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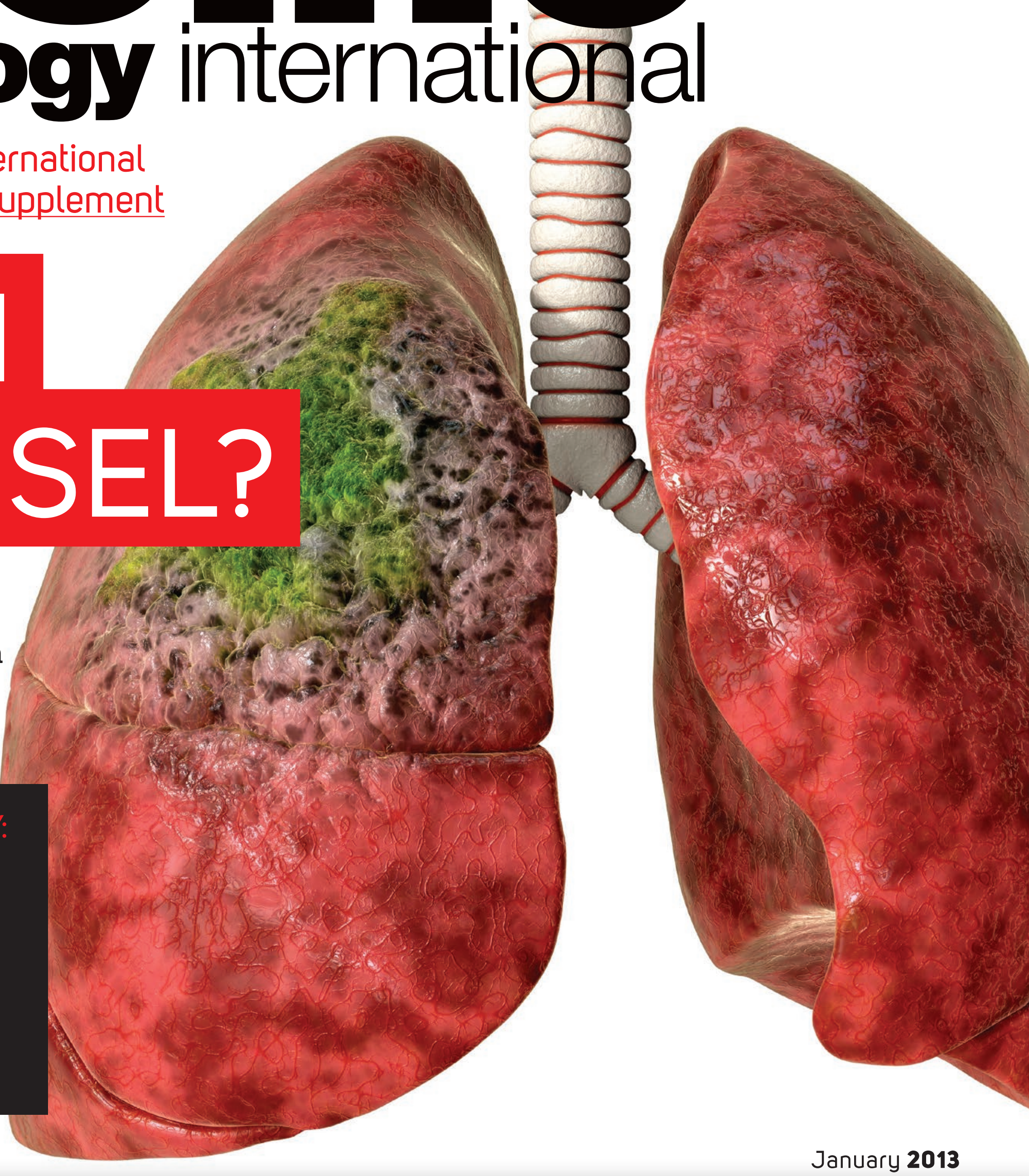

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January **2013**

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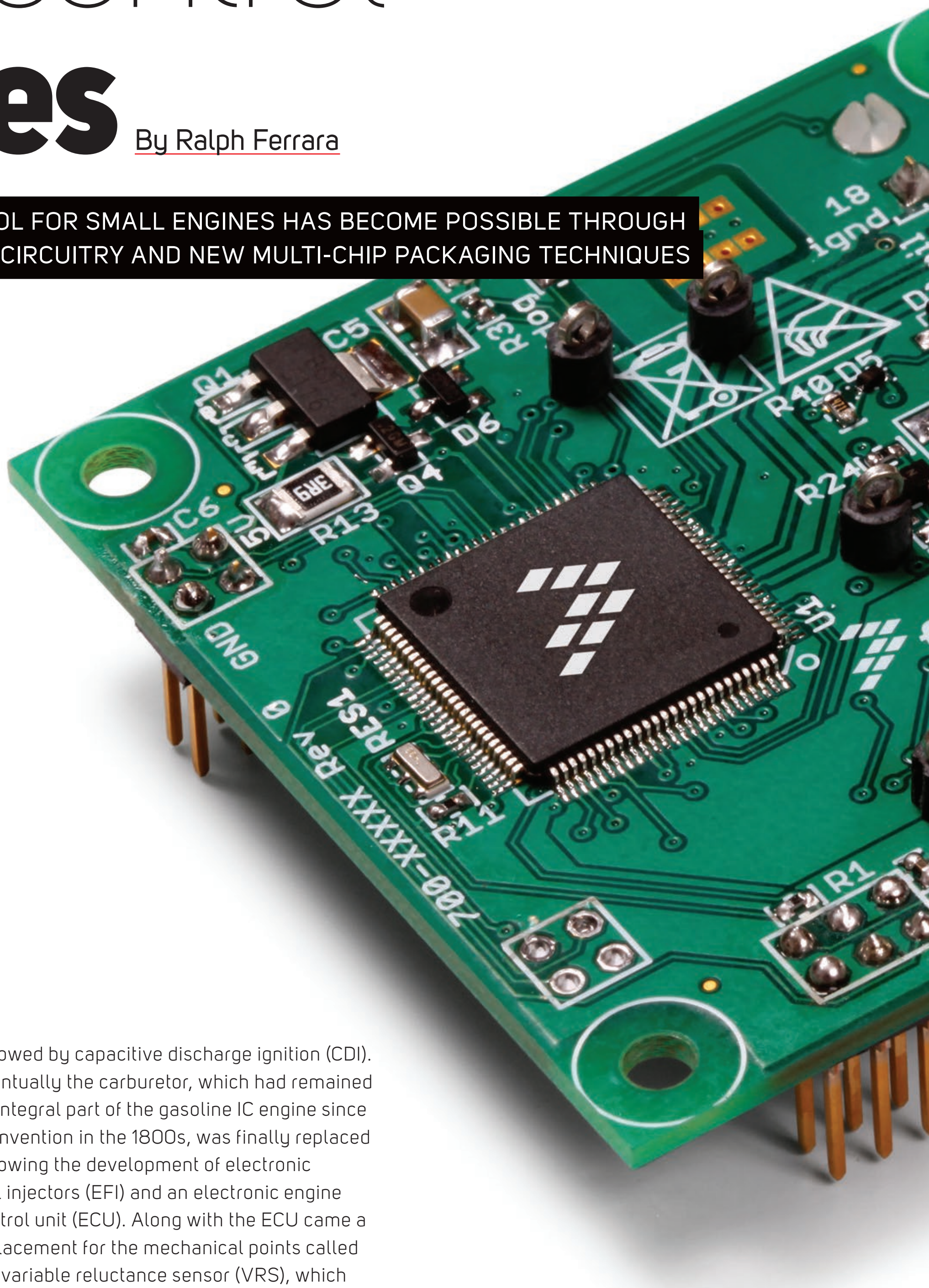
Engine control strategies

By Ralph Ferrara

REALIZING ELECTRONIC ENGINE CONTROL FOR SMALL ENGINES HAS BECOME POSSIBLE THROUGH THE USE OF MODERN SEMICONDUCTOR CIRCUITRY AND NEW MULTI-CHIP PACKAGING TECHNIQUES



It has been many years since automotive engine manufacturers discovered the need for electronic engine control to increase the performance and efficiency of the IC engine and to reduce the harmful emissions in its exhaust. Surprisingly, most small-engine manufacturers have not followed the lead of the automotive industry in applying electronic control solutions to improve performance of their engines.

The majority of the small-engine market today – especially in the BRIC nations – still relies on 150-year-old magneto and carburetor technologies to provide the ignition and fuel control in their engines. It is a sad fact that small engines, especially the two-cycle variety, are now responsible for more air pollution than the modern automobile. As an example, one need only observe the smoke billowing from gasoline-powered lawn mowers, string weed trimmers, backpack leaf blowers, chain saws, and hedge trimmers used in the landscaping industry to understand why electronic control of small engines is so sorely needed. In countries such as India, where the motorbike, motor scooter, and three-wheel taxi are the primary modes of transportation, the impact of this pollution can be measured daily in the number of lives lost to respiratory illnesses. So why is there such little progress in the modernization of the small engine?

Automobiles lead the way

In the 1970s the automotive industry realized that the mechanical ignition system, invented by Charles Kettering, needed to be replaced if the automobile was ever to improve its gasoline efficiency and emissions performance. Transistorized ignition (TCI) came first, followed by capacitive discharge ignition (CDI). Eventually the carburetor, which had remained an integral part of the gasoline IC engine since its invention in the 1800s, was finally replaced following the development of electronic fuel injectors (EFI) and an electronic engine control unit (ECU). Along with the ECU came a replacement for the mechanical points called the variable reluctance sensor (VRS), which provides crankshaft speed and engine cycle timing with the added benefit of never wearing out and having to be replaced.

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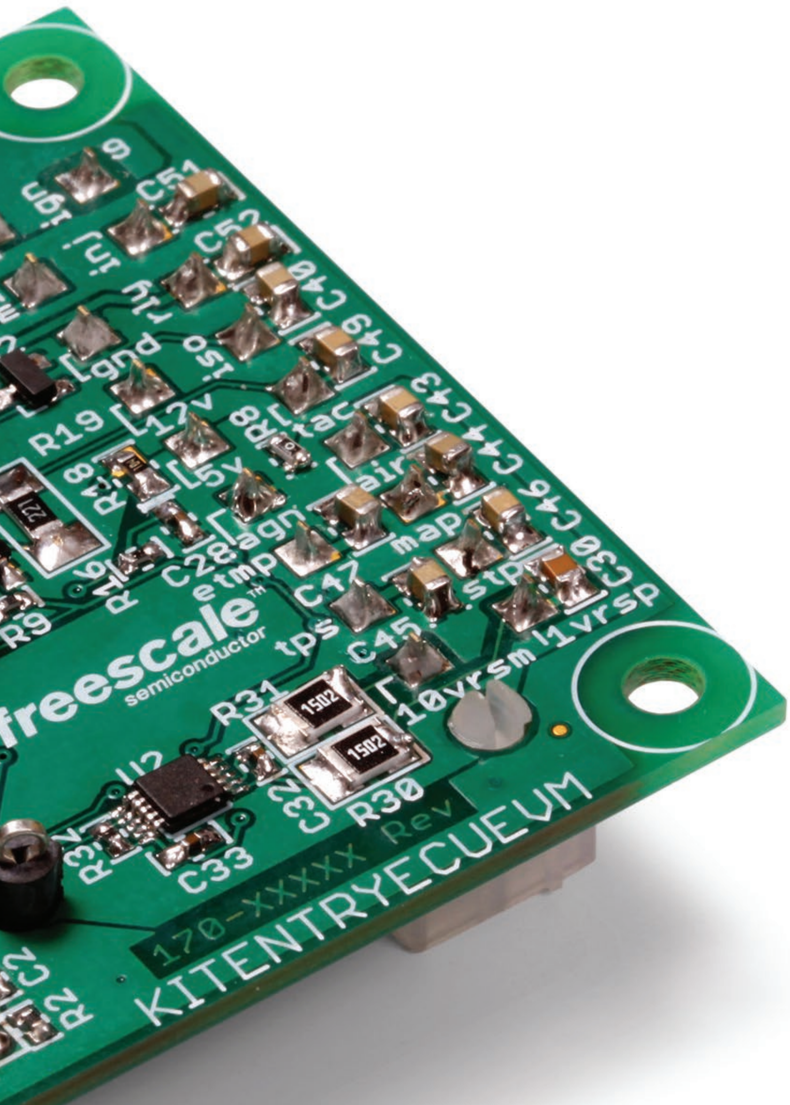
"A growing factor is the action by the governments of most countries to enact laws to force manufacturers to clean up their engine emissions"

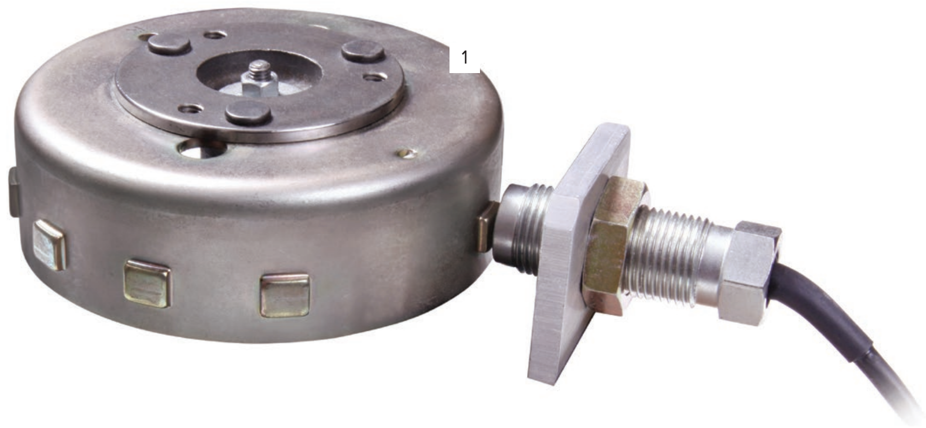


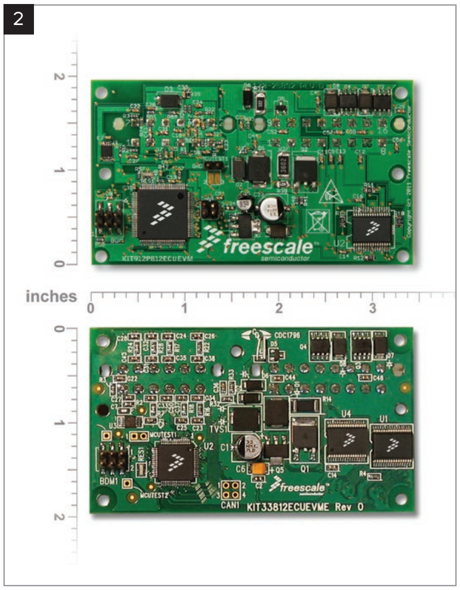
A small-engine ECU using SiP

There are many reasons for the reluctance of small-engine manufacturers to upgrade their small engines and what follows here will explore some of these reasons and propose a solution using the very latest semiconductor technology available. Consider the size and cost of a modern eight-cylinder automobile engine and contrast this with a small one-cylinder motorcycle engine that is 125cc or less. Conservatively, there is an order of magnitude difference, in both size and cost, between the two engines. However, the automobile manufacturer can easily afford to include an ECU costing US$50-100 because it is only a small percentage of the overall cost of the entire vehicle. The engine compartment of an automobile has enough spare room to house even the largest ECU. Now, taking these factors on board, it is important to think about the string weed clipper that sells for less than US$100 in local home improvement stores. Would a consumer of this product pay even an additional US$5 for an ECU for that engine? It is a hard sell, but if cold-start performance, reliability, and even fuel efficiency are considered – or more importantly governments imposed clean air standards – then the US$105 string weed clipper with an ECU starts looking like a better deal.

Packaging constraints

The problem is not just the cost but the space required for the small-engine ECU. The large engine compartment on an automobile is missing on a gasoline-powered hand tool – there is simply not enough room to house an





1: A small-engine flywheel with VRS

2: An ECU with discrete MCU and ASSP (the bottom image) compared to an ECU with Sip (the top image)

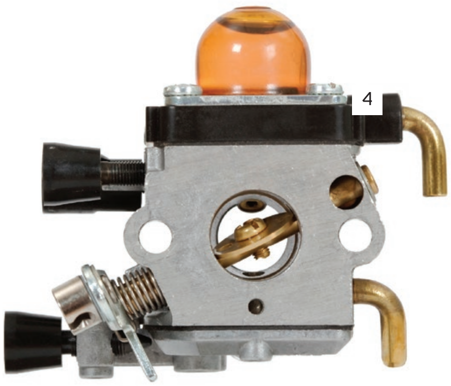
3: Capacitive discharge ignition module for a small engine design

4: A carburetor for small-engine applications

ECU of any appreciable size. On the basis of size and cost alone, the small-engine industry is somewhat justified for failing to upgrade gasoline-powered products to electronic fuel injection. A growing factor, and perhaps the most important one, is the action by the governments of most countries to enact laws to force manufacturers to clean up their engine emissions. The effect of polluted air on the health of the population has caused legislators to take a hard stand on the exhaust emissions of all gasoline- and diesel-powered engines. These new laws will become effective in the near future and they will force manufacturers to consider adding electronic control to be able to meet tough emissions standards. As a result, the time to provide electronic control in small IC engines is upon us.

What can be done?

One thing the electronics industry can do to help in this area is to minimize the size and cost of the small-engine ECU by reducing the number of components required through the use of semiconductor integration and discrete component elimination. As a result of the technology advances spurred by the growth in smartphone and tablet computer markets, the cost and actual size of electronic components has gone down dramatically in the past few years. New manufacturing techniques such as the surface mounting of components on printed circuit boards and the use of robotic manufacturing has further reduced the size and cost of an ECU. The small-engine ECU can now be reduced to just one analog integrated circuit, called an application-specific standard product (ASSP), and one microcomputer (MCU). While the single chip ECU is still a goal for the future, new breakthroughs in packaging technology mean the ASSP and MCU can be contained in a single package. This single package ECU, called a system in a package (SiP), reduces the size of a complete ECU to a circuit-board of less than 50 x 50mm and containing less than US$5 worth of components. As a result of these engineering advances, the goal of making an EFI system for small gasoline-powered engines is now easily possible.



The electronic industry can help bring this ‘make it clean’ revolution to small engines by supporting engine manufacturers with working reference designs of ECUs in order to help bring them up to speed with the new technology. When the automobile industry was learning how to develop ECUs back in the 1970s, the electronic industry provided this type of support until the automobile manufacturers developed such expertise in-house. Providing the ECU hardware and software designs to the small-engine makers, whose engineering staff is still mostly versed in mechanical design, helps reduce the overall time to market and eliminate start-up errors that are typical of radically new product introductions.

The software that is a necessary part of the ECU is also provided by the electronic industry so that engine manufacturers can learn how to tune their engines using this new technology. As small-engine manufacturers begin adopting electronic fuel injection, the cost of adding the ECU will decrease rapidly and the result will be better small-engine products and cleaner air.

make it CLEAN

In a global effort to make small engines more fuel efficient and less polluting, manufacturers must begin transitioning these engines from mechanical to electronic control. Mandatory governmental regulations and public demand for clean 2- and 4-stroke engines on everything from small-displacement motorbikes to outboard motors, lawnmowers, personal watercraft, leaf blowers and more, is encouraging companies that make the engines to clean them up. Our proven automotive experience and expertise help small engine manufacturers make a clean transition from mechanical to electronic control, creating engines that produce more power and pollute less than their carburetor-controlled predecessors. A cleaner world. Let's make it.

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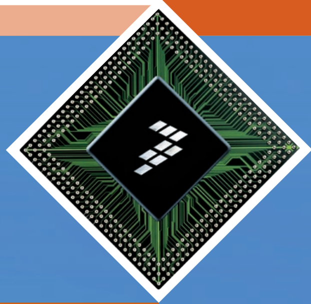
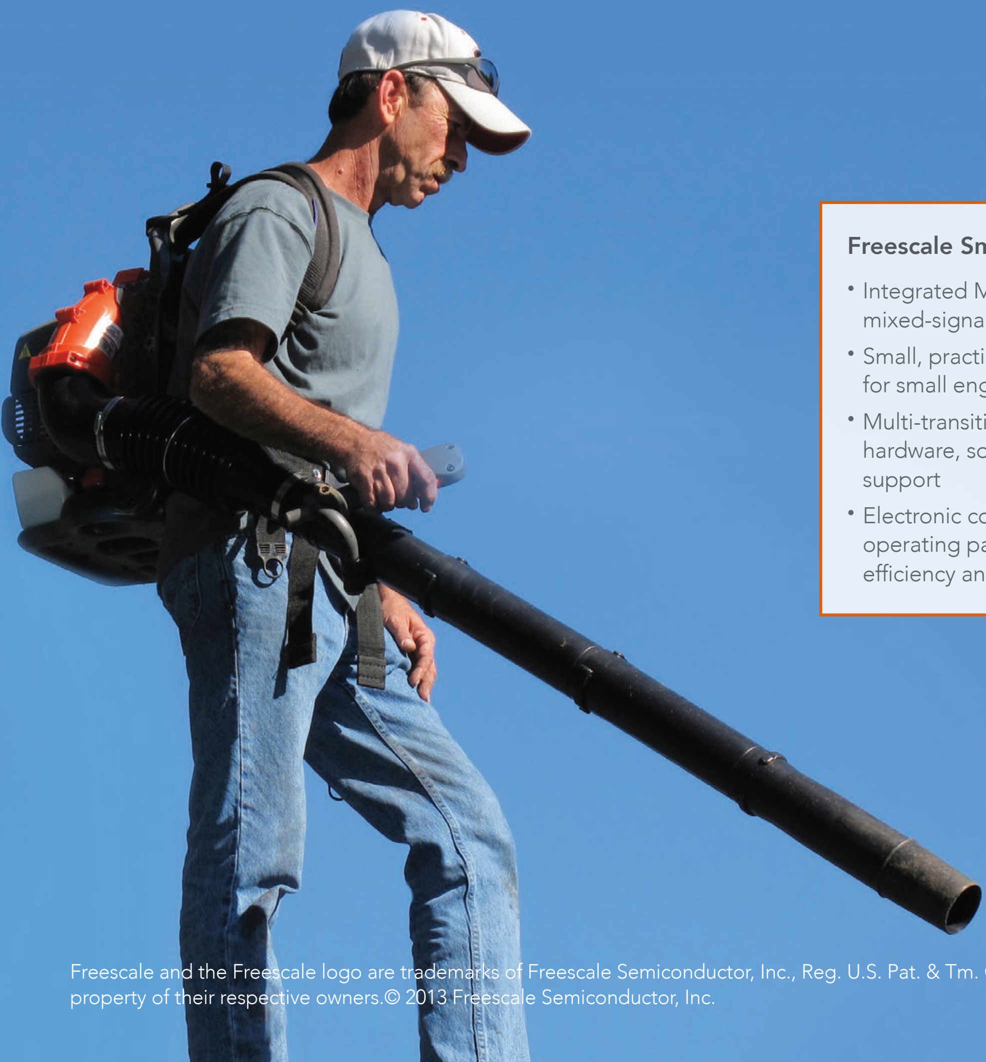




Freescale Small Engine Solutions

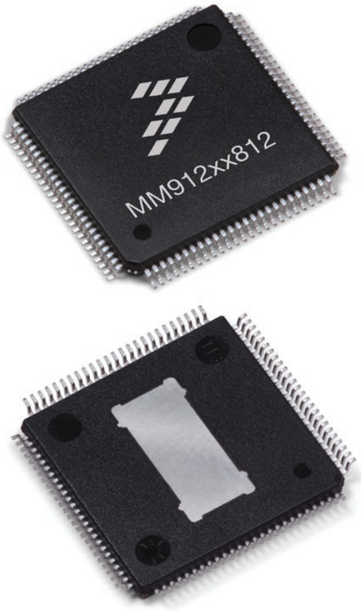
- Integrated MCU, analog and mixed-signal circuitry
- Small, practical form factors developed for small engine applications
- Multi-transition reference designs, hardware, software and technical support
- Electronic control unit-controlled operating parameters for maximum efficiency and minimal emissions

make it freescale™

Freescale Small Engine Technology

MM912_S812 S12xs

Multifunctional ignition and injector driver set new efficiency standards

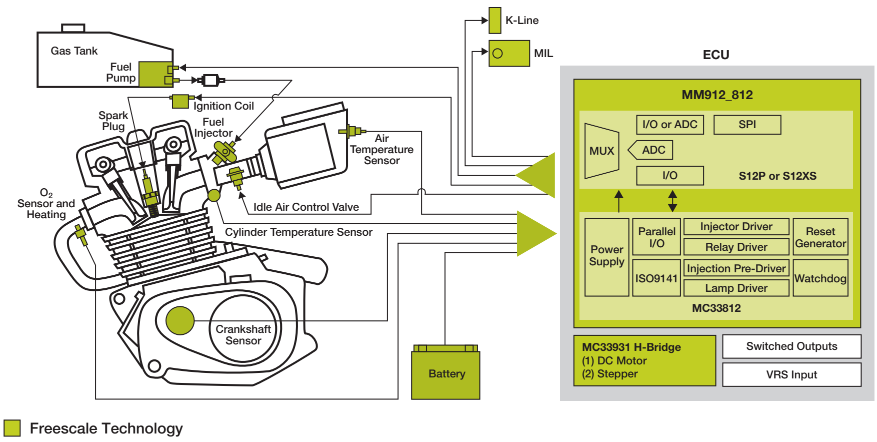


With increasing gas prices and worldwide emissions regulations, small engine applications face increasing pressure to be more fuel efficient.

In the automotive industry, Freescale has been on the forefront of the change from mechanical to electronic engine control. We are now leading the way to make this change in the small engine industry as well.

The 33812 is an engine control analog power IC intended for motorcycle and other single/dual-cylinder small engine control applications. The IC consists of three integrated low-side drivers, one pre-driver, 5.0-volt voltage pre-regulator, MCU watchdog circuit, ISO 9141 K-Line interface and a parallel interface for MCU communication. The three low-side drivers are provided for driving a fuel injector, a lamp or LED and a relay or another injector or fuel pump. The pre-driver is intended to drive either an insulated gate bipolar transistor or a bipolar Darlington transistor to control an ignition coil.

Small Engine Controls



Features

- Designed to operate over the range of ~4.7 volts ≤ VPWR ≤ 36 volts
- Fuel injector driver—current limit—4.0 amps typical
- Ignition pre-driver can drive IGBT or Darlington bipolar junction transistors
- Ignition pre-driver has independent high- and low-side outputs
- Lamp driver—current limit—1.5 amps power-on reset typical
- Interfaces directly to MCU using 5.0-volt parallel interface

Benefits

- Increased fuel efficiency when converting from a mechanical system to an electrical system
- Improved emissions using electrical system of this IC compared to a mechanical system
- Easiest way to interface an MCU to DC loads
- Simplified system design
- Reduced board space
- Reduce number of components
- Enhanced reliability

Performance

Performance	Typical Values
Outputs	Three drivers, two pre-drivers, one bi-directional
RDSON @ 25° C	0.2 Ω
Operating voltage	–0.3 to 45 volts
Continuous current	2 amps for injector drivers, 1 amp for lamp drivers
Control	Parallel
ESD, HBM	±2000 volts
Operating temperature (TA)	–40 °C to +125 °C
Junction operating temperature (TJ)	–40 °C to +150 °C

Protection

Protection	Detect	Limiting	Shut Down	Auto Retry	Status Reporting
Overvoltage	•		•	•	
Overcurrent/SC	•	•	•		•
Overtemperature	•		•	•	•
Open load	•				•

Orderable Part Numbers

Part Number	Core	Memory	Temperature Range	Package
MM912JS812AMAF	S12XS	128 KB	–40 °C to +125 °C	100 pin LQFP-EP
MM912KS812AMAF	S12XS	256 KB	–40 °C to +125 °C	100 pin LQFP-EP

Note: Add R2 suffix for tape and reel

Development Tools

Part Number	Description
KIT912S812ECUEVM	S12XS reference design with BDM multi-link
MC9S12XEP100	Calibration board (contact sales for availability)

For more information, visit freescale.com/smallengine

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