aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding

Vehicle Electrification Technology

Vehicle Traction, Belt-Driven Power Generation, Auxiliary Systems & Hydraulic Implements

Parker

ENGINEERING YOUR SUCCESS.

Parker Technology Expertise for Vehicle Electrification Applications

Vehicle Traction

In vehicle systems, power density is a key design factor. The torque density and speed capabilities of Parker's GVM internal permanent magnet AC (PMAC) motors, combined with voltage-matched inverters, provide the speed and torque required to achieve breakthrough performance in a variety of vehicle platforms:

- **Class 3-8 trucks**
- **Passenger vehicles**
- **Motorcycles and scooters**
- **Small transport vehicles**
- **Watercraft**
- **Personal recreational vehicles**
- **Off road trucks and equipment**
- **Construction vehicles**
- **Agriculture machines**

With design teams on multiple continents, Parker has developed traction motor solution that is highly innovative and flexible to integrate into nearly any powertrain design.

Hydraulic Implements

Parker motor controllers and motors provide frequency control of mobile hydraulic pump systems, particularly in the control of on-vehicle hydraulic implements. Typical vehicle systems include:

- **Construction machinery**
- **Aerial lift trucks**
- **Truck-mounted cranes**
- **Intermodal handling equipment**
- **Mining equipment**

Through the combination of electric motor-inverter systems with hydraulic pumps, in addition to an onboard battery system, the user is able to achieve significant fuels savings, the ability to operate equipment with the internal combustion engine off and has the ability to capture regenerative energy by using the kinematics of the hydraulic implements.

Parker's global leadership in hydraulics is an excellent compliment to the electrification of implements. Leverage our experience in both fluid and electric power.

Auxiliary Systems/ Power Generation

In addition to vehicle propulsion and implements, there are numerous systems that are traditionally reliant on the internal combustion engine for power, such as:

- **Alternators**
- **Power steering**
- **Compressors for climate control**
- **Air compressors for braking**
- **Cooling fans**

By decoupling these functions from the engine, and implementing battery-fed electric motor systems, the vehicle operator can achieve efficiency improvements in the engine, or be able to reduce the size of the engine.

Parker can assist with the development of motor-inverter systems to operate auxiliary vehicle systems across a range of battery voltages and control systems.

Electric and Hybrid-Electric Drivetrain/Vehicle Traction

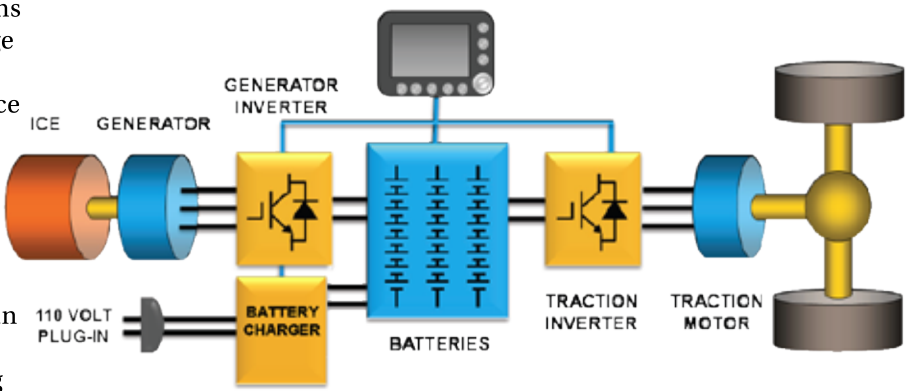
Permanent Magnet Motors and Inverters for Powertrain Applications

Parker offers complete solutions or sub-systems for a wide range of drivetrain and traction applications. High performance IGBT-based inverters provide maximum versatility, offering compatibility with PMAC motor designs.

When paired with Parker's GVM motors (PMAC), users can expect the highest efficiency and performance, minimizing losses both during motoring and power regeneration, and providing maximum vehicle range. Whether applied to series- or parallel-hybrid, or all-electric designs, you can rest assured that Parker has a reliable solution.

Powertrain/Traction Benefits

- **Optimized system design with PMAC**
- **Improved speed performance through flexible motor control: Resolver, encoder, sensorless**
- **Integration into vehicle control system via CAN communications**
- **Maximum performance and power density through flexible liquid and air cooling**



This illustration shows a typical plugin series-hybrid traction system. The internal combustion engine (ICE), which may be a traditional gasoline or diesel design, drives the Parker PMAC generator, which produces alternating current. The generator output is then converted to DC, used to keep the batteries charged. The battery bank can allow operation with the ICE offline, and also absorbs regenerative energy during braking.

A 110 or 240VAC battery charging circuit also allows the batteries to be recharged overnight via grid power. A battery management system coordinates charging and discharging while monitoring crucial battery parameters. The traction inverter produces variable frequency alternating current which is used to power the traction motor, which in turn drives the wheels of the vehicle. The system is coordinated by a central controller.

Vehicle Electrification Expertise

Electro-Hydraulic Actuation

Frequency-Controlled ePump Systems for Hydraulic Implement Control

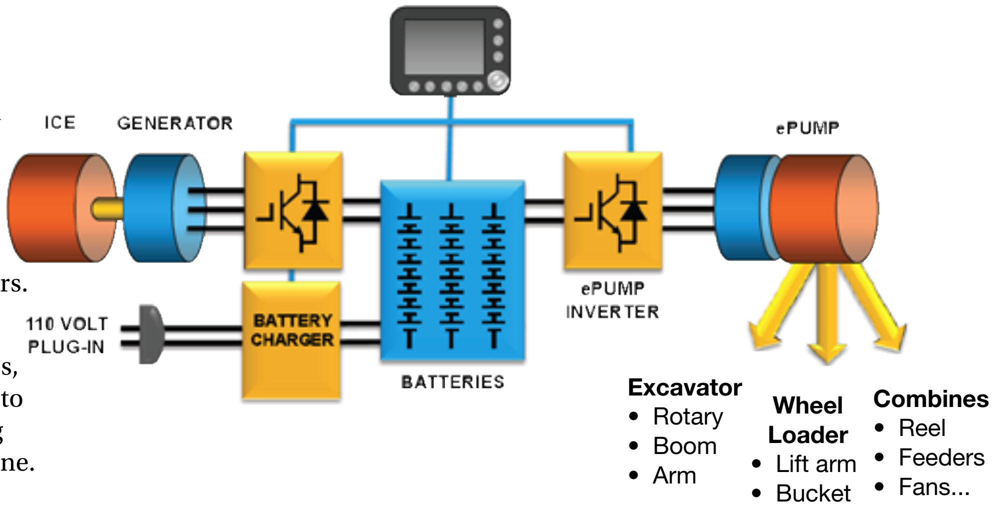
The combination of Parker's experience and expertise in hydraulics with high efficiency electric motors and inverters results in a comprehensive offering of "ePump" systems: hydraulic pumps driven by speed-controlled electric motors.

Especially suited to utility trucks and commercial vehicles, the ePump allows implements to be driven electrically, reducing load on the vehicle's main engine.

In cases where the vehicle is stationary during operation, idling can be eliminated, resulting in reduced fuel consumption and emissions. Vehicles using implements while in motion can benefit from less load on the engine possibly allowing a smaller, more efficient engine to be used.

ePump Benefits

- **Fuel savings from reduced idling**
- **Reduced emissions**
- **Quiet operation**
- **Reduced load on ICE**
- **Increased vehicle performance**



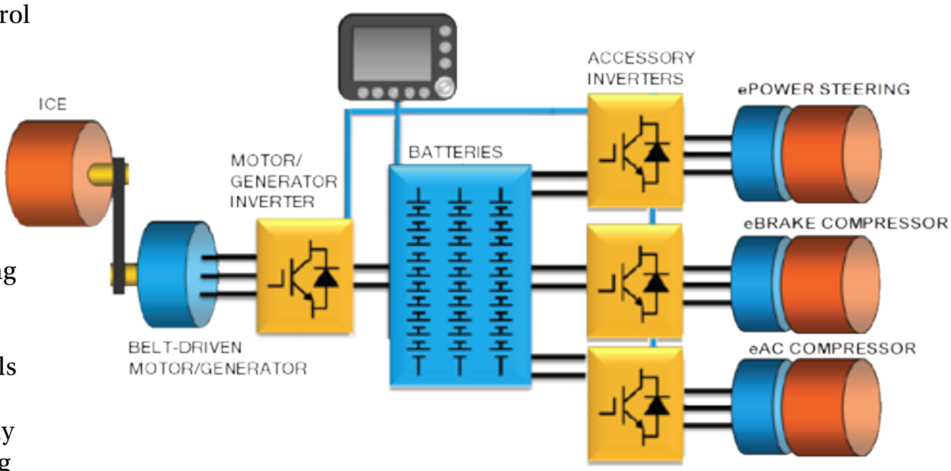
This illustration shows a typical ePump system that is used to power hydraulic implements. The PMAC motor driving the pump is powered by the battery bank through an efficient Parker mobile inverter. In this particular system, the batteries may be charged from line voltage while the truck is out of service, or by running a small combustion engine or turbine if plug-in access is not available.

The advantages of the ePump based system include fuel savings and reduced emissions, as an oversized combustion engine does not need to run continuously while the hydraulics are in use. When used in new applications, since the combustion engine is not relied upon to power the hydraulics, a smaller and more fuel efficient engine can be used. For a retrofit application, periods of engine idling can be reduced or even eliminated, reducing fuel consumption.

Vehicle Auxiliary Systems

Motors and Motor Controllers for Onboard Pumps, Fans, Compressors and Power Generation

Parker's vehicle motor and control technology is also applied to auxiliary systems. Whether on a full electric vehicle, or just electric running accessories, Parker's vehicle electrification products can be applied to air conditioning and brake compressors, and power steering pumps. Furthermore, Parker's power dense belt-driven motor/generators can supply high levels of power to recharge battery systems or be connected directly to the electric accessory – saving battery costs.



This illustration shows a possible configuration for a vehicle accessory system. The ICE, which may be a traditional gasoline or diesel design, drives the Parker PMAC belt-driven motor/generator, which produces alternating current. The generator output is then converted to DC, used to keep the batteries charged. The battery pack can allow operation with the ICE offline. The motor/generator can then start the engine when needed. A battery management system coordinates charging and discharging while monitoring crucial battery parameters.

The accessory inverter produces variable frequency alternating current which is used to power each of the accessory motors, which in turn drives the compressors or pumps to which they are attached. The system is coordinated by a central controller. This system can stand alone, or be integrated into a vehicle that has an electric traction system.

Electric Auxiliary and Power Generation Benefits

- **Optimized electric motor solutions for AC, brakes, and steering**
- **Belt-driven motor generator to recharge battery, power accessories and stop/start**
- **Flexible to fit into any electrical architecture – from 48VDC to 750VDC**
- **Significantly reduces fuel consumption by using the exact power required**

Vehicle Electrification Products

PMAC Motors – Traction, EHP and Auxiliary

Breakthrough Performance

Parker's GVM motor/generator design incorporates internal permanent magnets, segmented laminations, innovative heat transfer optimization, advanced automated winding processes and patent-pending cooling technology. All of these advanced features combine to produce very high output power.

- **Peak power density up to 4.2 kW/kg**
- **Continuous power density up to 2.3 kW/kg**

Only when using the best component technology and optimal design characteristics do traction motors/generators and controllers minimize losses both during motoring and power generation – increasing vehicle range.

- **Automated winding assembly produces very dense, high copper fill**
- **Ultra short winding endturns lowers winding resistance and I2R losses**
- **Patent pending cooling configuration yields very high cooling effectiveness over all lengths**
- **Up to 20% more range for a given battery pack**

GVM Motor Overview

Series Specifications	Unit	GVM142	GVM210
Motor Dimensions			
Diameter	mm	142	210
Length Choices		7	6
Overall Length	mm	175 to 450	225 to 582
Shaft Type		Female SAE A	Male Spline
Mass	kg	4 to 39	26 to 97
System Performance			
Winding Choices per Length		8	8
Peak Power	kW	15 to 90	50 to 403
Peak Torque	Nm	32 to 201	88 to 700
Stall Torque	Nm	11 to 113	44 to 350
Peak Efficiency	%	95	95
Max. Speed	RPM	10,500	10,500
Base Speed*	RPM	500 to 12,472	500 to 5500
Input Voltage	VDC	24 to 750	24 to 750
Motor Rated Thermal Limit	°C	140	140
Cooling Flow Rate	L/min	8	8

*Winding dependent

Broadest Scalability

The GVM motor line was designed to be used in a wide variety of vehicle applications. Inherent in the magnetic architecture is the ability to increase or decrease the length within each diameter.

This gives the GVM thirteen length options (9 standard, 4 custom), all with different envelope and torque output.

By selecting standard diameter, length and winding variations, the following parameters can be refined to the vehicle:

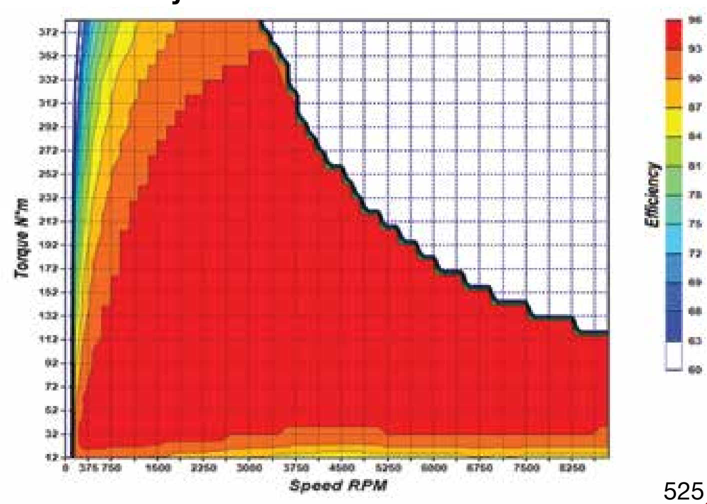
- **Base speed**
- **Rated speed**
- **Maximum speed**
- **Stall torque**
- **Rated torque**
- **Peak torque**
- **Rated power**
- **Peak power**

By choosing standard diameter, length and winding variants, the typical 3 to 5 week lead time is not impacted.

Highest Efficiency

In addition to the diameters and lengths listed above, Parker also has the ability to refine windings on each size. Customers have the ability to select the base speed of their motor. This characteristic gives engineers an additional tool to get the precise performance from the motor required for the best vehicle experience.

Efficiency Plot

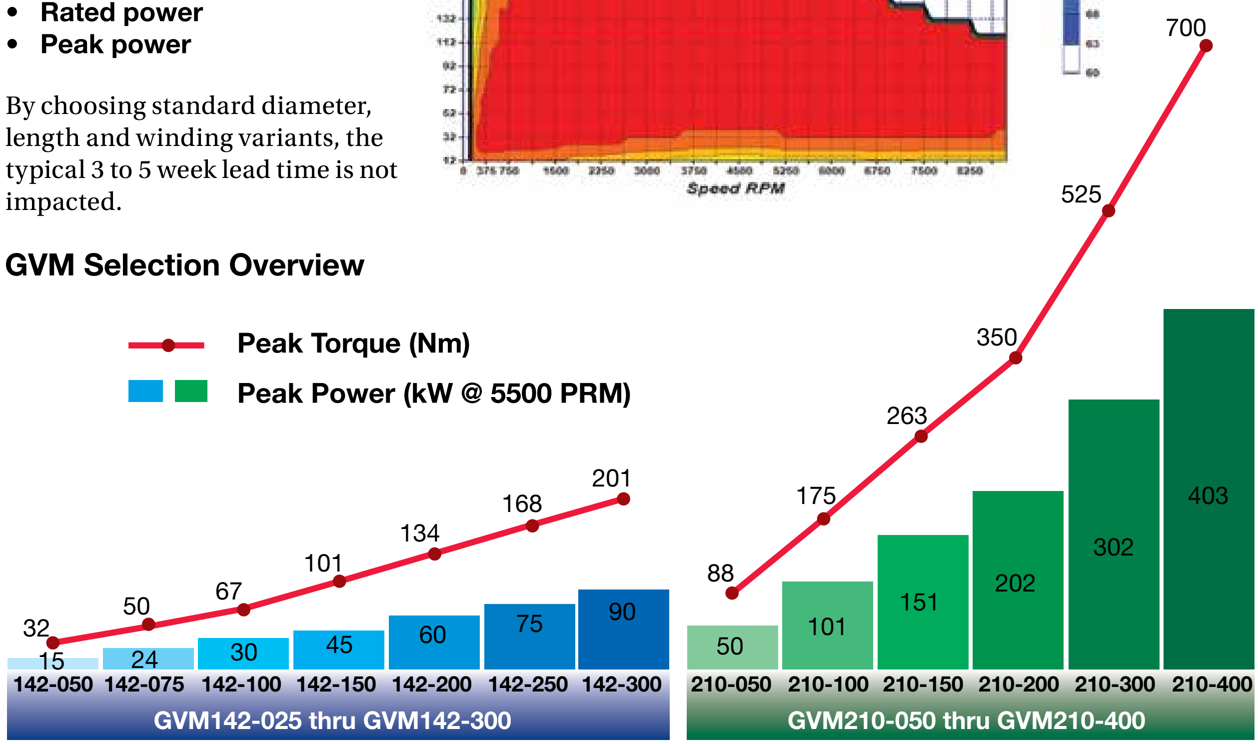


Mounting/ Environmental

The GVM comes with many industry standard mounting options:

- **Borg Warner eGearDrive Interface**
- **SAE A, B, C Hydraulic Interfaces**
- **Team Industries Traction Interface**
- **SAE J1455 Certified**
- **IP67**

GVM Selection Overview



Vehicle Electrification Products

Belt Driven Motor/Generator Unit

Parker's GVM motor/generator unit is designed specifically for under the hood operation. It mounts in the existing location of traditional alternators, but provides significantly more power – and at much higher efficiencies.

Typically the MGU is used to recharge battery packs, provide export power, directly feed power for auxiliary functions, stop/start functionality and/or run accessories during engine off mode.

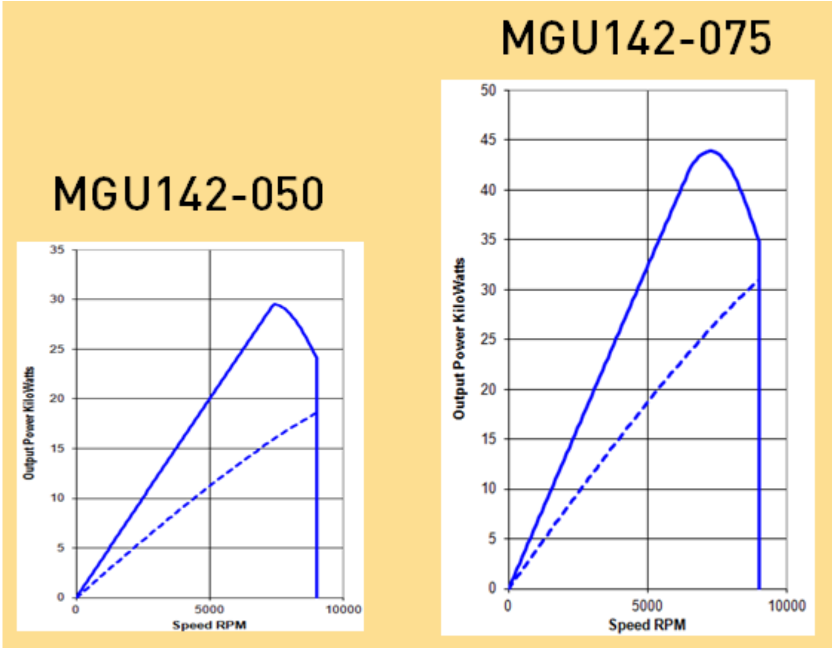
- **Liquid cooled**
- **48 VDC to 750 VDC, full power at all voltages**
- **142-050: 17kW continuous and 30kW peak power**
- **142-075: 30kW continuous and 42kW peak power**

Highest Reliability

Typical alternators are quite inefficient – both from an electromagnetic and cooling standpoint. These two aspects create excess heat loads that lead to premature failures.

The MGU is based on Parker Hannifin's highly efficient GVM magnetics and uses a patent-pending liquid cooling system. These two features combine to create a very robust design in a power dense package.

- **Up to 95% efficient**
- **Uses engine coolant**
- **Internal permanent magnets for high power density**
- **Standard engine pad mounting options**



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