

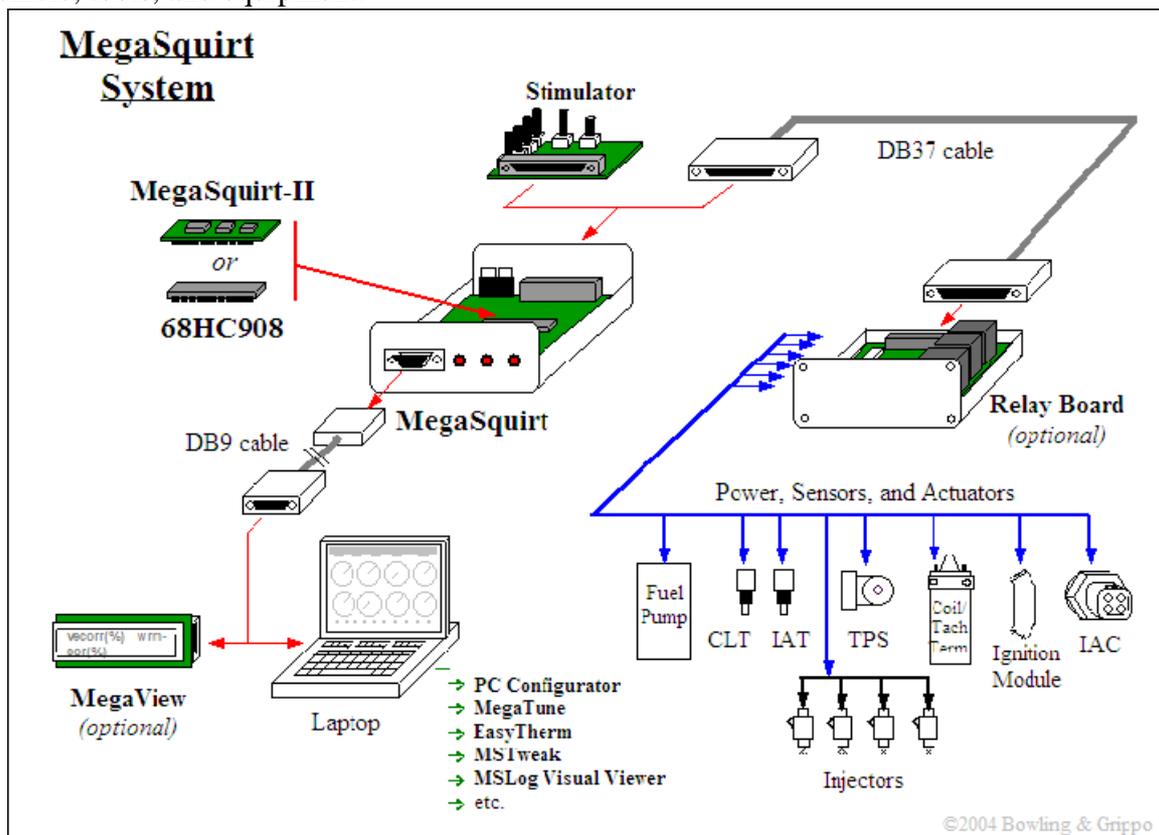
Introduction to the MegaSquirt® EFI Controller

The MegaSquirt® EFI Controller is an experimental Do-It-Yourself universal programmable electronic fuel injection controller for spark ignition internal combustion engines.

Experimental means that YOU will be responsible for sorting out some details of your fuel injection that are specific to your application and equipment. In order to assemble, test, and install and safely use MegaSquirt® EFI Controller, you must read, understand and follow this manual.

MegaSquirt® EFI controllers are not for sale or use on pollution controlled vehicles. Check the laws in your jurisdiction to determine if using a MegaSquirt® EFI controller is legal for your application.

In general, there is a lot of assistance available on the [MegaSquirt® EFI controller Forums Web site](#), in this [manual](#), and on the [MegaSquirt® EFI controller FAQ](#), but ultimately YOU are responsible for the safe and reliable construction and operation of your electronic fuel injection system and its components, including the MegaSquirt® controller. Before doing anything else, be sure to read and understand all applicable [safety precautions](#) for your vehicle, tools, and equipment.



The MegaSquirt® EFI Controller was designed by [Bruce Bowling](#) and [Al Grippo](#). In order to assemble, test, and install and safely use MegaSquirt® EFI Controller, you must read, understand and follow this manual.

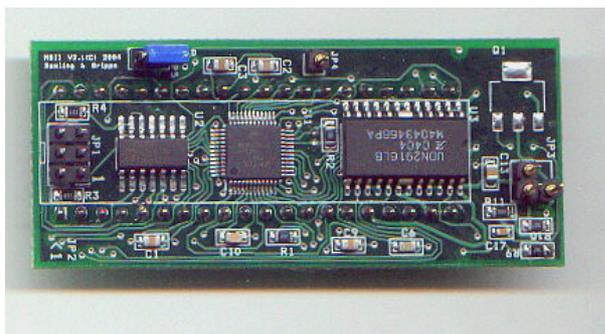
MegaSquirt® Features

The MegaSquirt-I™ EFI Controller uses an 8 MHz Motorola 68HC908 processor and a Motorola MPX4250AP MAP sensor to provide electronic fuel control. MegaSquirt-I™ is based on the Motorola MC68HC908GP32 Flash-based microcontroller operating at an internal bus speed of 8 MegaHertz (this is bus speed - remember that most microprocessors

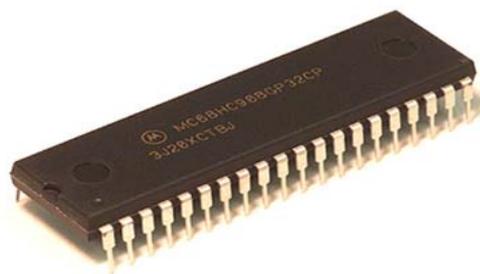
specify their parts at external crystal speed, which is then divided down by four to yield internal bus speed). MegaSquirt-II™ EFI controller upgrade uses a 24 MegaHertz HC9S12C32 processor.

Many OEM and popular aftermarket EFI systems use older processor technology (like the MC68HC11 or Z80) that operates at 1 or 2 MHz internal bus speed. The MegaSquirt® EFI Controller has a faster clock speed, coupled with direct assembly language programming, which give the MegaSquirt® EFI Controller its power.

MegaSquirt-II™ Controller:
(MC9S12C64)



MegaSquirt-I™ Controller:
(68HC908)



All of the embedded microprocessor code executed by MegaSquirt-I has been hand-written directly in assembler, not compiled from a high-level language, such as C. Working directly in assembler produces the most efficient and fastest-executing code possible. The result is that the MegaSquirt® EFI Controller can provide real-time fuel calculations up to 16000 RPM! As well, the assembly code for the MegaSquirt® EFI Controller is available on the MegaSquirt® EFI Controller [web site](#), for anyone who wishes to view or customize it. A freeware compiler is available at that site too, so there are no extras to buy.

MegaSquirt-II™ code is written in C, and the [freeware GCC compiler](#) is available for you to write your own code or modifications. MegaSquirt-II™ adds ignition capabilities (including missing tooth crank wheel support), as well as much higher fuel pulse width resolution, stepper motor IAC control, and a number of other features you can read about in [this link](#). Additionally, the on-chip Flash memory makes either MS-I™ or MS-II™ EFI controllers use processors that are a true single-chip set-up, reducing cost and extending reliability. Also, using Flash technology allows the instant re-programming of constants, enrichments, etc. while the vehicle is running. The processor can even be re-loaded with other control code using a simple programming interface and no additional hardware. The flash can be re-written at least 10,000 times, and it has a retention duration of 20 years.

Commonly available (from General Motors) coolant and air temperature sensors are used as default sensors, though you can substitute others. The MegaSquirt® EFI Controller provides either speed-density or alpha-N fuel control. The MegaSquirt® EFI Controller uses Windows9x/ME/XP-based MegaTune software for firmware reprogramming, engine monitoring, and tuning. The tuning software is freely available at no cost. Even without a computer connected, the three LEDs on the MegaSquirt® EFI Controller enclosure allow you to monitor injection pulse [commanded], warm-up enrichment, and acceleration enrichment at any time.

The MegaSquirt® EFI Controller is an open project. The schematics are available for all to inspect and to use for troubleshooting. The MegaSquirt® EFI Controller microprocessor code is available, and you are encouraged to make and share modifications (for use on B&G boards) to suit your installation. Several modified versions have been developed for particular applications/features already. Other people have developed and shared helpful freeware for MegaSquirt® EFI Controller, including:

- [MegaTune](#) - for tuning and datalogging the MegaSquirt® EFI Controller with a laptop computer running Windows 9x/ME/XP, (Eric Fahlgren)
- [MegaTweak3000](#) - for refining your volumetric efficiency table from datalogged data, (Darren Clark) and
- [EasyTherm](#) - to simplify the substitution of non-standard temperature sensors and to upload software revisions (*MegaSquirt-I only, MS-II™ can be recalibrated in MegaTune*). (Roger Enns)
- [MegaSquirt® Logfile Visual Viewer](#) - for a graphical representation of datalog files (Mike Robert)
- [MS Palm](#) - to tune and datalog with a Palm (Roger Enns)
- [MegaTunix](#) tuning/datalogging software for Linux, Unix and Mac OS-X - *MS-I only* (and now cross-compiled for Windows) (Dave Andruczyk)

In addition, ancillary hardware has been developed, or is being developed, for your MegaSquirt. These include:

- [MegaStimulator](#) - to test your completed MegaSquirt® EFI controller unit prior to installing it. (Jeff Clarke)
 - [Relay board](#) - to simplify wiring of the MegaSquirt. (Bowling and Grippo)
 - [MegaView](#) - to provide a dedicated display for the [MegaSquirt](#) - available NOW!. (Bowling and Grippo)
 - [MegaSquirt-II™](#), which has ignition control, available now (hardware). (Bowling and Grippo)
- As well, Jim Willette has developed the [Willette programmer](#) - for programming blank or corrupted MegaSquirt-I™ processors, and a [MegaProgrammer\(.ZIP file\)](#) is also available for the same purpose.

The best feature of [MegaSquirt®](#) is that you build it yourself! Since you assemble the controller, and all information about the design is available to you, you are able to troubleshoot the board if a problem arises, and, in almost all cases, repair the unit yourself. The system as it exists today is a complete “turn-key” solution. You solder it together, install in the vehicle or boat, tune, and use it. The complete source code is available for those who want to understand or even modify the control algorithms.

The Development of MegaSquirt®

The MegaSquirt® EFI controller came about because of the apparent need for an inexpensive, “turn-key” fuel injection controller by many individuals. Bruce and Al had design and offered the [EFI332 system](#) for Do-It-Yourself EFI enthusiasts. The hope was that the [EFI332](#) project would result in a system that could ultimately be used for all applications, and this was one of the main reasons for offering their 4-layer MC86332 board as the [EFI332](#) platform in 2000. However, relatively few [EFI332](#) systems had been built and installed on vehicles at first. Bruce and Al feel that one of the main reasons for the small number of operational systems was due to the complexity of the current [EFI332](#) system. One has to be both a hardware and software expert, install and learn a bunch of software development tools, write embedded code, and become an expert in engine control algorithms. The [EFI332](#) system is very powerful and flexible, but requires a tremendous learning curve, a wide range of skills, and many hours to install successfully. Bruce and Al thought that there is another group of people out there who want an EFI system in a more complete and turnkey state, and somewhat simpler. This was the idea behind the [MegaSquirt®](#) EFI controller.

The philosophy for the MegaSquirt® EFI controller system is simple: provide a controller for fuel injectors which can be adapted to any application, without having to write embedded

code or understand the details of engine controls. In addition, the plan has been to publish the schematics, software, algorithms, etc. to everyone to enhance the MegaSquirt® EFI controller's potential as an educational project. This is not a commercial unit, but an experimental unit directed at Do-It-Yourself applications for people who want to learn about electronic fuel injection control systems.

An early version of the MegaSquirt-I™ EFI Controller was described in [Circuit Cellar](#) magazine in an article titled "*Building a Fuel-Injection ECU*" by Bruce and Al in January 2002.

The MegaSquirt-I™ EFI Controller uses a flash-based Motorola microprocessor (MC68HC908GP32) for the calculation of fuel pulse width and injector control. Additionally, host software (Windows-based) was developed which allows the run-time adjustment of control parameters.

In 2005, [MegaSquirt-II](#), a replacement daughtercard for the MegaSquirt-I™ EFI Controller's 68HC908 processor became available from Bowling and Grippo. This daughtercard included a much faster processor and increased memory, and also included control options for stepper style IAC controllers and ignition systems. All but the earliest version of MegaSquirt-II are [CAN](#) (controller area network) enabled, allowing them to 'talk' to add-on modules such as sequential injections drivers and transmission controllers.

The MegaSquirt® EFI controller uses standard sensors (coolant temp., intake manifold air temp., throttle position, oxygen, and trigger from existing ignition system) to perform batch fuel injector (two banks) pulse width control. Not having ignition control makes this an ideal unit for replacing a carburetor - you can keep your existing ignition.

What you NEED to Install a MegaSquirt® EFI Controller®

The MegaSquirt® EFI controller is a universal electronic fuel injection controller that can be made to work on any spark ignition internal combustion engine, with the right external parts. However, the success of your installation depends on YOU. In order to make the [MegaSquirt®](#) controller work on YOUR car, boat, chainsaw, or whatever, you will need:

- Tools and ability to assemble and test an electronic printed circuit board,
- Additional parts to suit your installation, including:
 - Coolant and air temperature sensors,
 - Oxygen sensor and bung is highly recommended (either narrow-band or wide-band),
 - Wiring and various connectors for the sensors, injectors, etc.,
 - Injectors and bungs/manifold,
 - Throttle body,
 - High pressure fuel pump and supply/return lines, and a
 - Fuel pressure regulator,
- Tools and ability to cut the aluminum case end-plates for connectors and LEDs,
- Knowledge and skills to install all of the necessary sensors and wiring,
- Knowledge and experience to be able install or adapt a complete high-pressure fuel system in your vehicle for MegaSquirt® EFI Controller,
- Windows 95 (or better) laptop computer with a **serial port** to configure and tune your MegaSquirt® EFI Controller, and
- Enough mechanical aptitude to know what to do to make the engine run right.

Installing the [MegaSquirt®](#) controller in a vehicle that already has EFI means you will need to consider how you will run the ignition and any other devices the OEM ECU controls [such as the transmission, speedometer and other gauges, and emissions devices], how you will

interface the MegaSquirt® EFI controller to your existing wiring harness, and whether you can [reuse your existing sensors](#).

Do YOU have enough knowledge, skills, money, and energy to complete your installation? The MegaSquirt® EFI controller is the fuel injection controller only, and YOU will have to figure out everything else you need for your vehicle. This manual covers much of the specific information you need for the [MegaSquirt®](#) controller, and general guidelines for things like fuel systems, etc.

Generic information about electronic fuel injection can be found on the web in many forms, including the [DIY EFI message list](#). A good book on OEM and aftermarket electronic fuel injection systems is *Fuel Injection: Installation, Performance Tuning, Modifications* by *Jeff Hartman* (1993). It is published by Motorbooks International [ISBN 0-87938-743-2]. Other references can be found [here](#).

You will not be dealing with your [MegaSquirt](#) alone, however. Nearly a thousand [MegaSquirt](#) kits have shipped. There is a huge amount of collective experience and knowledge related to the assembly and installation of the MegaSquirt® EFI controller in various vehicles available on the [MegaSquirt® Forums web site](#).

What You Do NOT Need

- **Programming skills.** The assembly language software is already written and loaded, and the tuning interface is through a straightforward Windows application. You can, of course, conceive, write and load you own code if you wish.
- **PROM burner** to make tuning changes. A serial port connection allows adjustment of all the tuning parameters. Software updates are up-loadable through the serial connection as well.
- **Advanced electronic skills.** If you can solder and follow directions, or are willing to learn, you should be able to successfully assemble a MegaSquirt® EFI controller. You do not need to know what each and every component does, as there is a comprehensive assembly guide to walk you through the entire assembly and testing process.
- **Latest laptop computer.** In fact, newer computer often do not have the serial port that is needed to communicate with the MegaSquirt® EFI controller (instead they have USB ports). USB/Serial adapters can be used, but an older laptop is very cheap, and often a better solution. You may want a faster computer for processing data logs with MSTweak3000, but these can be done separately on a faster desktop machine.

Purchasing a MegaSquirt® EFI Controller

You can buy complete kits (which include everything - the PCB, programmed processor, all required electronic parts, along with the case, etc.) from The MegaSquirt® EFI controller [distributors](#) that accept various forms of payment. These distributors have been essential to growth and support within the MegaSquirt community. Be SURE to check the [Products and Services forum on www.msefi.com](#) for information on the reputation and service of particular [distributors](#) before ordering. In general, you should be very cautious of distributors not listed below.

MegaSquirt® EFI controllers are not for sale or use on [pollution controlled vehicles](#). Check the laws in your jurisdiction to determine if using a MegaSquirt® EFI controller is legal for your application.

[DIYAutoTune](#)

Offers the full line of Bowling and Grippo's MegaSquirt® Products as kits or fully assembled and ready for use. All kits are fully labeled, including

www.diyautotune.com
(websales@diyautotune.com)

everything you'll need to build your own unit. Additionally DIYAutoTune.com carries wideband o2 systems and other tuning products that integrate nicely with your MegaSquirt® Engine Management System. Same day shipping on in-stock orders received by 2pm EST.



[Glen's Garage](#)

[Glen's Garage](#) is the original distributor of MegaSquirt® products from Bowling and Grippo. [Glen's Garage](#) sells a complete line of MegaSquirt® kits and accessories. Items in stock ship the same business day if ordered by Noon (Central time zone).



Glen's Garage
Your home for MegaSquirt kits
www.glensgarage.com

www.glensgarage.com
(glen@glensgarage.com)

[RS AutoSport](#)

offers professionally-assembled and tested MegaSquirt controllers enhanced for MS Extra duty, label-stamped and color-coded wire harness kits (all wires needed for an EFI conversion), sensors, connectors, and other items. They guarantee the best quality PCB assembly available, and all products carry a lifetime warranty (see site for details).



www.rs-autosport.com
(sales@rs-autosport.com)

[ExtraEFI.co.uk](#)

is *Philip Ringwood's* site (one of the authors of the MSnS-Extra code) dedicated to UK and European based sales of fully assembled and tested MegaSquirt® ECU's running the MSnS_Extra code. The ECU's include a wiring harness, RS232 communication cable and the relevant software / drawings, etc.



www.ExtraEFI.co.uk
(philip.ringwood@ntlworld.com)

[EFI Source](#)

is dedicated to supplying the highest quality EFI products to the performance minded automotive community. Our goal is to make programmable EFI systems affordable to everyone without sacrificing quality or functionality. We will constantly be adding new products in order to meet this goal.

www.efisource.com
(info@efisource.com)



[ProtoCar Electronic Corp.](#)

Offers a complete selection of MegaSquirt® products and accessories. We offer the finest quality assembled MegaSquirt® ECU's and wiring harnesses, clearly labeled MegaSquirt® kits, and many other accessories! In addition, we offer a professional repair and upgrade service. All in-stock orders will ship on the same business day if received before 2pm EST.

ProtoCar Electronic Corp.

WWW.PROTOCAR.NET



www.protocar.net

sales@protocar.net

[MegasquirtPR.com](#)

En MegasquirtPR.com distribuimos sistemas MegaSquirt® para Puerto Rico y Latinoamérica. Hablamos español, te podemos ayudar. Contamos con servicio de reparación local. Ofrecemos ayuda específica para tu instalación por medio de Internet o via telefónica. Tenemos asociados disponibles para servicio de instalación y tuneo en Puerto Rico. Contamos con más de 3 años de experiencia. Tenemos disponibles accesorios racing tales como: Sistemas Wideband o2, Blowoff valves, Wastegates, Intercoolers, etc. ¡Visítanos!"

MegaSquirtPR.com

info@MegaSquirtPR.com

MegaSquirt PR .Com

Note that there are also a number of vendors selling MegaSquirt® EFI controllers in other venues, such as eBay. These vendors do not all have the same level of build quality, customer service, or commitment to the MegaSquirt® EFI controller community as the distributors listed above. If you are not sure about a vendor, ask for customer feedback on www.msefi.com, and check how active a vendor is on those forums as an indication of their level of support.

There is a listing of a number of additional MegaSquirt® EFI controller sellers on the forums at: www.msefi.com

It is strongly suggested that you purchase the following:

1. A complete MegaSquirt® EFI controller kit,
2. A complete MegaStim kit.

You will have to decide if you want a MegaSquirt-I™ controller or a MegaSquirt-II. There's lots more information to help you make that choice here:

- MegaSquirt-I™ controller (*fuel only*):
- MegaSquirt-II® controller (*fuel, spark, and stepper IAC*):

The V3 main board is the latest version, and in most cases this is what you should use. It has a number of features that make upgrades and installations easier. See [this link](#) for more information about the V3 main board.

An optional unit that eases installation (especially on previously carbureted engines) is the [relay board](#).

Bruce and Al do not support individuals who produce or sell their own version of the PCB. Bruce and Al cannot assure the quality control for any such boards, and every issue become prefaced with “*what PCB are you using...*” Having a sole source for the PCB is important because it is very time consuming to troubleshoot problems arising from other PCB designs or production methods. With the current system, the quality of the boards is assured and the people on the [MegaSquirt Forums](#) can answer questions relating to them. Users are not allowed to produce their own version of the PCB without express written permission from Bruce Bowling and Al Grippo. In general, such permission is granted only for one or two personal boards which will not be distributed in any form. Also note that such boards are NOT supported in any form on the MegaSquirt® EFI controller forums.

About this Manual

This manual has been produced for people new to the [MegaSquirt®](#) EFI controller to assist them to assemble, install and tune the [MegaSquirt®](#) EFI controller from the B&G partial kit and the specified Digi-Key parts. Unless noted otherwise, it is always assumed that:

- The reader is assembling and installing a [MegaSquirt®](#) version 2.2 or version 3 main board, 68HC908 processor with “standard” version 3.00 embedded software OR MegaSquirt-II™ daughtercard, and tuning software MegaTune 2.15 or higher,
- The installation is intended to be the primary fuel controller,
- The [MegaSquirt®](#) EFI controller will be installed on a gasoline-fueled spark ignition engine vehicle,
- The engine, if supercharged, will see less than ~21 psi of boost (the limit of the standard MAP sensor),
- Prices are in U.S. dollars, and
- Part numbers are applicable to North American automobiles and parts suppliers.

However, many MegaSquirt® EFI controllers have been installed on vehicles that do not conform to the above criteria. Many MegaSquirt® EFI controllers have been built in countries other than the U.S., and they have been installed on rotary engines as well. If your engine does not conform to the above list, read this manual first, and then check the [MegaSquirt® EFI controller forums](#) for information specific to other configurations and locations.

This manual follows a sequence of tasks you need to follow to get [MegaSquirt®](#) working for you. However, it will not tell you absolutely everything you must do. This is not a step-by-step guide to everything you need to accomplish to install your [MegaSquirt®](#) (apart from the assembly guide for the unit itself). You will have to think some things through for yourself. This manual assumes you have some basic automotive, computer, and electronics background, or are willing to find, understand, and apply this information yourself. If you do not have such knowledge, you MUST consult a qualified mechanic. Otherwise you might be unlikely to successfully assemble, test, install, and tune the MegaSquirt® EFI controller. It is an experimental fuel injection unit, after all.

One of the reasons the MegaSquirt® EFI controller came about was because Bruce and Al wanted to increase understanding of fuel control requirements for as many people as possible. In order to help the process of gathering knowledge, you need to understand your system thoroughly; something a step-by-step guide for everything is not conducive to. If you require a “turn key” EFI solution, one of the commercial controllers might suit your needs better.

A great many advanced topics have been left out of this manual, including: the hi-resolution code, the many useful variations of the standard code and hardware, running propane injection, etc. For information on these and other topics, see the [FAQ](#) and the [msefi forums](#).

Please report any errors, omissions, or clarifications to the [MegaSquirt® EFI controller Forums](#), so everyone will be notified.

Some Conversion Factors				
Inches	x 25.4	= millimeters	x 0.0394	= inches
Feet	x 0.306	= meters	x 3.281	= feet
Miles	x 1.609	= kilometers	x 0.621	= miles
cubic inches	x 16.378	= cubic centimeters	x 0.061	= cubic inches
US gallons	x 3.785	= litres	x 0.264	= US gallons
Pounds	x 0.454	= kilograms	x 2.205	= pounds
pounds per square inch (psi)	x 6.895	= kilopascals	x 0.145	= psi
pounds per square inch (psi)	x 0.068	= atmospheres	x 14.696	= psi
Horsepower	x 745.7	= Watts	x 0.0013	= horsepower
miles per hour (mph)	x 1.609	= kilometers per hour	x 0.0621	= mph

degrees Fahrenheit (°F) = (degrees Celsius x 1.8) + 32

degrees Celsius = (degrees Fahrenheit - 32) x 0.56

To convert pressure (kPa, Hg, psi, etc.), use Eric F.'s [calculator](#).

miles per US gallon = 235/(litres/100km)

litres/100km = 235/(miles per US gallon)

Last Updated: 05/24/2008 19:53:04

MegaSquirt® is an experimental device intended for educational purposes. MegaSquirt® controllers are not for sale or use on [pollution controlled vehicles](#). Check the laws that apply in your locality to determine if using a MegaSquirt® controller is legal for your application.

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