

T Level Resource Improvement Project

TEACHING AND LEARNING RESOURCES FOR THE
VEHICLE OCCUPATIONAL SPECIALISM

Education & Training Foundation

COURSE OVERVIEW

Hybrid Electric Vehicle Operation and Maintenance



COURSE OVERVIEW

This course is designed for technicians who maintain and repair hybrid technology vehicles, but not the hybrid system itself. It contains the knowledge required to work safely around a vehicle's hybrid system, whilst carrying out repairs or maintenance. Therefore on completing this course, technicians will have gained both knowledge of high voltage hybrid technologies and an understanding of their dangers.

AIMS AND OBJECTIVES:

Following this series of sessions,
candidates will be able to:

- Explain the need for HEV development
- Know (identify) hybrid system components and operation
- Know (explain) how to work safely on hybrid and related vehicle systems
- Know (explain) how to carry out maintenance and repair activities when working on hybrid vehicles

PRIMARY TOPICS:

- What is a hybrid vehicle and how do they differ from conventional vehicles?
- Principles and operation of hybrid systems
- Hazards and how to mitigate them
- Battery types
- Regenerative braking
- Service and repair



INTRODUCTION TO HYBRID VEHICLES:

- A Hybrid vehicle is a vehicle that uses two or more distinct power sources to move the vehicle i.e. HEV (Hybrid Electric Vehicle)
- Such as a vehicle powered by both an electric motor and an internal combustion engine as a source of power for the drive train
- Petrol + Motor = HEV



INTRODUCTION TO HYBRID VEHICLES:

Although we consider hybrid power sources as emerging over the past 15-20 years, in other fields they are already proven and reliable.



PETROL/PEDAL POWER

1970's - 1990's



DIESEL/ELECTRIC

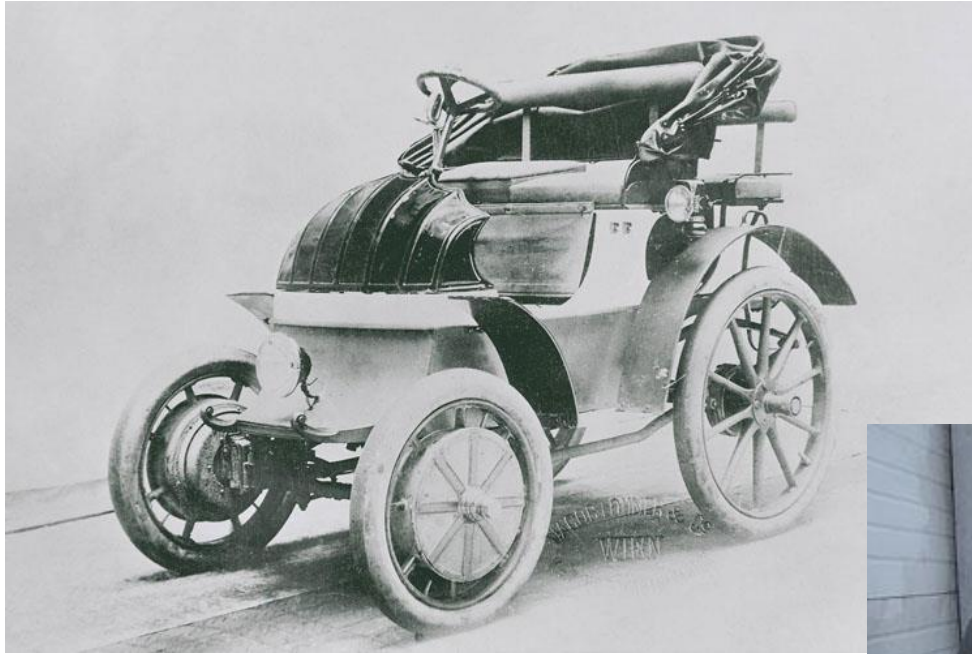
1960's - PRESENT



NUCLEAR/ELECTRIC

1950's - PRESENT

....SOME MORE



WHAT'S THE POINT?



Global Warming
Depleting oil reserves
Rising costs of fuel
If we don't try, how do we know?

HYBRID MISCONCEPTIONS:

SLOW.....

POOR RANGE

MAYBE NOT!

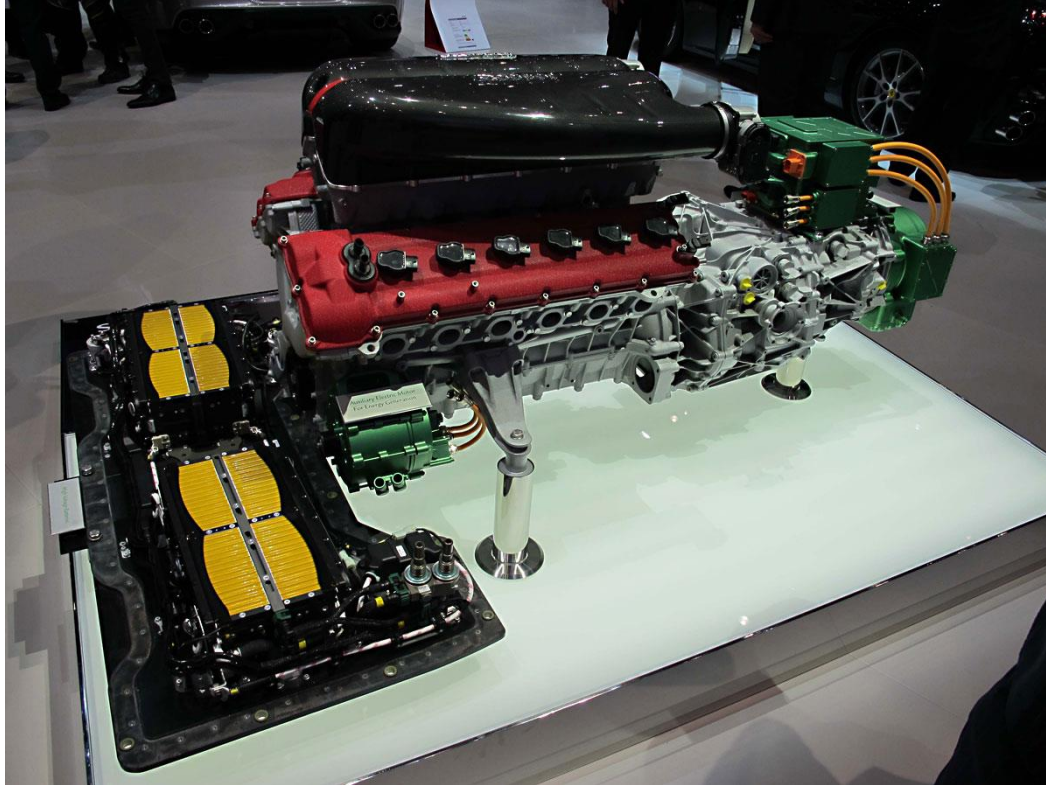


HYBRID MISCONCEPTIONS:

Unveiled at the 2013 Geneva motor show, the LaFerrari utilises HEV technology as a supplement as opposed to an economical or ecological solution.



HYBRID MISCONCEPTIONS:



6.2 litre V12

789bhp

516lb/ft torque

These figures do not
include motor
assistance!

950bhp and 664lb/ft of torque!

HYBRID MISCONCEPTIONS:



The McLaren P1 - 375 built and sold almost immediately.

0-60 mph in 2.8 seconds.

124 mph in 6.8 seconds.

Top speed 217 mph.

34 mpg.

HYBRID MISCONCEPTIONS:



Porsche 918

887 bhp.

Top speed 210 mph.

0-60 mph 2.4 seconds

145 mph 10 seconds

WHAT ARE THE ALTERNATIVES?:

FULL ELECTRIC POWER

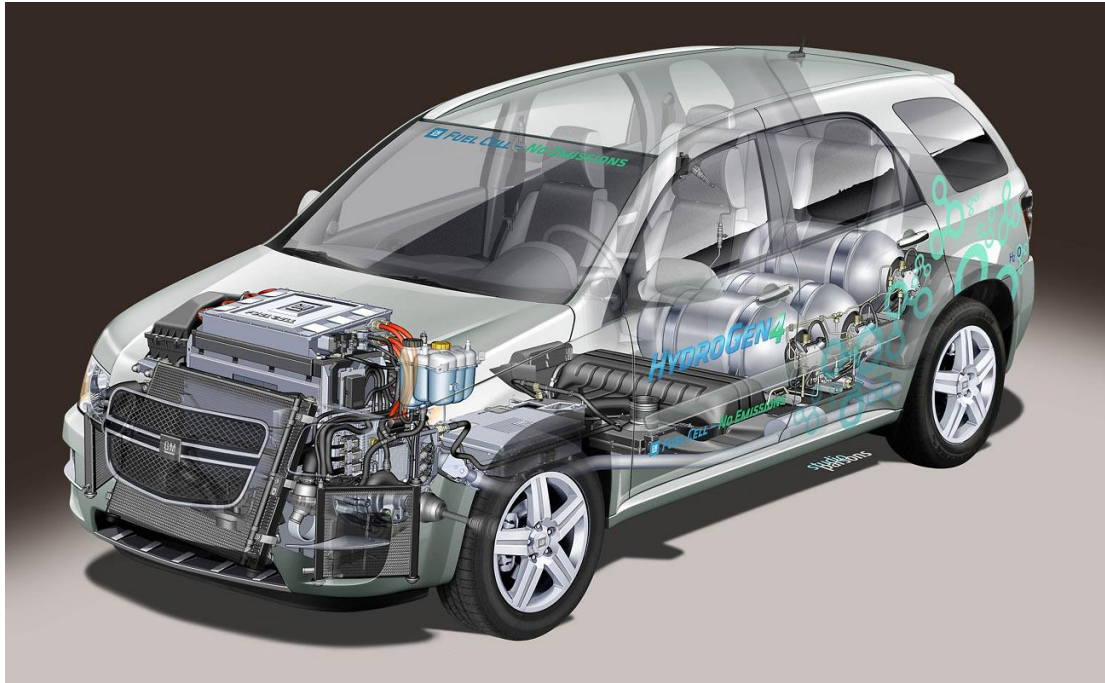


Advantages:

- Instant torque, resulting in smooth acceleration
- Tax incentives
- Fuel cost savings
- Reduced CO₂ emissions
- Reduced maintenance costs

WHAT ARE THE ALTERNATIVES?:

FUEL CELLS



Advantages:

- High efficiency energy conversion (approx 80%)
- High power density (compact size)
- Zero harmful emissions
- Quiet operation

WHAT ARE THE ALTERNATIVES?:

Both fully electric powered vehicles and fuel cell powered vehicles have numerous advantages over conventional internal combustion engine driven vehicles, some of which that are very similar.

- Improved efficiency levels
- Reduced emissions



WHAT ARE THE ALTERNATIVES?:

Technology moves quickly!



INTRODUCTION TO HYBRID VEHICLES:

HEV's are not the perfect solution to all future requirements of the modern vehicle; however, they are currently a stepping stone to the next phase.



INTRODUCTION TO HYBRID VEHICLES:

HEV's tackle the problems commonly associated with alternatively powered vehicles:

- Range
- Charging/Re-fuelling infrastructure



HEALTH AND SAFETY



With the number of Hybrid vehicles on Britain's roads ever increasing, knowledge and familiarisation of systems is a necessity to ensure that technicians remain safe and that the vehicles can be maintained and repaired effectively and efficiently.

INTRODUCTION TO HYBRID SAFETY:

As we all know, everybody is different and our bodies react differently to electricity passing through them.

The threshold for voltage that can be fatal is 60 volts, but for some people that may be as low as 50 volts.



INTRODUCTION TO HYBRID SAFETY:

Voltage is the amount of electrical pressure or potential difference within a circuit. No doubt, most of us have received a “tingle” from an HT lead which was probably carrying approximately 50kV.

Current is the amount of electrical flow within a circuit and is the factor which may cause injury or possibly death.

0.2 Amps can be fatal!

INTRODUCTION TO HYBRID SAFETY:

Orange cable code indicates upwards of 60 volts.



In reality there is 200-650V



South Devon College Automotive



INTRODUCTION TO HYBRID SAFETY:



INTRODUCTION TO HYBRID SAFETY:

If the “READY” light is illuminated the internal combustion engine can start and run without warning.

- When you are working under the bonnet!!!!
- When the vehicle is on a ramp with the engine oil drained!!!!



SAFETY SIGNAGE

MANDATORY



Mandatory signs designate a “must do” order.

Mandatory signs are circular in shape and have a blue background with white images and/or lettering.

PROHIBITION

Prohibition signs designate a “must not do” order.

Prohibition signs are circular in shape and have a red outline with a red diagonal line running across the diameter.



WARNING



Warning signs warn of a risk to health and safety.

Warning signs are triangular in shape and have a yellow/amber background with a black outline.

HAZARD



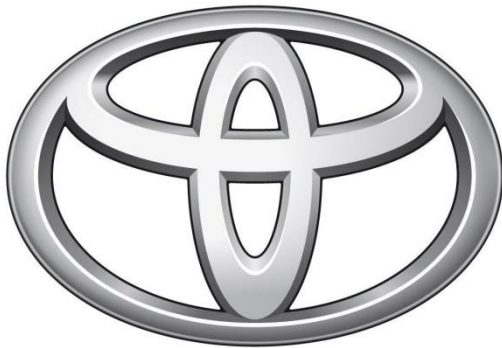
Hazard signs warn of hazardous materials, objects or locations. Hazard signs are amber/yellow in colour and have a black outline. Hazard signs differ in shape.

HYBRID VEHICLE PRINCIPLES:



HYBRID VEHICLE PRINCIPLES:

The majority of this presentation is based on Toyota systems and technology, with references to Honda systems. As additional manufacturers develop and launch HEV's systems continually develop.



TOYOTA



HONDA

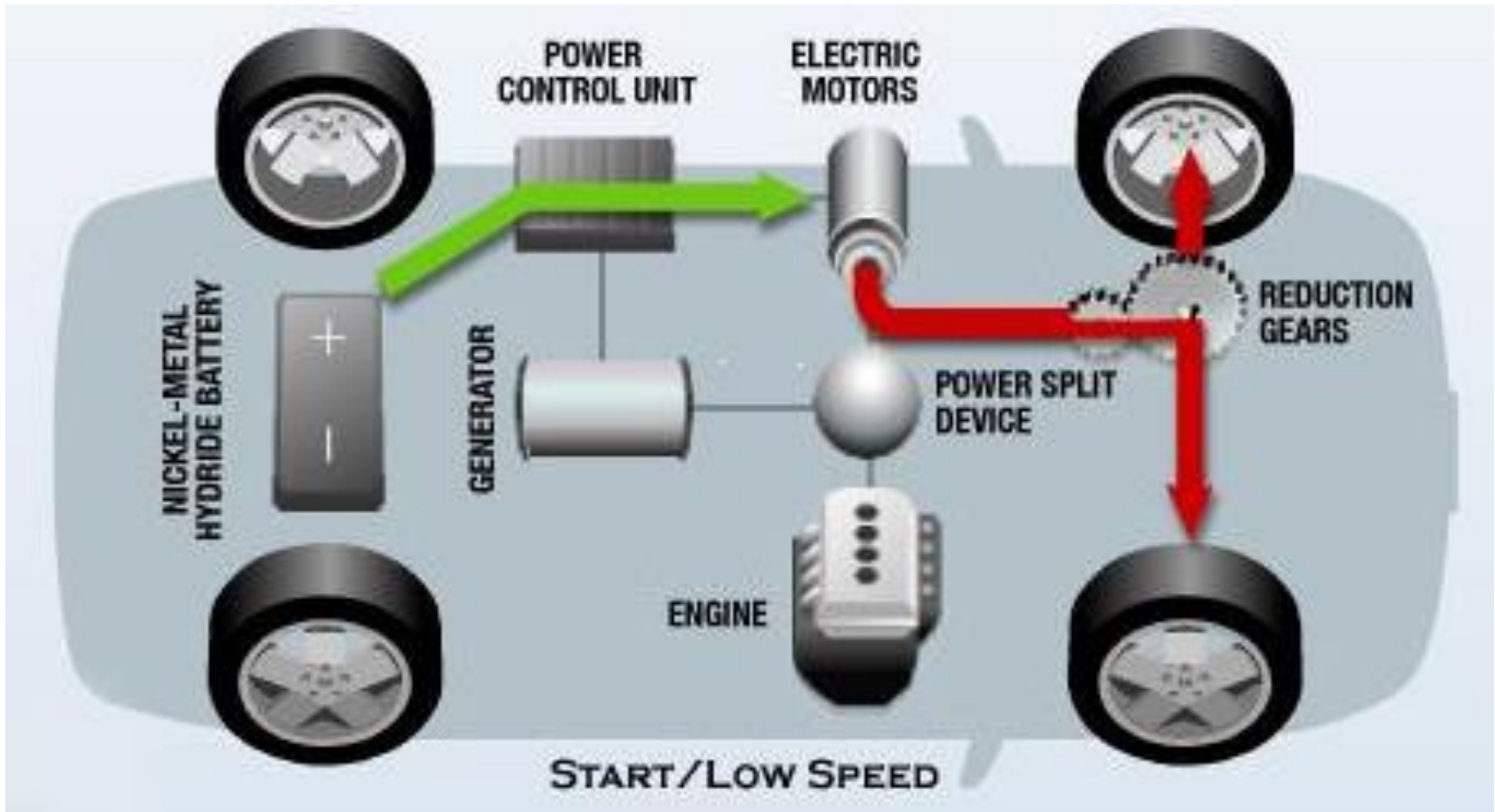
This presentation is not a hybrid gospel!

PRINCIPLES OF OPERATION

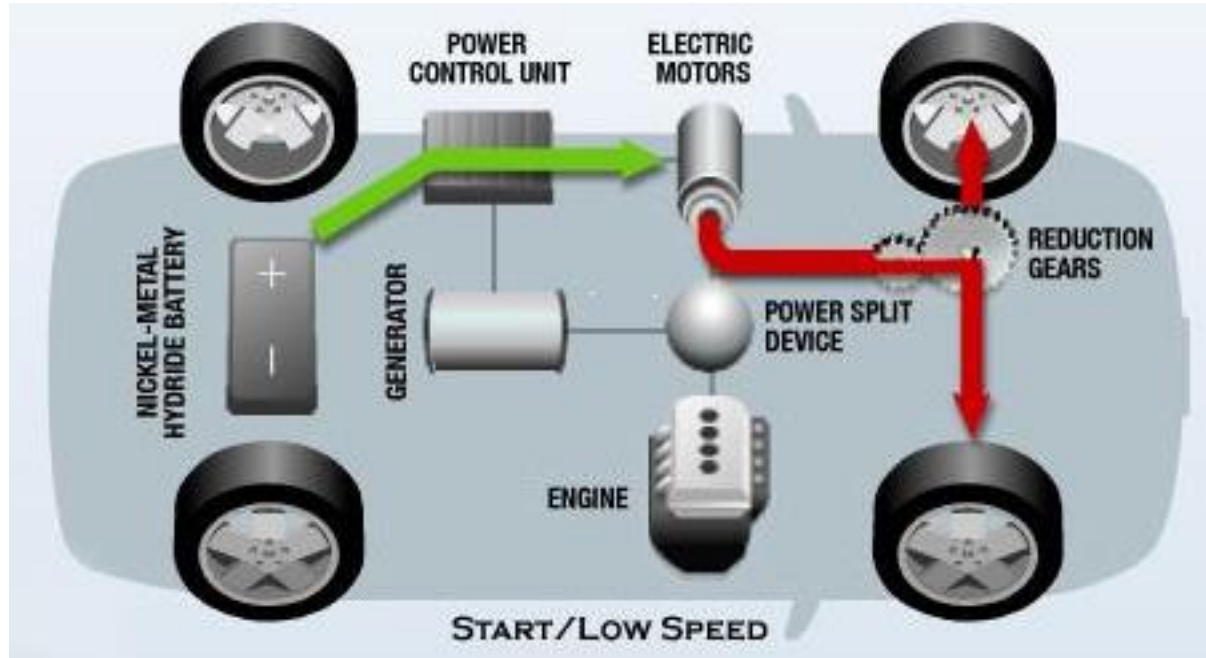
BASIC MODES OF OPERATION:



TOYOTA



BASIC MODES OF OPERATION:

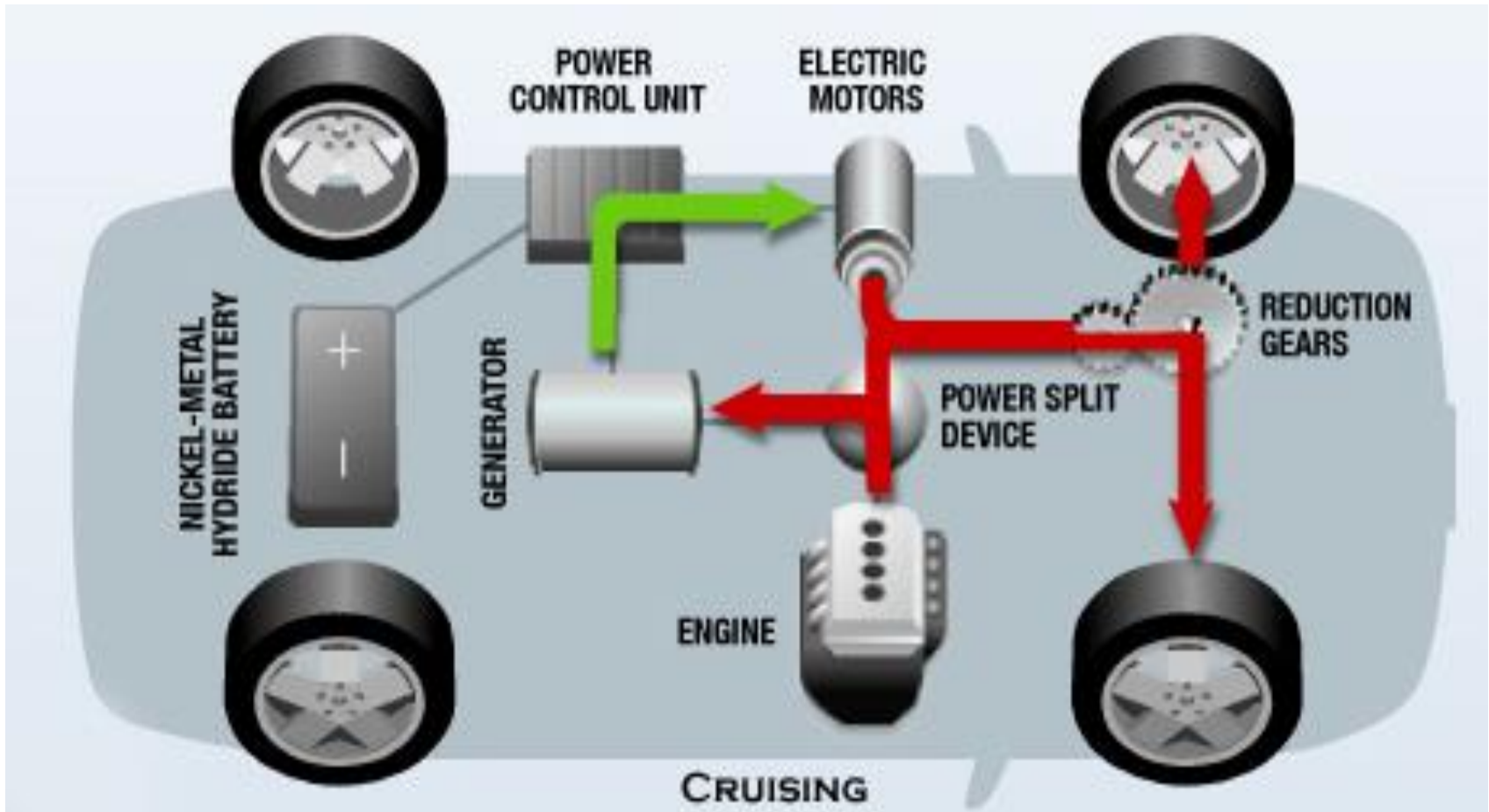


This phase operates from initial pulling away up until approximately 20mph. The vehicle is powered only by the electric motor.

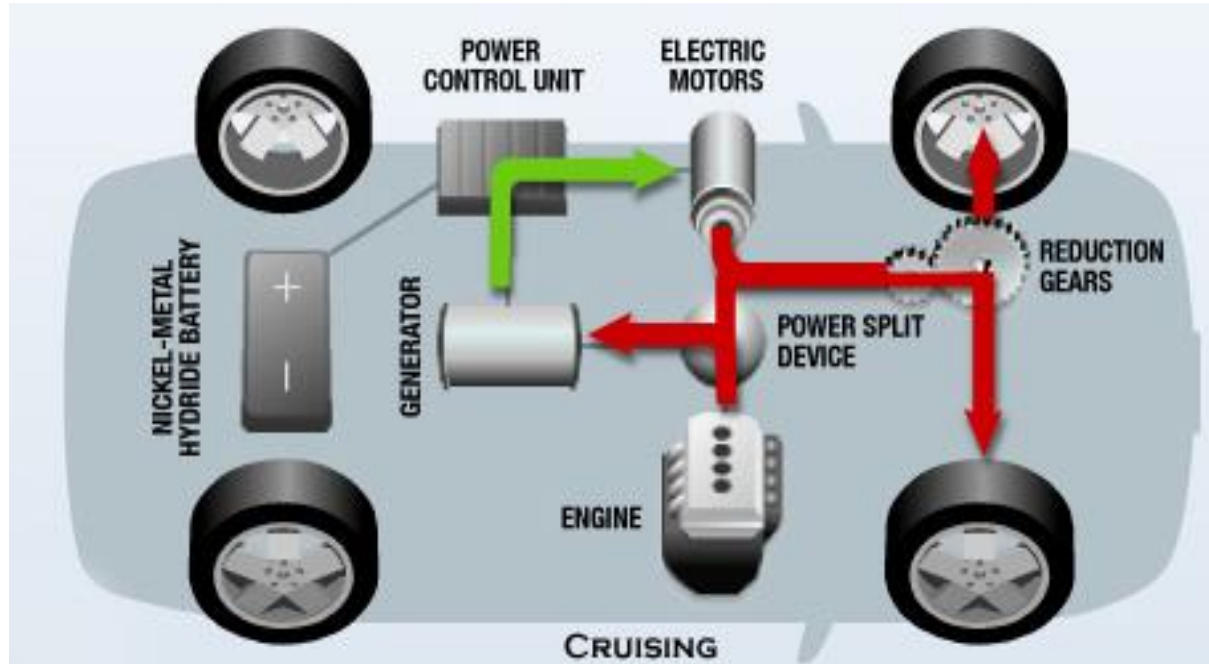
BASIC MODES OF OPERATION:



TOYOTA



BASIC MODES OF OPERATION:

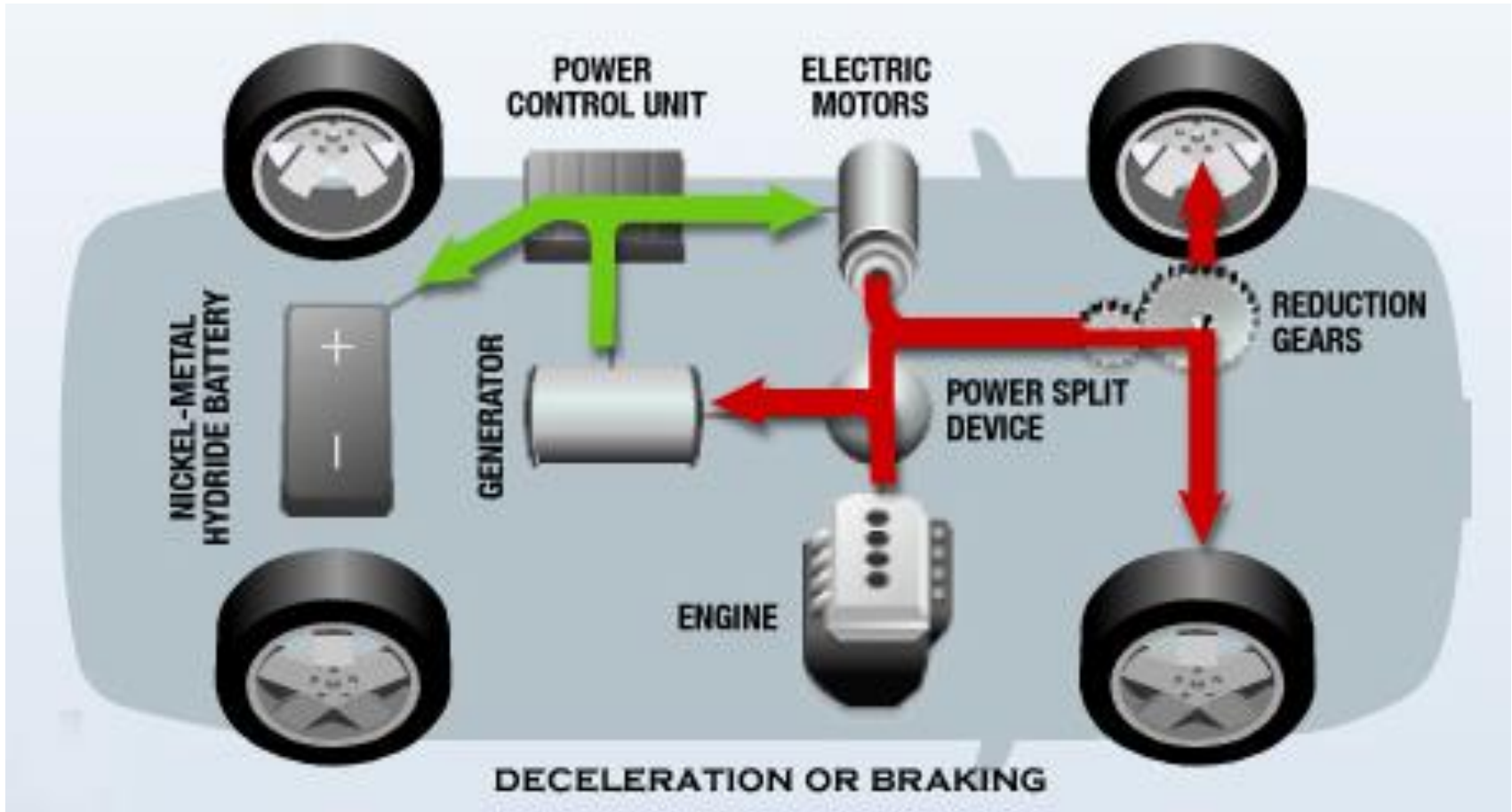


This phase operates when cruising. The vehicle is powered by a combination of motor power and ICE power.

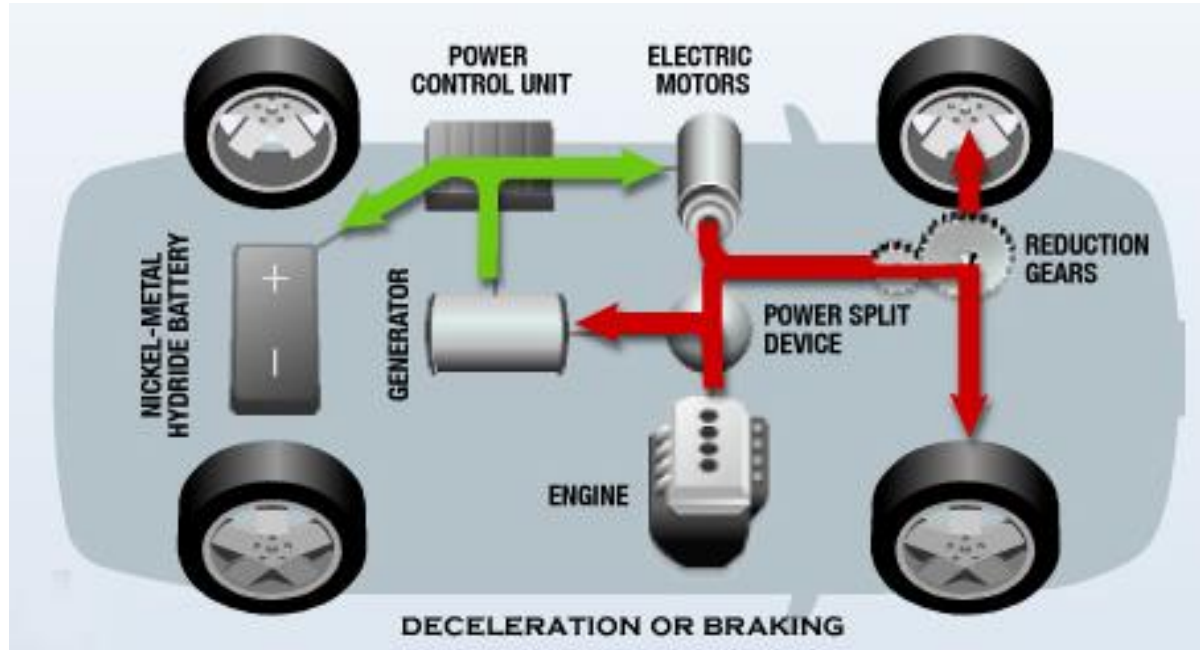
BASIC MODES OF OPERATION:



TOYOTA



BASIC MODES OF OPERATION:

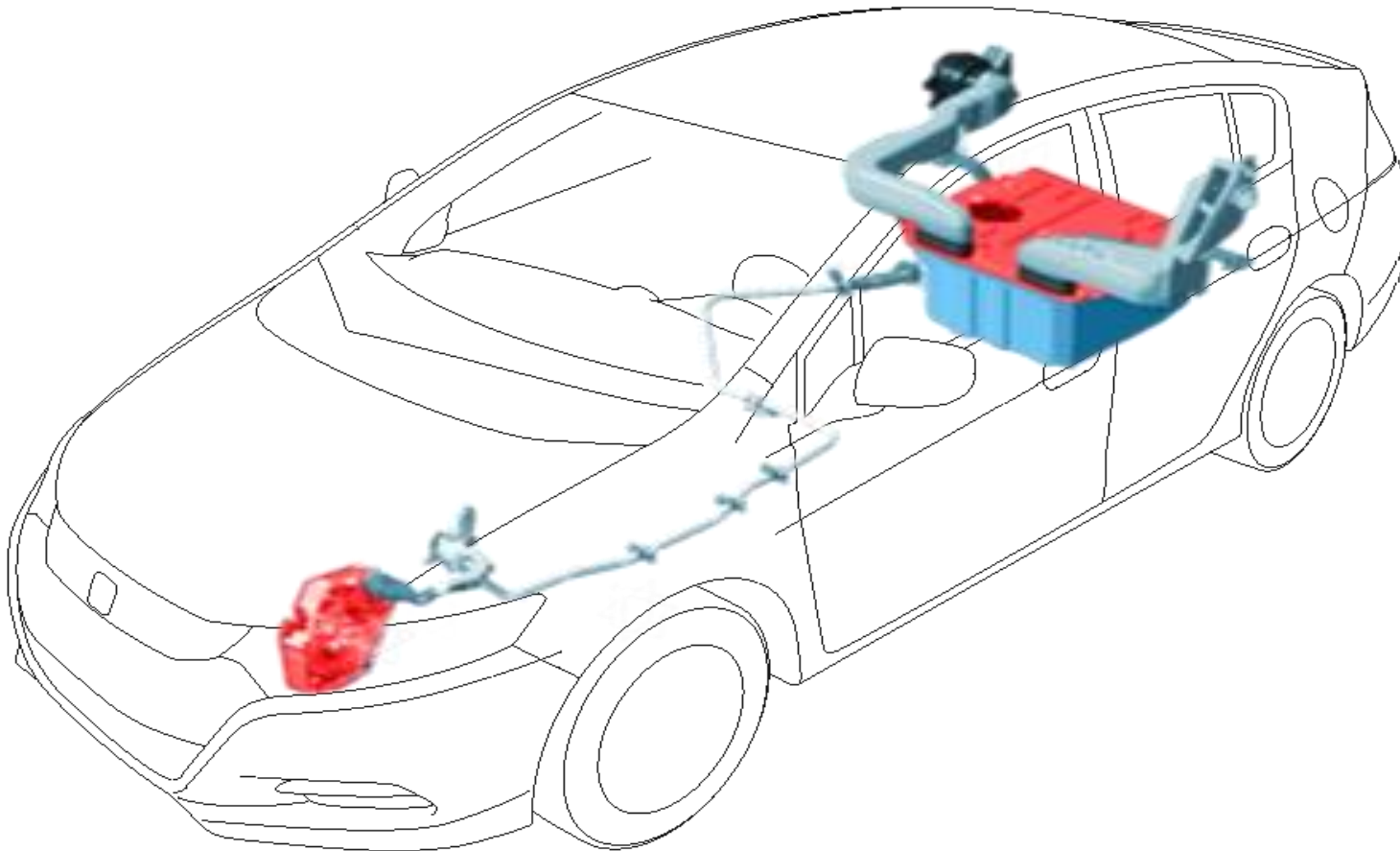


During deceleration, the high voltage battery receives charge from the generator.

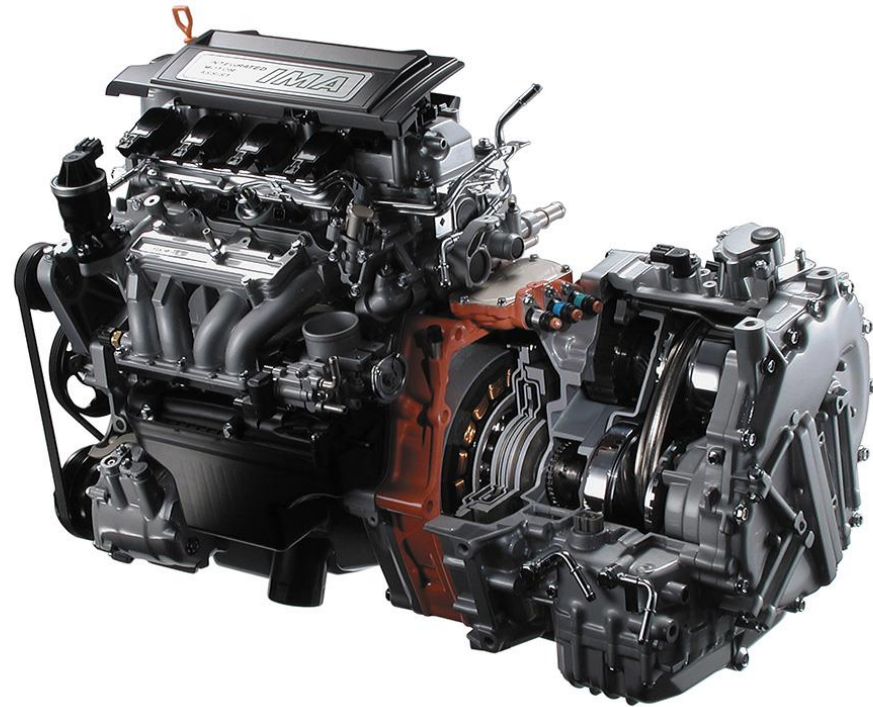
BASIC MODES OF OPERATION:



BASIC MODES OF OPERATION:



BASIC MODES OF OPERATION:

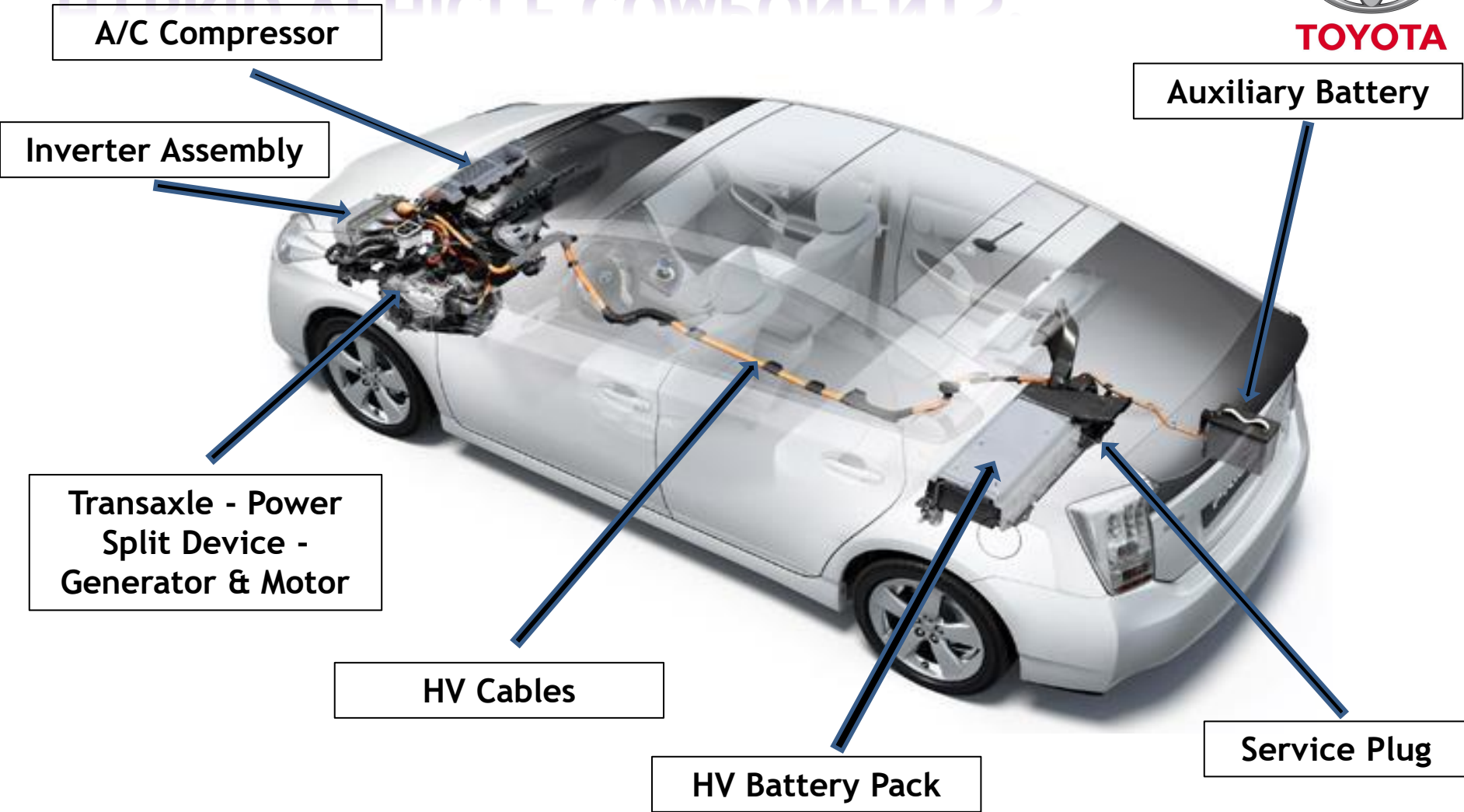


HEV COMPONENTS

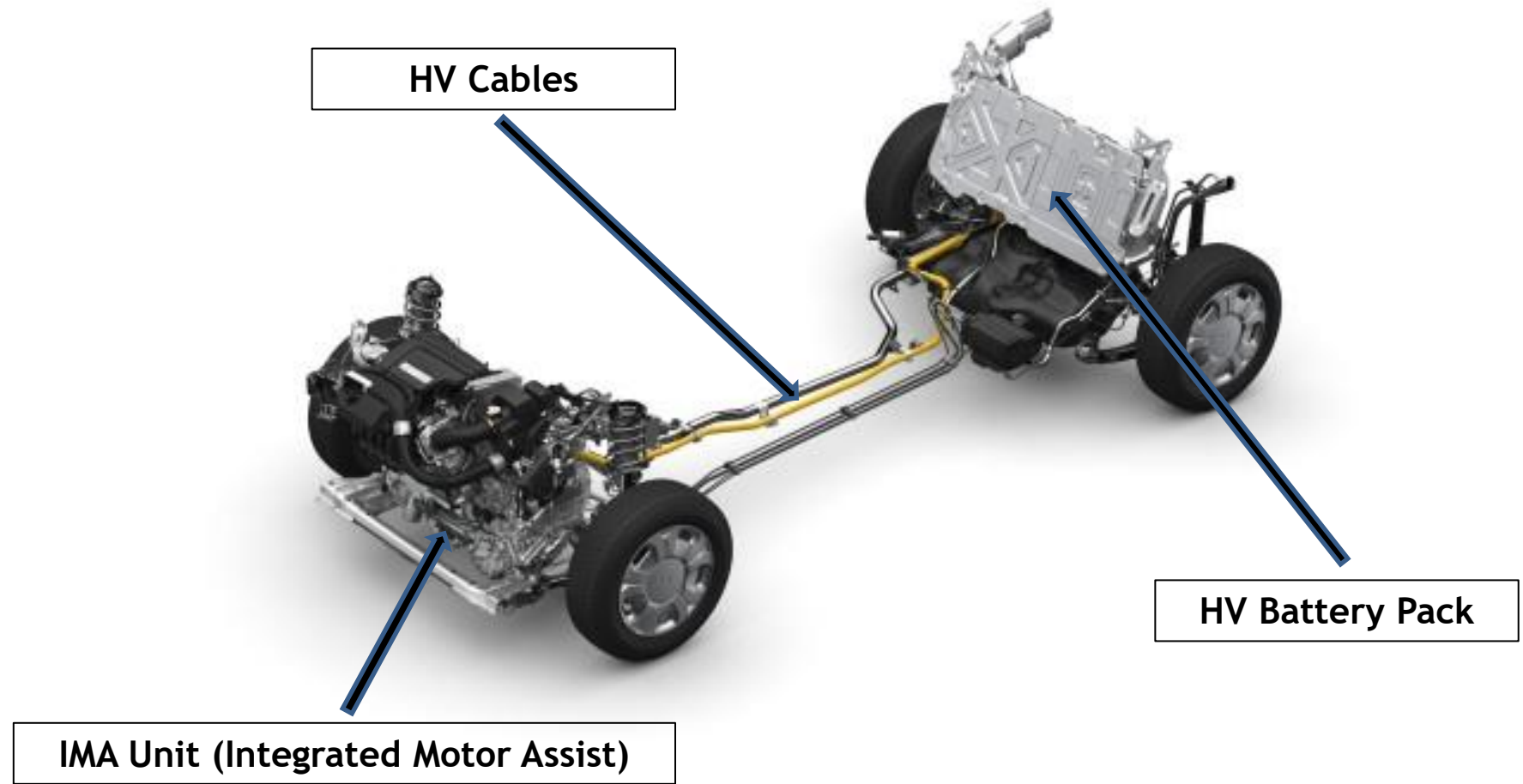
HYBRID VEHICLE COMPONENTS:



TOYOTA



HYBRID VEHICLE COMPONENTS:



INVERTER ASSEMBLY:

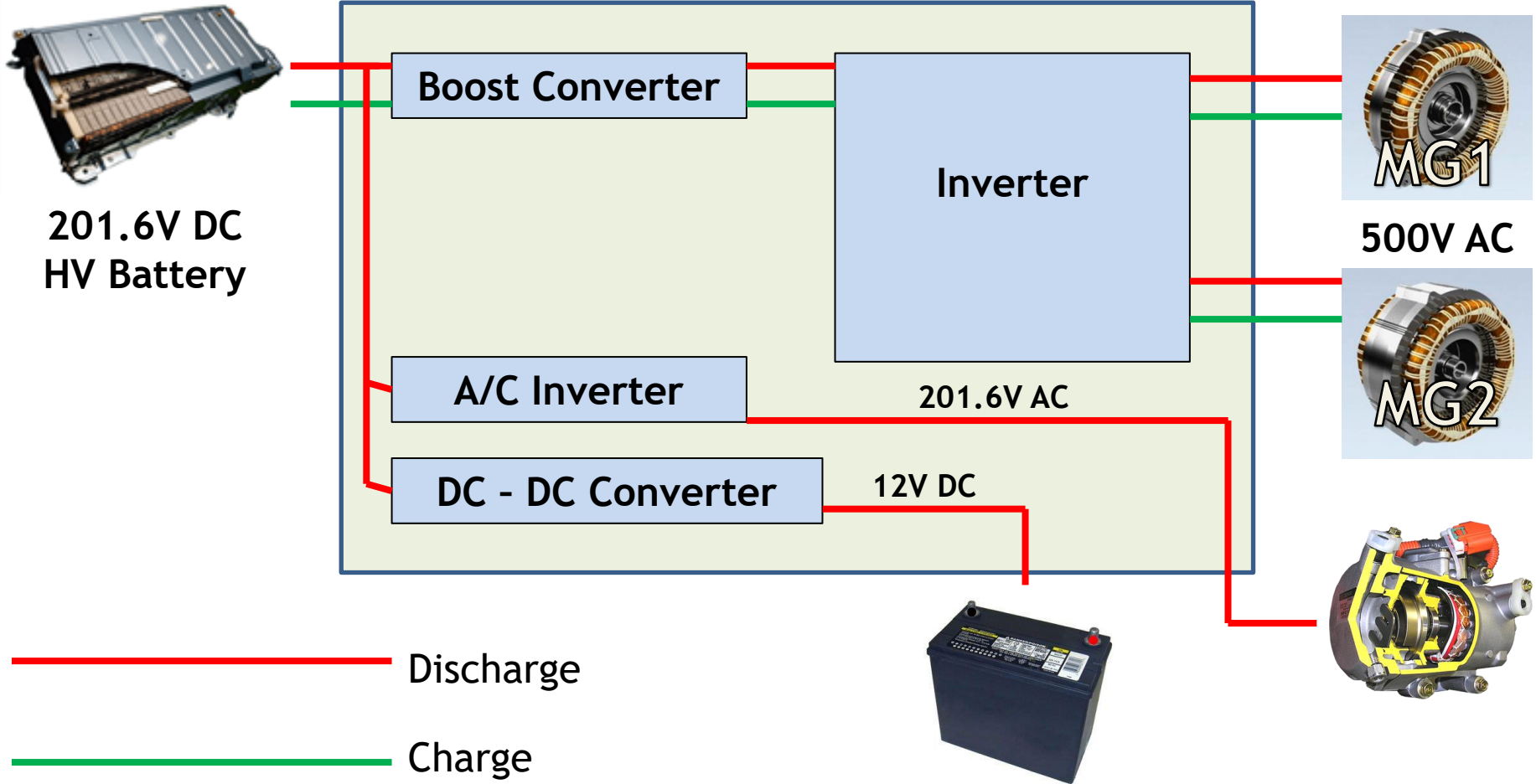


The inverter can be described as a distribution unit. In fundamental terms, the inverter takes high voltage from the HV battery, converts, boosts and distributes it to other HV components.

INVERTER ASSEMBLY:



TOYOTA



BOOST CONVERTER:



The boost converter is a component within the inverter that is capable of increasing the high voltage that is supplied to the motor/generator assemblies. The 201.6 volts that is produced by the HV battery, can be increased up to a maximum of 500 volts.



DC - DC CONVERTER:



The DC - DC converter lowers the high voltage produced by the HV battery to approximately 12 volts which is then utilised to supply the vehicle's auxiliary electrical system and to charge the auxiliary battery.



AUXILIARY BATTERY:



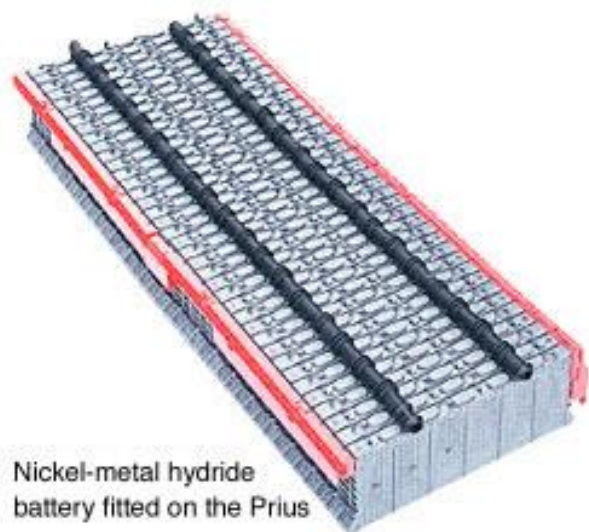
TOYOTA

The auxiliary battery is a conventional sealed 12 volt lead acid battery. The 12 Volt auxiliary battery powers the vehicle's electrical system similar to a conventional vehicle. As with conventional vehicles, the negative terminal of the auxiliary battery is grounded to the metal chassis of the vehicle.

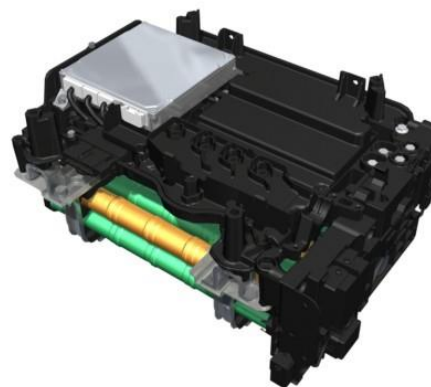


HIGH VOLTAGE BATTERY:

The high voltage batteries used on hybrid electric vehicles generally fall into two fundamental categories.



Prismatic



D - Cell

HIGH VOLTAGE BATTERY:



The prismatic type batteries used by Toyota are Nickel Metal Hydride (Ni-MH). This type of battery is similar in construction to a conventional lead-acid type battery.



HIGH VOLTAGE BATTERY:



Prius and Auris models have used prismatic batteries which are constructed of 28 modules each consisting of 6 cells. The nominal voltage of each cell is 1.2 volts.



Cell = 1.2 volts

Module = 7.2 volts (6 x 1.2)

Battery = 201.6 volts (7.2 x 28)

HIGH VOLTAGE BATTERY:



Through advances in technology and development, the 2013 model year Yaris has a battery consisting of 20 modules giving an output of 144 volts DC.



Cell = 1.2 volts

Module = 7.2 volts (6 x 1.2)

Battery = 144 volts (7.2 x 20)

HIGH VOLTAGE BATTERY:



The prismatic type battery modules are sealed units and contain an electrolyte gel which is absorbed into the plates.



The electrolyte is an alkaline (Potassium Hydroxide - KOH).

HIGH VOLTAGE BATTERY:



In extreme cases, for example collision damage, the electrolyte gel may be exposed. The electrolyte gel is harmful to skin.



BORIC ACID

can be used to neutralise the electrolyte gel contained in the Ni-MH battery modules.

HIGH VOLTAGE BATTERY:



Boric Acid (800 gr)

+

Water (20l)

=

Saturated Boric Acid

Following the neutralisation procedure, the PH can be tested if necessary with Litmus paper.

HIGH VOLTAGE BATTERY:



The HV battery has an integral, motor driven air cooling system. The battery has 3 temperature sensors which relay information to the battery ECU which in turn controls the fan motor speed by PWM (Pulse Width Modulation).



HIGH VOLTAGE BATTERY:



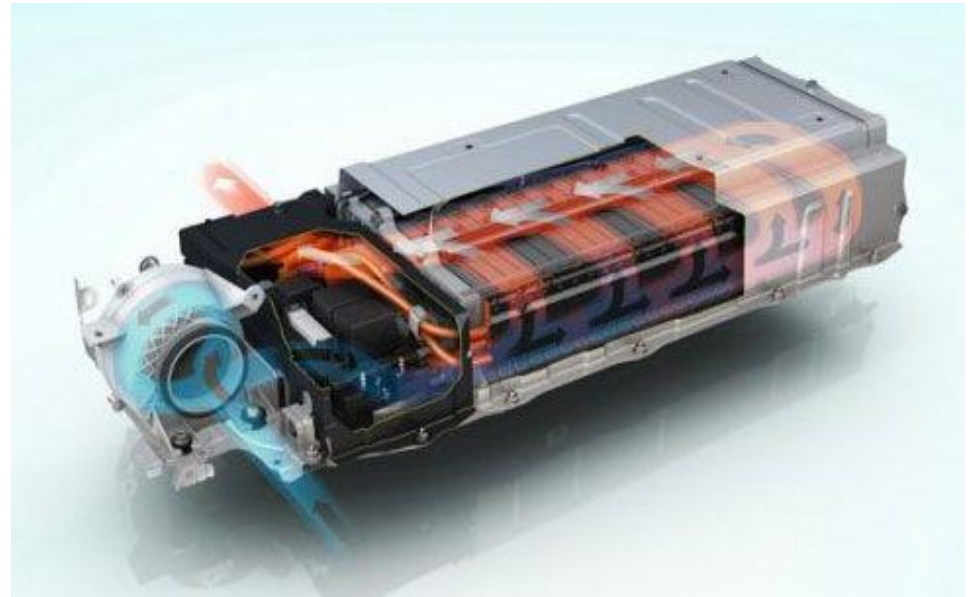
The intake for the battery cooling must be restriction free!

HIGH VOLTAGE BATTERY:

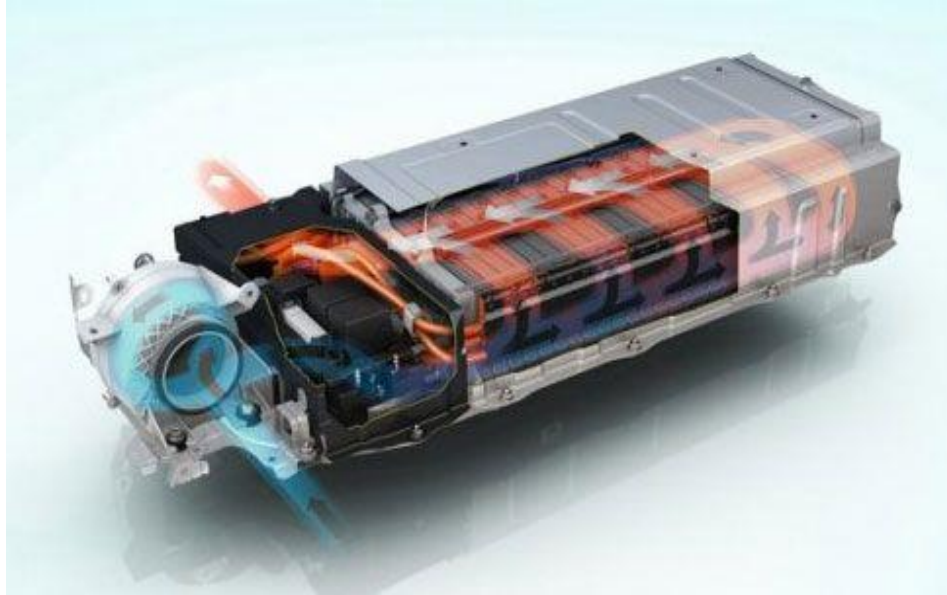


If the HV battery develops a fault, the individual module will generate a DTC (Diagnostic Trouble Code) which is retrievable with appropriate diagnostic equipment.

If a battery is replaced, the unit must be returned to the manufacturer.

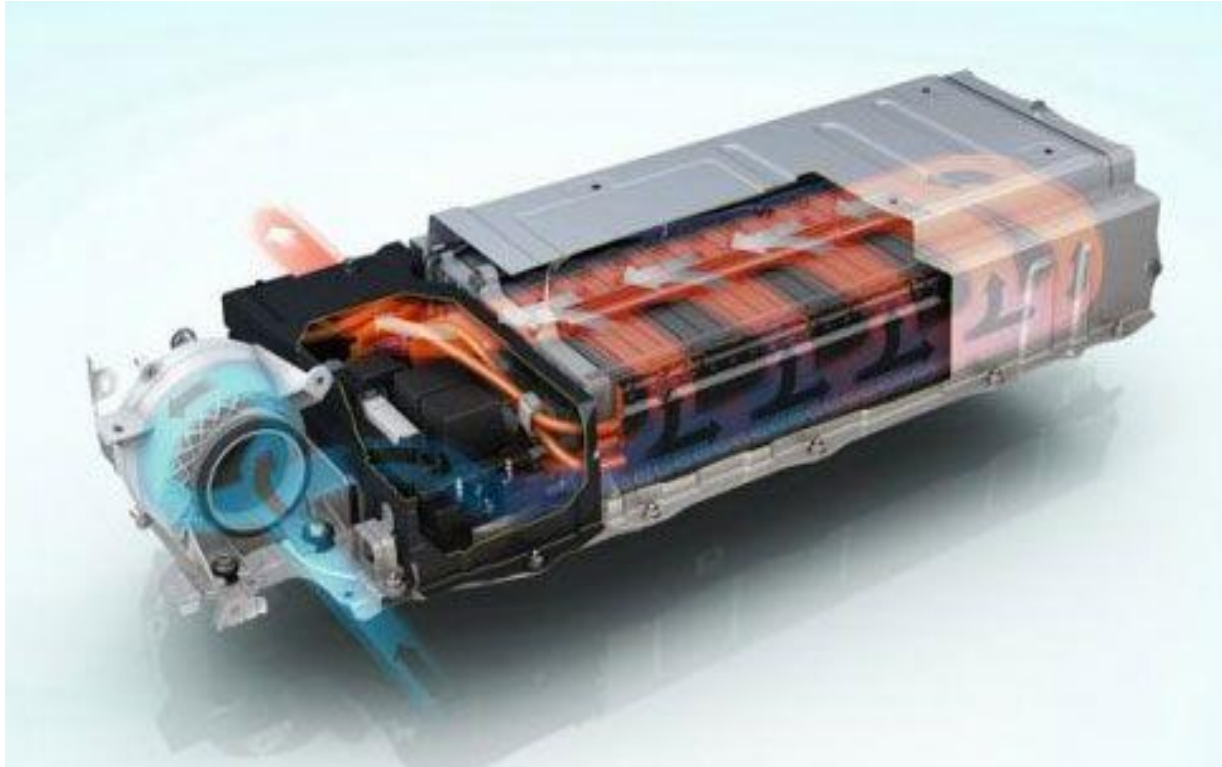


HIGH VOLTAGE BATTERY:



HV battery modules are available as individual units; however, discussions with the local franchised dealer network has shown that HV batteries are replaced as complete units.

HIGH VOLTAGE BATTERY:

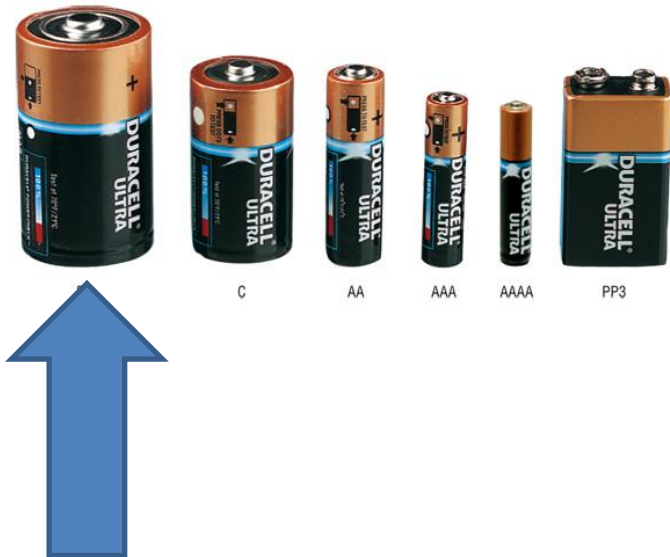


One of the fundamental issues that vehicle buyers have shown concern over has been battery life.

HIGH VOLTAGE BATTERY:



Honda systems use a battery consisting of D-cells connected in series. The D-cells are very similar to a domestic type of battery.



HIGH VOLTAGE BATTERY:



Early Honda HEV's used 144 volt Ni-MH systems with later Civics using 158.4 volts.

$$144\text{v} = 20 \times 7.2\text{v}$$

$$158.4\text{v} = 22 \times 7.2\text{v}$$



HIGH VOLTAGE BATTERY:



Some current Honda models utilise a newly developed Lithium-Ion battery pack.



HIGH VOLTAGE CABLES:



High voltage cables are mounted externally and run along the centre line of the vehicle to minimise damage and risk in the event of side impact.

HIGH VOLTAGE CABLES:

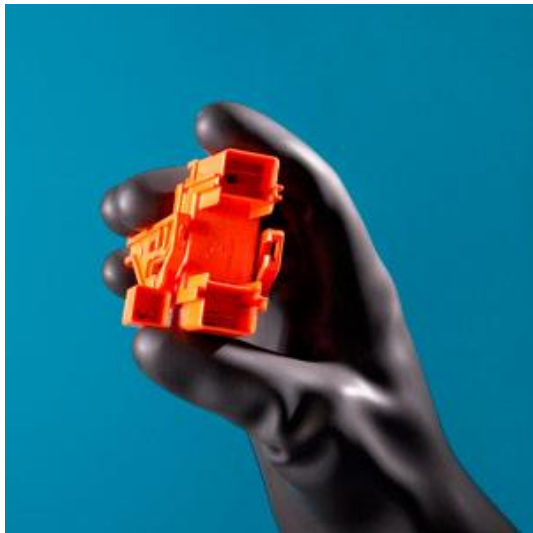


If HV cables become damaged, they **must** be replaced.

BATTERY ISOLATION:



Battery isolation will be discussed in greater depth in the future. Toyota use a “battery service plug” to isolate the HV battery voltage.



The battery service plug is basically a 125A fuse which is connected in series between the battery modules. When the service plug is removed, the battery circuit is open.



BATTERY ISOLATION:



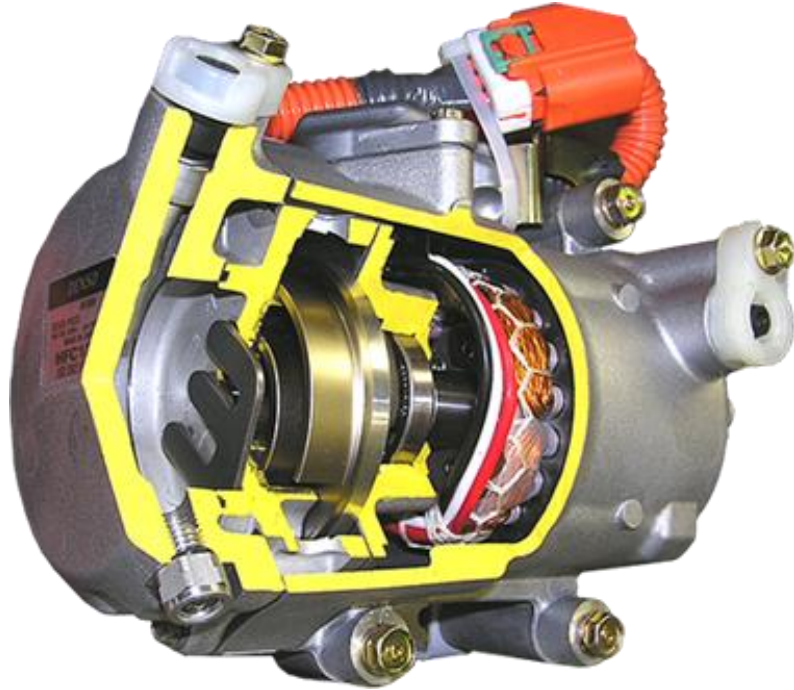
Honda systems incorporate a cut off switch in the HV battery.



AIR CONDITIONING SYSTEMS:



Toyota currently use fully electrically driven A/C compressors which are powered by the high voltage system.

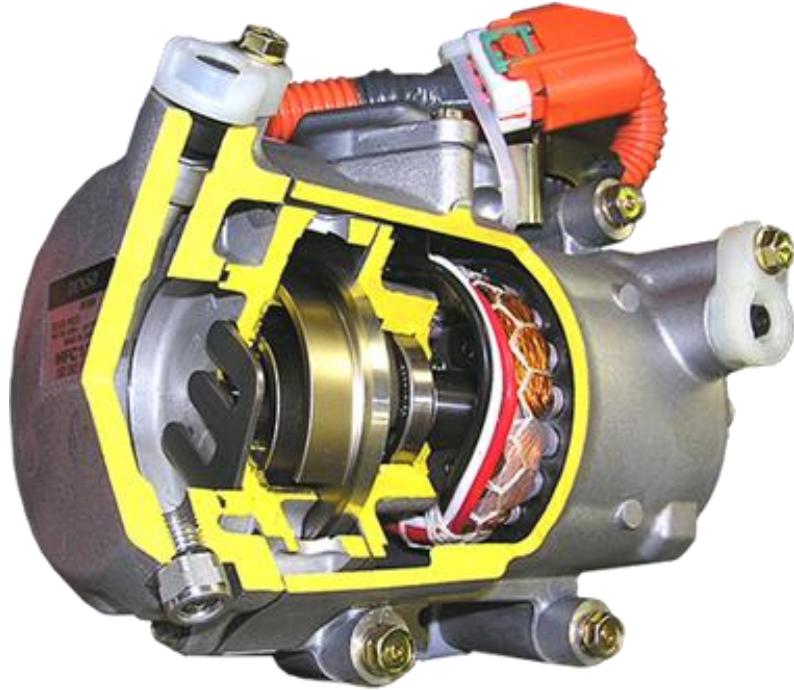


The compressor is of a scroll type construction and the A/C system uses conventional R134a refrigerant.

AIR CONDITIONING SYSTEMS:



Before any repairs are carried out on the compressor, the high voltage system must be isolated.

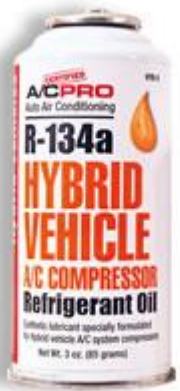


The fundamental difference in A/C systems fitted to HEV vehicles is the A/C oil that is used.

AIR CONDITIONING SYSTEMS:



The A/C oil used must have insulating properties to ensure that the HV internal components are isolated from the compressor housing and therefore the chassis.



- Use only approved A/C oil
- Once opened oil cannot be resealed or reused
- Follow service procedures carefully
- Incorrect service or repair procedures may result in **INJURY** or **DEATH**



AIR CONDITIONING SYSTEMS:



Toyota HEV's use the following A/C oil:

ND11 (ND11-08885-09129)

AIR CONDITIONING SYSTEMS:



A number of Honda models have utilised a “hybrid” A/C compressor, (termed hybrid as it has two distinct power sources). This type of compressor has two scroll type mechanisms, one powered by the ICE via a belt and the other by the high voltage power supply.



AIR CONDITIONING SYSTEMS:



As with Toyota systems, the correct A/C oil is vital.



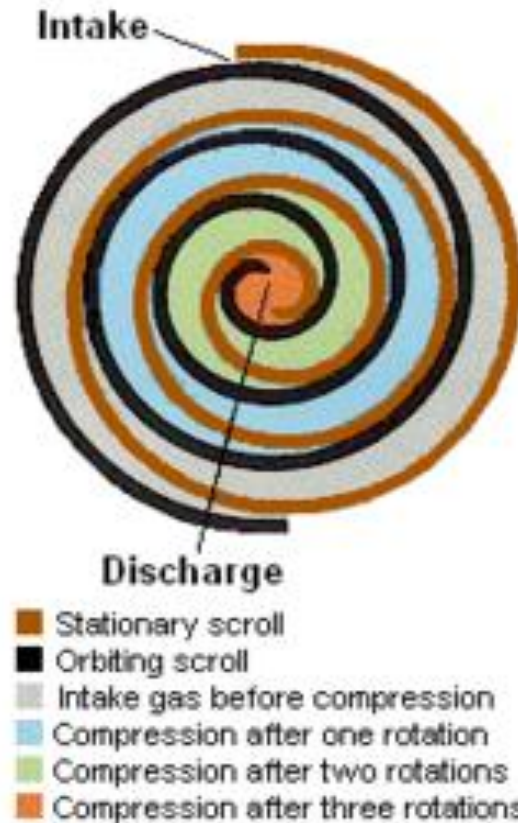
SCROLL TYPE COMPRESSOR:



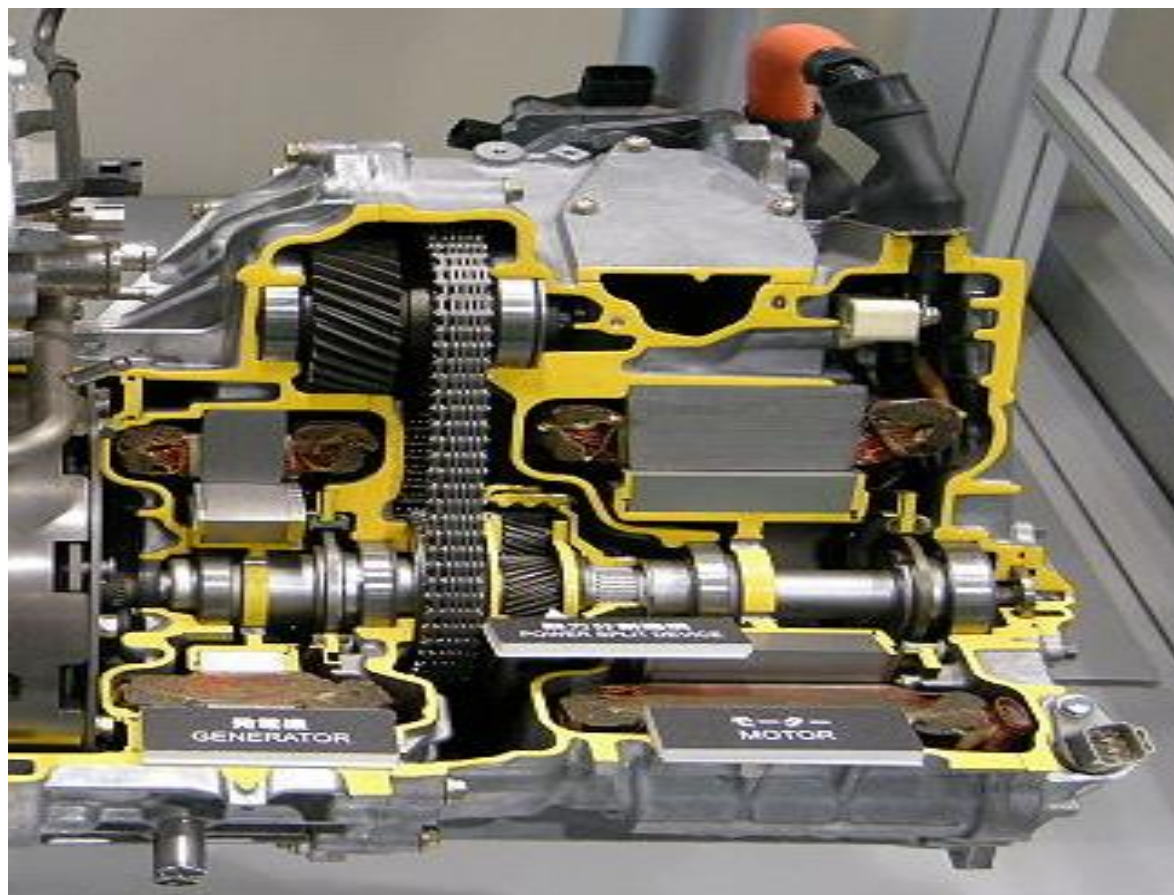
TOYOTA



HONDA



TRANSAXLE - POWER SPLIT DEVICE - MOTOR GENERATORS



TRANSAXLE - POWER SPLIT DEVICE - MOTOR GENERATORS



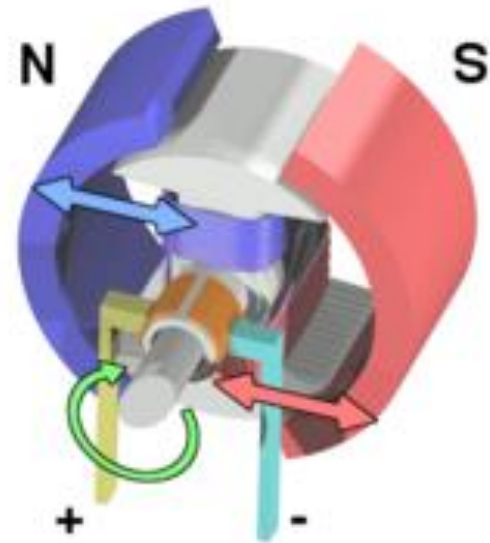
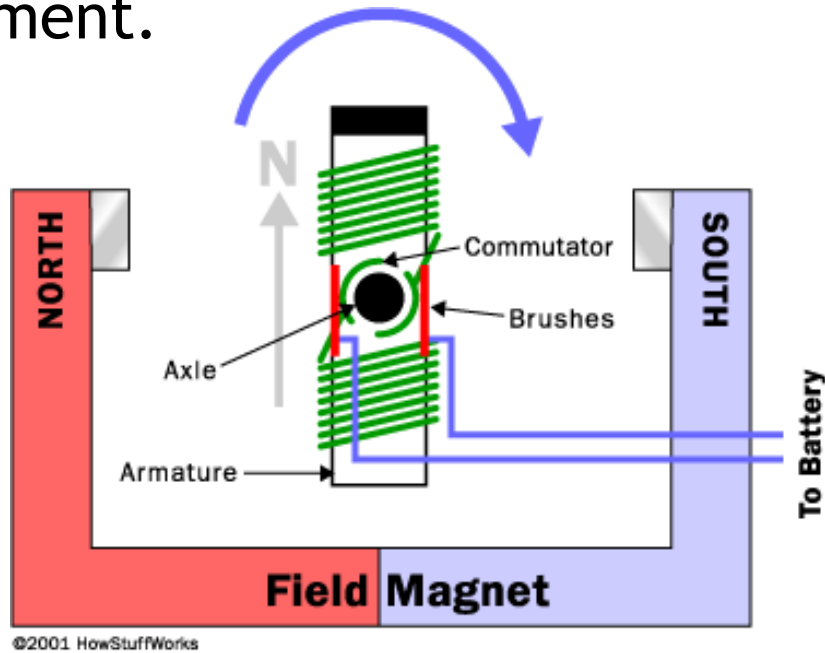
Before investigating the internal operation of the Toyota driveline systems some fundamentals and mechanical principles need to be discussed.

- **Motor/Generator Principles**
- **Planetary Gear Sets**
- **CVT**



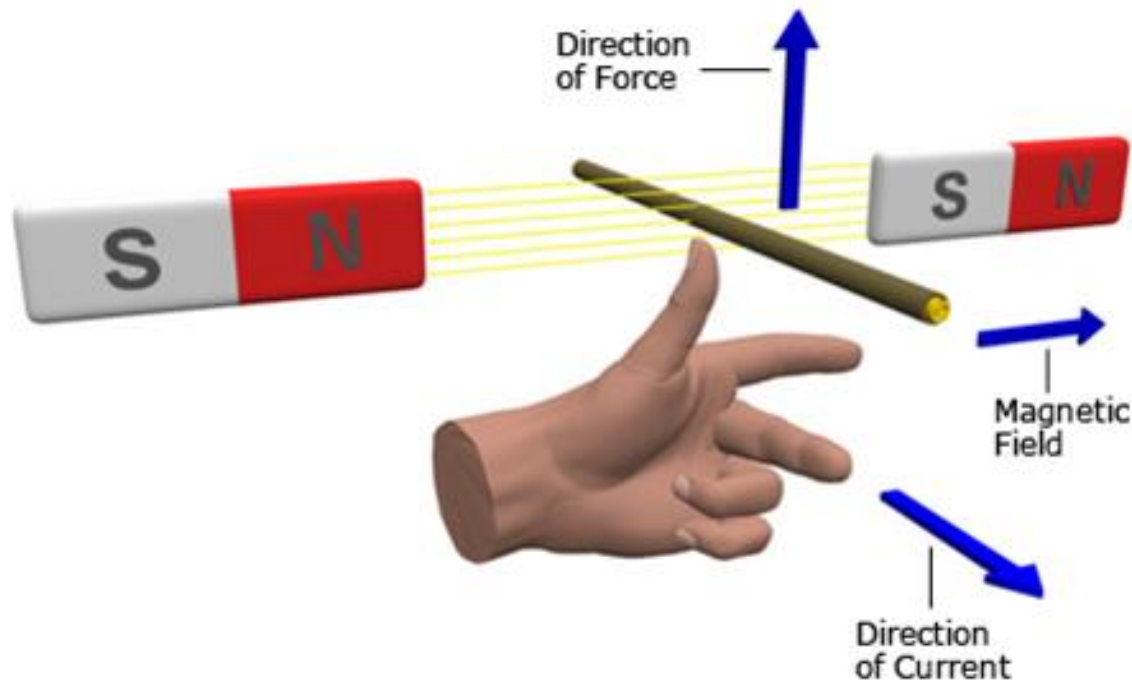
MOTORS:

In simple terms a motor is a device which converts electrical energy into mechanical energy. The principle of magnets attracting and repelling between a stationary permanent magnet and an axle mounted electromagnet cause rotational movement.



MOTORS (FLEMING'S LEFT HAND RULE):

The direction of movement of a current carrying wire in a magnetic field can be determined using Fleming's Left Hand Rule.

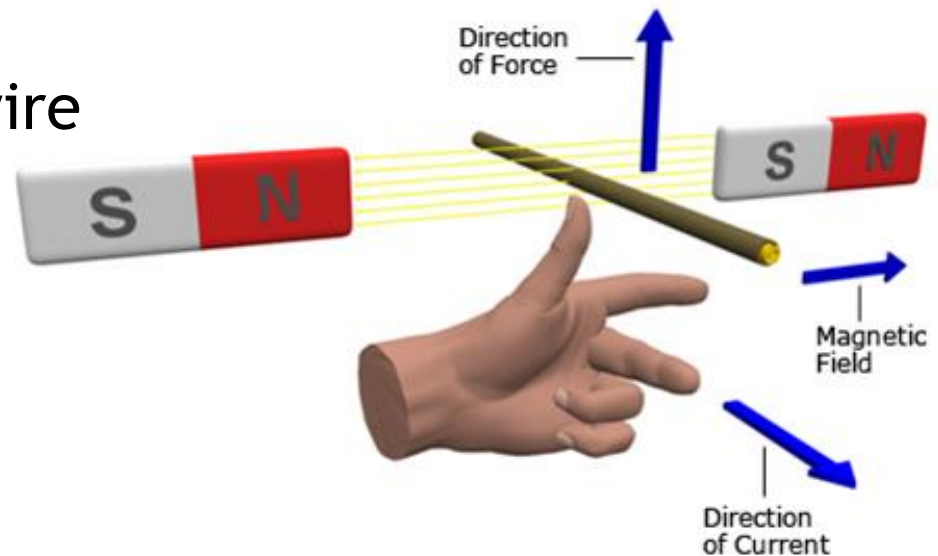


MOTORS (FLEMING'S LEFT HAND RULE):

First Finger = **F**ield (Magnetic North to South)

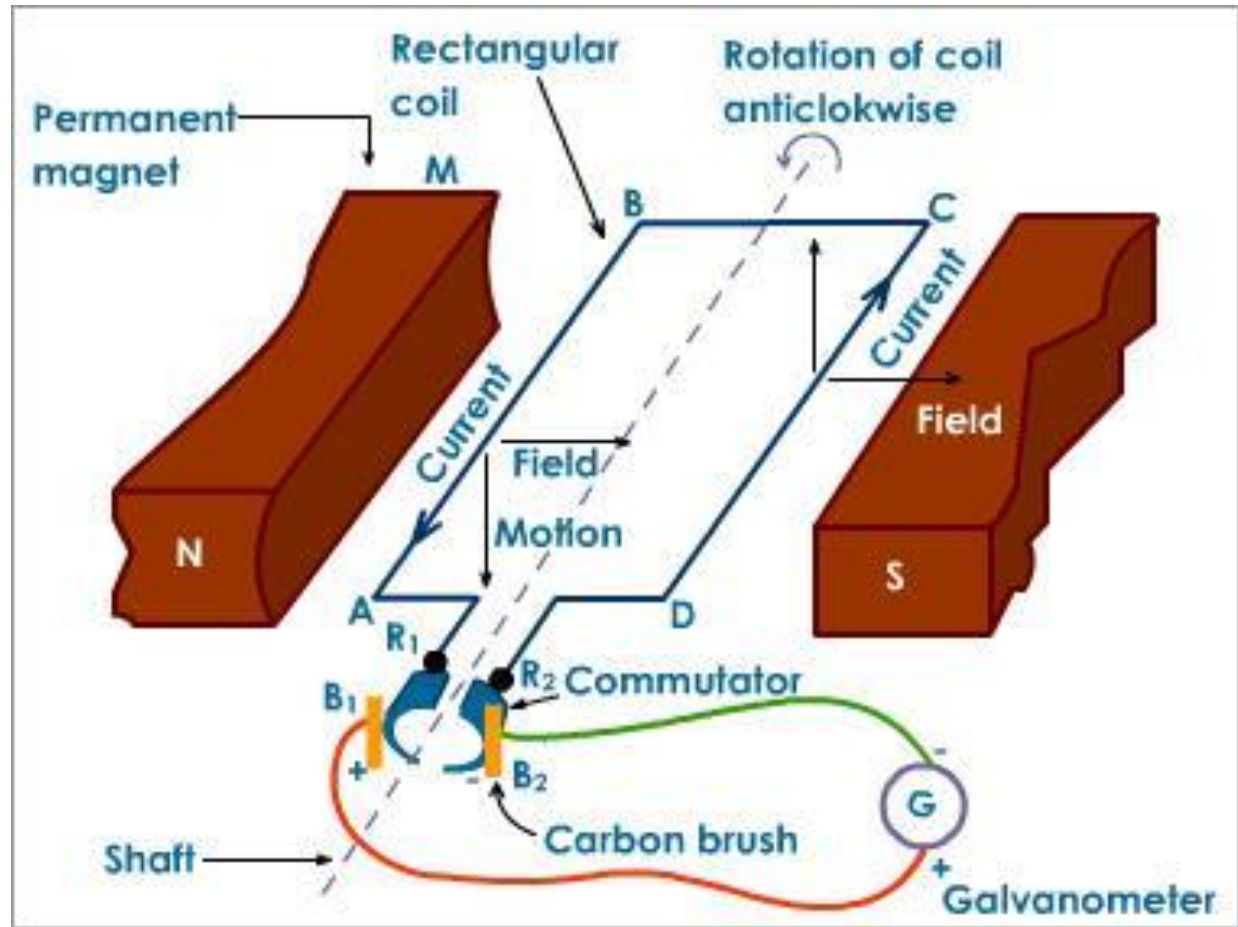
Se**C**ond Finger = **C**urrent (Conventional flow positive to negative)

Thu**M**b = **M**ovement of the wire



GENERATORS (FLEMING'S RIGHT HAND RULE):

A generator is a device which converts mechanical energy into electrical energy. In basic terms, a generator uses the same principles of a motor but in reverse. The rotation of the armature within a permanent magnet induces a current flow within the armature windings.

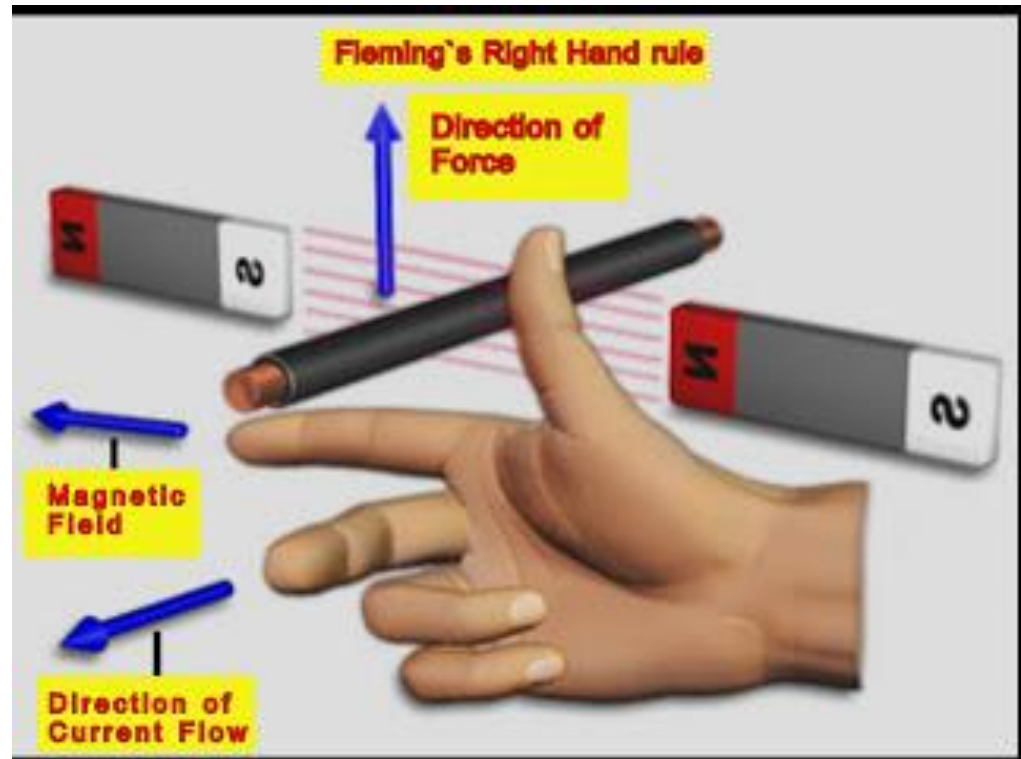


GENERATORS (FLEMING'S RIGHT HAND RULE):

First Finger = **F**ield
(Magnetic North to South)

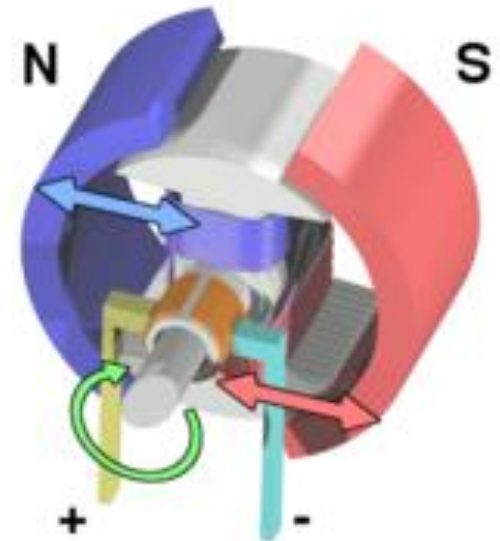
Se**C**ond Finger = **C**urrent
(Conventional flow
positive to negative)

Thu**M**b = **M**ovement of the
wire



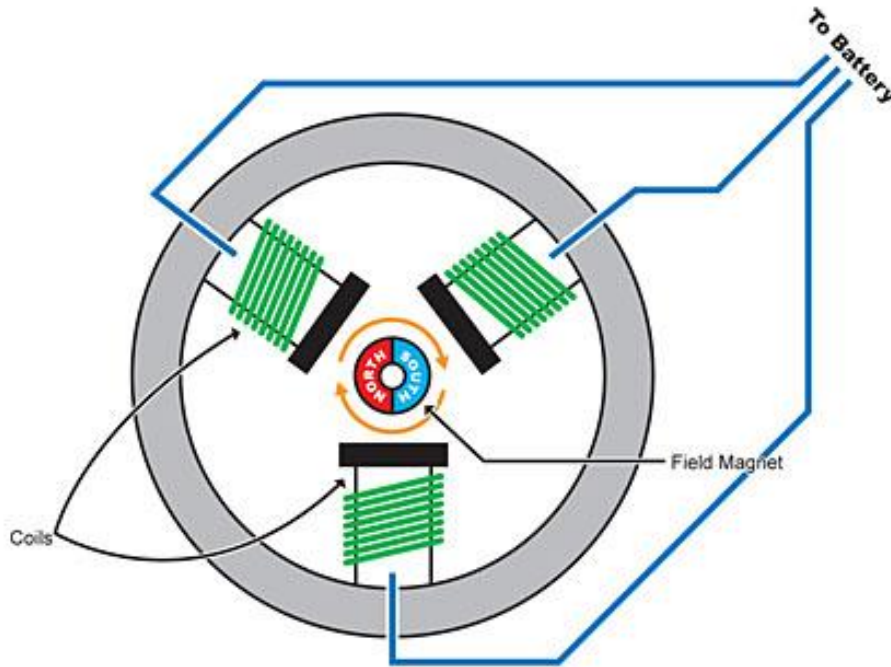
MOTOR LIMITATIONS:

- Brushes create arcing and electrical noise
- Brushes limit the maximum motor RPM
- Using brushes limits the poles that the armature can have
- Brushes wear out
- The armature location hinders cooling



BRUSHLESS MOTORS:

A brushless motor is basically a conventional motor turned inside out. The permanent magnets are fitted to the rotor and the electromagnets are fitted to the casing.



The energising of the electromagnets is computer controlled which improves precision and speed control of the motor in comparison to a motor with brushes.

ADVANTAGES OF BRUSHLESS MOTORS:

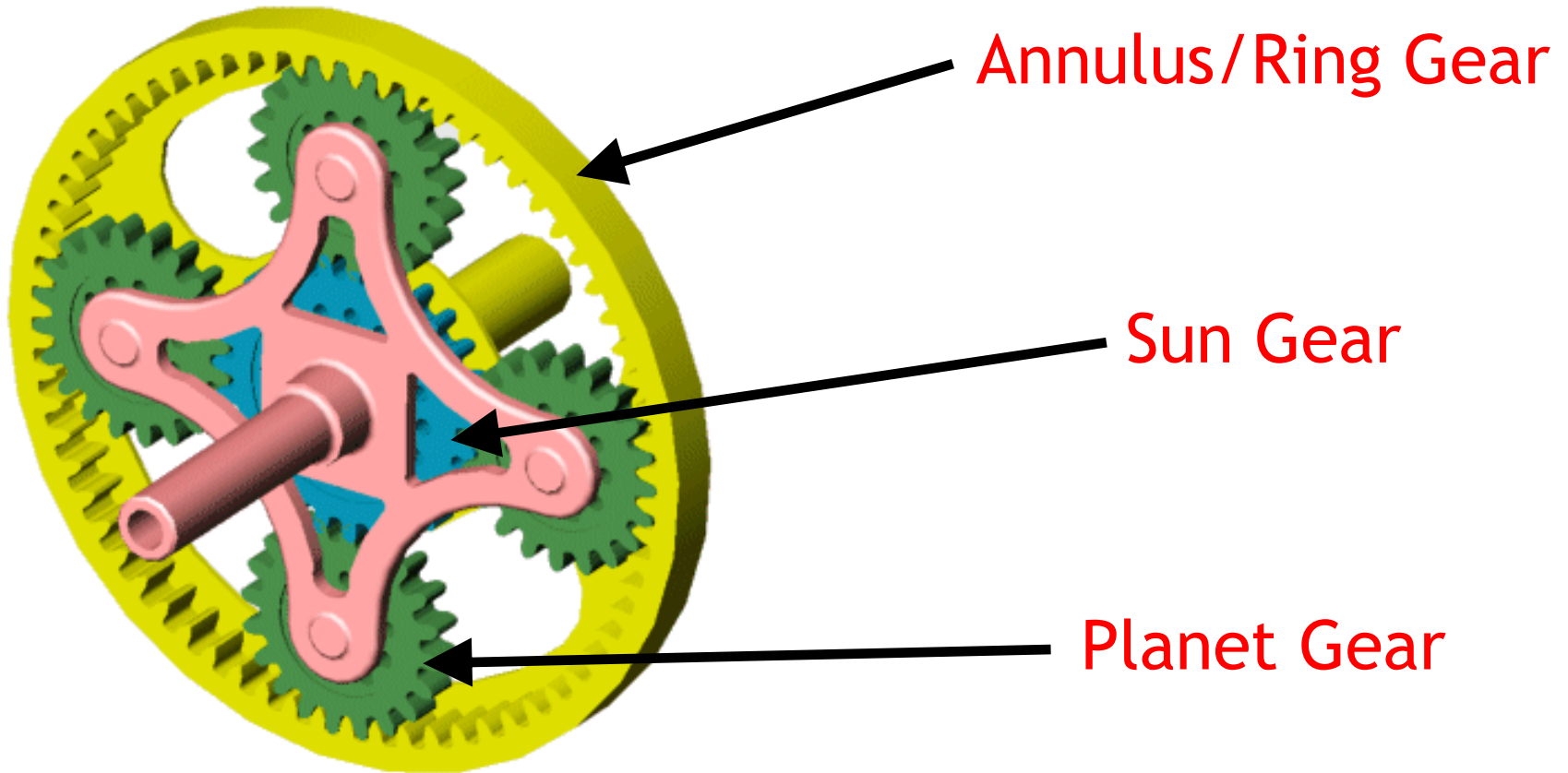
- Precise control
- Reduced electrical arcing and noise
- No brushes to wear
- Facility to incorporate many electromagnets on the stator for added precision and control
- Easier cooling



The only disadvantages of brushless motors are the initial production and control costs.

PLANETARY GEAR SETS (EPICYCLIC):

Identify the components:



PLANETARY GEAR SETS (EPICYCLIC):

Planetary gear sets have been common place in automotive applications for many years, especially within automatic transmission systems. The power split device located in the Toyota transaxle assembly employs the use of planetary gear sets.



PLANETARY GEAR SETS (EPICYCLIC):

As discussed earlier, the gear set consists of three basic elements:

1. Annulus/Ring
2. Sun
3. Planets

By holding the individual elements stationary, different outcomes become achievable.



PLANETARY GEAR SETS (EPICYCLIC):

Here are some of the fundamental advantages of using planetary gear sets:

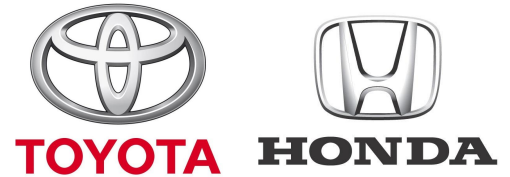
- High power density
- Space saving
- Multiple ratio achievement



CVT ?

CONTINUOUSLY VARIABLE TRANSMISSION

CVT:

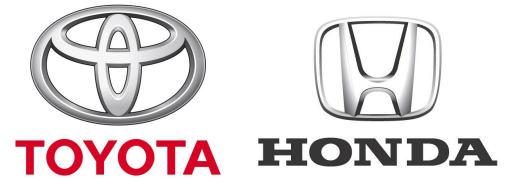


A CVT transmission offers infinite gear ratios within a certain band with uninterrupted torque transmission between gear changes.

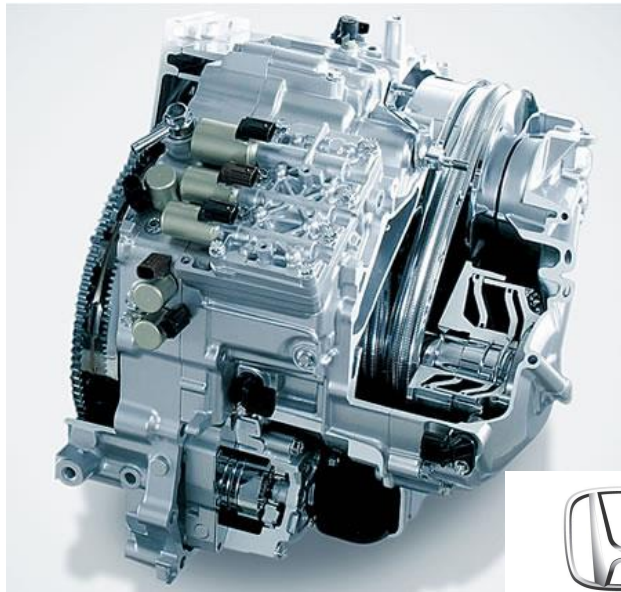
Theoretically a CVT can allow an engine to run at it's most efficient RPM for a range of vehicle speeds, therefore improving fuel economy.



CVT:



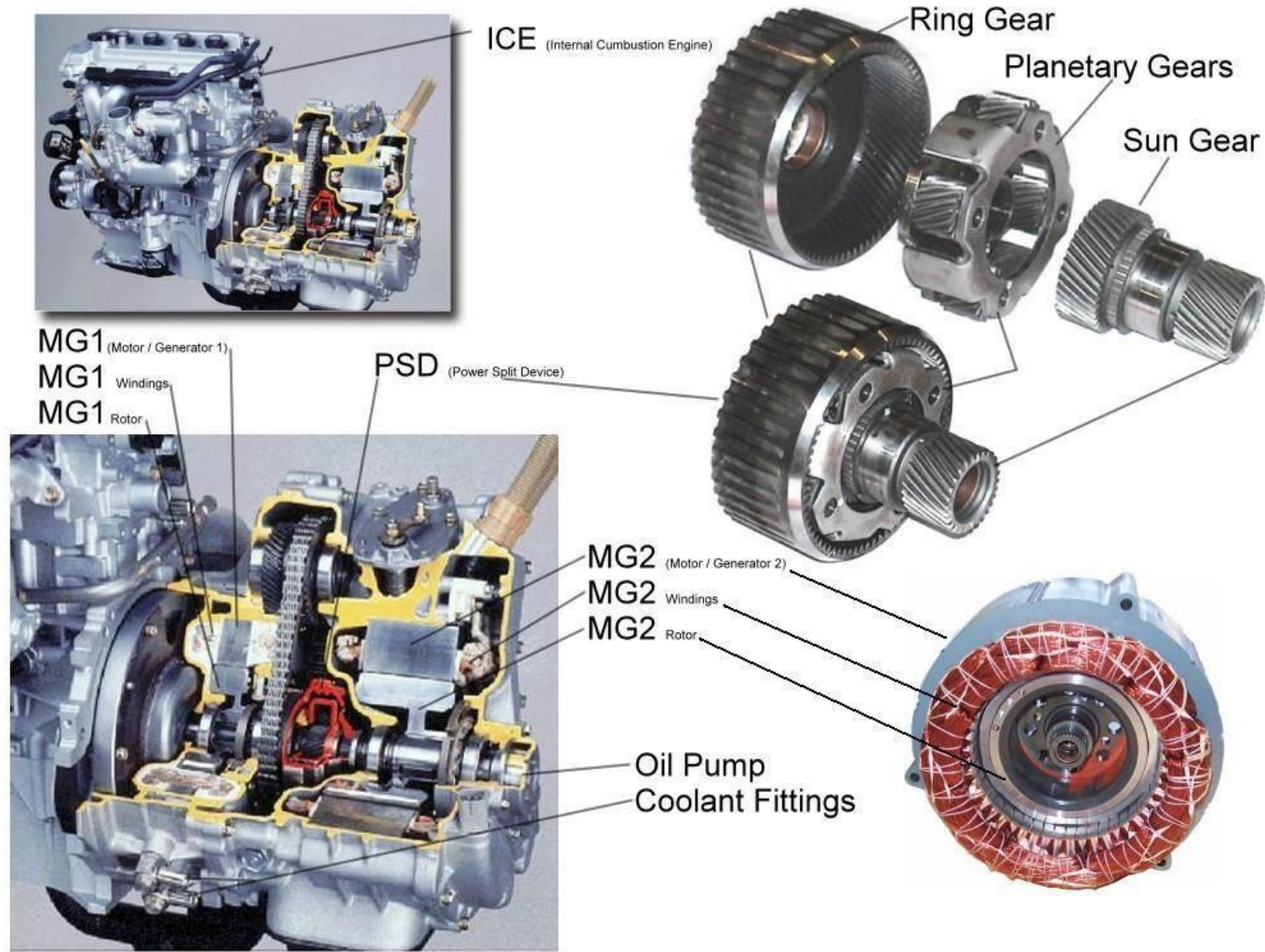
Currently Honda use a stand alone CVT and Toyota incorporate a CVT system in conjunction with their power split device.



TOYOTA TRANSAXLE OVERVIEW:



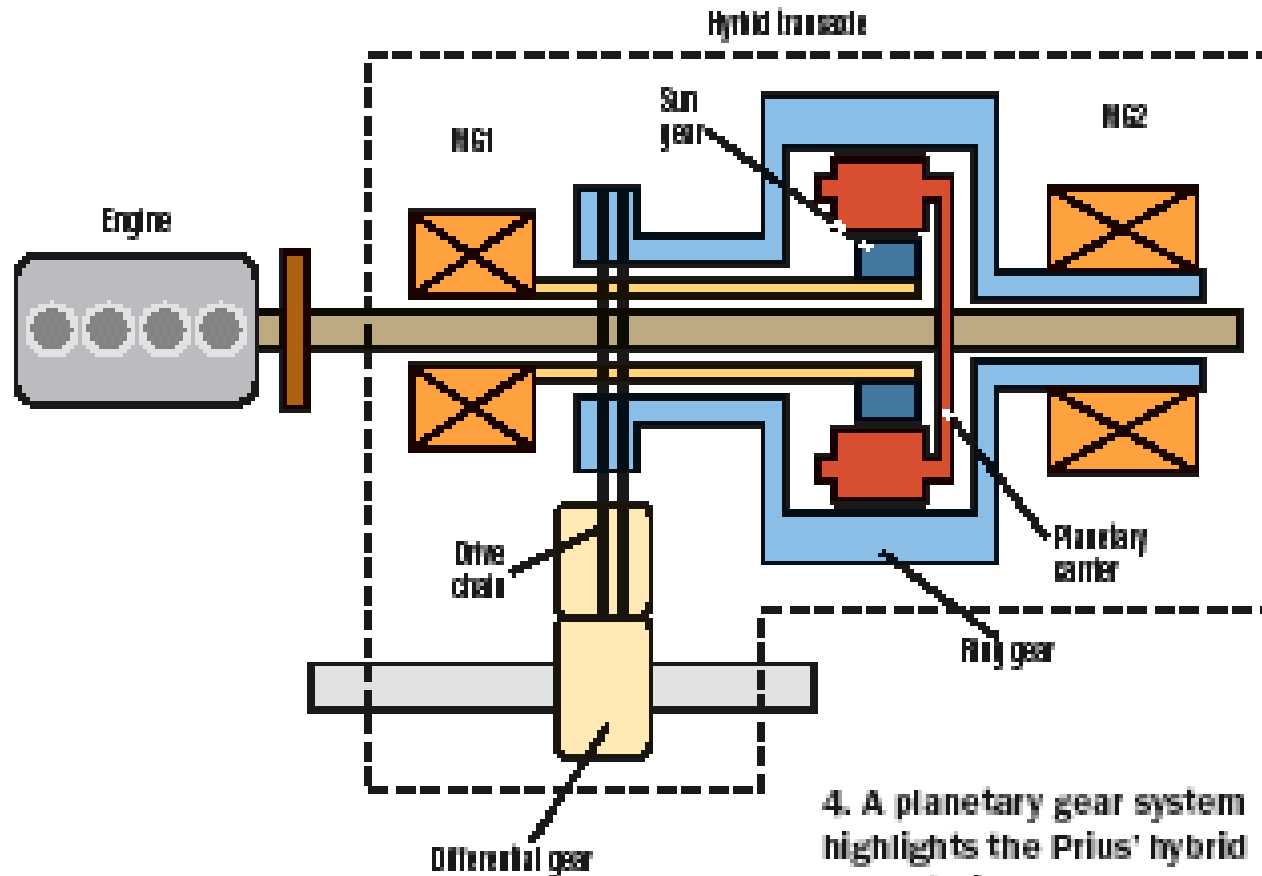
TOYOTA



TOYOTA TRANSAXLE OVERVIEW:



TOYOTA



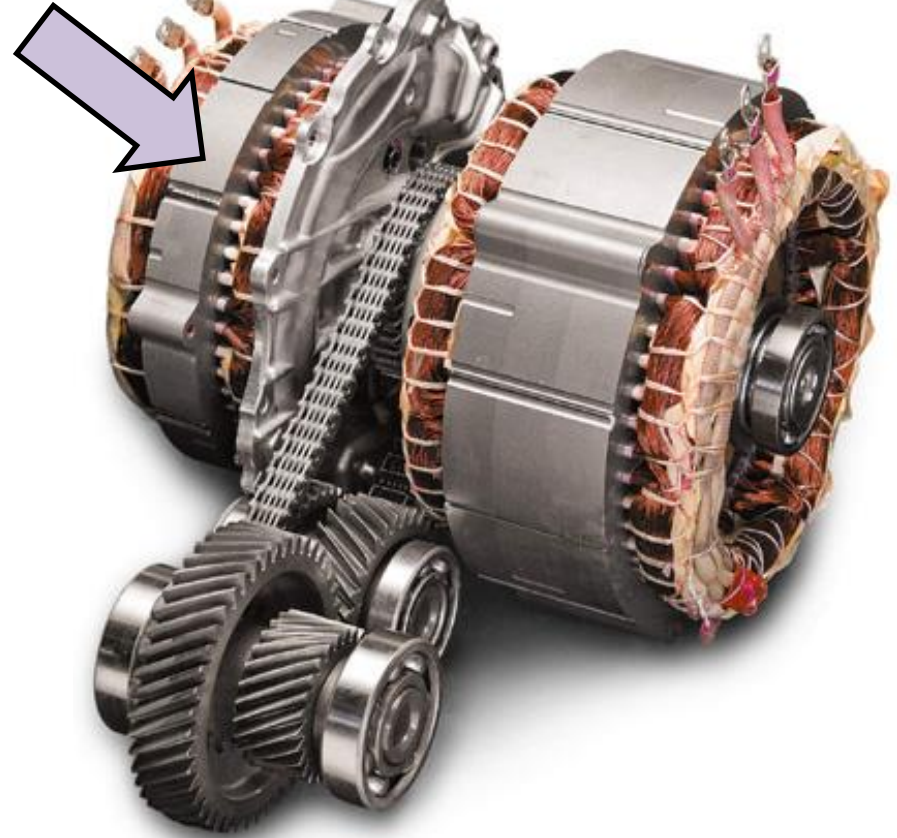
4. A planetary gear system highlights the Prius' hybrid power train.

TOYOTA TRANSAXLE COMPONENT OVERVIEW (MG1):



Motor/Generator 1 is the secondary motor and is physically smaller in size than motor/generator 2. MG1 acts as a motor sharing power with the internal combustion engine to drive MG2. MG1 charges the HV battery when acting as a generator and is also used to start the internal combustion engine.

MG1



TOYOTA TRANSAXLE COMPONENT OVERVIEW (MG2):



Motor/Generator 2 drives the vehicle wheels. MG2 powers the vehicle from stand still up to approximately 20 mph. During regenerative braking, MG2 acts as a generator converting kinetic energy into electrical energy which further charges the HV battery.



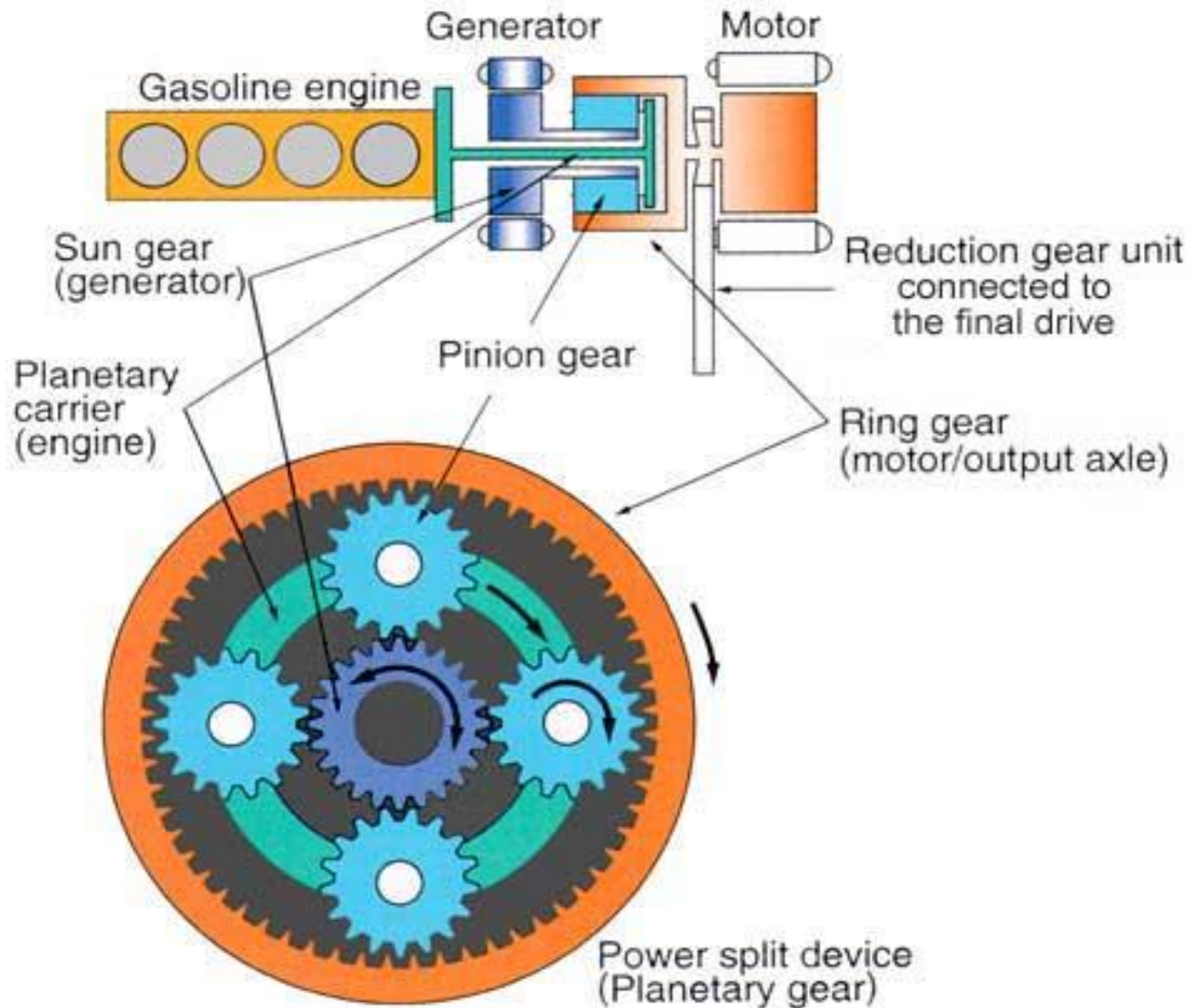
MOTOR GENERATORS:



	MG1	MG2
Type	Synchronous Motor	Synchronous Motor
Function	Generator, Engine Starter	Generator, Wheel Drive
Rated Voltage (V)	650 AC	650 AC
Max Output-kW(PS)/rpm	37.8(51)9500	50(68)1200-1540
Max Torque-Nm(kgf/m)/rpm	45(4.58)0-6000	400(40.8)/0-1200
Amps at Max Torque (A)	75	230
Max rpm	10000	6700
Cooling System	Water Cooled	Air Cooled

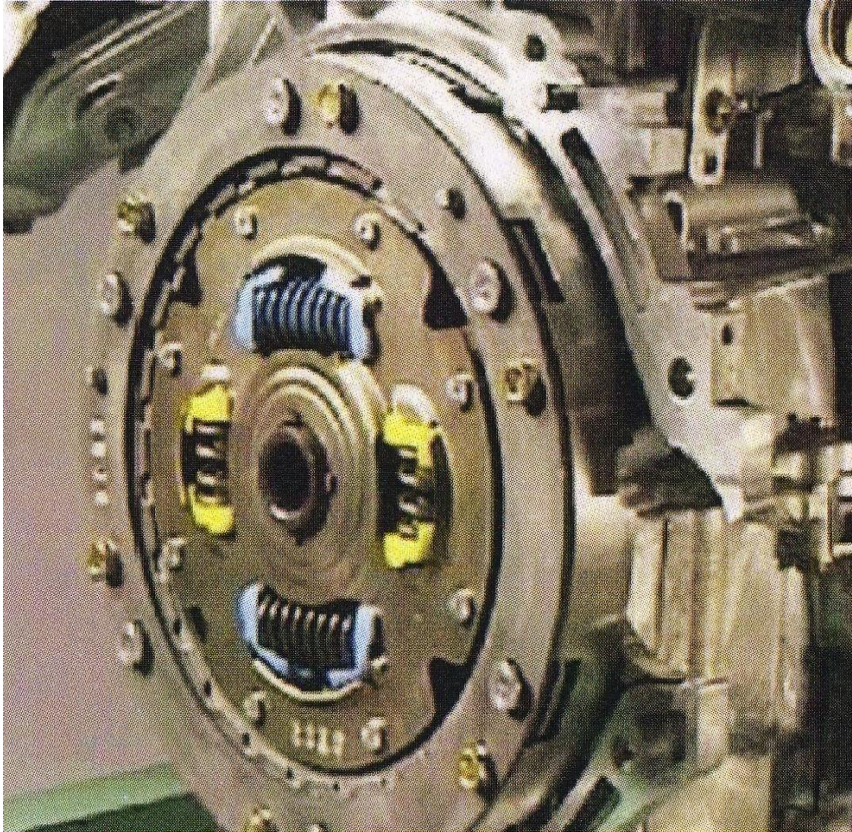


TOYOTA



Courtesy: Toyota Motor Corporation

TRANSAXLE DAMPER:



The transaxle damper is positioned where a traditional clutch plate would be located. The purpose of this component is to reduce the shocks which occur when kinetic energy is transmitted.

HEALTH ISSUES:

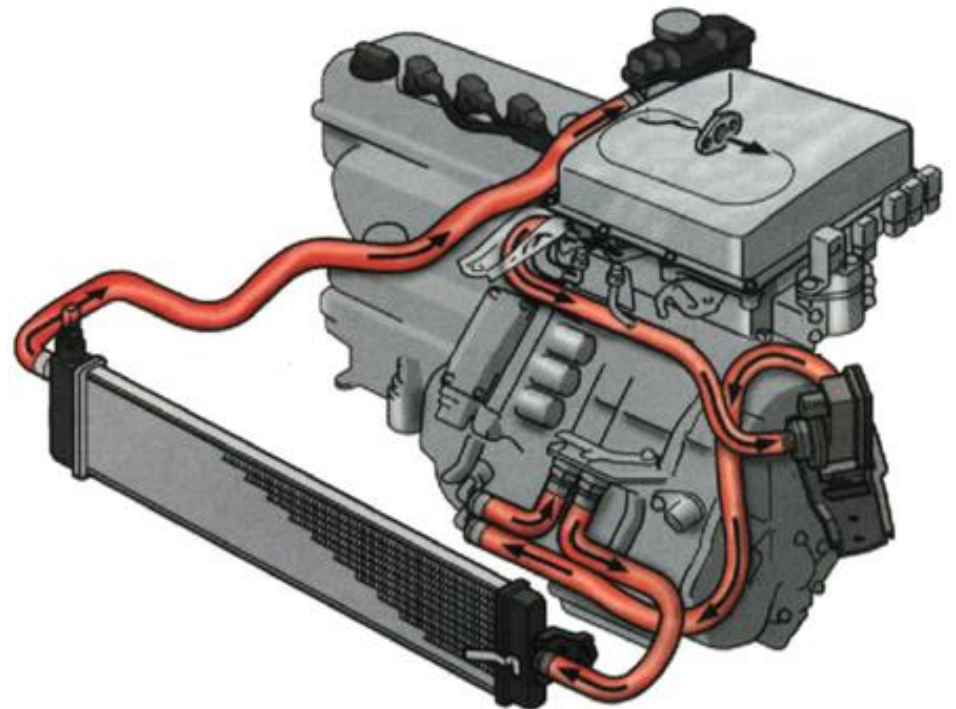
There is some risk that highly magnetic fields from the motor assembly could cause interference with heart pacemakers!



HV COOLING SYSTEM:



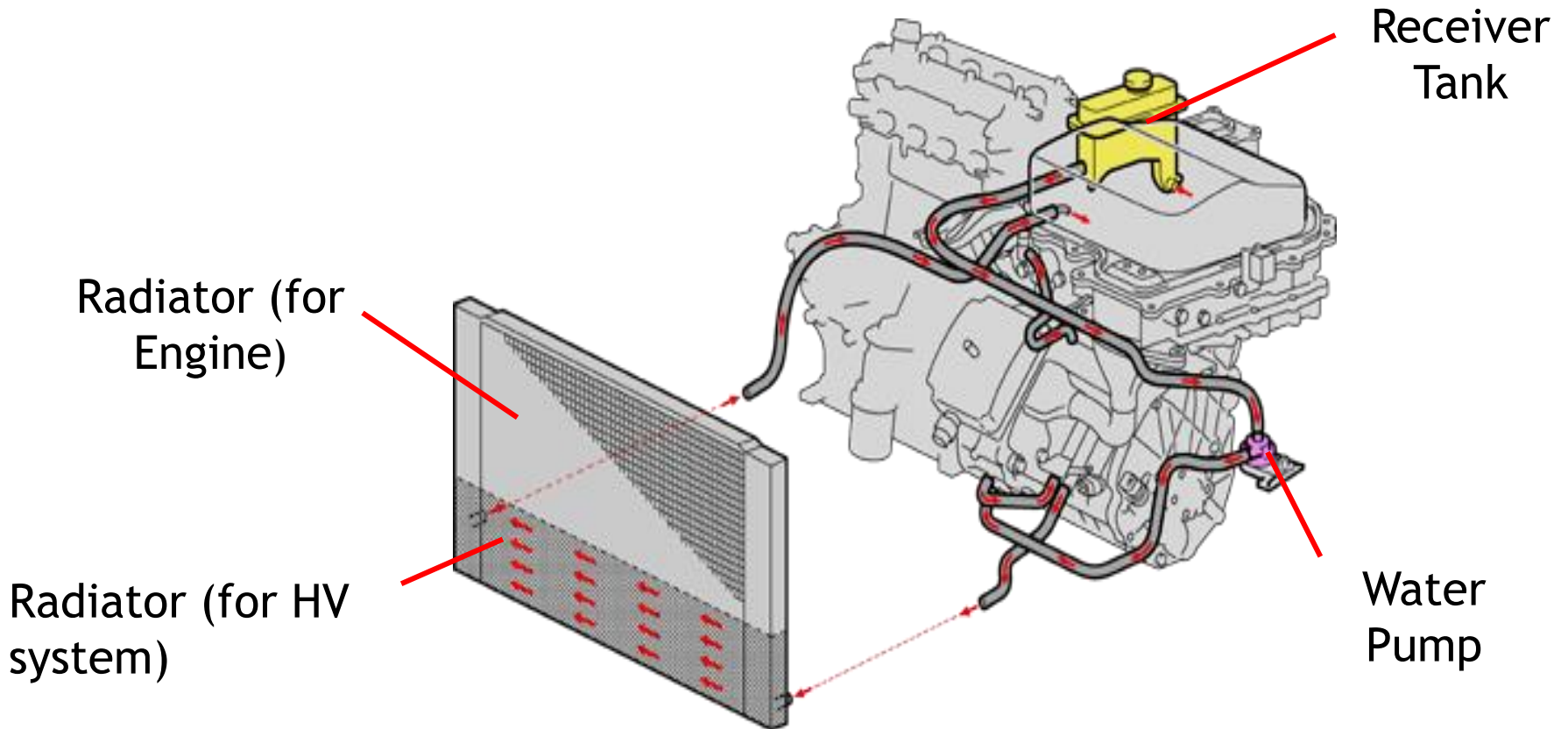
Due to the temperatures produced by the electrical components of the hybrid system, a separate cooling system is incorporated.



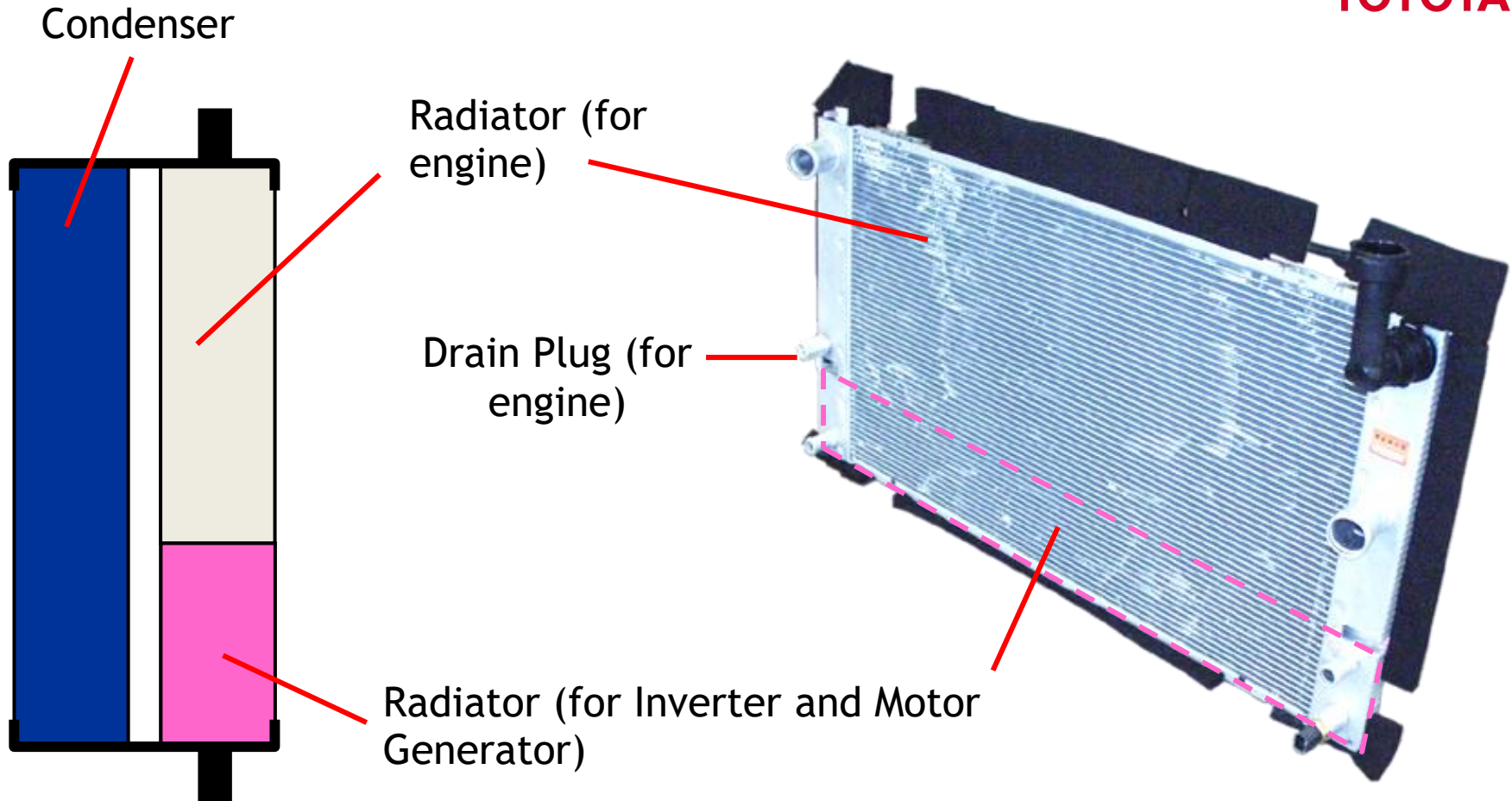
HV COOLING SYSTEM:



TOYOTA



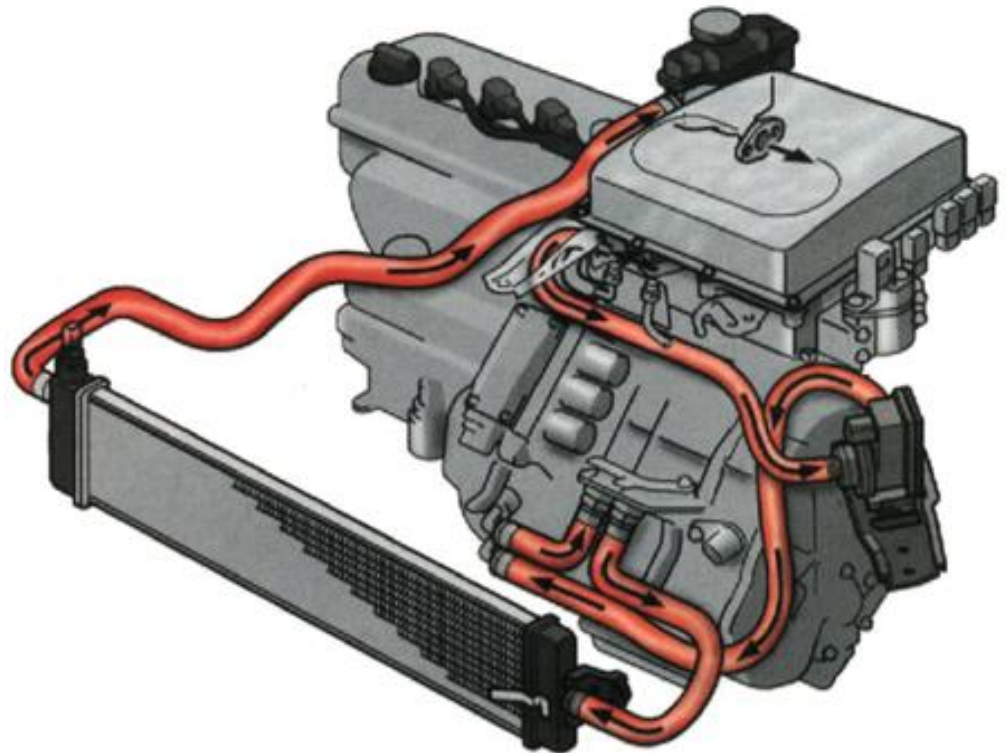
HV COOLING SYSTEM:



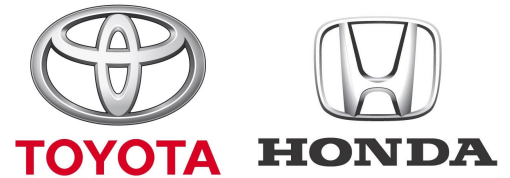
HV COOLING SYSTEM:



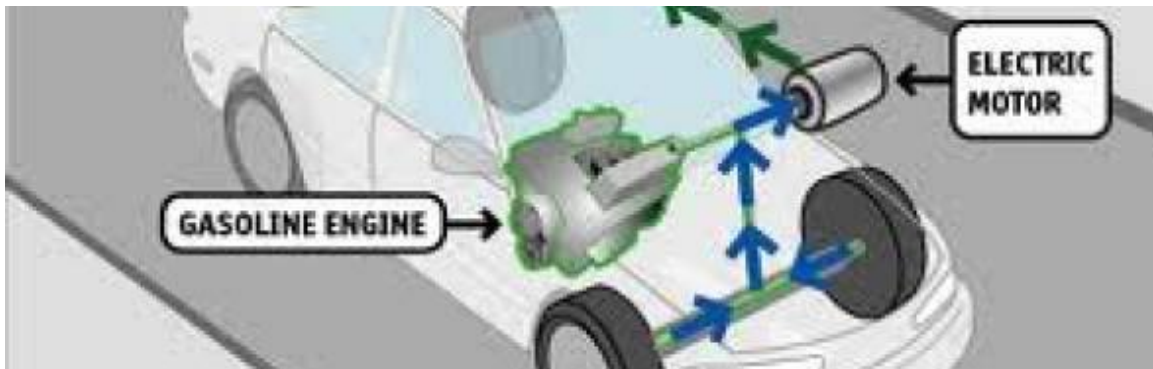
The hybrid cooling system has a capacity of 2.7 litres and uses Super Long Life coolant - 08889-80072



REGENERATIVE BRAKING:



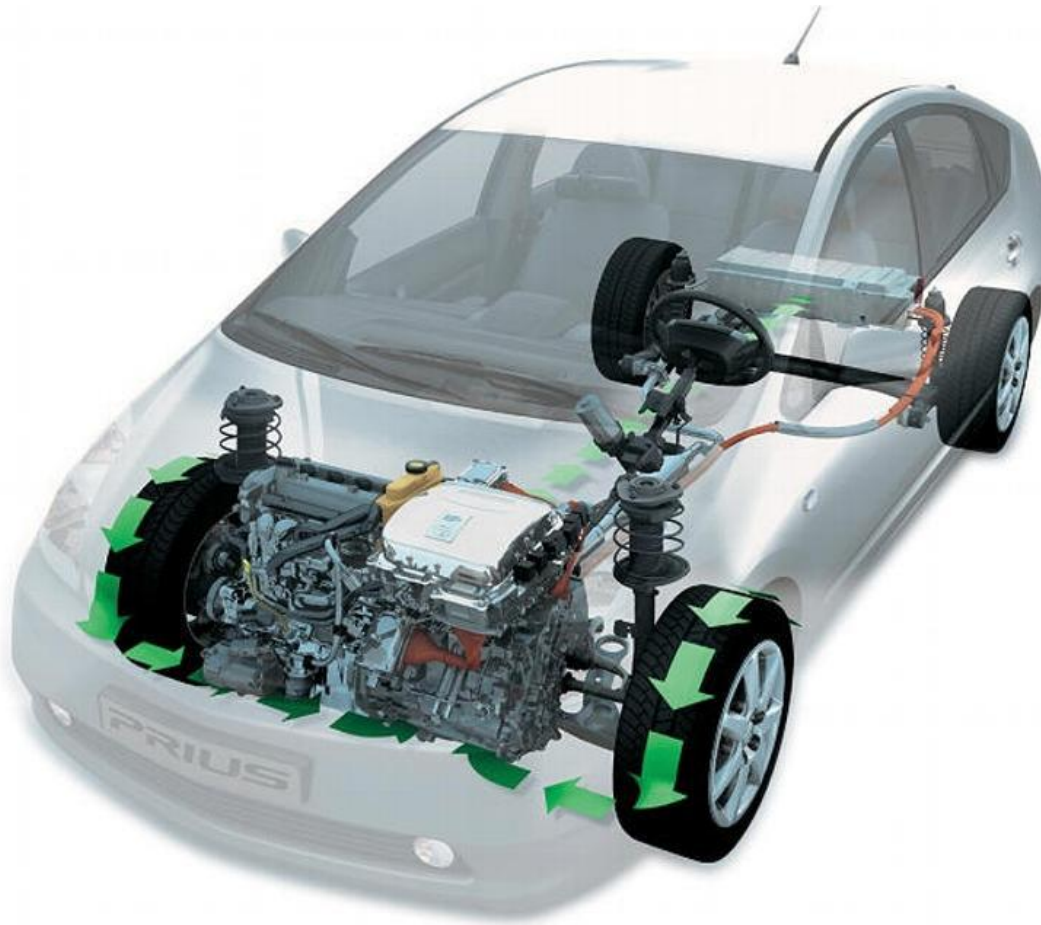
On HEV's, regenerative braking can be described as the capturing of kinetic energy which would otherwise be wasted. The kinetic energy is converted into electrical energy which is then used to charge the HV battery.



REGENERATIVE BRAKING:

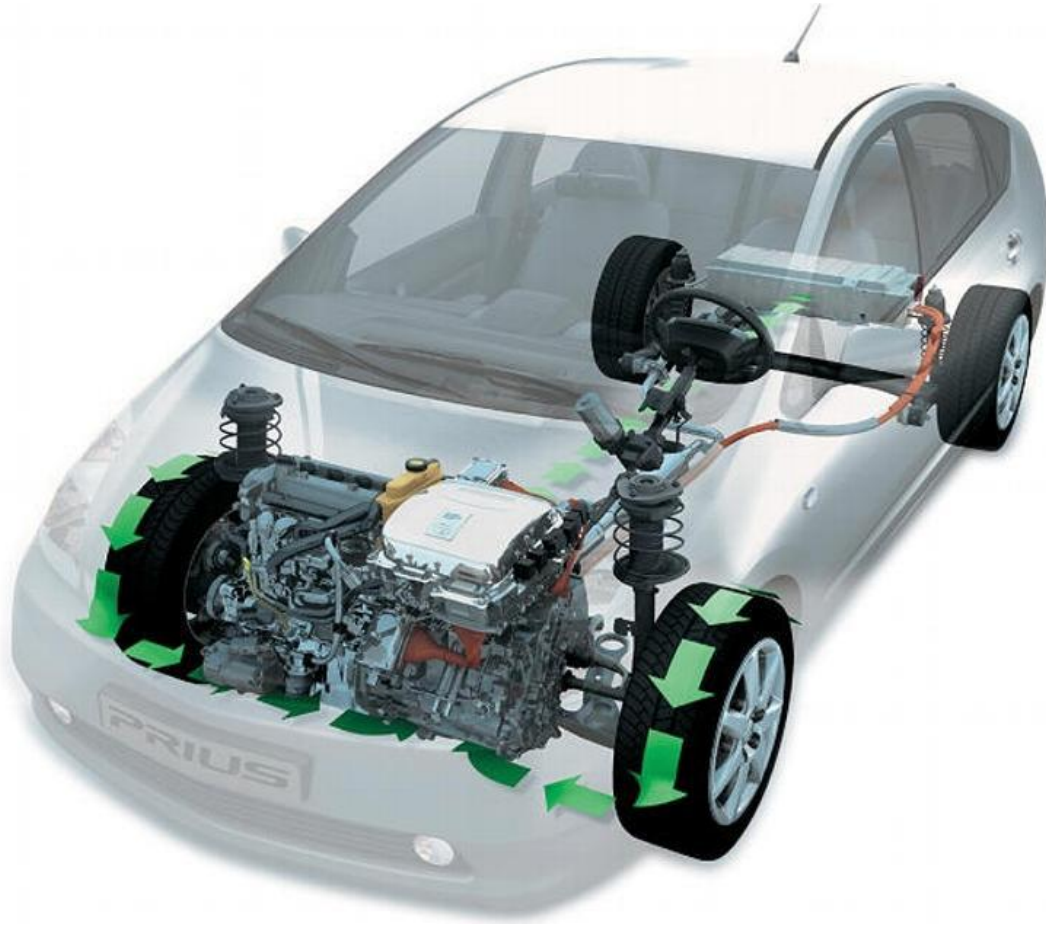


TOYOTA



On Toyota systems, in addition to storing electrical energy in the HV battery, the hybrid regenerative braking system stores electrical energy within a capacitor which is located in the inverter assembly. The electrical energy stored in this capacitor is released when the throttle is applied to assist with acceleration and fuel efficiency.

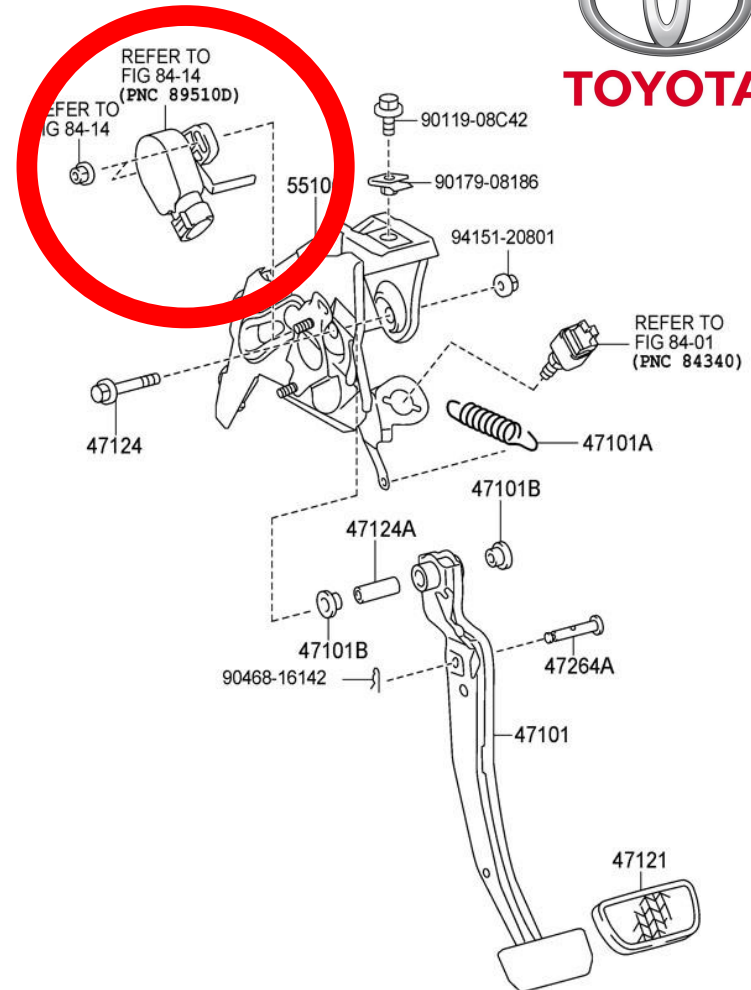
REGENERATIVE BRAKING:



As the brake pedal is applied, the hydraulic pressure is monitored by the ECU. The ECU then allows sufficient hydraulic force to be applied to the mechanical brakes. Additional braking is carried out by MG2.

REGENERATIVE BRAKING:

Brake pedal position is monitored via a stroke sensor. The information received from the sensor influences the amount of applied brake force.



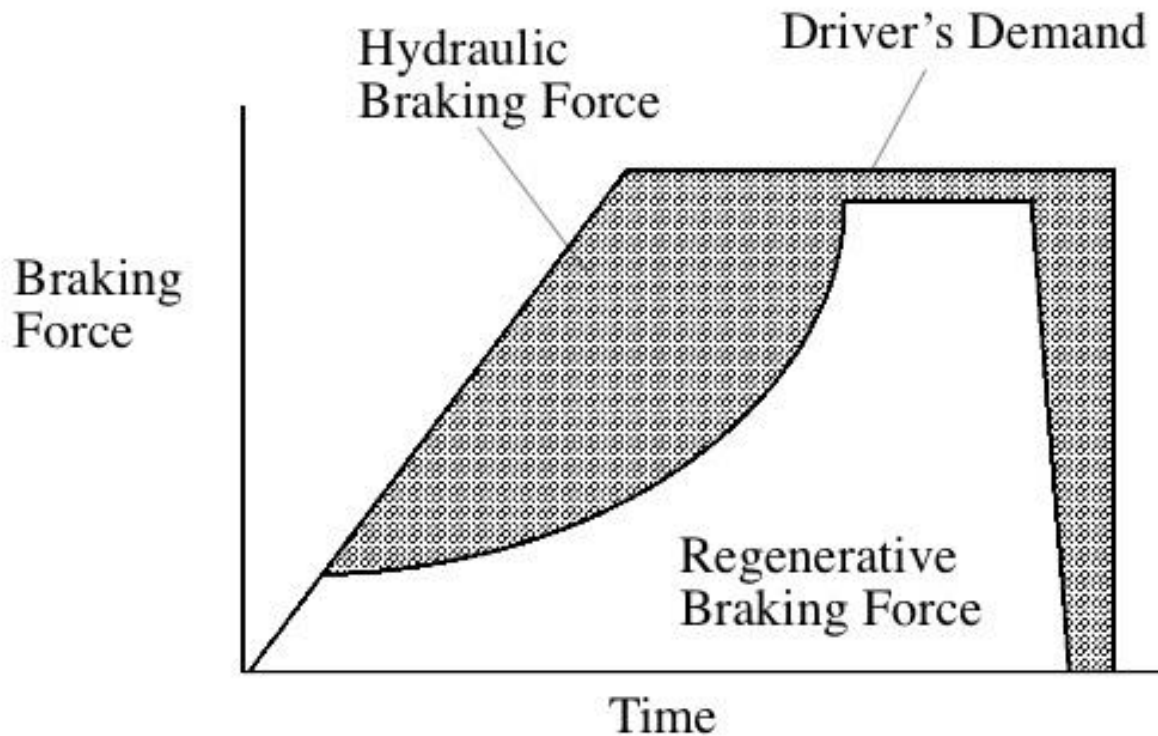
REGENERATIVE BRAKING:



Brake regeneration is activated by the ECU following the interpretation of information from various sensors.

In some instances, it is stated that regenerative braking is activated by pressure sensing within the braking circuit?

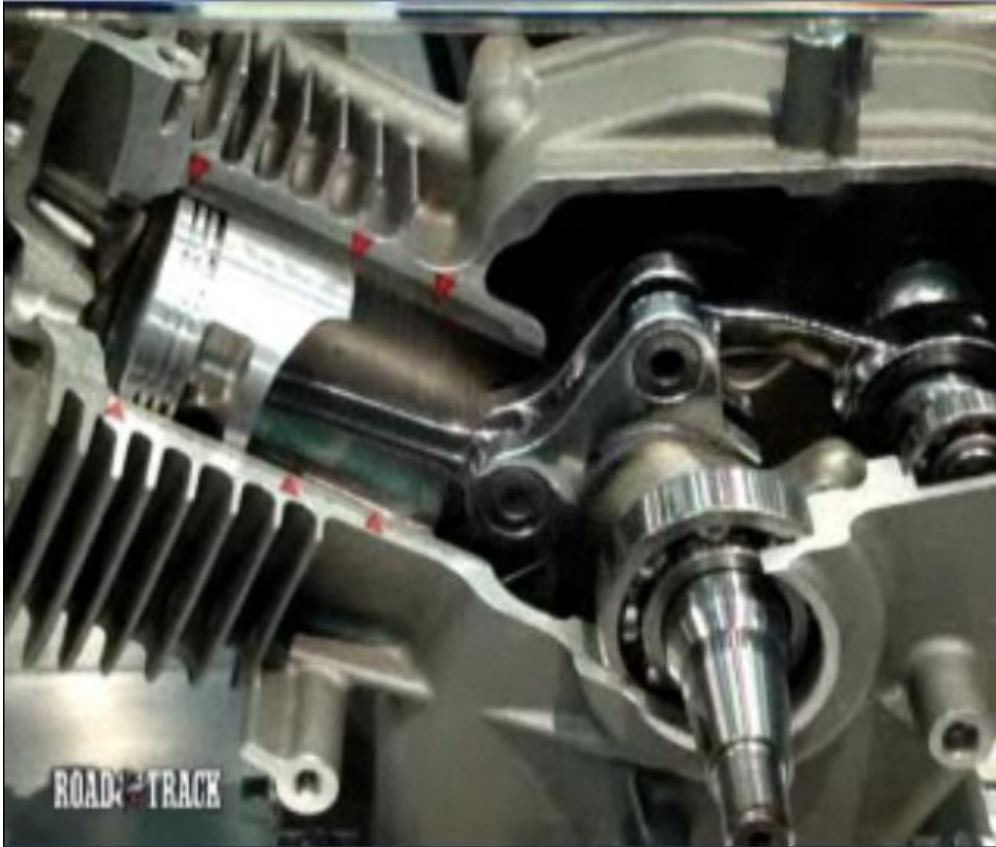
REGENERATIVE BRAKING:



Changes in Braking Force Apportionment

ICE DEVELOPMENTS FOR HEV USE

ATKINSON CYCLE:



The Atkinson cycle was originally developed in the late 1800's. The cycle incorporates the four cycles of induction, compression, power and exhaust that we are familiar with; however, they are carried out with one crankshaft rotation.

ATKINSON CYCLE:

The principle of the Atkinson cycle was achieved using additional linkages. On the intake stroke, the piston does not travel fully down the bore. The piston rises on the compression stroke and the air/fuel mixture is ignited. On the power stroke, the piston now travels fully downwards to the lowest achievable point. The exhaust stroke is then completed and the four strokes are completed.

The reduction in compression and reduced fuel usage does result in reduced power and torque output, but efficiency is improved due to the one power stroke per one crankshaft revolution.

ATKINSON CYCLE:



A petrol driven internal combustion engine adopting the Atkinson Cycle suits an HEV in the method of it's operation.

Fuel usage is reduced leading to increased fuel economy and reduced exhaust emissions. The losses in power are compensated for by the motor assemblies.



ATKINSON CYCLE:



Toyota label their HEV ICE as an Atkinson engine.

As opposed to additional linkages on the crankshaft, the Toyota system uses VVT (Variable Valve Timing) to replicate the Atkinson Cycle. The inlet valve is opened for a prolonged period to reduce compression pressure.



ATKINSON CYCLE:



- In the case of the Prius engine, the effective compression ratio is about 8:1, while the expansion ratio is about 13:1. As a result, it is 12% to 14% more efficient, in terms of power output per fuel consumed, than the non-Atkinson engine upon which it is based.
- Use of the Atkinson cycle results in improved efficiency, but it also results in a significant narrowing of the rpm range in which the engine makes useable power.
- There are two ways to solve this problem. One way is to couple the engine to a continuously variable transmission (CVT) so that the engine always will run in its optimal rev range. The other is to give the engine supplemental power such as an electric motor. Toyota do both of those things.
- Even better, by using our Variable Valve Timing-intelligent (VVT-i) system to continuously adjust intake-valve timing between Atkinson-cycle valve timing and conventional valve timing, the Prius engine can maximise fuel efficiency while still producing maximum power.

I-VTEC:



During certain phases of operation the Honda ICE has the capability to keep all valves closed by using the iVTEC system. Effectively the motor alone is powering the vehicle.

ROUTINE MAINTENANCE

BASIC PRECAUTIONS:



Never assume a Hybrid is shut off because it is silent. Always observe the instrument pack for the “Ready” indicator status to verify whether the vehicle is switched on or shut off. The “Ready” light must be off before commencing work.

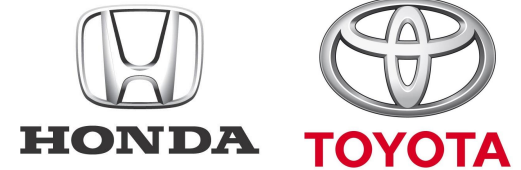


PRE-WORK CHECK:

Draw attention to the vehicle on which the HV system is being inspected or repaired by placing a sign on the roof of the vehicle.



GLOVES:



- During the disabling of the hybrid HV system and whilst carrying out repairs on the HV system you must wear insulated gloves
- Gloves must be rated HV class 1000 volt rubber gloves
- Preferably the gloves should have an outer leather shell



DISABLING THE HV SYSTEM:



1. Turn the ignition switch off
2. Remove key from key cylinder and carry key
3. Disconnect the auxiliary battery negative terminal
4. Check the insulated gloves
5. Remove service plug
6. Wait 5 minutes or more
7. Measure the approximate voltage
8. All high voltage wire harnesses are **ORANGE**

DISABLING THE HV SYSTEM (STEP 1):

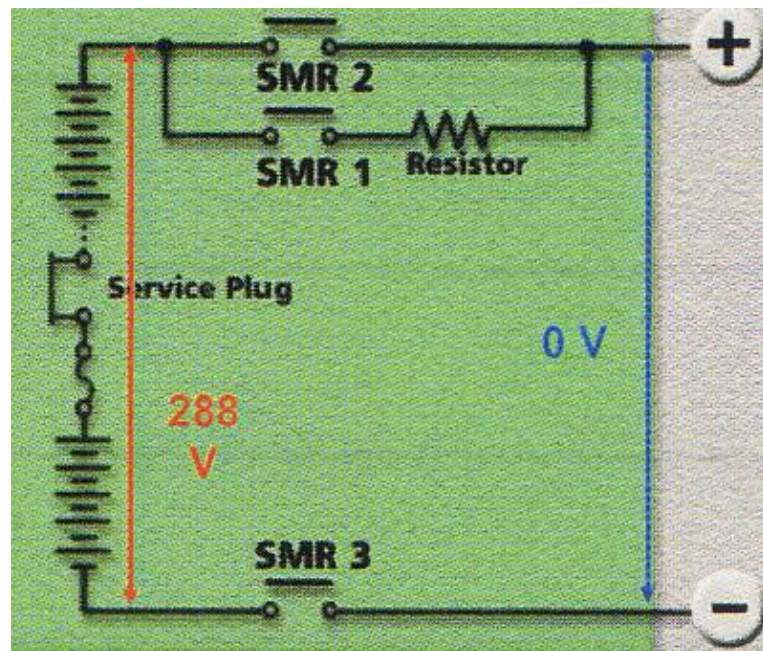
Turn the ignition switch off.



DISABLING THE HV SYSTEM (STEP 2):

Remove ignition key and place in pocket.

These actions will disable the SMR's (System Main Relays).

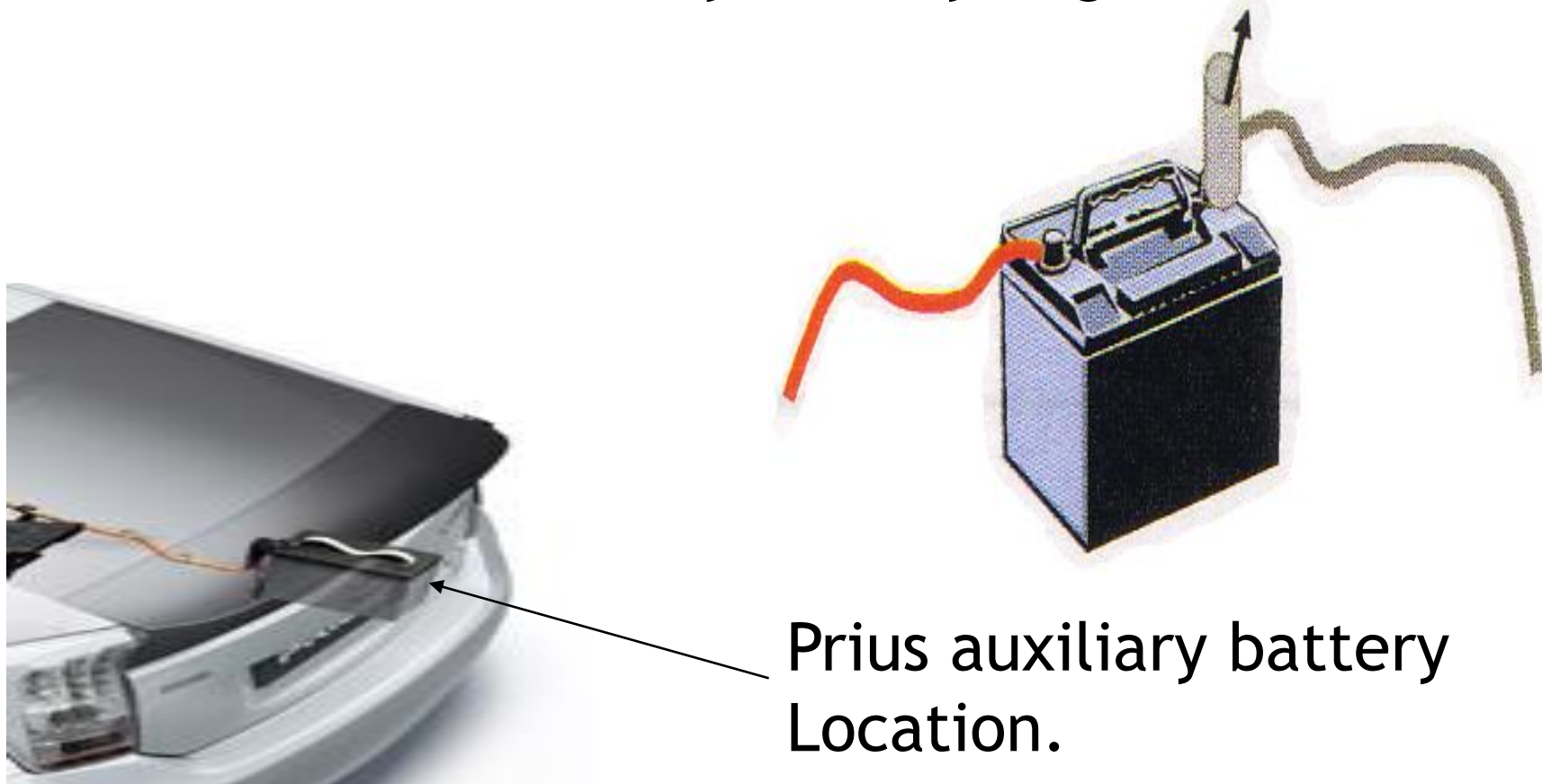


DISABLING THE HV SYSTEM (STEP 3):



TOYOTA

Disconnect the auxiliary battery negative cable.



Prius auxiliary battery
Location.

DISABLING THE HV SYSTEM (STEP 4):

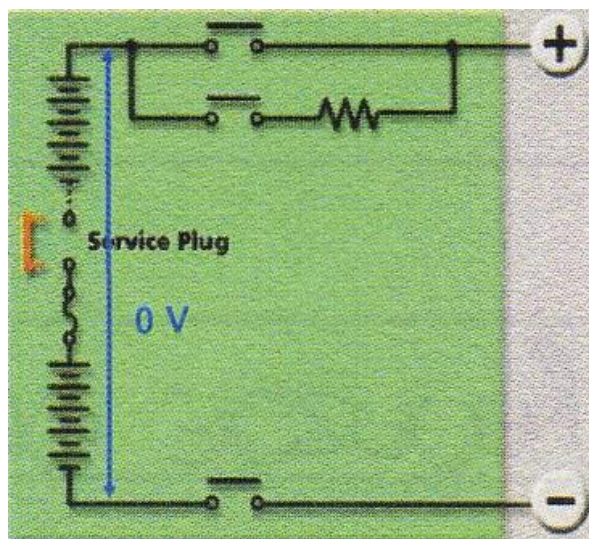
Check the insulated gloves.



DISABLING THE HV SYSTEM (STEP 5):



Remove the HV battery service plug whilst wearing the appropriate insulated gloves. Place service plug in designated area.



This procedure creates an open circuit between battery modules 12 and 13.

DISABLING THE HV SYSTEM (STEP 6):

Wait for approximately 5 minutes.



This will allow the HV capacitors to discharge.

DISABLING THE HV SYSTEM (STEP 7):



TOYOTA



DISABLING THE HV SYSTEM (STEP 7):



Test DC Voltage at main feed terminals
From HV Battery to Inverter.



DISABLING THE HV SYSTEM (STEP 7):



TOYOTA

Test AC Voltage at 3 Terminals Inverter to MG1.



DISABLING THE HV SYSTEM (STEP 7):

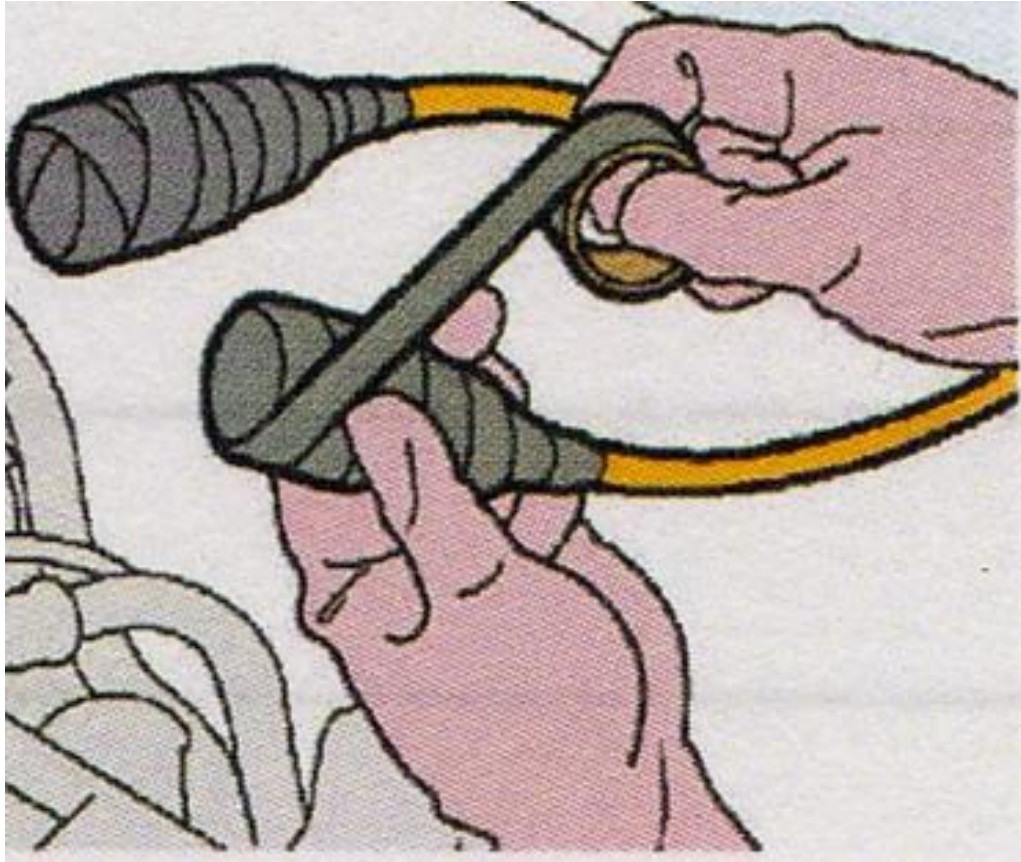


TOYOTA

Test AC Voltage at 3 Terminals Inverter to MG2.



DISABLING THE HV SYSTEM (STEP 7):

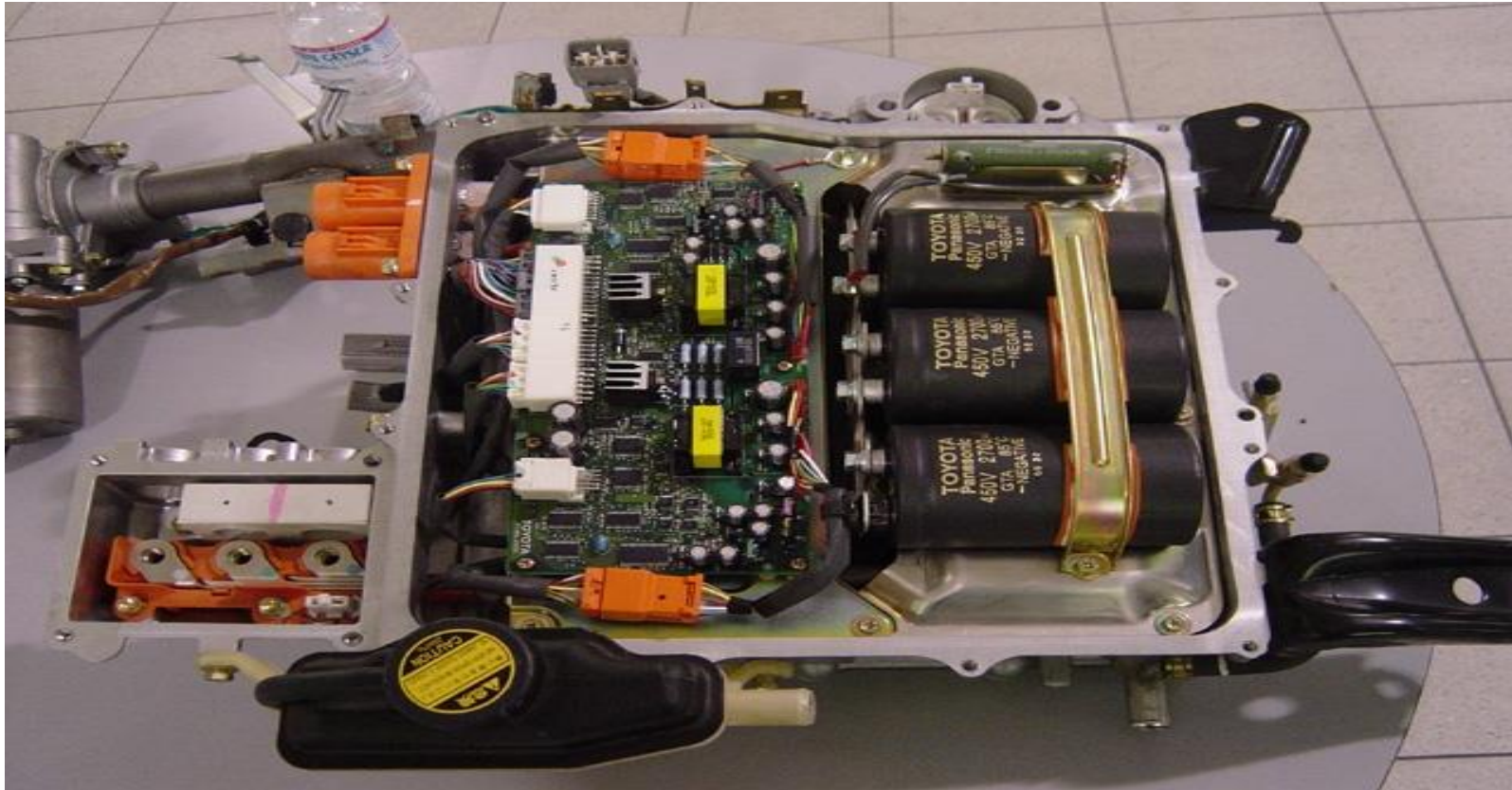


During maintenance and repair operations, cable ends must be insulated.

DISABLING THE HV SYSTEM (STEP 7):



TOYOTA



Once all voltages measure zero, insulated gloves can be removed and repairs can be undertaken.

HIGH VOLTAGE ISOLATION:



SYSTEM MAIN RELAYS (SMR):

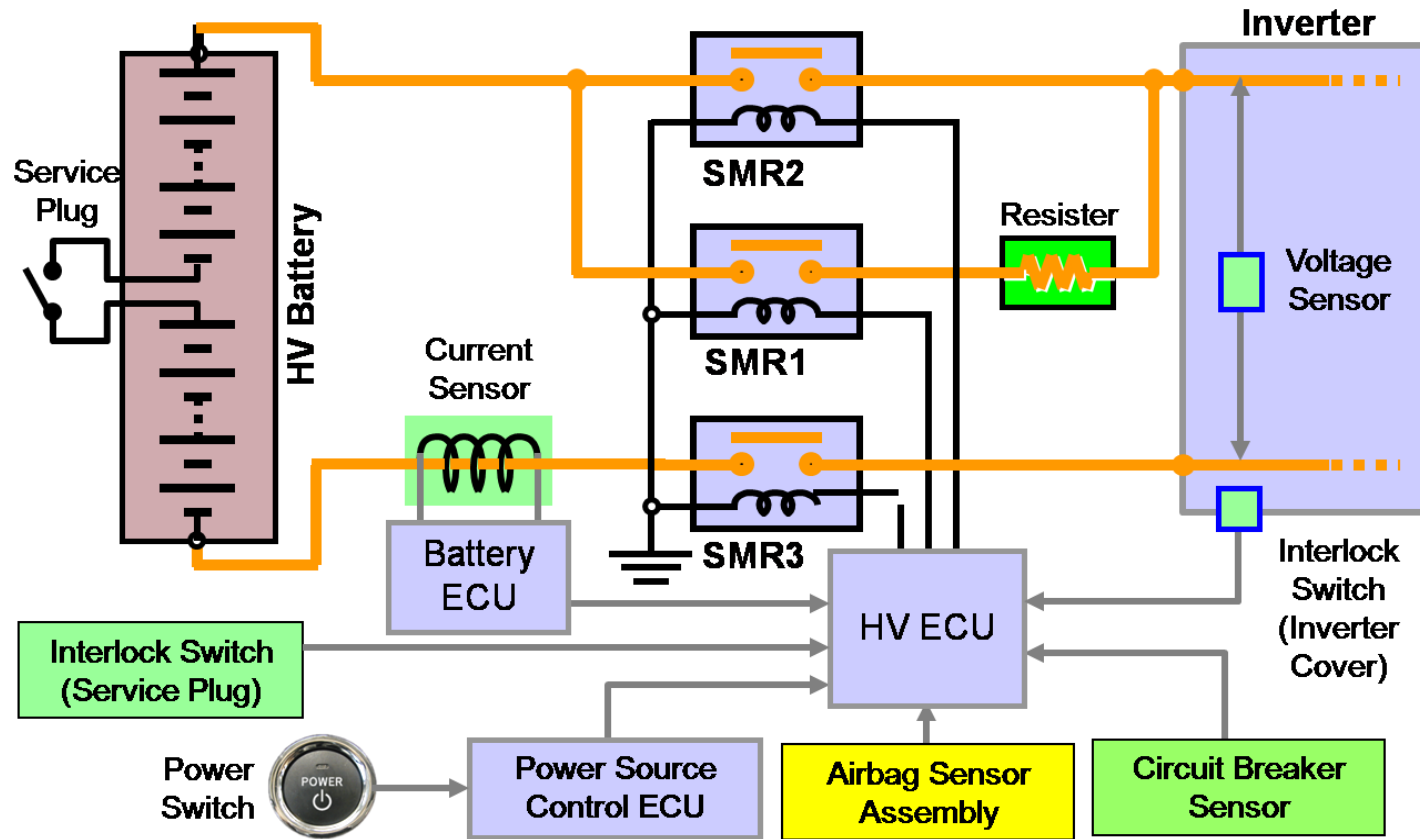


The system main relays control power flow from the HV battery (on and off). In the event of collision or signal from the inverter sensor, power is shut off. The SMR are located in close proximity to the HV battery.

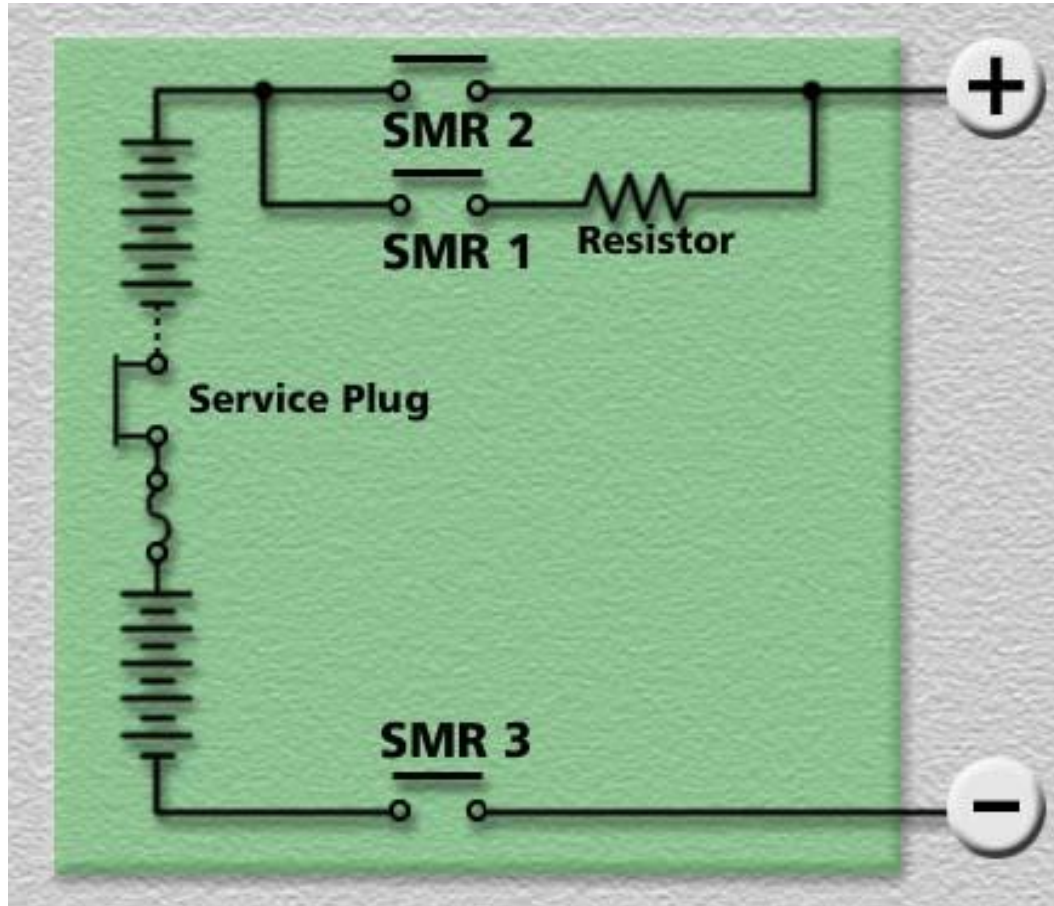


SMR
(System Main Relay)

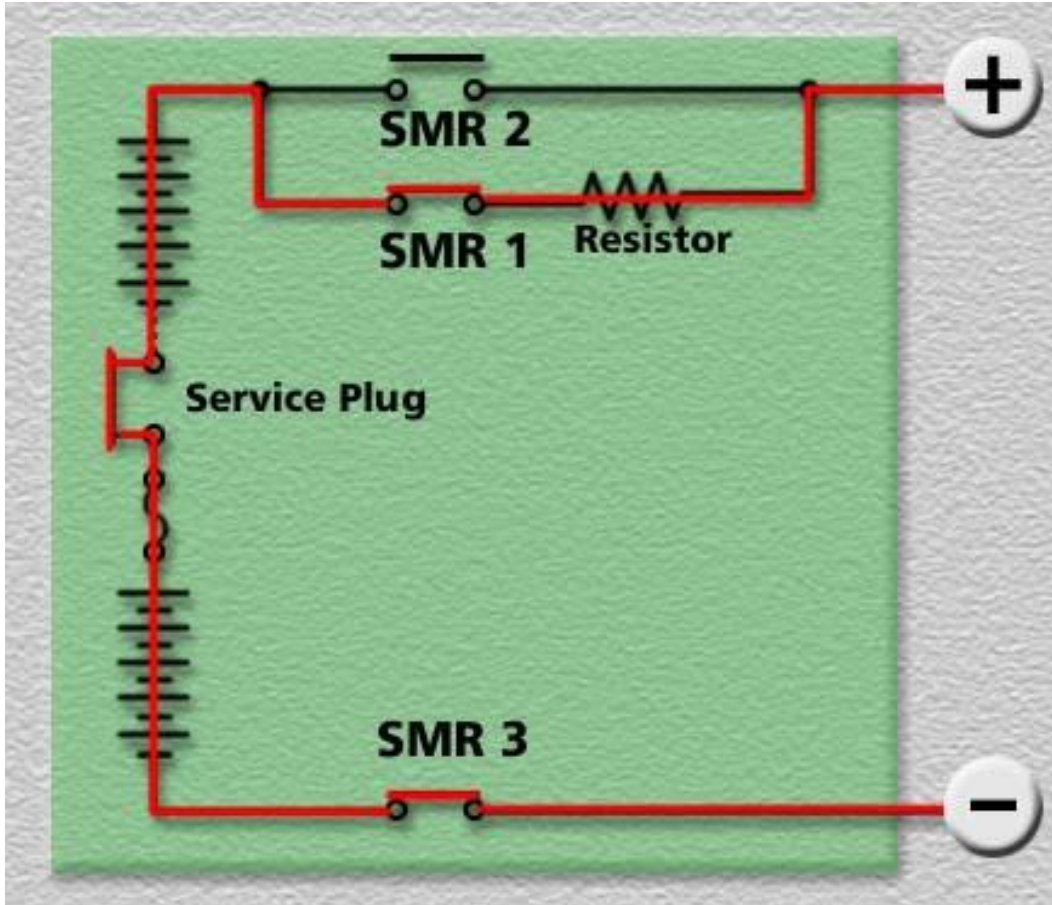
SMR (System Main Relay)



SYSTEM MAIN RELAYS (SMR):



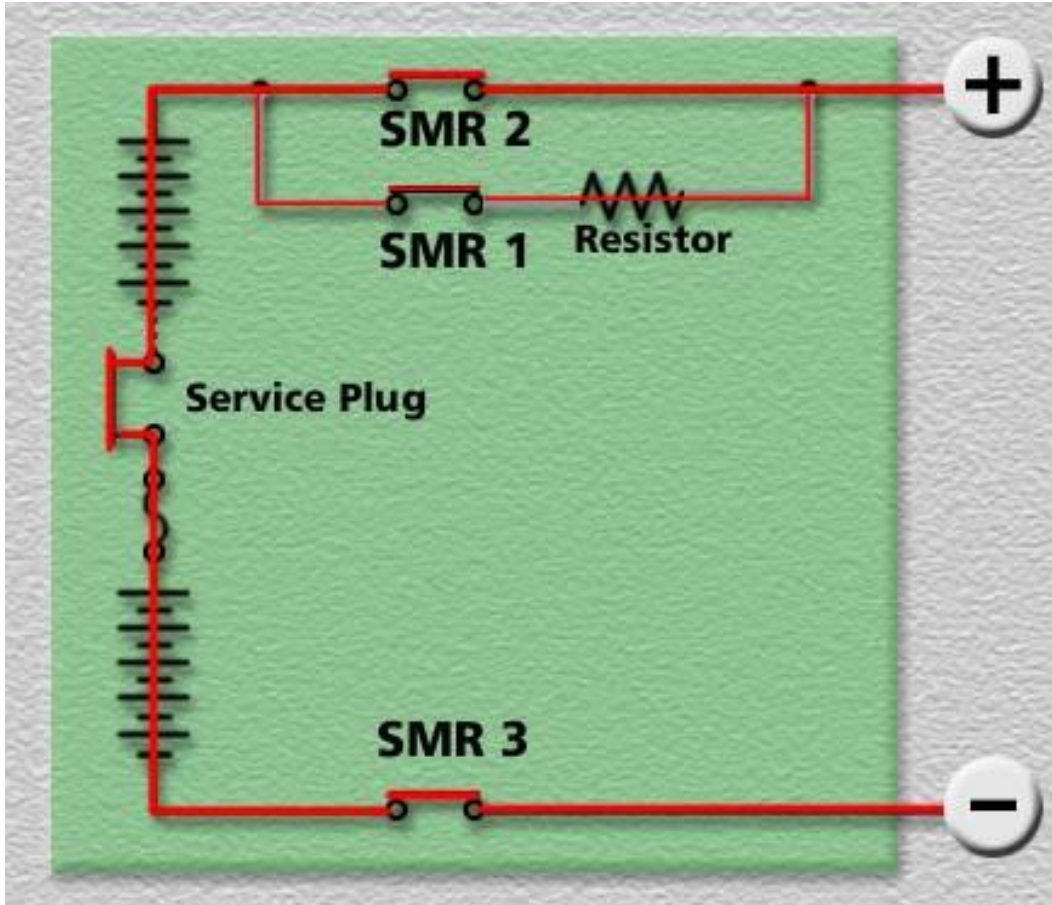
SYSTEM MAIN RELAYS (SMR):



“READY” ON - Step 1:

SMR 1 + SMR 3 - ON

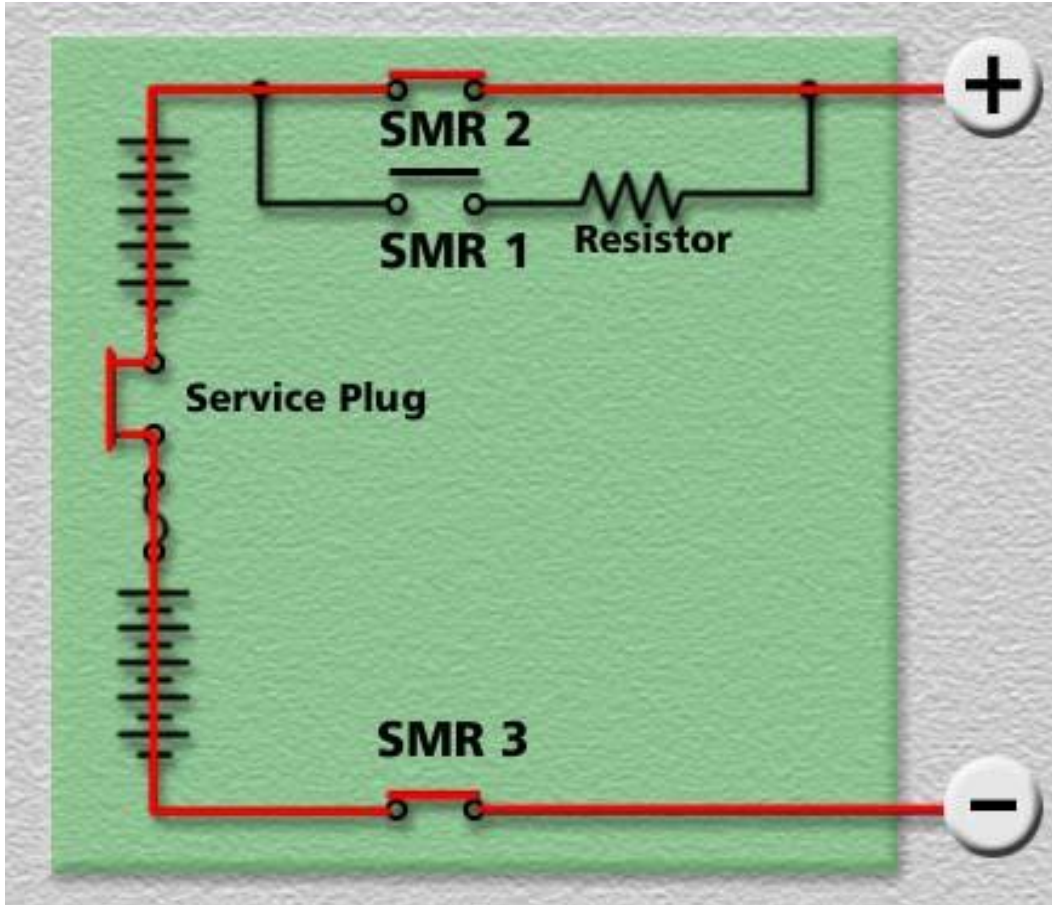
SYSTEM MAIN RELAYS (SMR):



“READY” ON - Step 2:

SMR 2 - ON

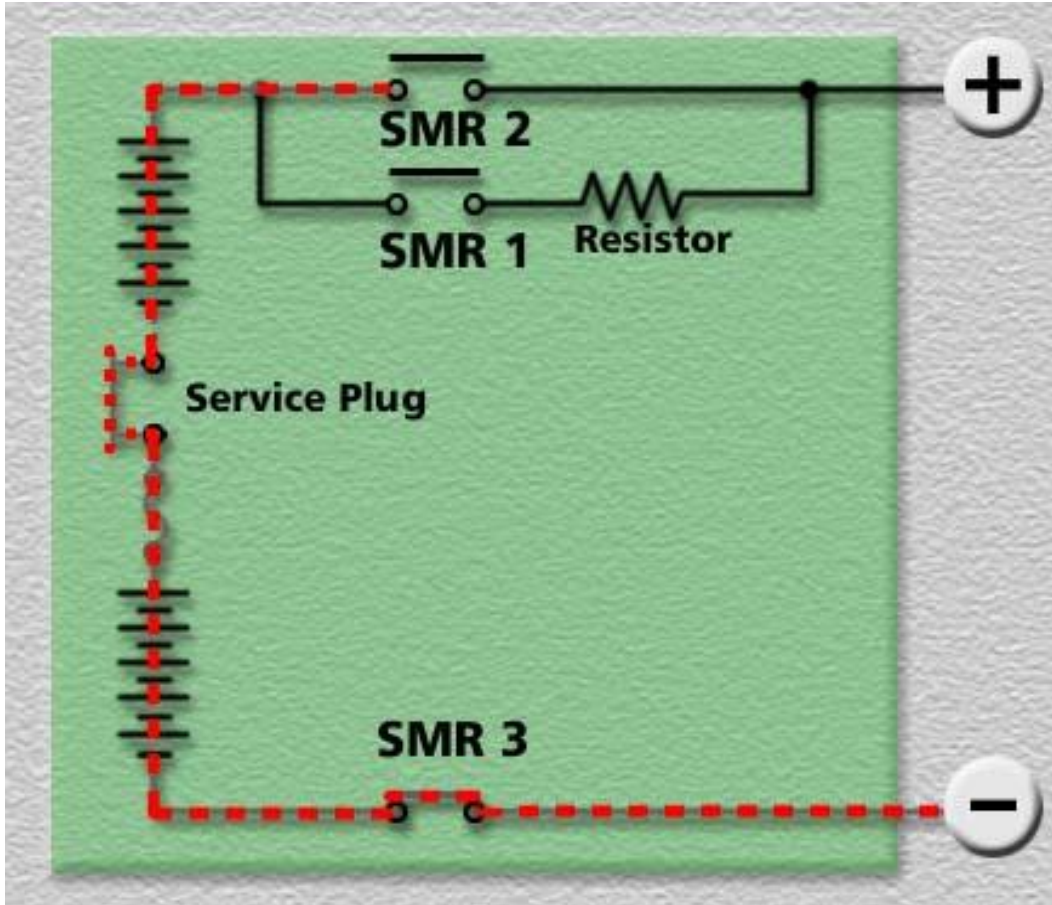
SYSTEM MAIN RELAYS (SMR):



“READY” ON - Step 3:

SMR 1 - OFF

SYSTEM MAIN RELAYS (SMR):



POWER OFF:

SMR 2 - OFF

SMR 3 - OFF

BATTERY CARE

BATTERY CARE:



Toyota recommend that the following procedures are carried out by HEV owners to promote battery longevity.

HV BATTERY:

Keep “Hybrid System” on (READY) for 30 minutes with electrical consumers switched off. This will charge the HV battery and auxiliary battery to compensate for “static current drop”.

Note: A fully charged Ni-MH HV battery can hold charge for approximately 60 days.

BATTERY CARE:



If the HV battery voltage does become too low the Hybrid Synergy Drive system will stop operating to protect the battery.

201.6V HV battery CAN NOT be jump started!

Toyota HEV's CAN NOT be push/bump started!
(Similar to an automatic transaxle vehicle).

BATTERY CARE:



If the auxiliary battery voltage does become too low then it CAN be jump started.

When jump starting, 12 volts can be applied at the appropriate jump starting connection point located in the fuse box.



EMERGENCIES

EMERGENCIES:

Emergencies involving HEV's can be handled in a similar manner to conventional vehicles, except on the following:



Extrication

Fire

Overhaul

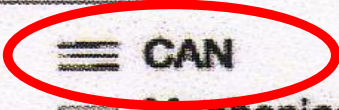
Recovery/Recycling of HV battery

Spills

First Aid (PPE-Absorption-Inhalation-Ingestion)

Submersion

NETWORKING



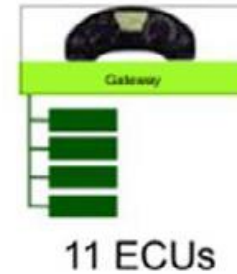
NETWORKING:

Electronic Vehicle Systems Yesterday and Today

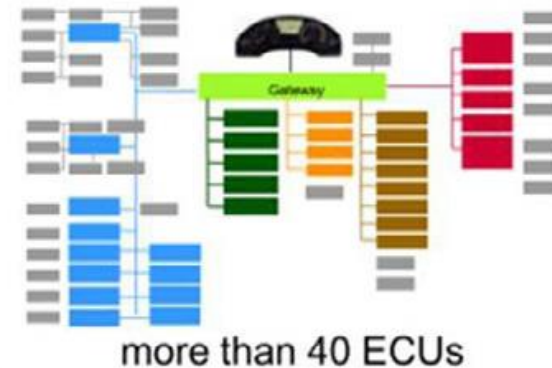


© Volkswagen AG

Model Year 1998



Model Year 2008



Outlook: 2012

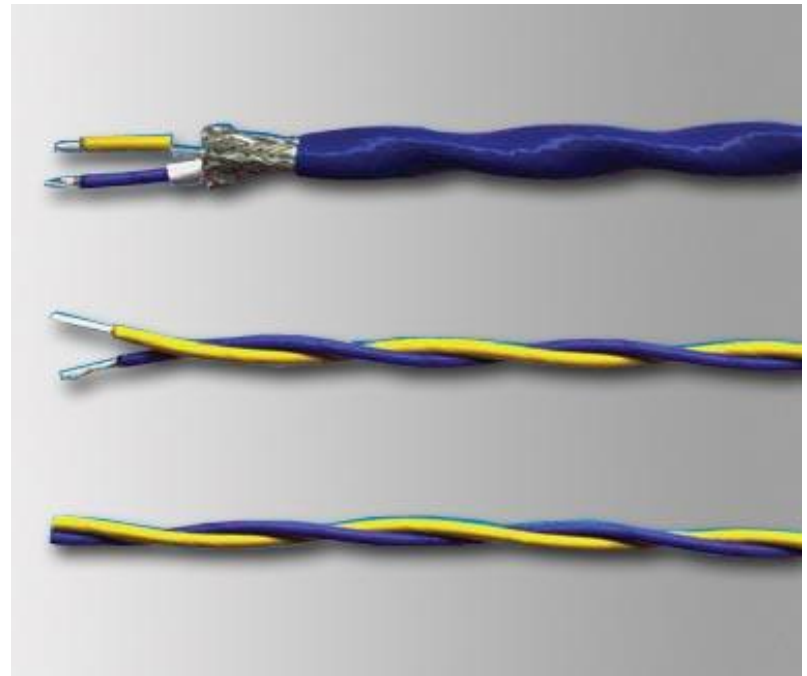
more than 84 ECUs

NETWORKING (MULTIPLEXING):

Benefits of using multi-plexing

Huge reduction in wiring and therefore vehicle weight. This helps to meet anti-pollution standards.

The reduction of the number of connections (and in some cases components) gives increased system reliability due to fewer “weak points”.



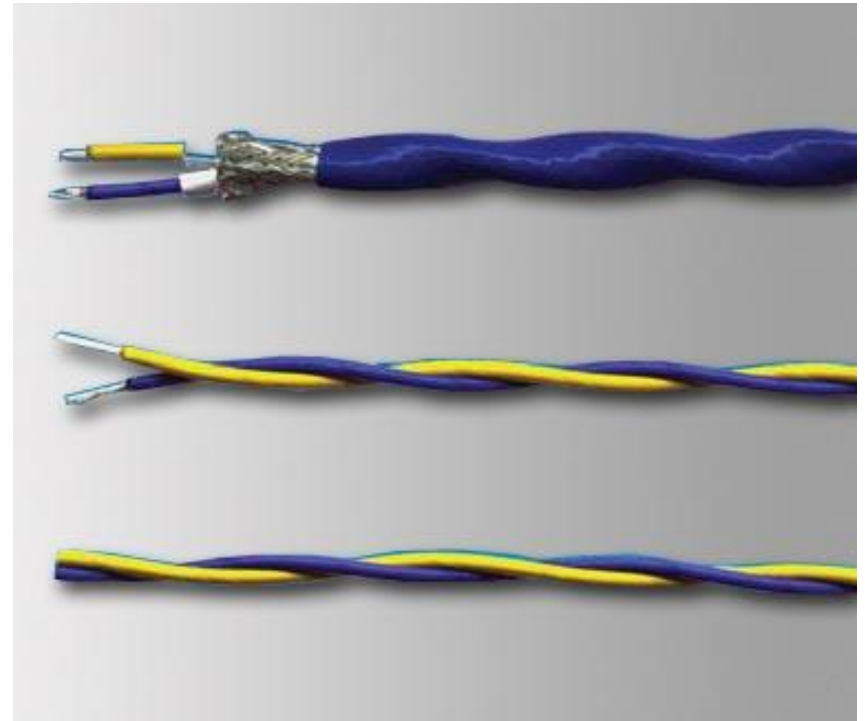
NETWORKING (MULTIPLEXING):



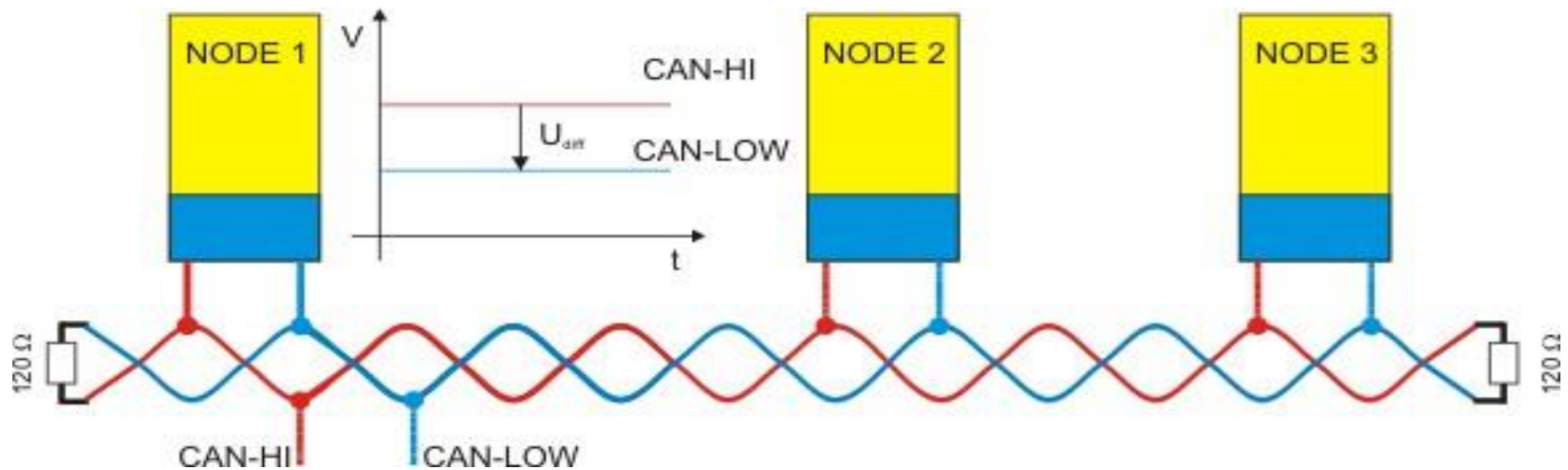
The data is carried on two wires between ECUs. The wires are twisted together to guard against interference.

Toyota use CAN Bus for their networking.

CAN (Controller Area Network) - Bosch.



NETWORKING (MULTIPLEXING):



The end of line resistors ensure that data packets do not “bounce” along the communication lines. The resistors are rated at 120Ω .