HV-M4

Two motors.

One engine.

Zero charging.

A True 21st Century Vehicle

Building on the innovations introduced in the Toyota Prius, the HV-M4 is the first hybrid four-wheel drive in the world. The THS-C hybrid system links a high-performance engine with a pair of electric motors and a continuously variable transmission (CVT) to form a powertrain that never requires external charging. The HV-M4 also acts as a "generator on wheels," supplying household electrical current via several 100V outlets. The vehicle embodies the latest advances in styling and information-age functionality. The body design is intelligent and futuristic. The interior is spacious, comfortably seating six. And multiple MONET multimedia consoles transform the interior into a media-rich living space. The HV-M4 is a true next-century vehicle.

TOYOTA

Development Concept

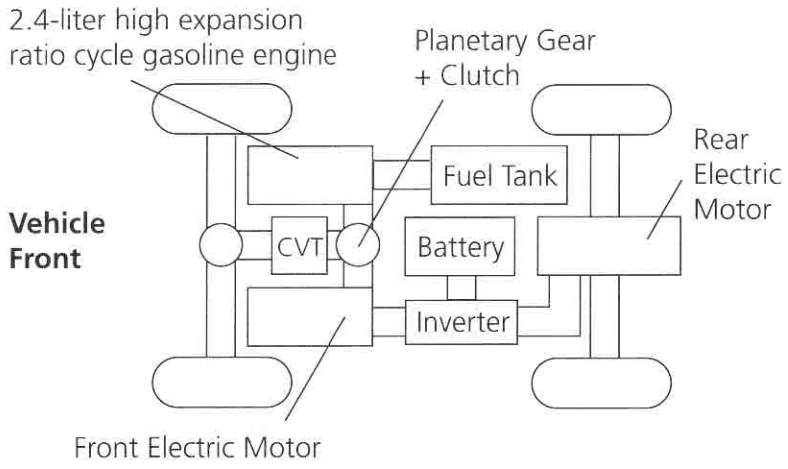
The HV-M4 mid-sized minivan was developed to demonstrate the type of vehicle we could expect in the future. "We have designed the HV-M4 to exceed all expectations," explains Chief Engineer Shigeru Matsuhashi. "Our primary development concept was to extract maximum performance from minimal resources."

The vehicle tail lamps, for example, use neon and LED, significantly cutting energy use. The next-generation propulsion system fully embodies this minimalist principle. The THS-C hybrid system combines a 2.4-liter gasoline engine with two electric motors and a continuously variable transmission (CVT). Only the absolute minimum of energy is used to move the vehicle, so the HV-M4 has a fuel efficiency double that of vans of the same class (in Japan's 10-15 test mode). The HV-M4 also meets the requirements of Japan's forthcoming cleanest emissions category: J-ULEV.

Why a hybrid system?

The combination of a gasoline engine with an electric motor can radically improve fuel efficiency and lower emissions to J-ULEV levels, while eliminating the problem associated with electric vehicles—the need to recharge the battery overnight. The hybrid system simply charges the battery during normal driving as required.

Figure 1: THS-C schematic



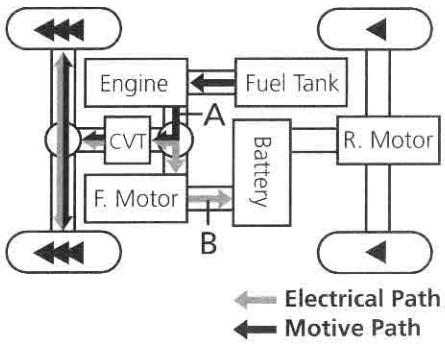
How the system works

The THS-C hybrid system comprises a high-efficiency gasoline engine, which provides the primary power, plus two electric motors—one of which drives the front wheels, the other the rear. The transmission includes a power split device that allocates power from the engine, diverting a portion of it to the electric motor or to the battery via inverters, depending on operating conditions . This system, working in concert with the regenerative braking system, achieves large improvements in fuel economy, while also producing smooth acceleration and deceleration under all loads. And it does all this while automatically charging the battery when needed.

Normal driving/battery-charging

The power provided by the engine is transmitted directly to the front wheels via the CVT (path A). An electronic control unit (ECU) controls the level of charge in the battery. When this falls below a certain value, a portion of the engine power is diverted to the battery as determined by instructions from the ECU. By using the front motor as a generator and pushing the torque in reverse, the batteries can be charged (path B).

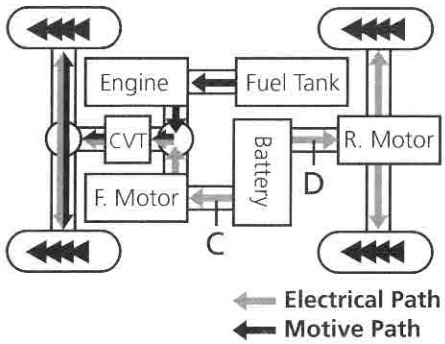
Figure 2: Normal driving



Full-throttle acceleration

During full-throttle acceleration, the battery supplies electricity to drive the front motor, thereby providing additional power to the front wheels (path C). If a further power boost is required, the rear motor can also be used for short periods (path D).

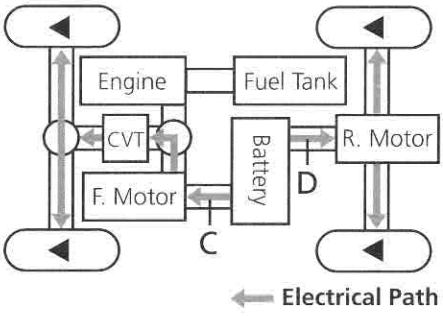
Figure 3: Full throttle



Light load

When the vehicle is operating on a light load—for instance, moving at very low speeds or going down a gentle incline—the engine cannot run at peak efficiency. At these times, the engine is not engaged. The vehicle is driven by the front motor using power supplied by the battery (paths C, D).

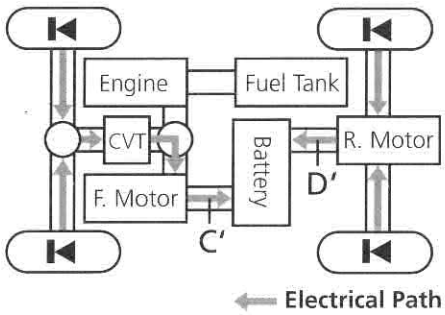
Figure 4: Light load



Deceleration/braking

As the vehicle slows, both sets of wheels drive the respective motors in reverse. Acting as generators, the front and rear motors convert the vehicle's kinetic energy into electricity, and send it through the inverters to be stored in the battery (paths C', D').

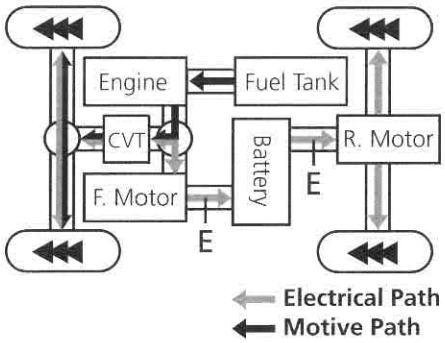
Figure 5: Deceleration



4WD mode

On low-friction road surfaces, if any front wheel slippage is detected, the power to the front axle is reduced by diverting power received from the engine. The front motor is then used as a generator to absorb engine power and produce electricity to drive the rear motor (path E). The net effect is a transfer of power from the front to the rear wheels to combat the slippage. If the power generated by the front motor is insufficient, it can be augmented by the battery.

Figure 6: 4WD Mode



Through these various systems, the HV-M4 has a fuel efficiency double that of vans of the same class (in Japan's 10-15 test mode). It also meets the extremely strict requirements of the J-ULEV category of vehicles.

Mobile Power Source

The HV-M4's hybrid system can supply electric power to appliances outside of the powertrain circuit. It is equipped with three AC 100V sockets on the inside and one on the outside that allow occupants to use electrical devices freely. It can be connected up to power-hungry goods such as hair dryers, microwave ovens and televisions—and still never need any external charging. In essence, this makes it a convenient "generator on wheels."

The power supply is approximately 1.5 kW. This makes the HV-M4 useful not only for camping or other leisure activities, but also for powering electric wheelchairs or medical devices. It could be used as an ambulance, or as a camper. Even when supplying maximum power, the engine only turns over at low revolutions, so users do not need to suffer any of the noise usually produced by an oil-powered general-purpose generator.

Packaging

The HV-M4 embodies the advances in styling and information-age functions that characterize the latest minivans. The external body design is deliberately futuristic and intelligent.

One notable feature is the innovative choices of exterior vehicle lighting. The low-beam head lamps use fiber optic cables to deliver light from a remote light source. Because fiber optics are flexible and can transfer light waves without loss, the head lamp light source can be placed literally anywhere within the vehicle, maximizing space efficiency. Moreover, rather than using lens to create separate beams which are targeted at areas in front of the vehicle, the HV-M4 uses fiber optics to create individual beams that can be aimed separately. The low-beams are encased in a stack of four rhomboid lamps, adding to the hi-tech feel of the front end.

The lighting on the vehicle's rear is just as futuristic. The red loop encircling the center of the rear end of the vehicle contains a neon tube light. The poles of this red strip function as the tail lamp. On either side of the rear end, eight LEDs are clustered. The five outermost LEDs glow orange and function as the turn signals. The innermost stack of three LEDs glow red, functioning as both the stop and tail lamps. Altogether, these eco-friendly exterior lighting innovations make this one vehicle that you will notice.

Inside the HV-M4, the cabin will comfortably seat six, with plenty of space for everybody to have a good time, either individually or as a group. The second seat is equipped with a MONET multimedia monitor, while the third seat features an overhead console, allowing passengers to relax on their own in peace. "It's designed to be a kind of multimedia living space," comments Mr. Matsuhashi.

A dashboard-mounted multi-purpose display panel provides a wealth of information to the driver and front passenger, and acts as the interface for the HV-M4's various intelligent transport systems (ITS).

The HV-M4's human-machine interface is well suited to the demands of the information age. Navigation functions can be controlled by voice commands, and frequently used audio switches are readily accessible on the steering wheel. Instrumentation is easy to read, and controls are grouped together for maximum ease of use.

An added benefit of the hybrid system is that the drive shaft tunnel down the center of the vehicle can be made extremely small. This frees up space usually reserved for hidden mechanical parts and lets you make the most of the cabin.

The HV-M4 contains a number of ITS features designed to give the driver and other occupants extra help and to perform communications functions. These include millimeter-wave radar cruise control and an auto-follow function for traffic jams. A newly-developed guidance function helps the driver back into tight parking spaces. The HV-M4 even has an onboard PC to facilitate Internet access.

The vehicle is also equipped with a card interface to use at electronic toll collection (ETC) booths on expressways, which are due to begin operation in Japan during the coming year. In addition, the HV-M4 will be able to receive wireless broadcasts of audio and video material, which Mobile Broadcasting Corporation, a Toyota affiliate, is planning to start in 2001.

Supporting Companies:

Toyota Auto Body Co., Ltd.

Araco Corporation

Koito Manufacturing Co., Ltd.

Denso Corporation

Toyoda Gousei Co., Ltd.