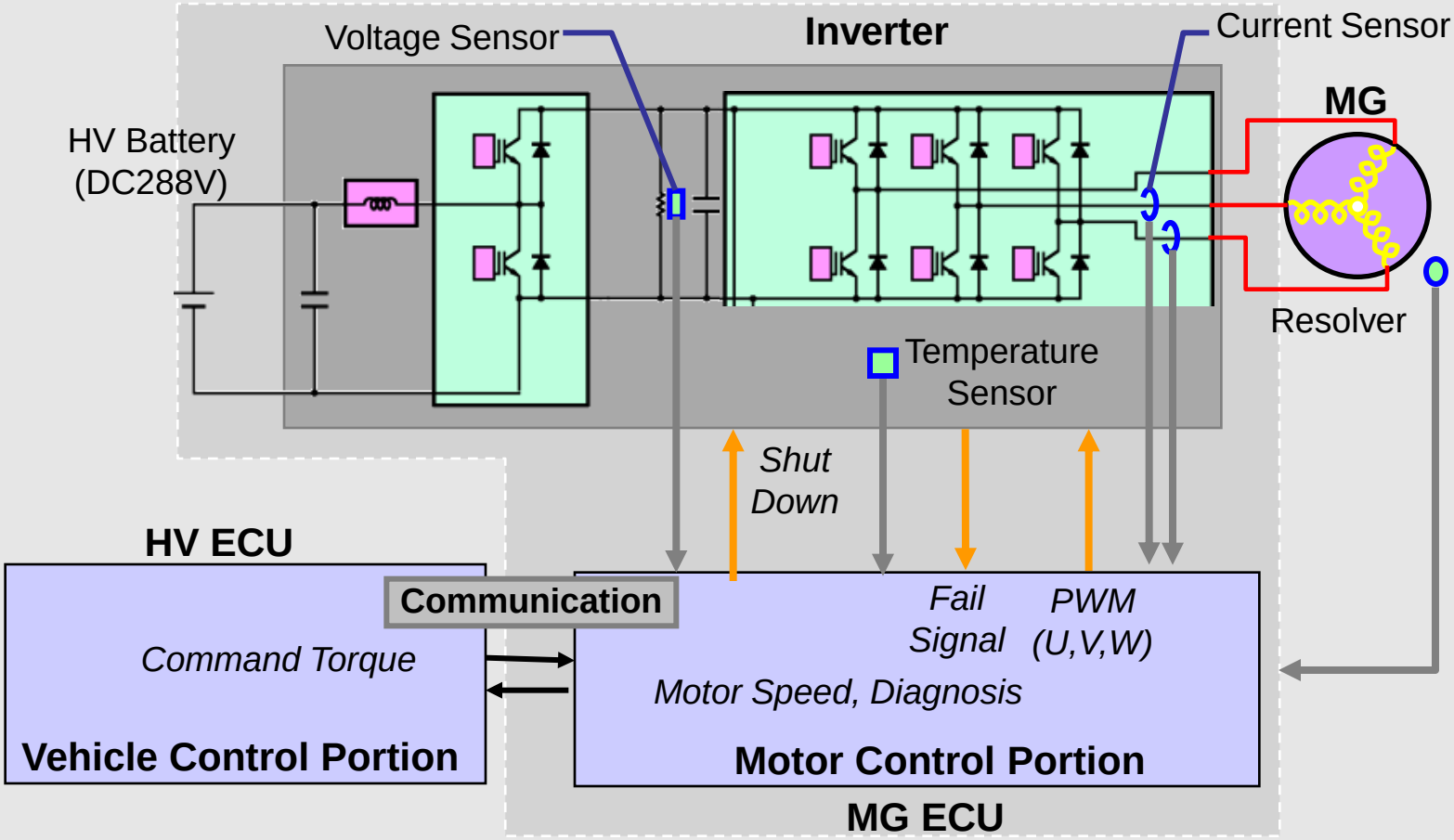
- System Diagram (PRIUS)



TOYOTA

Motor Control

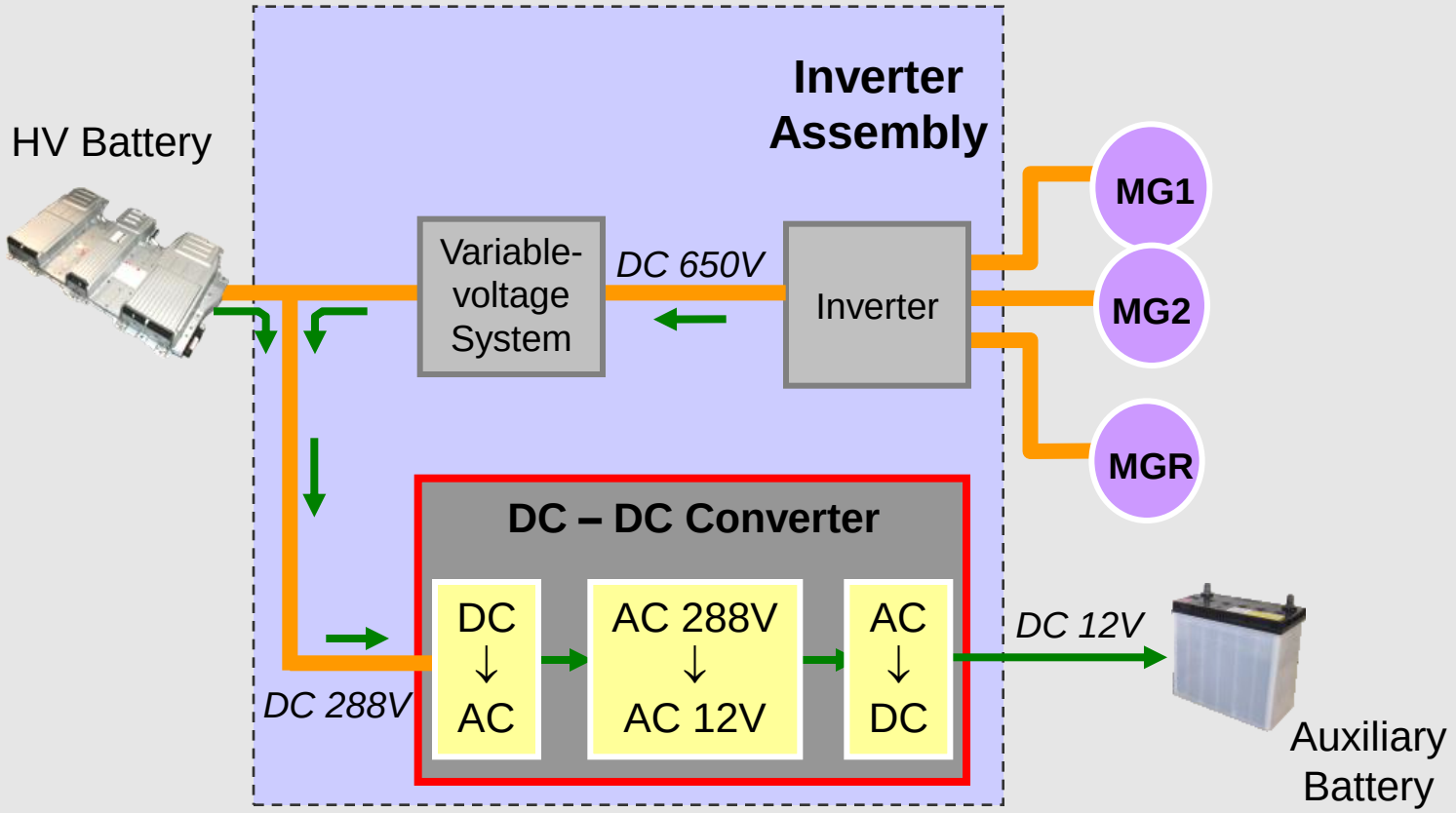
- System Diagram (RX400h)



TOYOTA

Inverter Assembly

- DC – DC Converter
  - Converts DC 288V → DC 12V



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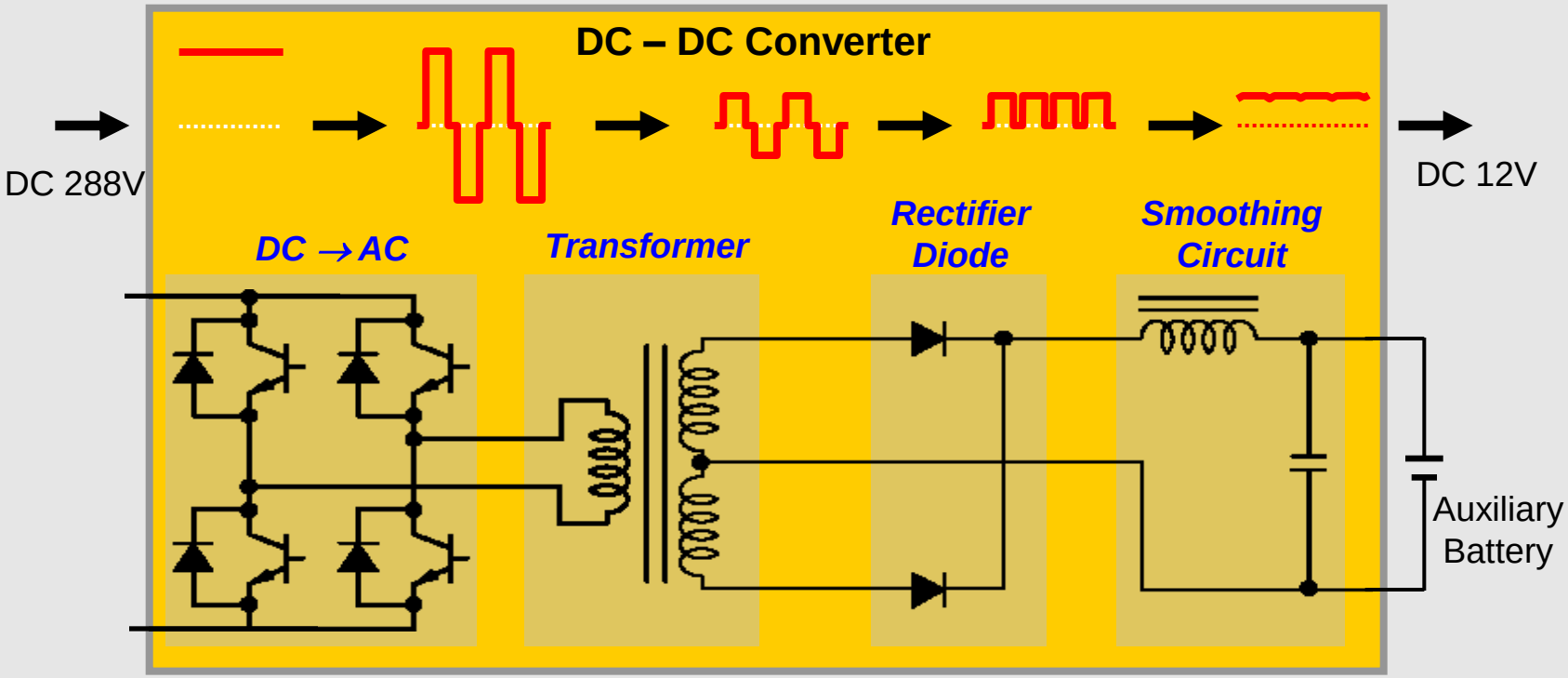
Inverter Assembly

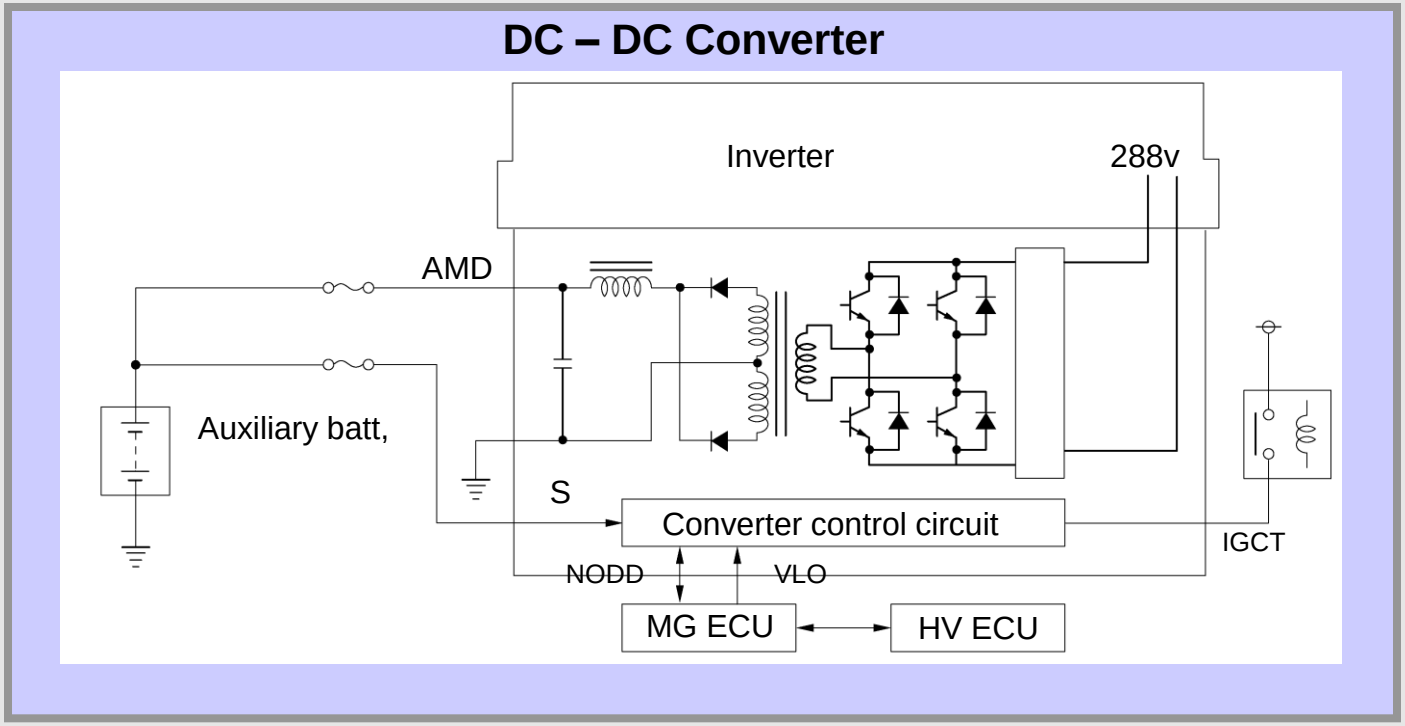
- DC – DC Converter
  - Operation



TOYOTA

Inverter Assembly

- DC – DC Converter
  - Operation



TOYOTA

Auxiliary Battery

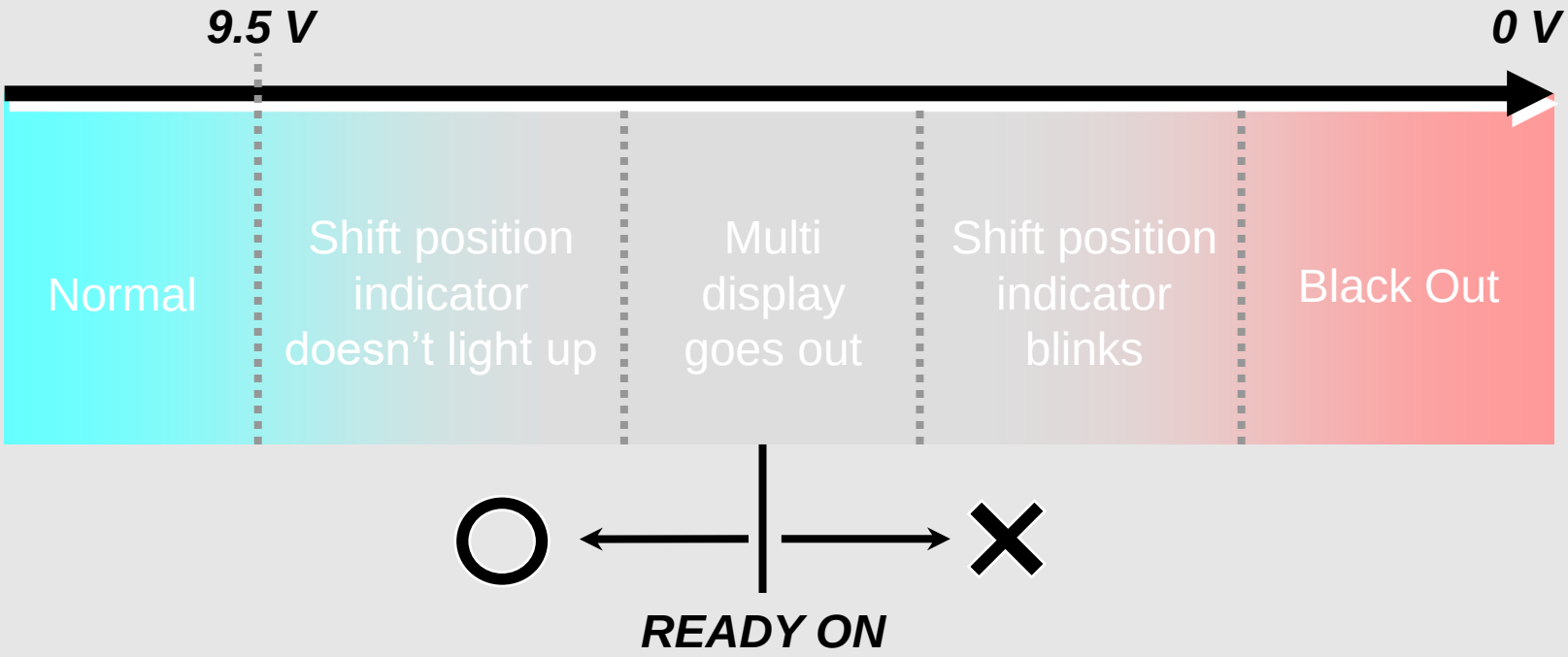
- Vehicle conditions when auxiliary battery low voltage

Vehicle Condition	Auxiliary Battery Voltage	
	PRIUS	RX400h
Shift position indicator doesn't light up *(It can turn to READY ON)*	9.5 V or less	9.5 V or less
It cannot turn to READY ON	7 V or less	8.6 V or less

Auxiliary Battery

PRIUS

- Vehicle conditions when auxiliary battery low voltage



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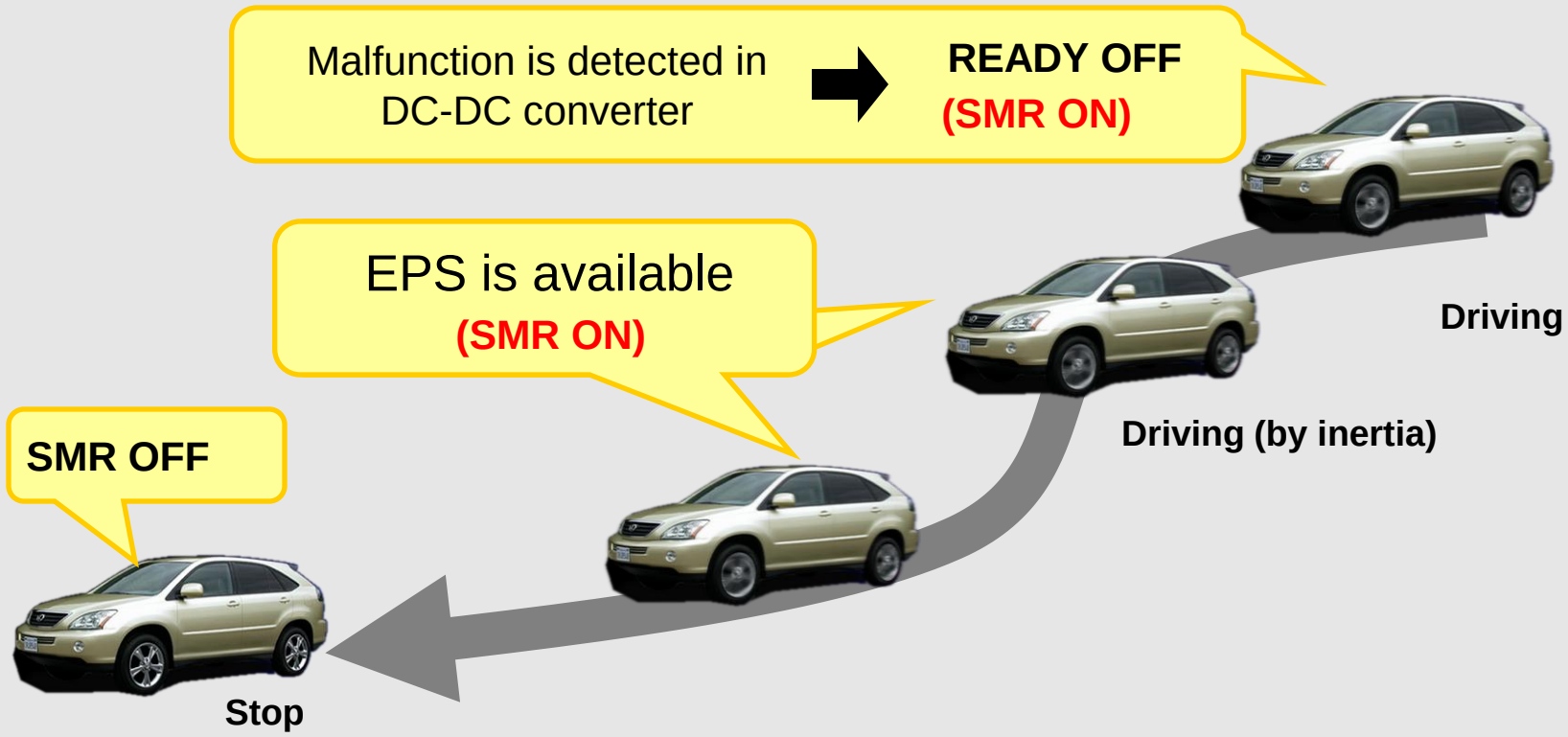
Service Point for RX400h

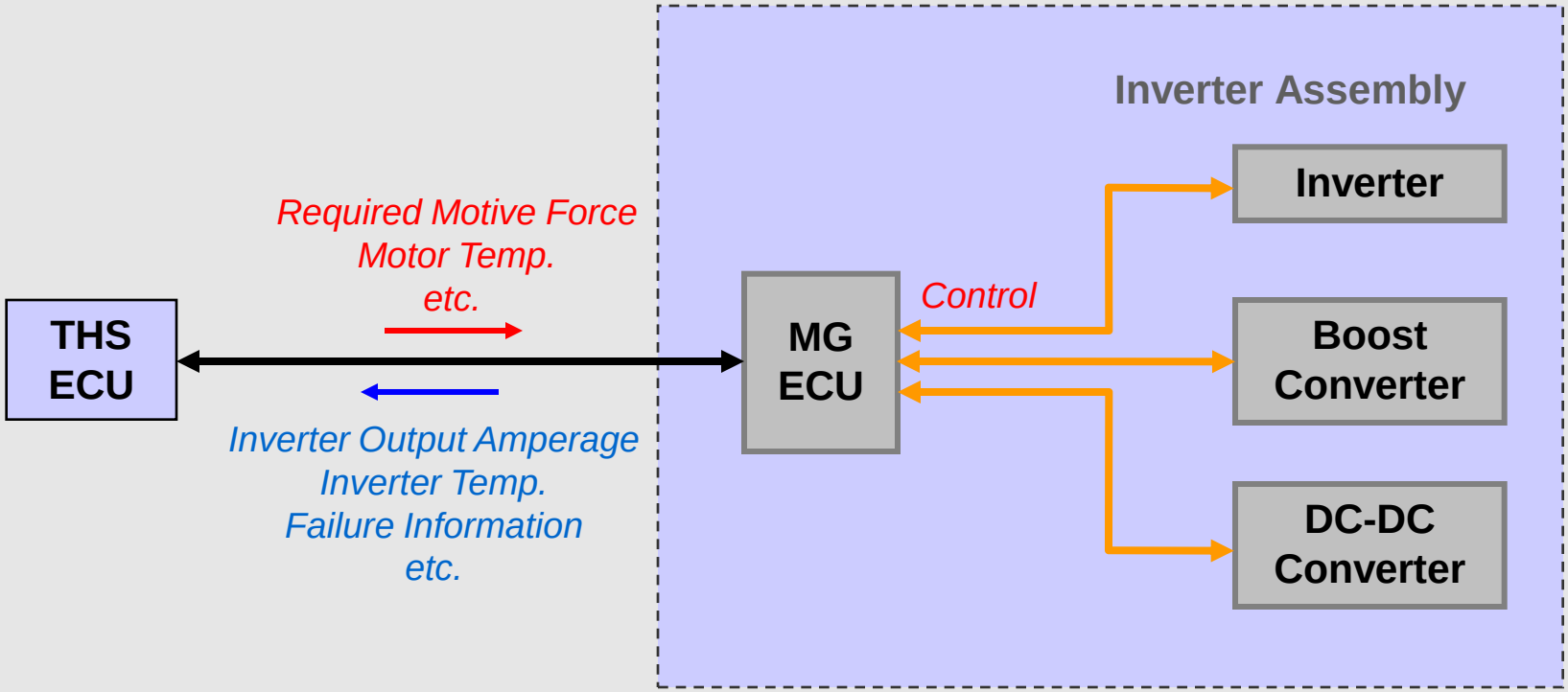
- Fail-safe
  - DC-DC converter (for auxiliary battery) malfunction



TOYOTA

Inverter Assembly

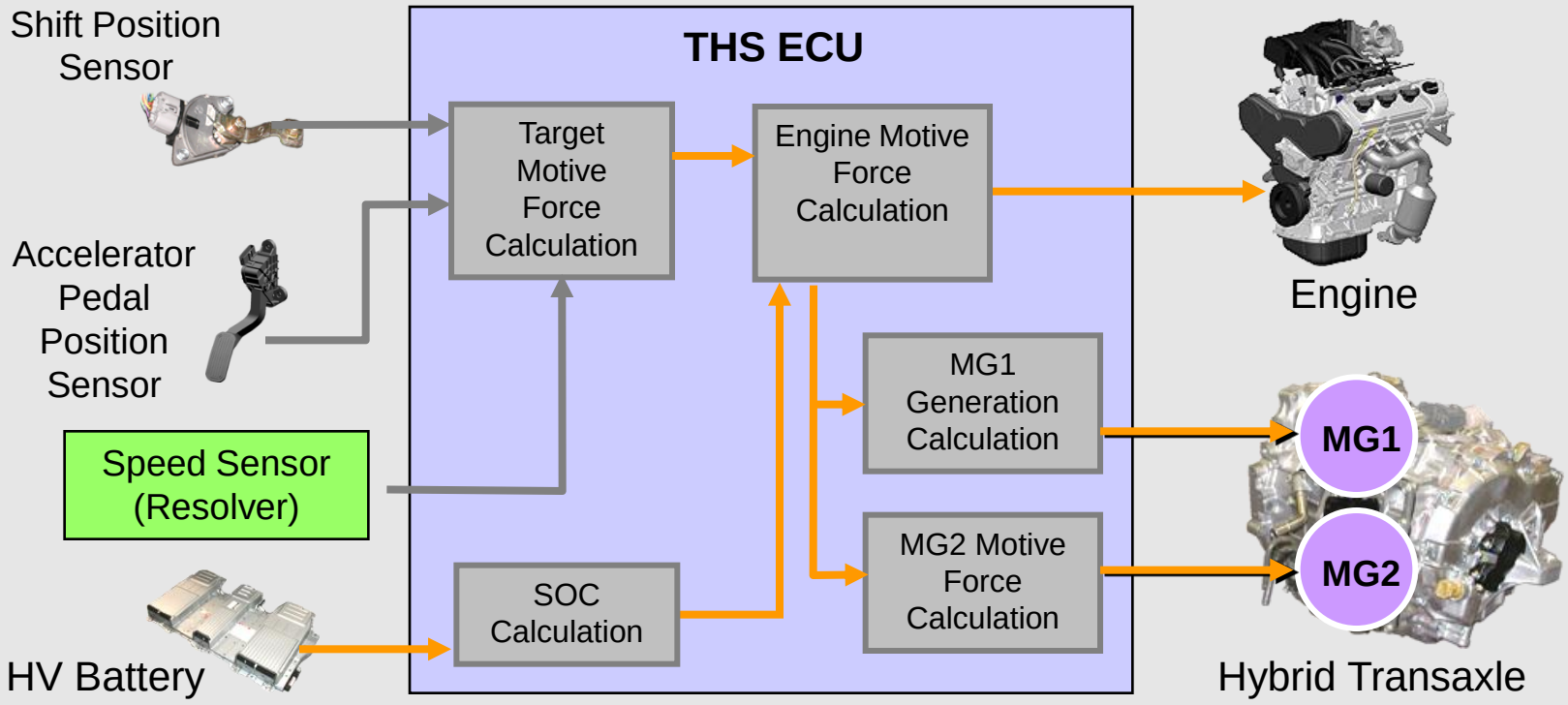
- MG ECU
  - Controls the inverter components in accordance with the signals from the THS ECU



TOYOTA

THS-II Control System

- Motive Force Calculation
  - Target Motive Force - Engine Motive Force = MG2 Motive Force



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Toyota Hybrid Synergy Drive®

Service & safety

TOYOTA

Content

1. Disable Vehicle for Service

- Procedure
  - **READY indicator**
  - **Service Plug**
  - Precautions
  - **Insulated gloves**
  - **Waiting period before service (discharge time HV condensers)**
  - **“CAUTION” sign during service**
  - **High Voltage colour code**

2. Hybrid vehicle storage
3. Emergency response guide
4. Roadside Assistance

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Disable Vehicle for Service

Warning:

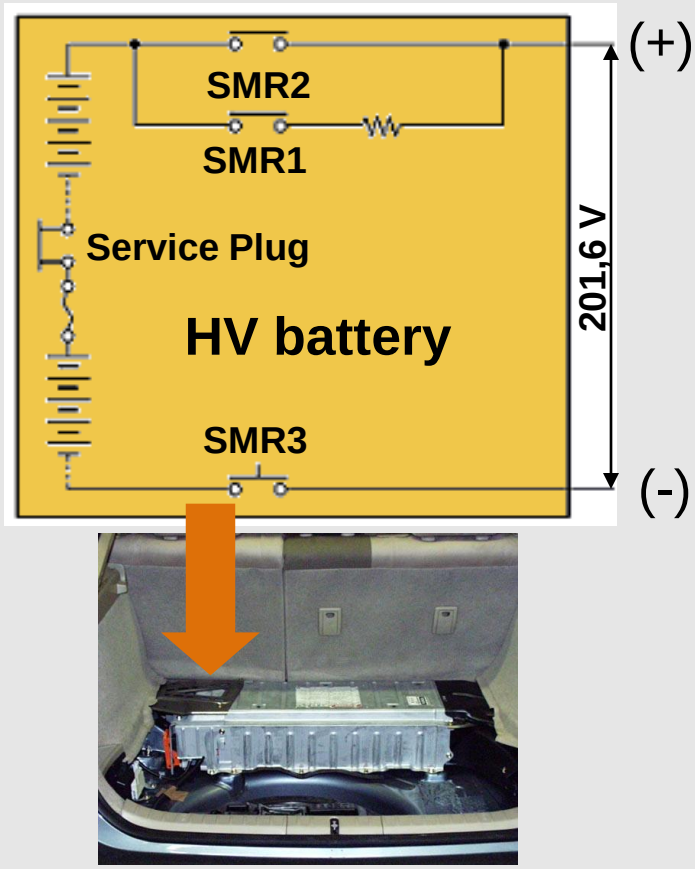
- **= Engine may run**

- **Never** assume the Prius is **shut OFF**, simply **because** it is **silent**.

- **Always observe** the instrument cluster for the **READY indicator** status to verify whether the vehicle is ON or shut OFF.

TOYOTA

Disable Vehicle for Service



- Push POWER button to turn **READY OFF**

→ **S**ystem **M**ain **R**elays (**SMR**) turn OFF:

  – To disconnect HV battery from HV circuit

- **Disconnect 12V** battery
- Remove HV battery **Service Plug**

  - Cuts the high voltage circuit (wear insulated gloves)

- Place Service Plug **in your pocket**
- Wait **5 minutes** (discharge HV condensers of Inverter)

Note: *Collision control:*

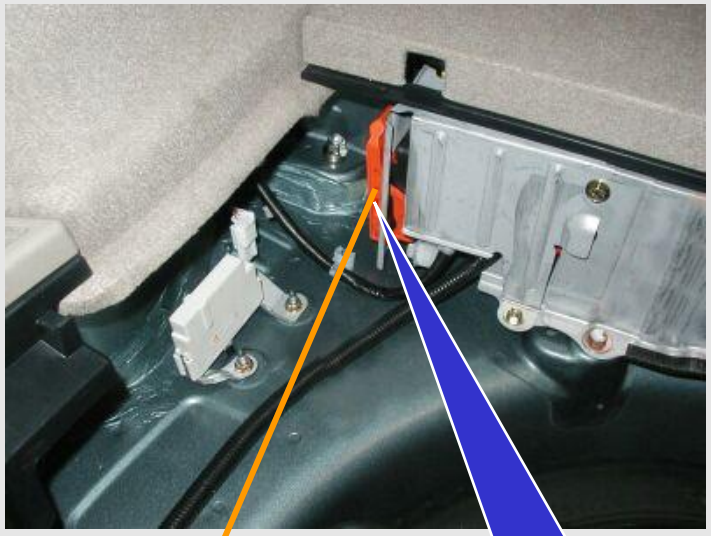
  - *SRS Airbag sensor + sensor in Inverter turn SMR relays OFF*

TOYOTA

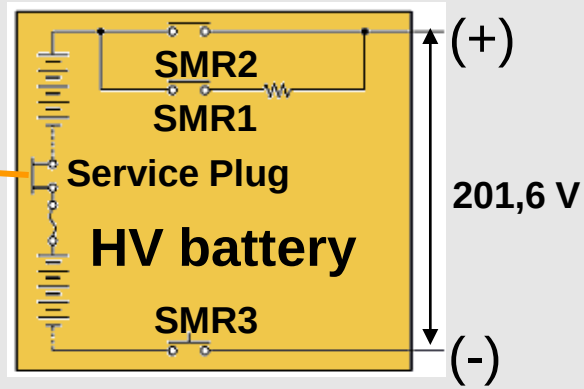
Disable Vehicle for Service

Service Plug:

- **Disable high voltage** current from the HV battery
- **Cuts** high voltage circuit between No.19 and No.20 module
- **125 A fuse** is integrated



Service Plug



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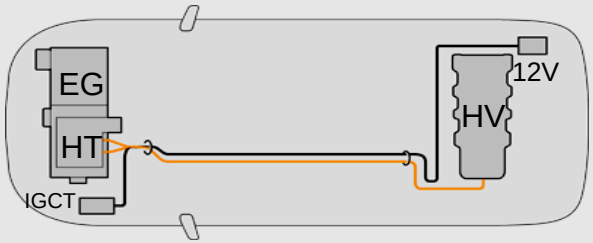
Disable Vehicle for Service

Precautions:

- Wearing HV **insulated gloves while removing** the **Service plug**.

- Place it **in your pocket**.
  (Prevent other technicians from reinstalling it while you are servicing the vehicle)

- **Wait 10 minutes** before touching any HV terminals or connectors.
  (to **discharge HV condensers** inside the inverter)
- All high-voltage wire harness connectors are colored **orange.**



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Disable Vehicle for Service

HV Battery

- Service Plug
  - Installation

Connect the service plug

Turn the lever

Push the lever downward until the **“click”** is heard

Caution: Wear insulated gloves

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Disable Vehicle for Service

Precautions:

- Before wearing HV insulated gloves:
  - Ensure they are **not cracked**, **ruptured**, **torn** or damaged in any other way.
  - Do **not wear wet** insulated gloves.

- When servicing the vehicle:
  - Do **not wear metal objects** like self-propelling pencil, ruler or other objects that may drop and cause a short circuit.

- Before touching a **bare HV terminal**:
  - **Ensure** the terminal has **no voltage** using a **multimeter** whilst wearing HV insulated gloves.

- After **disconnecting or exposing** a HV connector or terminal:
  - **Insulate** it immediately using **insulation tape**.

- The screw of a **HV terminal** should be tightened firmly to the **specified torque**. Both insufficient and excessive tightening torque can cause failure.

Disable Vehicle for Service : HV system awareness

Precautions:

- Draw attention to the vehicle on which the HV system is being inspected or repaired by placing a "**CAUTION: high voltage do not touch during operation**" sign.

- **After servicing HV system** and before reinstalling Service Plug, check again that:
  - you have not left a part or tool inside
  - the HV terminal screws are firmly tightened
  - the connectors are correctly engaged.
- All **high-voltage** wire harness connectors are colored **orange**.

TOYOTA

Disable Vehicle for Service

Do **not** place HV battery **upside down** while removing and installing it.

Install Service Plug before starting the system:

- Starting Hybrid system with Service Plug removed may damage the vehicle.

Car storage & battery maintenance

HV Battery (201,6 V)

Auxiliary 12 V Battery (Sealed-type)

12 V Power Source Backup Unit for ECB brakes

Auxiliary 12 V battery

- Supplies power to headlights, audio, other accessories and all ECU's
- Special for Prius
- Maintenance-free

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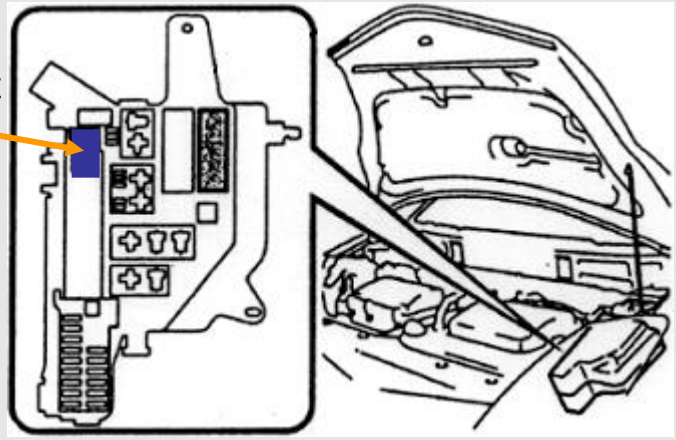
Car storage & battery maintenance



Auxiliary 12 V battery

- Before delivery:
  - Fully charge 12 V battery in slow charge (**max. 3,5 A**)
- In order to store the car for **more than 10 days**:
  - **Disconnect** wire harness **from jump start terminal** of **12 V** battery (prevent discharge due to current to ECU's and Smart key system)
  - **Close** the **cover** of the jump start terminal and **fasten** the **wire harness to** the **protruding part of** the **cover** (short circuit!)

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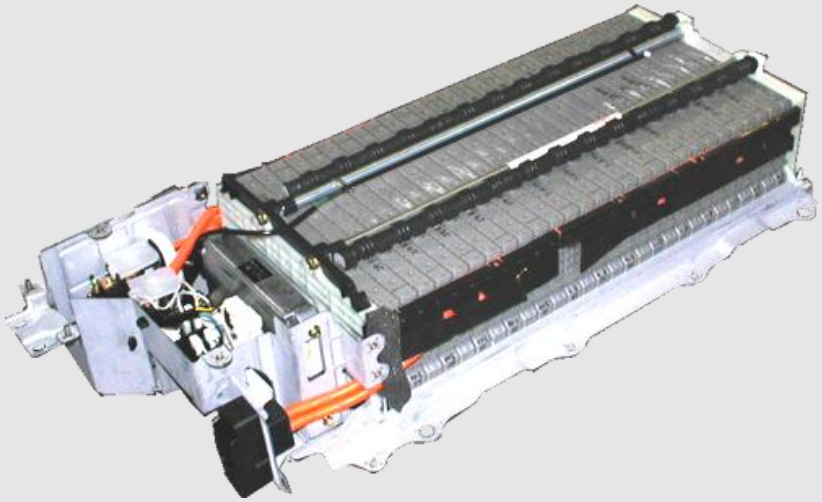
Car storage & battery maintenance



HV battery

- Every **two months**:
  - Keep “Hybrid system” ON (**READY ON**) for **30 minutes**
    (in order to charge HV battery and auxiliary battery - static current drop)

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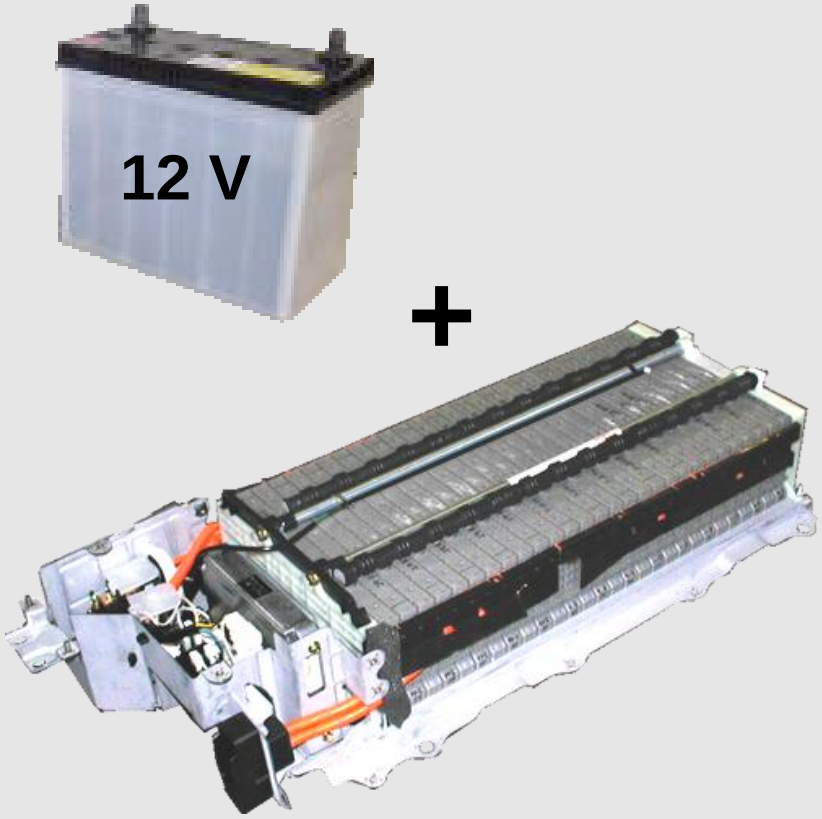
Battery maintenance by customer



Recommended

HV battery / 12 V battery charging by **customer**

- Charge every **2 weeks** for +/- 30 min.
  - By starting the hybrid system (“**ON**”)
  - All **electrical components OFF**
- Fully-charged **HV battery** can hold charge for +/- **60 days**

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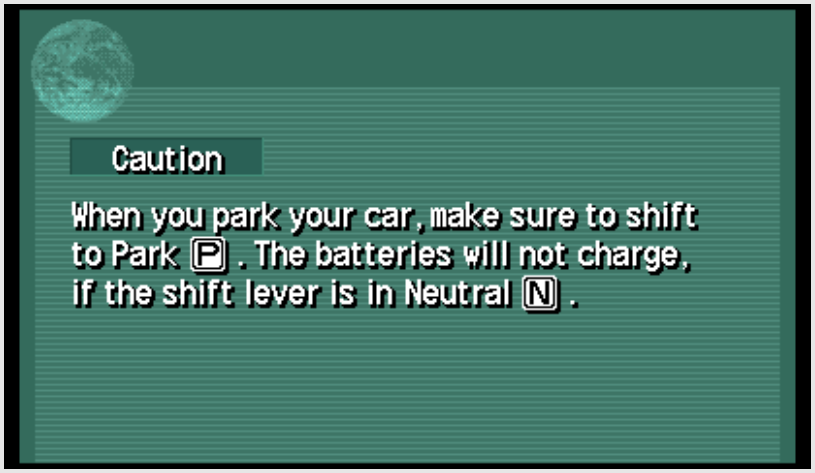
Car storage & battery maintenance



Message prompt in multi-display

Charging HV battery pack

- The HV battery will not be charged in the “N” position
- Generator operates only in “P”, “D” or “B” position
- In traffic jam: select “D”.
- If vehicle stopped for a long time: select “P” position!

TOYOTA

Car storage & battery maintenance

EV mode switch
(LHD model)

HV battery capacity

- EV mode:
  - +/- 1 km < 45 km/h
    on a level road
    (with standard state of charge
    of the HV battery)

TOYOTA

Car storage & battery maintenance

Power source backup unit:

- Supplies electric power to brake system when voltage power supply decreases
- When power mode turned OFF:
  - Power Source Backup unit starts to discharge
  - Is charged every trip

Mechanical fail-safe function

- Conventional *(non-assisted)* hydraulic brake on front wheels

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Car storage & battery maintenance

Too much discharged HV battery

- If HV battery voltage becomes too low:
  - Hybrid Synergy Drive® system stops operating to protect HV battery
- 201,6 V **HV battery** can **NOT** be **jumpstarted !**
- **Engine** is **started** by the 500 V “generator/motor” **using** 201,6 V **HV battery**
- **No HV battery charger** for NMSC’s
- Vehicle **cannot be push-started !** (similar to an automatic transaxle vehicle)

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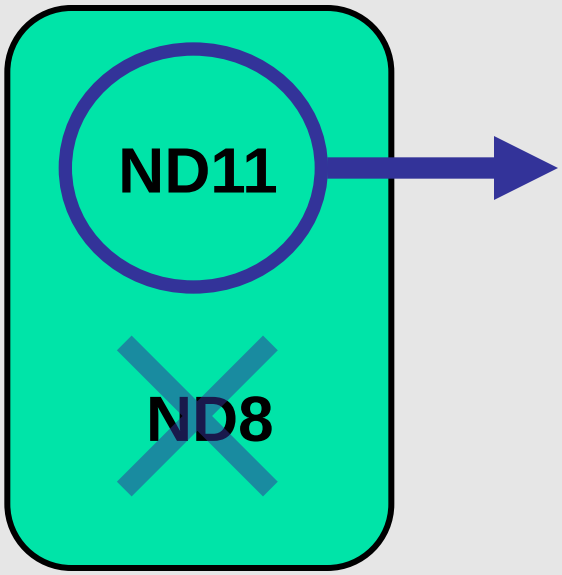
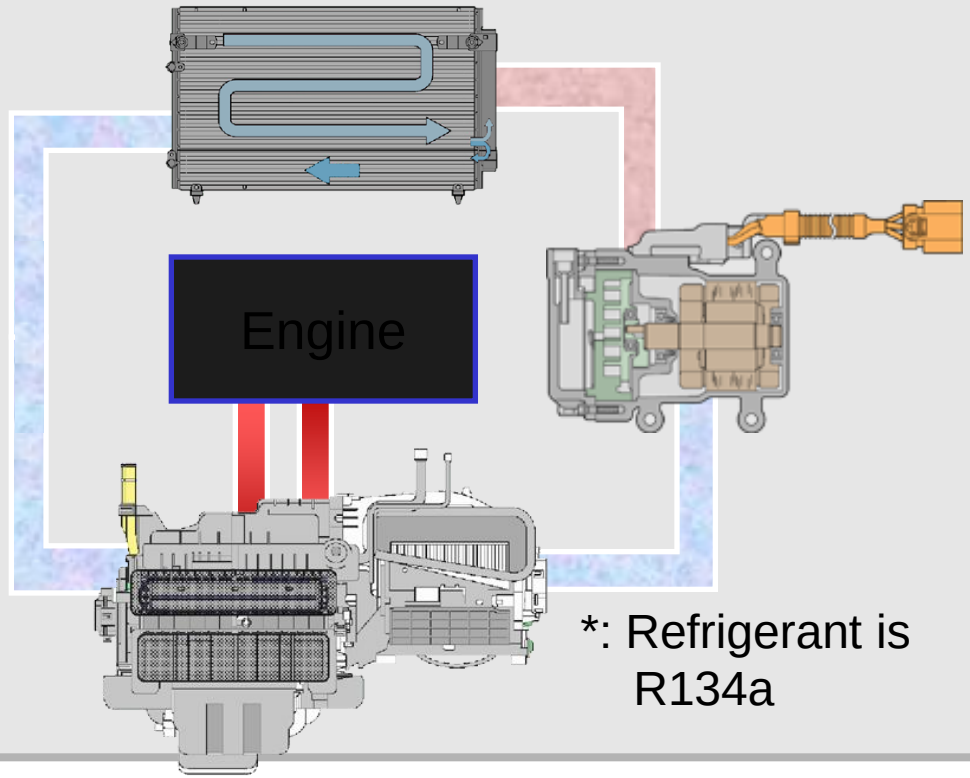
Air conditioning - Service Point

General

- Don’t use the compressor oil other than ND11
  (electric insulation performance)
  (high voltage in compressor!)

Compressor Oil





*: Refrigerant is R134a

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Extended Warranty Coverage

Hybrid system:

- 8 years
- 160 000 km

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Emergency Response

Emergencies involving the Prius may be handled **like other automobiles, except** for the following situations:

- Extrication
- Fire
- Overhaul
- Recovery
- Spills
- First Aid
- Submersion



The following information and procedures in this presentation may not be considered as complete.

*Please consult **for detailed information** the **Emergency Response Guide**!*

TOYOTA

Emergency Response

Warning:

- **= Engine may run**

assume the Prius is **shut OFF**, simply **because** it is **silent**.

- **Always observe** the instrument cluster for the **READY indicator** status to verify whether the vehicle is ON or shut OFF.

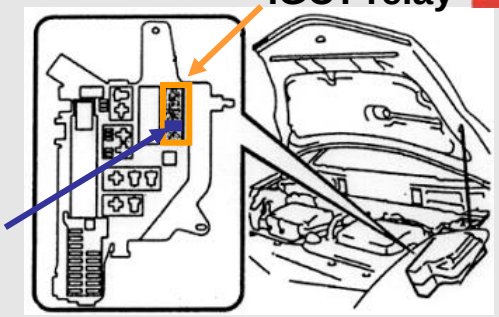
TOYOTA

Emergency Response

Extrication

- **Immobilize Vehicle**
  - Chock wheels + set **parking brake**
  - Push **P switch** + confirm **P indicator** is **ON**

- **Disable Vehicle** (HV battery, SRS airbags and fuel pump)
  - Push POWER button + confirm **READY** is **OFF**
  - Disconnect **12V** battery
    - ***OR, if POWER button is inaccessible***:
  - Disconnect **12 V** battery
  - Remove the **IGCT relay or HV fuse** (in engine compartment)



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Emergency Response

Extrication

- Warning:
  - After disabling the vehicle power is maintained for:
    - **90 seconds** in **SRS** airbag
    - **5 minutes** in **High Voltage** system !
  - High voltage power cables are **orange** **= danger !**

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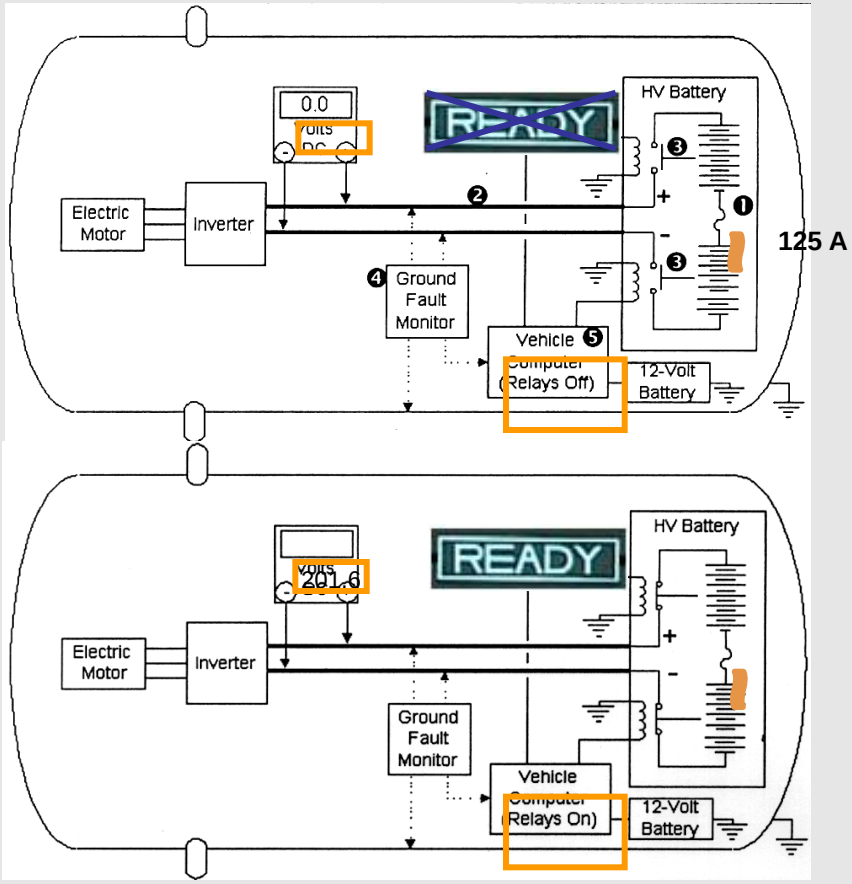
Emergency Response

Extrication



- High Voltage Safety System
  - HV **125 A fuse** protection in Service Plug
  - **READY OFF**: **stop electric current** flo from HV battery
  - **READY ON**: **201,6 V** on **power cables**
  - After READY OFF: **power remains 5 min!**
  - Both **cables** (+ and -) are **isolated** from metal chassis

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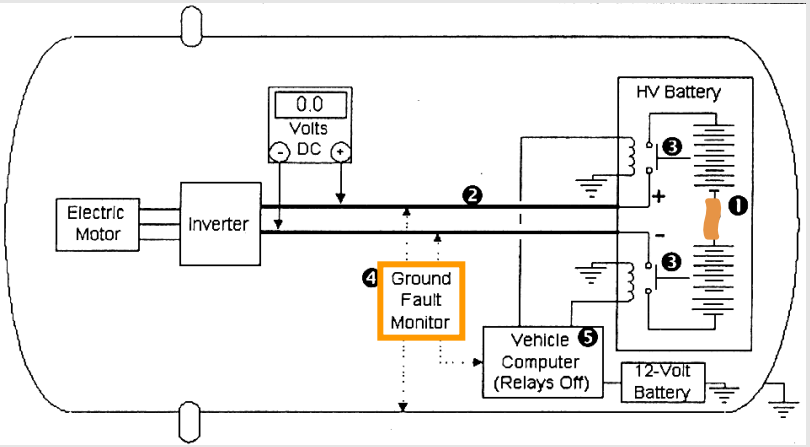
Emergency Response



Extrication

- High Voltage Safety System
  - **Ground fault monitor**:

    If leak to chassis:
    - Master Warning Light ON
    - Hybrid Warning Light ON
  - **Stop electric current flow**:
    - By SRS Airbag sensor assembly
    - By circuit breaker sensor in Inverter

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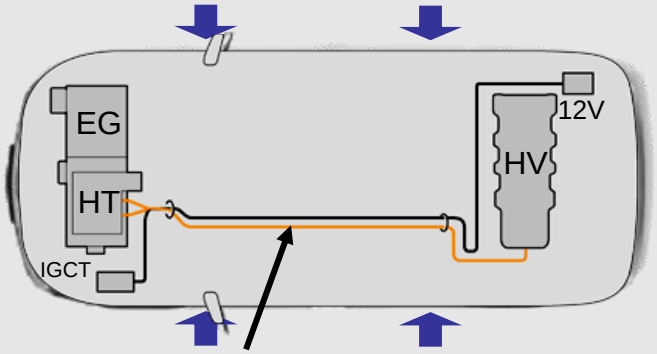
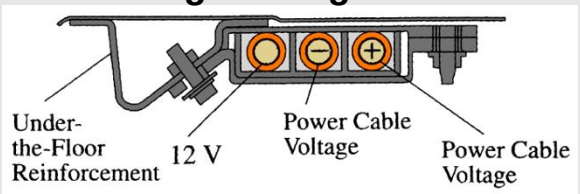
Emergency Response

Extrication

- Stabilize Vehicle
  - 4 cribbing points, directly under front and rear pillars can be used
  - Do not place cribbing under high voltage power cables, exhaust or fuel tank



High Voltage wire harness



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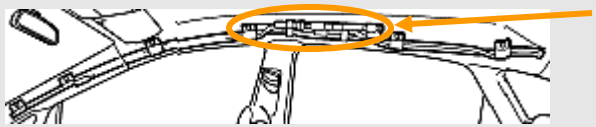
Emergency Response

Extrication

- Access Patients
  - – **Glass** removal: normal procedure
  - – **Door** removal / displacement: use conventional tools
  - – **Dash** displacement: use conventional tools
  - – **Roof** removal: don't cut, SRS curtain airbags!



  - – Rescue Lift Bags: not under HV power cables, exhaust or fuel tank
  - – Steering and seat controls (see OM)

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Emergency Response

Fire

- Extinguishing Agent
  - **If used in a large amount**, **water** has been proven to be a **suitable extinguishing agent**
  - ABC fire extinguisher (Applicable to both oil flames and electric flames)
- **Initial Fire Attack**
  - Perform a fast, **aggressive attack**
- Fire in the **HV battery**
  - Warning:
    - NiMH battery electrolyte, a **caustic alkaline** = Potassium hydroxide (**KOH**) & Sodium hydroxide (**NaOH**)
    - HV battery modules in **metal case** (only small access on top)
    - **Never remove cover!** (severe electrical burns, shock or electrocution)

TOYOTA

Emergency Response

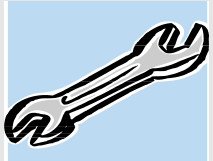
Fire

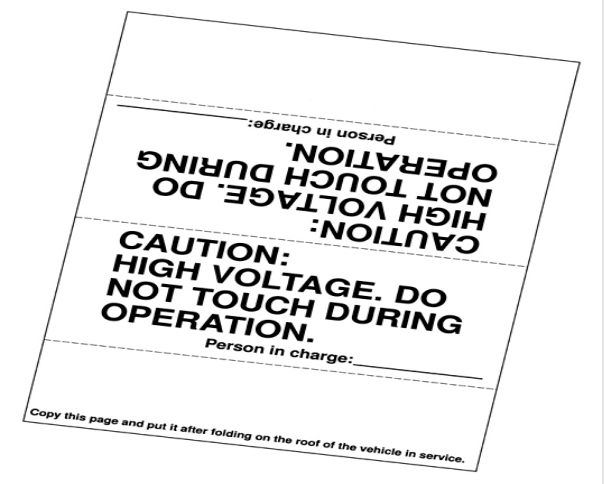
› Fire in the HV battery (continued)

- **Offensive fire attack**:
  - **Flooding** HV battery pack with **copious** amounts of water
- **Defensive fire attack**:
  - **Pull back** at safe distance
  - **Water stream or fog** can be used.

Emergency Response

Overhaul





› Draw attention to the vehicle on which the HV system is being inspected or repaired by placing a "**CAUTION: high voltage do not touch during operation**" sign.

› If not already done:

- **Immobilize and disable vehicle**

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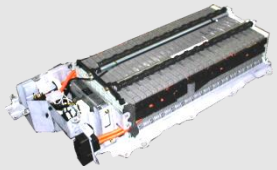
Emergency Response

Recovery/Recycling NiMH HV battery pack

› Toyota Service Centers will be informed about the recycling procedures



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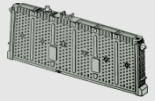
Emergency Response

Spills

- Prius contains same common automotive fluids, with *exception* of **NiMH electrolyte**.
- NiMH electrolyte **is a caustic alkaline** (pH 13,5) **damaging human tissues**.

- NiMH electrolyte is **absorbed in cell plates** and form a **gel**.
- NiMH electrolyte **will normally not spill or leak** out of module if battery module is cracked.



*(If battery would be overcharged, **gases** are **directed outside** the **vehicle** through a vent hose connected to each NIMH battery module)*

- **Modules** are **protected by metal** battery pack **case**.
- **Boric acid solution** or **vinegar** is used to **neutralize** a NiMH battery **electrolyte** spill.

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Emergency Response

Spills

- Personal **protective equipment**:
  - › Splash shield or safety goggles
  - › Rubber, latex or Nitrile gloves
  - › Apron suitable for alkaline
  - › Rubber boots

- **Neutralize** NiMH **electrolyte**:
  - – Use **boric acid solution** or **vinegar**

    Boric acid solution: **800 g boric acid** + **20 l water**
  - – Check with **red litmus paper**:
    - ➢ Blue =
    - ➢ Red = OK

TOYOTA

Emergency Response

First Aid

- Personal **protective equipment**: *see previous slide*
- Absorption:
  - › **Rinse** affected areas for **20 minutes**
- Inhalation - non-fire situations:
  - › **No toxic gasses** are emitted **under normal conditions**
- Inhalation – fire situations:
  - › **Toxic gasses** are emitted as a **by-product of combustion**.
    - Wear proper protective equipment
    - Remove patient and administer oxygen
- Ingestion:
  - – **Do not induce vomiting**.
    - ➢ Allow patient to drink large quantities of water (to dilute electrolyte)

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Emergency Response

Submersion

To safely handle a Prius that is fully or partially submerged in water, **disable the high voltage electrical system and SRS airbags**

- **Remove** vehicle from water
- **Drain** water from vehicle if possible
- Follow the **extrication and vehicle disabling procedure** *(see first procedure)*

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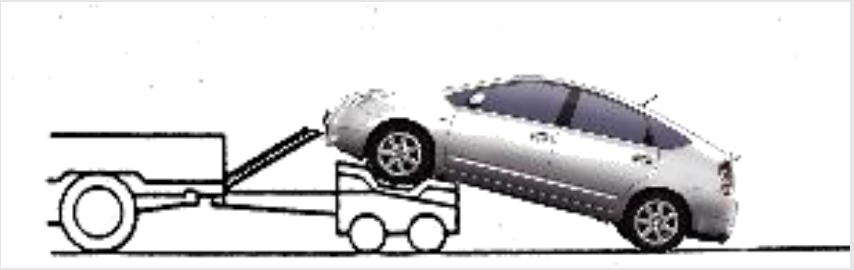
Roadside Assistance

Towing

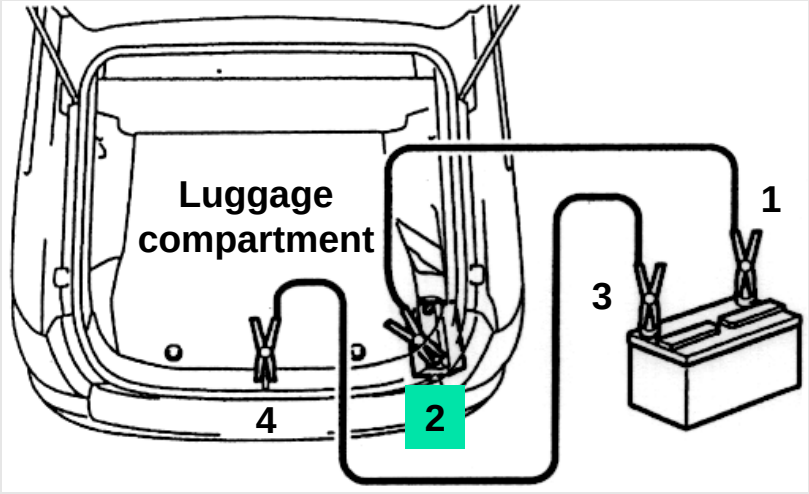
- Front wheel drive:
  - **Front wheels off the ground**



Roadside Assistance

12 V battery Jump Sta

- 12 V auxiliary battery in luggage compartment



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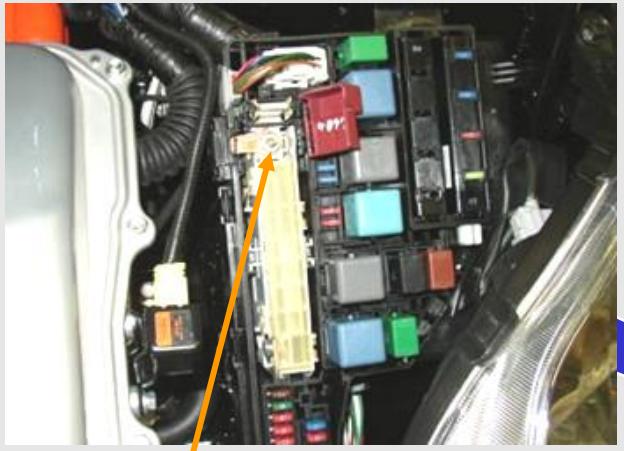
Roadside Assistance

12 V battery Jump Starting (cont.)

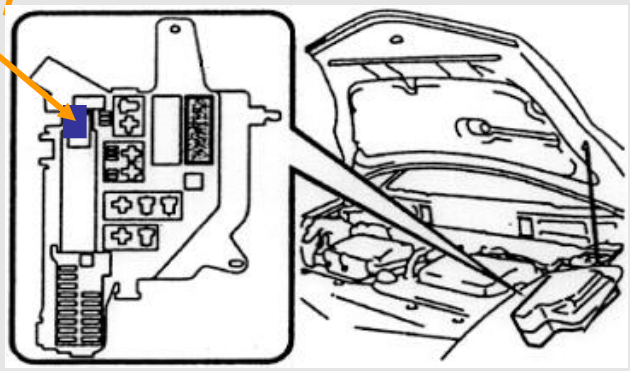
- Back door opens electrically:
  - If auxiliary battery is discharged:

    You cannot access it!

  → Use Jump Start ”+” terminal in engine compartment



Jump Start Terminal



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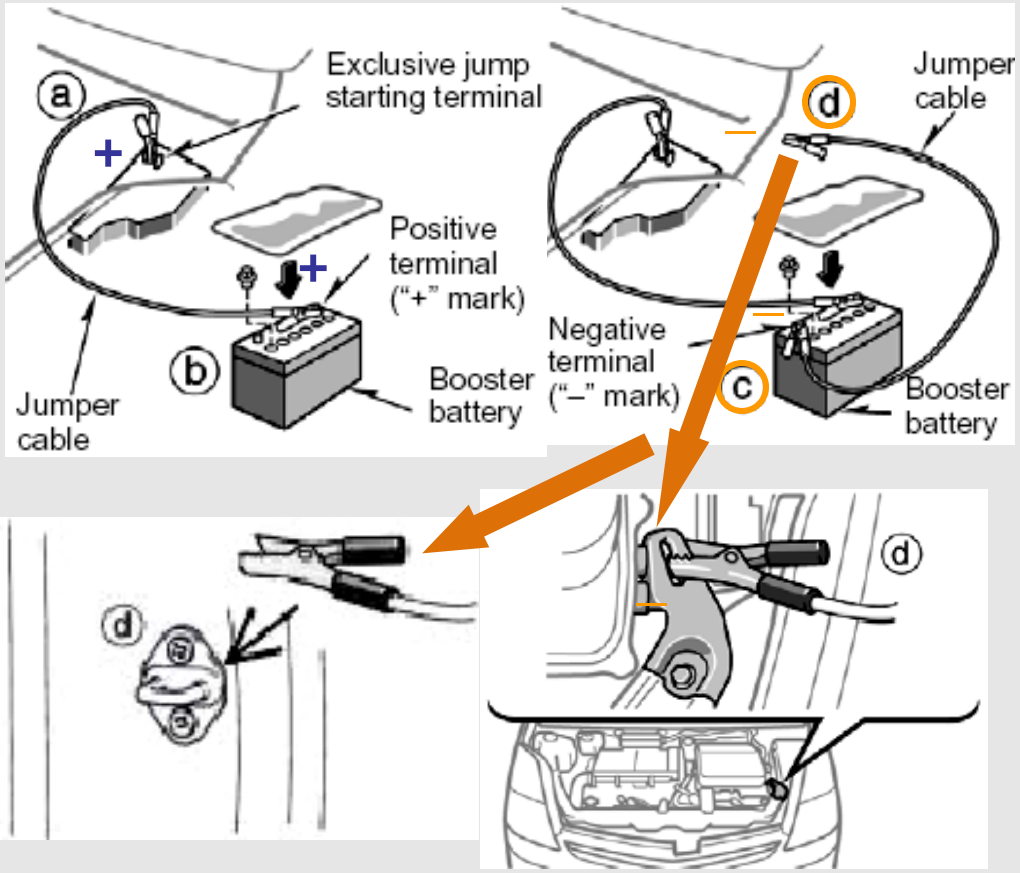
Roadside Assistance



12 V battery Jump Starting (cont.)

- Connect jumper cables in the order a, b, c, d

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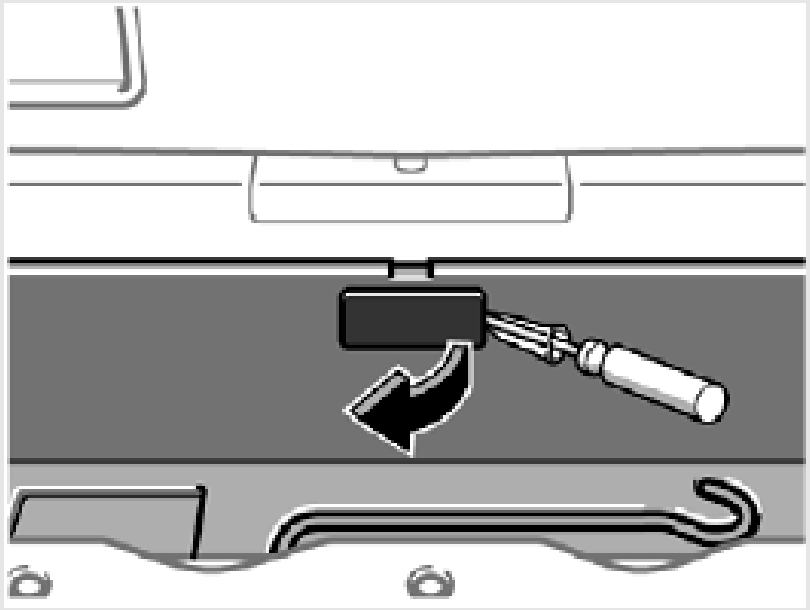
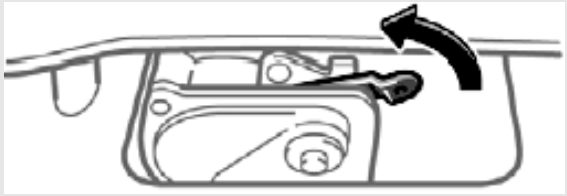
Roadside Assistance

Jump start failure

- After jump start failure:
  - One extra trial
- After 2nd failure:
  - Contact TOYOTA Service Center

Roadside Assistance





12 V battery Jump Starting (cont.)

- If you cannot operate back door opener,open back door from inside:
  - Open luggage storage box
  - Remove the cover
  - Pull the lever with back door motor

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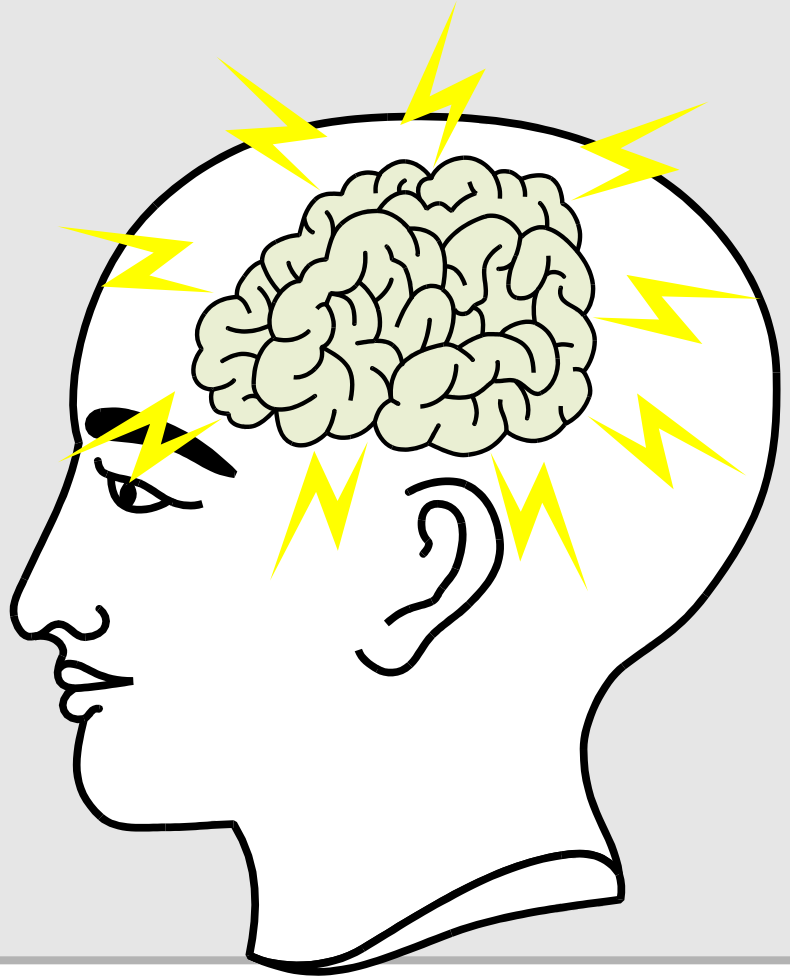
What is the most important tool when working on a Hybrid vehicle?



Think first!
Then act!

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Diagnosis

Troubleshooting

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Diagnosis

- Data List

Function View System Bar Help

Hybrid Control / Data List

All Data	Value	Unit
Engine Coolant Temp	68	F
Vehicle Spd	0	Km/h
Engine Run Time	0	s
+B	11.367	V
Accel Pedal Pos #1	15.680	%
Accel Pedal Pos #2	31.752	%
Ambient Temperature	69	F
Intake Air Temperature	75	F
DTC Clear Warm Up	0	
DTC Clear Run Distance	0	km
DTC Clear Min	69	Min

DTC | Data List | View | Active Test | Utility

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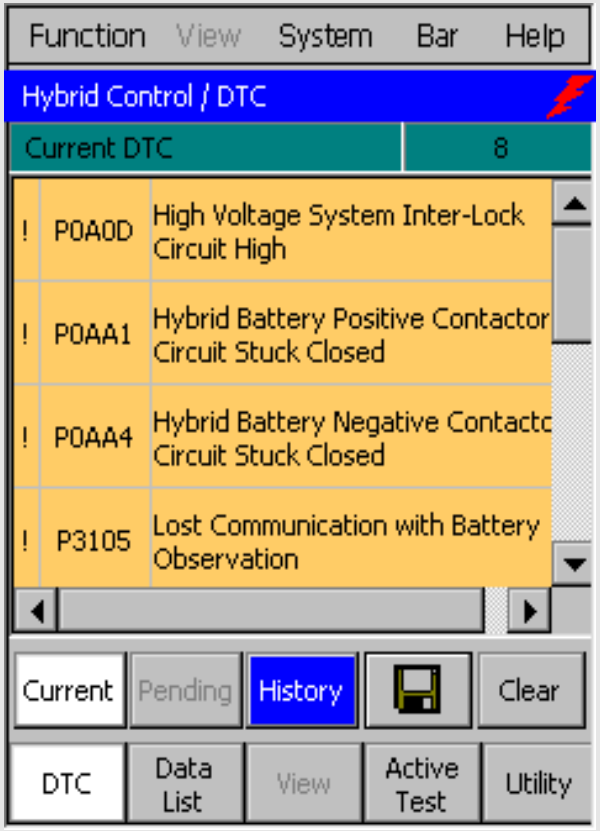
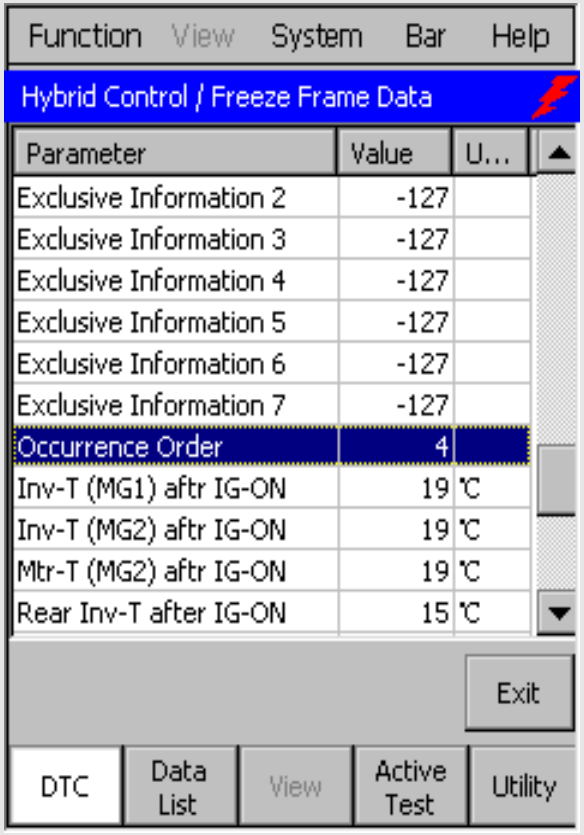
Diagnosis

- DTC & occurrence order





•Check all DTC's and there order of occurrence (in FFD)

•Start investigating at the lowest occurrence order

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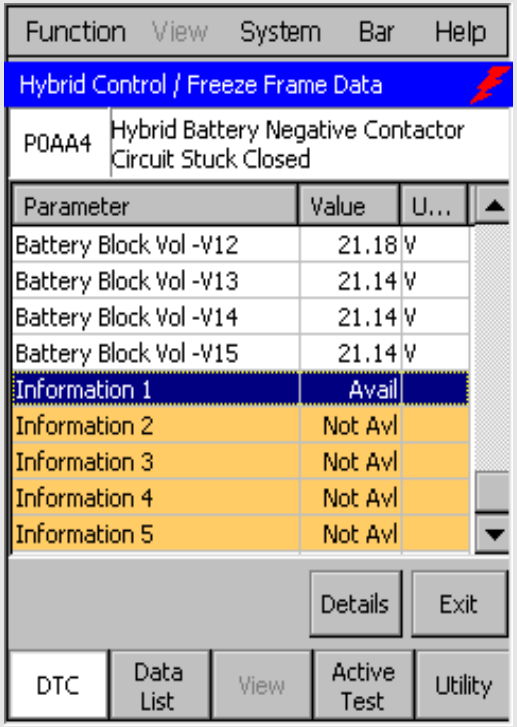
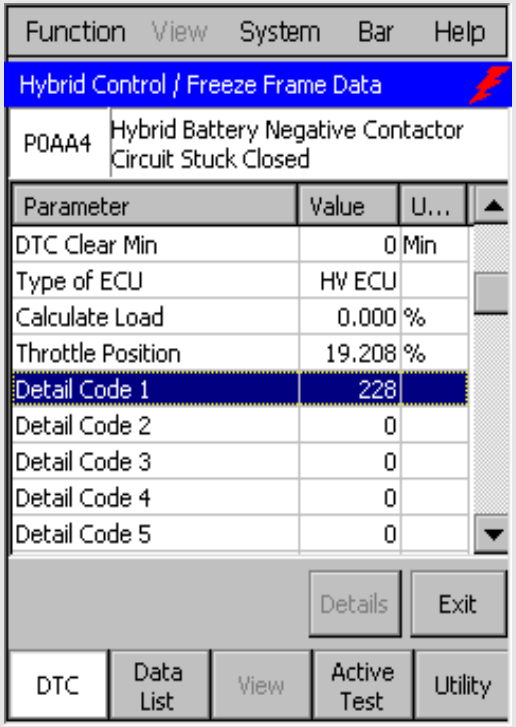
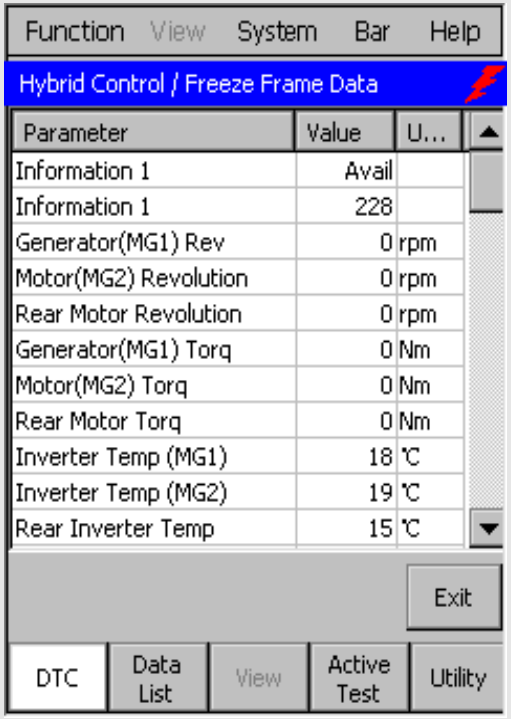
Diagnosis

- Information & Detail code







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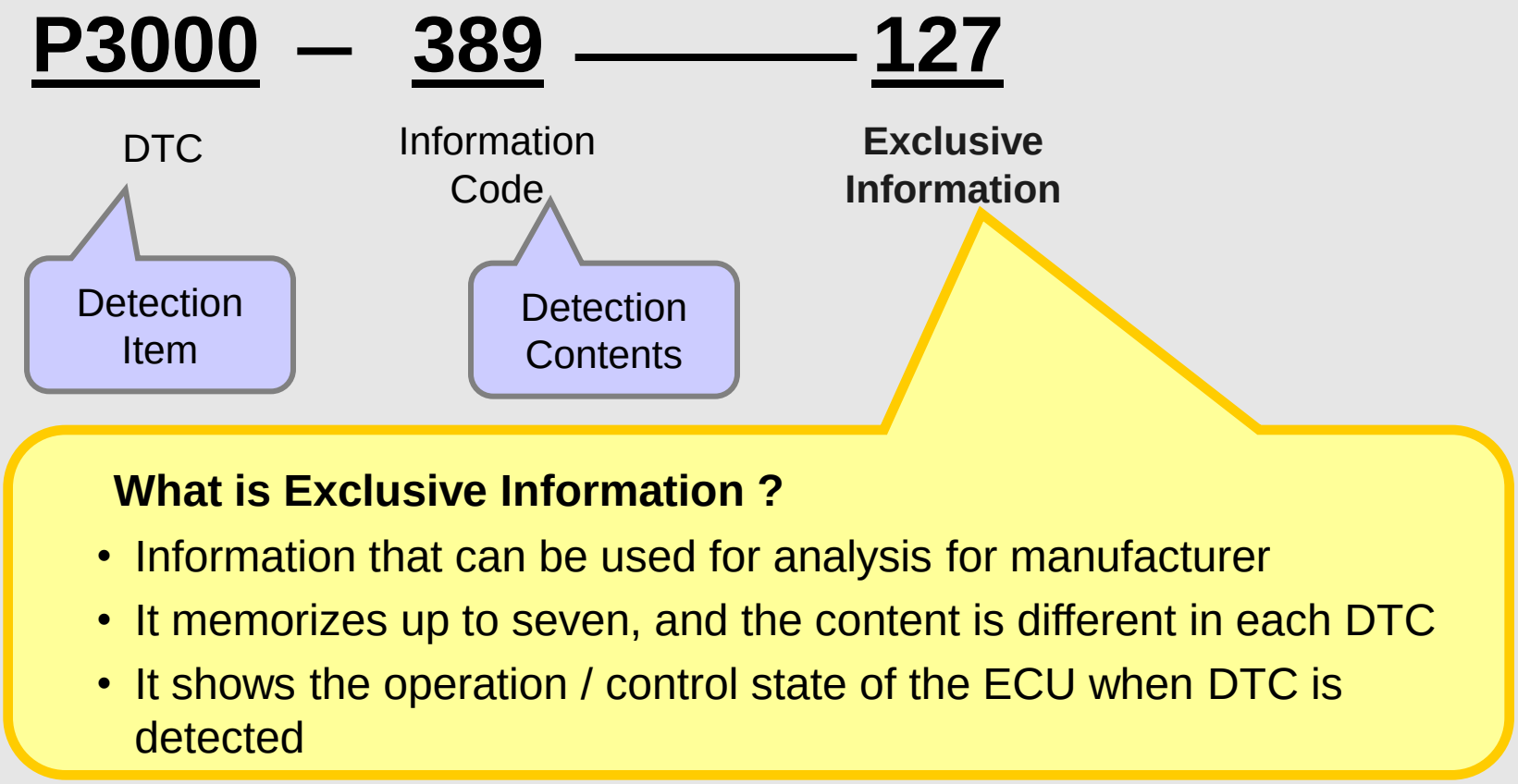
DTC

- Information Code and Exclusive Information



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Freeze Frame Data

- Utilize Freeze Frame Data

1. It can be used for the reproduction test by knowing the driving / operating state when the malfunction detected

2. Think about “OCCURRENCE ORDER” = 1 in Information as a main factor

Point! *Be sure to record the FFD and Information, when the vehicle is brought to workshop*

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Freeze Frame Data

- Understand the time that a DTC was stored

Item	Contents
ENG RUN TIME	Elapsed time after starting engine in 1 trip
DTC CLEAR WARM	The number of trips after clearing DTCs
DTC CLEAR RUN	Drive distance after clearing DTCs *(Drive distance after the malfunction detection can be estimated by comparing DTC CLEAR RUN with Data List information)*
DTC CLEAR MIN	Elapsed time after clearing DTCs
OCCURRENCE ORDER	The order when malfunction occurs

Freeze Frame Data

- Practice
  - Estimate the time series

- Freeze Frame Data -

Item	Contents
DTC CLEARWARM	30 times
DTC CLEAR RUN	160 km

- Data List -

Item	Contents
DTC CLEARWARM	36 times
DTC CLEAR RUN	208 km

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