AT Electronics

Automotive Electronic Systems Simulation and Diagnostic Software

Operations Manual

Automotive Technology

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www.automotive-technology.co.uk

Cover image: Bosch Press Photo

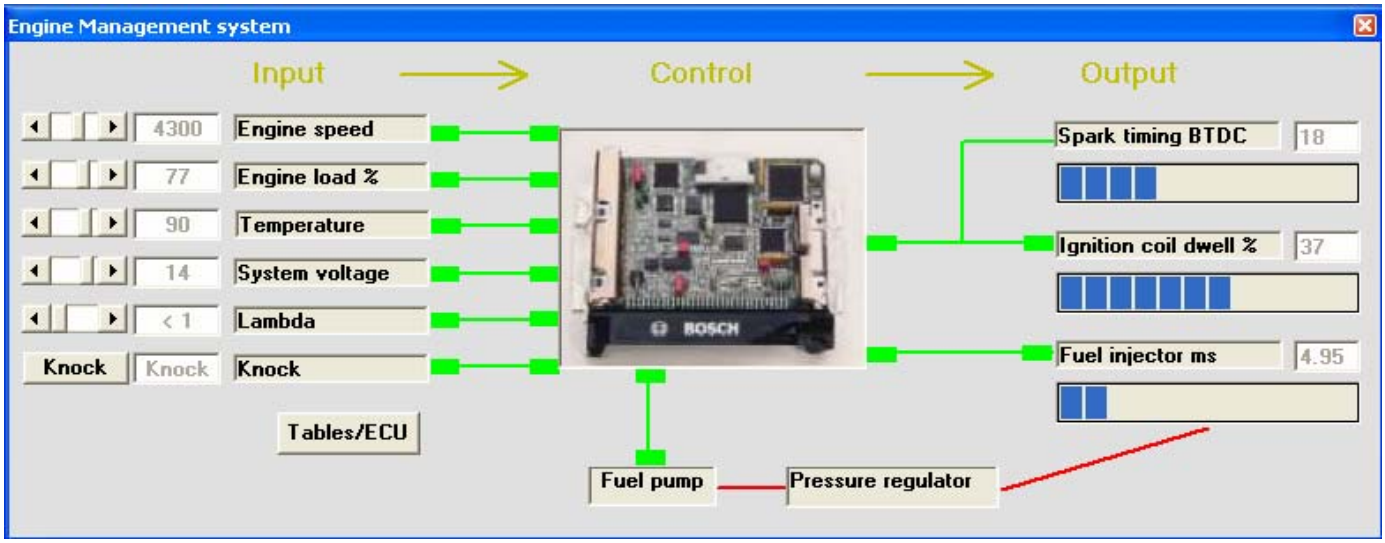
Contents

Start Here!

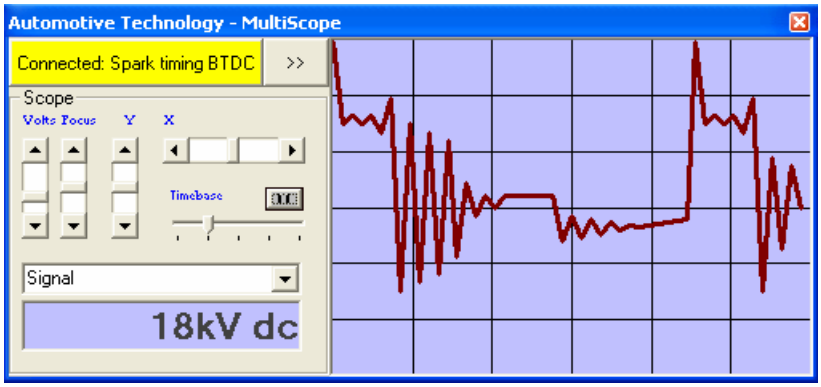
The AT Electronics program is all about learning how complex automotive systems work - and how to fix them when they do not!

Ideally the complete learning package consists of the main program, textbooks and learning tasks:

AT Electronics - Helps you learn how systems (engine management in particular) operate. How the inputs to a system affect its outputs, and the effects when a fault occurs. Diagnostic routines, which are built in to the program, will allow you to put into practice some of the skills you develop but ensure that you work in a logical way.

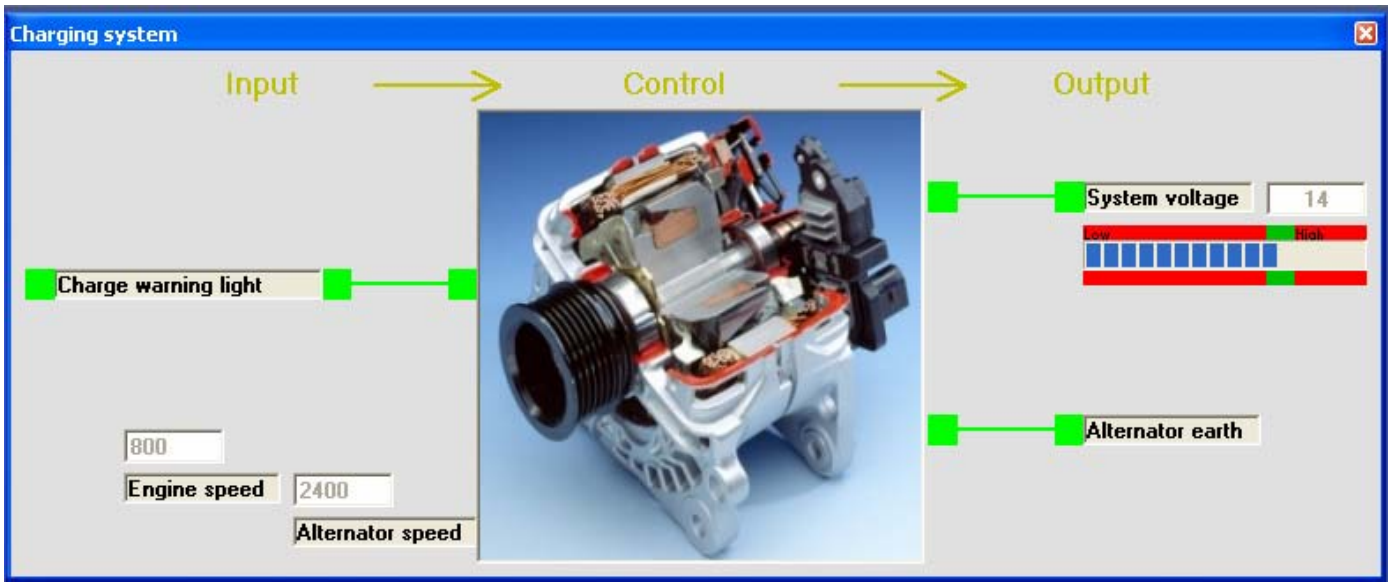


MultiScope - Allows you to examine signals from sensors and those supplied to actuators. It also contains a scanner and multimeter to show typical readings. A telemetry screen, text and pictures window can also be used. MultiScope is included as part of the main program.

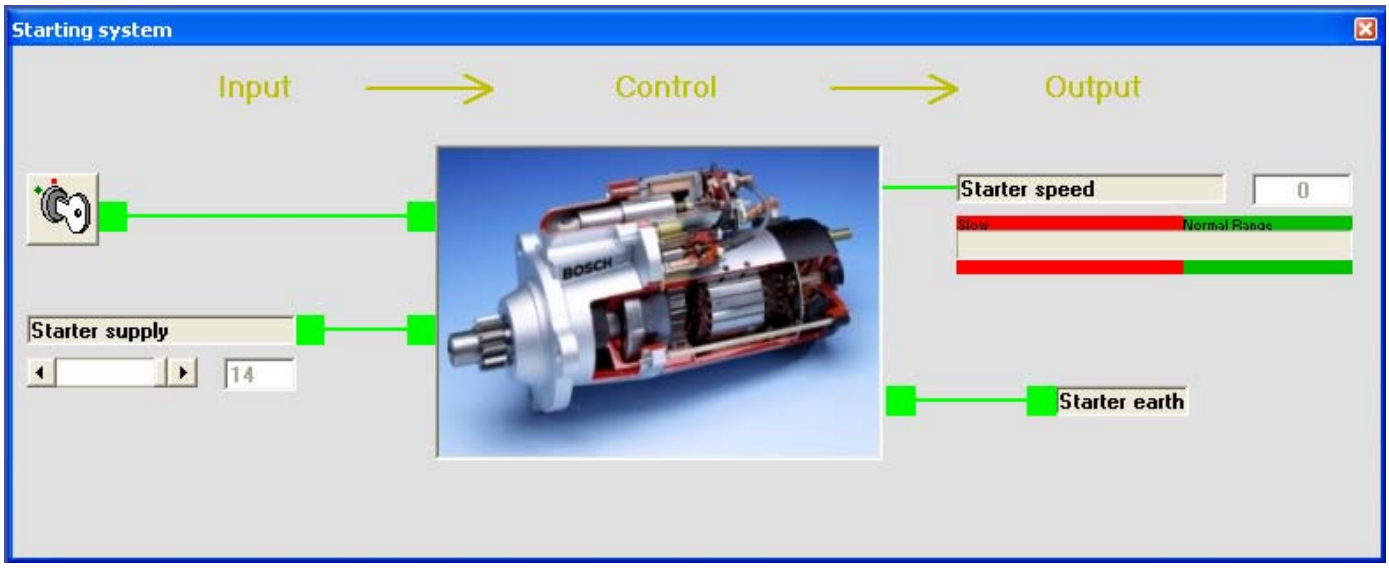


Textbooks - For detailed study of all aspects of automotive technology - from basic motor vehicle engineering to electrical systems and advanced diagnostics.

Learning tasks (which are part of the help file) - Will help you work your way through the program. Print out the tasks or better still the complete help file. Remember, it is all about INPUTS and OUTPUTS...



The program allows you to control the inputs to systems and note the effect this has on the outputs. In this way you will start to understand the operation of automobile electronic systems. The figure shows the engine management simulation. In this case an example of an input sensor would be the engine speed sensor, and an example of an output actuator would be a fuel injector.



Diagnostics is possible by creating a fault and carrying out tests to locate it! A database is built in to the program to assist with this and MultiScope has lots of functions to help.

The methods used are appropriate for use on real systems. This is an ideal training system for trainees and students or anyone with an interest in automotive technology.

Menus and toolbars

Toolbar

The toolbar allows access to the common menu commands described further below. The buttons from left to right are: Exit, Open, Start engine, Diagnostics, Scope and Telemetry.

Menus

File

The usual 'File' commands can be found here.

The 'Open' option relates to working with any appropriate files. The files are opened with MultiScope.

'Close' just closes the current window.

The 'Close All' command is useful for tidying up - it closes all open windows!

It is possible to print the contents of any window within the program by choosing the 'Print' option. A comprehensive diagnostic routine sheet can also be printed if the diagnostic window is active.

'Properties' displays information about the program and the current window.

'Login...' allows an instructor to access the list of faults available. Access is restricted to prevent cheating!

'Start/Stop engine' starts or stops the engine!

'Exit' ends the program - no warning given...

Systems

This is where you start the vehicle system you wish to work with. Some will only work when the engine is running and the program must be registered for them all to operate without interruption. The following commands, some of which can also be accessed from the toolbar, start the system listed:

- Engine Management
- Starting

- Charging
- Instruments
- Trip Computer
- Controls

The 'Set Faults' option shows the faults screen where you can enter faults to practice diagnostic techniques.

Tools

Several options are available here:

Clicking on the 'MultiScope' command starts the MultiScope! Or its different functions can be chosen individually.

'Diagnostics' starts the main diagnostic database program.

The 'Memory Maps' command shows a window containing a graphical representation of the ECU lookup tables. These can be shown in four different chart styles by clicking the options. Changing the data in the lookup tables will change the 'Maps'. This is a good way of ensuring the data is within reasonable limits.

'Fill tank' fills the fuel tank - if the program is registered...

User Details allows you to customize the printouts with your name and company details.

'Options' allows some customization of how the program operates.

Window

A list of the systems in use can be accessed from this menu

Help

The 'Help' command starts the help program

The 'About' command shows the 'About' box. From here you can check version and registration details as well as accessing system information.

'Tip of The Day' shows the Tip of The Day!

The 'AT web site' takes you to the web site www.automotive-technology.co.uk

Mouse

Right clicking the mouse in most places will provide easy access to the following useful commands:

Open File - Opens Text, Pictures, Scope and other files

Close - Closes the current window

Close all - Closes all the open windows

Start / Stop Engine - Starts or stops the engine!

Increase engine speed - Increases engine speed by 50 rev/min

Select the throttle on position

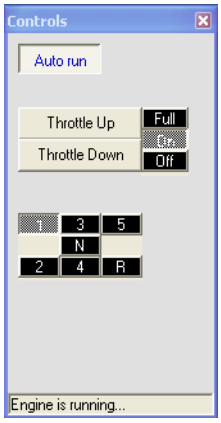
Change a gear up

Change a gear down

Exit - Exits the program

Inside 'Text' windows and 'Tables' the mouse menu changes to editing options.

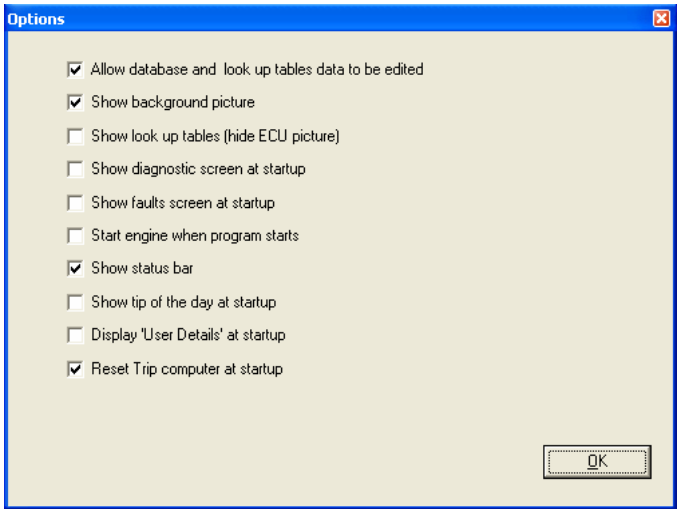
Controls



Click the ‘Auto run’ button to run the car with random settings. The ‘Throttle Up/Down’ changes the engine speed in increments of about 200 rev/min. The gears can be changed – in any order! The ‘Full/On/Off’ options work like a throttle switch. If the switch is off, then engine speed will reduce to idle.

Setting options

Options can be set by removing or adding a check mark in one or more of the boxes on the Options screen. The changes will be made immediately and will also be saved for next time the program is started.

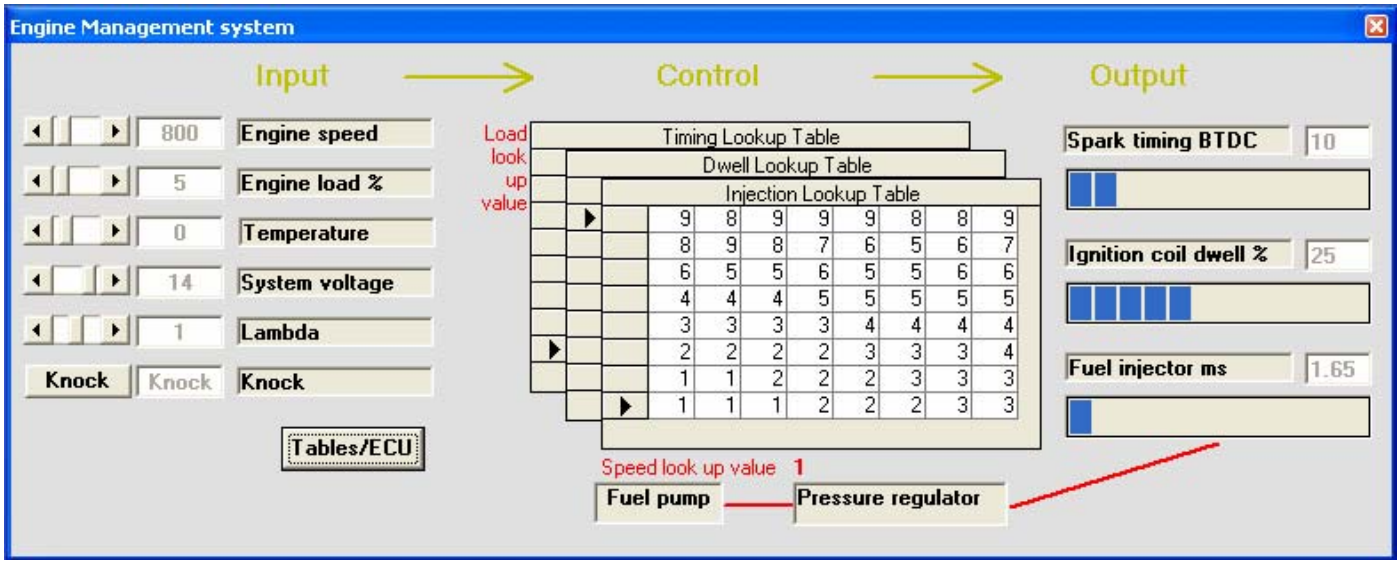


Take care if you choose to edit the lookup tables as just like on a real car settings too far out of range will cause damage. However, a special password is required to set this option!

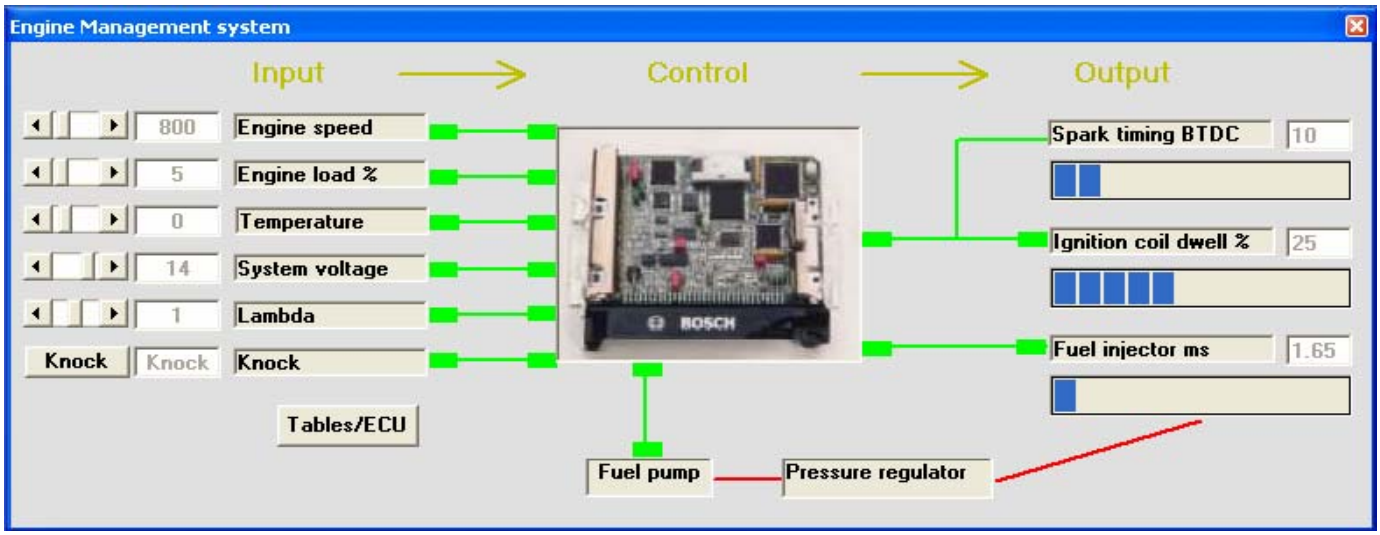
The Set Path button allows you to choose where various working files that the program uses will be stored. The default is My Documents. Network users will need to set this to their own workspace area.

Engine management

The best way to learn how to use this program and about how the electronic systems work is to have a go! The only thing to leave alone until you know a bit more is the data in the tables as shown in the screen shot.

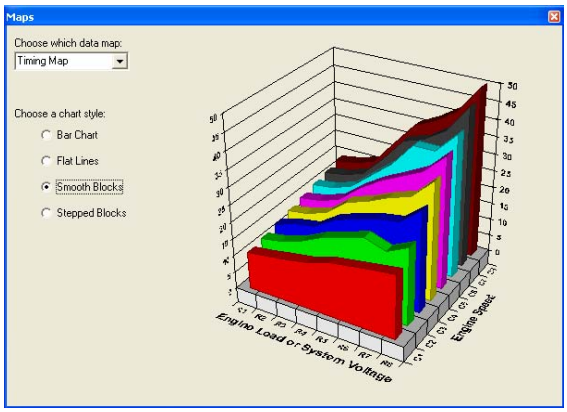


Click on the key button in the toolbar to start (or stop) the engine and the 'Engine management' window will open. Choose from the 'Run' menu the other electronic systems you would like to operate or work with. You can also right click the screen and choose to start the engine from there. Check that the car is not in gear - or else it won't start!



The first figure shows the engine management screen with the lookup tables visible. The second figure shows the ECU and its associated connections to the sensors and actuators. This option can be toggled on and off. You can set or control the operating inputs to the system.

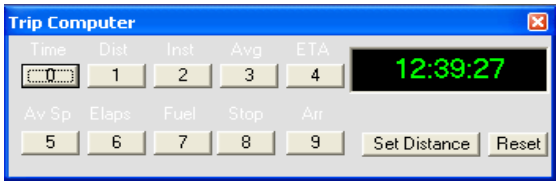
For engine management control, these are engine speed, engine load, temperature and so on. The system will react and control the outputs in just the same way as a real vehicle.



Instruments

The Instrument panel is shown here. This allows monitoring of the systems - just like on a real car! The instrument panel shows engine rev/min, road speed (in km/h or miles/h), fuel and temperature. Warning lights also appear as on a normal car.

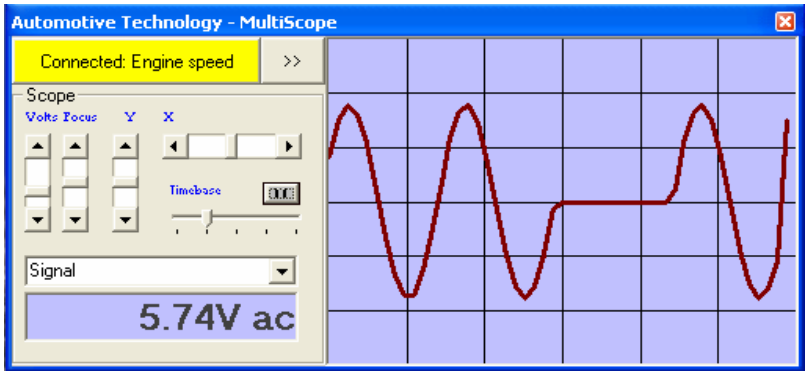
Trip computer



The trip computer works just like in a real car. You can select a variety of options such as time, fuel consumption, distance and many others. Use the consumption (instantaneous or average) option, for example, to look at how changes to the engine operating conditions such as temperature, affect how quickly fuel is used.

MultiScope

Scope/DMM



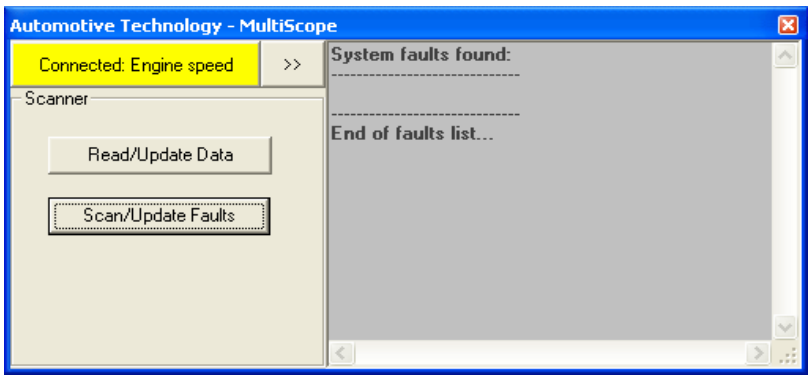
Use the built in waveform generator or choose the ‘Open’ button to view a selection of pre-recorded waveforms. The controls such as Voltage and Time base are operated in the same way as a real scope. You can edit the pre-recorded waveforms by double-clicking on the scope screen and change them along with the DMM readings.

If you drag and drop any of the labels or ECU connections from the main simulation screens on to the 'Drag/Drop Connection Terminal' the waveform will be displayed. This is an ideal way to trace faults. Remember that a scope is just a voltmeter that draws a graph. The voltage is the vertical scale and time the horizontal scale.

Select the required connection from the drop down box, and the meter will read the values typical of a real system. Note the values are examples and may differ from one vehicle to another. Check out real manufacturers data to be sure. Shown here is the voltage of a fully charged battery. Several options are available from the drop down box.

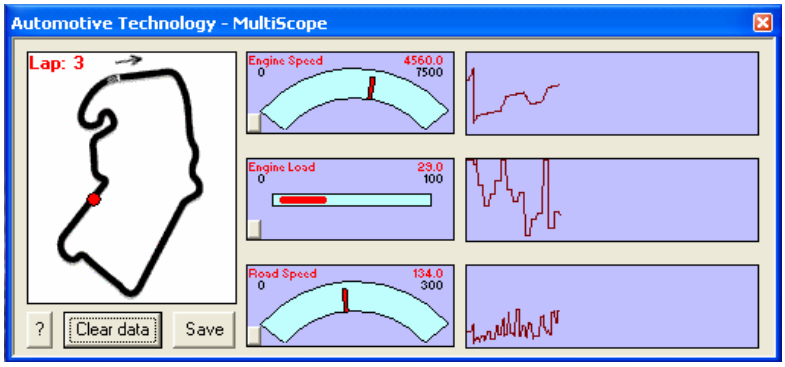
Alternatively if you drag and drop any of the labels or ECU connections from the main simulation screens on to the 'Drag/Drop Connection Terminal' the reading will be displayed.

Scanner

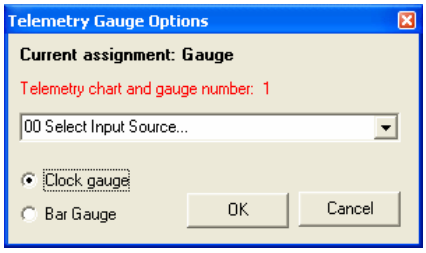


Change to the scanner by choosing the scanner symbol on the toolbar. The two buttons then allow you to scan the vehicle for faults or to see the system operating data. The operating data will change as the conditions change so don't forget to update it by clicking the button. Fault information is updated each time the 'Read' button is clicked. It will be necessary to do this after a fault has been put on the system.

Telemetry

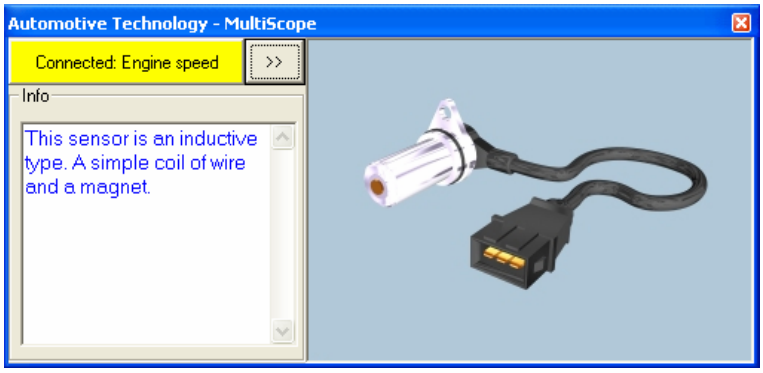


Live data is read on the MultiScope Telemetry screen. The racing circuit as shown here is Silverstone, the current UK F1 track. The red dot is the car! It will navigate the track at a speed proportional to the current road speed - you do not need to steer! This is much like a telemetry screen used by professional race teams. Set certain engine conditions and run a lap. Note the fuel consumption using the trip computer. Set different conditions and run the lap again to compare results.



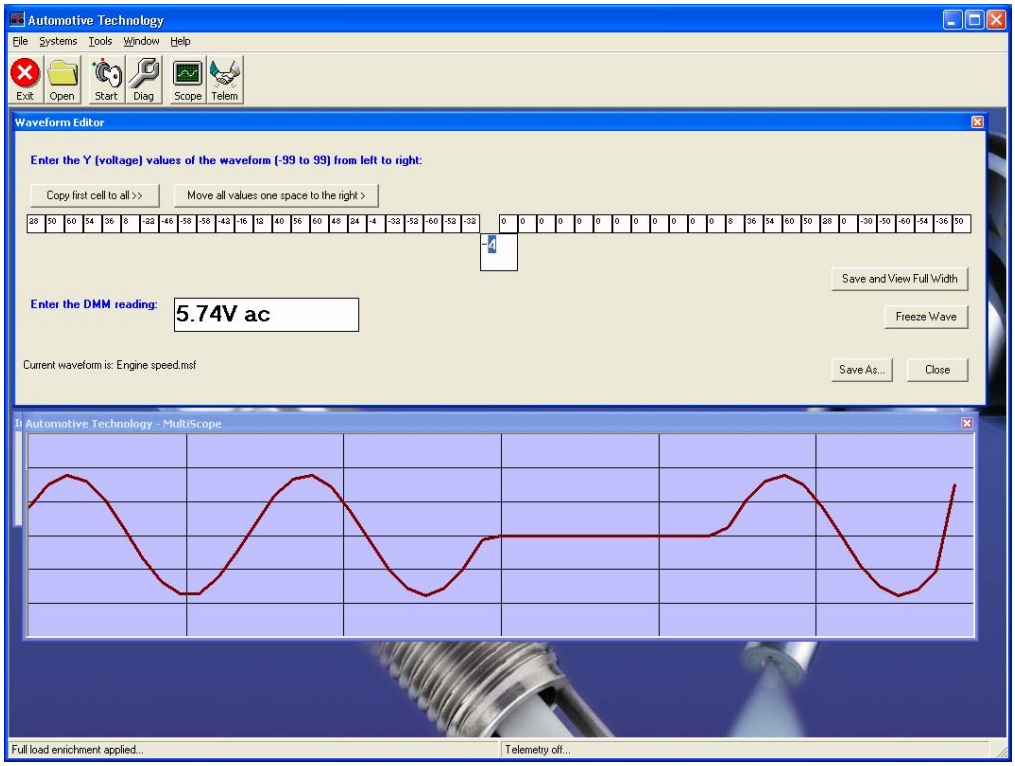
Click the small button to display the window shown above. This allows the source, style and settings of each gauge (and its associated chart) to be customized.

Pictures/Info



Pictures of all the sensors, actuators and some other components can be displayed using the Open button. Alternatively if you drag and drop any of the labels or ECU connections from the main simulation screens on to the 'Drag/Drop Connection Terminal' the picture will be displayed. Short text descriptions of all the sensors and actuators are also displayed as a picture is opened.

Waveform Editor



Waveforms can be edited using the built in editor. Double-click the scope screen when a wave file is open. Fifty 'X' values (horizontal scale) are used. The 'Y' values can be any positive or negative value within the range -99 to +99.

The 'Save and View Full Width' button allows the wave to be compared to the values as shown here.

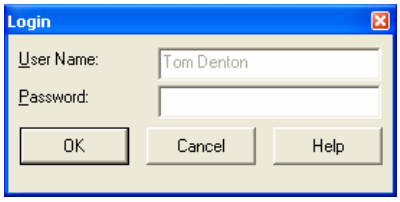
Setting faults

A fault, or a number of faults, can be set by removing the check mark in one or more of the numbered boxes on the Faults screen.

The program will react in the same way as a real vehicle when faults occur.

A list of what each numbered fault refers to can be seen by logging in to the system using a password (initially set to 'password').

This is to make sure that students do not cheat!



The 'Faults list' button displays what each numbered check box refers to - but only the instructor can see it when required. Close the Faults list after use so that it can only be accessed by the login password (initially set to 'password'). The numbered faults are in no particular order.

Diagnostics

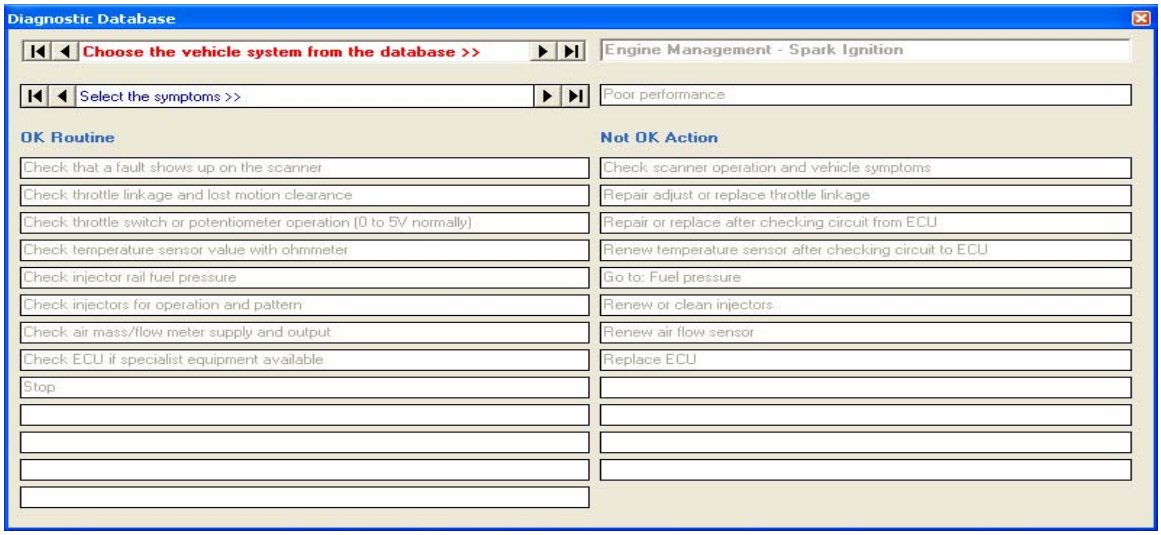
Tests can be carried out on the simulation windows almost as if they were real systems. Click any label or connection point leading to or from the ECU, and drag it to the MultiScope 'Drag/Drop Connection Terminal'. The MultiScope, as well as showing a text description and a picture, will also display an appropriate waveform and multimeter reading. These can be used for finding the faults. Check out the rest of this section for more details about specific techniques.

The faults are set in the system by removing a check mark next to the number on the faults screen (open this from the Systems menu). A password, which is initially set to 'password', is needed to see the list of faults. This is so an instructor can hide the list from students if necessary!

The terminology included in the following table is provided to ensure we are talking the same language...

Symptom	**The effect of a fault noticed by the driver, user or technician**
Fault	**The root cause of a symptom/problem**
Diagnostics	**The process of tracing a fault by means of its symptoms, applying knowledge and analysing test results**
Knowledge	**The understanding of a system that is required to diagnose faults**
Logical procedure	**A step by step method used to ensure nothing is missed**
Report	**A standard format for the presentation of results**

Routines



Click on the ‘Spanner’ button in the toolbar to open the Diagnostic Routine window if it is not already visible. If the engine is running or cranking for test purposes it will not be affected. The window as shown here is the main diagnostics screen.

Systems

The first step involved in diagnosing a fault, is to select the vehicle system under examination using the top database control, engine management for example.

Symptoms

Select the 'Symptoms' that match as near as possible the observed symptoms from the second database control, poor performance for example. A routine will appear in the boxes. The stages on the left should now be followed in order from top to bottom.

If the stated test or observation result is NOT correct then carry out the corresponding action on the right hand list. Continue in this way until the fault is found.

The diagnostic routine currently displayed can be printed for use in a workshop as well as for use with the simulation program. Select Print from the File menu in the normal way.

Methods

Black box technique

The technique that will be covered here is known as ‘black box faultfinding’. This is an excellent technique and can be applied to many vehicle systems from engine management and ABS to cruise control and instrumentation.

As most systems now revolve around an ECU, the ECU is considered to be a ‘black box’, in other words we know what it should do but how it does it is irrelevant! There is an old saying, “Any colour, so long as it's black,” Henry Ford (1920s). I doubt that he was referring to ECUs though...

A block diagram can be used to represent any number of automobile electrical or electronic systems. Treating the ECU as a ‘black box’ allows us to ignore its complexity. The theory is that if all the sensors and associated wiring to the ‘black box’ are OK, all the output actuators and their wiring are OK and the supply/earth connections are OK, then the fault must be the ‘black box’. Most ECUs are very reliable however and it is far more likely that the fault will be found in the inputs or outputs.

Other methods

Normal faultfinding or testing techniques can be applied to the sensors and actuators. For example, if an ABS system uses four inductive type wheel speed sensors, then an easy test is to measure their resistance. Even if the correct value were not known, it would be very unlikely for all four to be wrong at the same time so a comparison can be made. If the same resistance reading is obtained on the end of the sensor wires at the ECU the almost all of the ‘inputs’ have been tested with just a few ohmmeter readings.

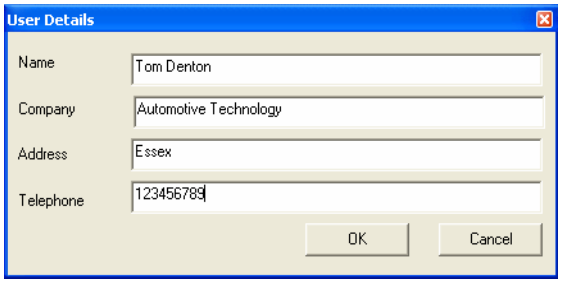
Sometimes however, it is almost an advantage not to know the manufacturers recommended readings. If the ‘book’ says the value should be between 800 and 900W, what do you do when your ohmmeter reads 905W? Answers on a postcard please...

Finally, don’t forget that no matter how complex the electronics in an ECU, they will not work without a good power supply and an earth! Check out the textbooks for more information...

(See: www.automotive-technology.co.uk for details)

User details

Set your name, company etc. (if applicable) by using the following dialog. This is accessed form the Tools menu. These details are printed out with the diagnostic routines.



Shareware legal stuff

Not applicable to purchased CD versions…

Registration

You are licensed to use this software for evaluation purposes without charge for a period of 21 days. If you use this software after the 21 day evaluation period a registration fee is required.

When payment or registration notice is received you will be sent a unique code. This will be within a day or two wherever possible. You will also be entitled to free updates.

To activate the full version of the program, click 'Yes' when prompted as the program starts. Enter your name and registration number in the boxes, exactly as supplied to you.

Evaluation

This software program is distributed as shareware. The essence of shareware is to provide you with software that you get to 'try before you buy', while rewarding the efforts of the developers. When you think about it, the opportunity to try before you buy is the ultimate guarantee of a product's quality and usefulness to you. The price of shareware is often lower because it does not have to cover expensive marketing costs.

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Learning tasks

Follow the step by step instructions in the learning task sections to learn how some of the complex automotive systems operate and then how to diagnose faults with them. You should work through the tasks in order, take your time and complete each one before moving on to the next. You may find it useful to print out each learning task as you carry it out. Each task will be presented as shown below.

Tasks:	What you should know when the tasks are completed:	Questions:
Description of the tasks	**What you should be able to do when all tasks are completed**	**Some questions based on the work you have done.**

Use the Help option and textbooks for detailed information when completing the learning tasks - remember it is not a race, take your time, enjoy and learn something useful!

Program Operation

Tasks:	What you should know when the tasks are completed:	Questions:
Try out all aspects of the program. You will not be able to damage anything. Include all the menu commands and the toolbar buttons **Check out the help file as required** **Enter your name and details in the user details form** **Do NOT change any values in the tables or the diagnostic database** **Do some background reading about engine management**	**What the toolbar buttons do** **What each menu command does** **How the options settings vary the way the program works** **How pictures and other files can be shown** **How to change inputs to the engine management system**	**State the effect of clicking the 'Open' button** **Describe how to show the circuit and start the car moving** **Describe how MultiScope can be made to show different features** **State the different methods of showing the main diagnostic form** **State THREE ways of starting or stopping the engine**

MultiScope Functions

Tasks:	What you should know when the tasks are completed:	Questions:
Start the engine and run it with 'normal' operating conditions at about 2000 rev/min Open up MultiScope and run through its various facilities making a note of key points Use the scanner to check for faults and system readings Customize the Telemetry screen by clicking the buttons on each display in turn	All the different functions of the MultiScope program The purpose of a Scanner Typical Multimeter reading of common system components How to customize the telemetry screen How to open several different file types using MultiScope	State the multimeter reading expected from a: fully charged battery, thermistor at freezing point and a crank sensor when cranking Describe how a scanner helps with faultfinding List EIGHT functions of the MultiScope State how to view and edit waveforms

Engine Management

Tasks:	What you should know when the tasks are completed:	Questions:
Click on the Key button to start the engine and the Clock button to show the instruments if required Move the throttle into the On position and select first gear. Increase the engine speed to 1000 rev/min Make a note of the ignition timing, dwell and injection time Increase the engine speed slowly to 5000 rev/min then back down to its lowest reading. Note the effect this has on timing, dwell and injection time. Set the engine speed back to 1000 rev/min Repeat this process (maximum to minimum) with the other sensors making sure you cover the whole range and reset them to the base reading before moving on to	The effect different input conditions have on the outputs or in other words how changes in what the sensors are sensing changes what the actuators do! Conditions that produce maximum and minimum results How the values in look up tables affect the outputs	State the conditions necessary to produce: Maximum fuel use Minimum fuel use Maximum timing advance Minimum timing advance Maximum dwell % Minimum dwell % Describe how the look up values vary for ignition timing (hint use the View Data maps facility) Describe the conditions that produce engine knock Describe the conditions necessary for implementation of overrun cut-off

the next **By experimentation, set all the sensors as required to produce:** **Maximum fuel use** **Minimum fuel use** **Maximum timing advance** **Minimum timing advance** **Maximum dwell %** **Minimum dwell %** **Note throughout all the changes how the system 'looks up' values in the tables**		

Sensors and Actuators

Tasks:	What you should know when the tasks are completed:	Questions:
Make sure the engine management screen is visible, stop the engine and activate MultiScope in 'Picture' mode Click on each of the sensor and actuator labels in turn and then drag and drop each one on to the MultiScope 'Drag/Drop Connection Terminal'. This will show engine management sensors and actuators as used on a Bosch Motronic system. The window can be printed if required or use Alt+PrntScrn to copy the picture to the clipboard Repeat the drag and drop routine but this time concentrate on the scope screen. This will show typical waveforms relating to the sensors and	What typical sensors and actuators look like What the fuel pump, filter and pressure regulator look like The waveforms produced by a variety of sensors The effect sensors have on engine operation Which sensors are critical	Make a sketch to show a typical lambda sensor Make a sketch to show a DIS coil Describe the effect on engine operation of a faulty temperature sensor State which sensor(s) are critical to engine operation List five sensors used by engine management systems

actuators **Repeat the drag and drop routine but this time concentrate on the multimeter screen. This will show typical readings relating to the sensors and actuators** **Make changes to sensor settings (inputs) and note the results on the actuators (outputs)** **Read further about sensors and actuators in Automobile Electrical & Electronic Systems**		

Operating Conditions

Tasks:	What you should know when the tasks are completed:	Questions:
Start the engine and make sure the, trip computer and MultiScope telemetry circuit are visible. Select throttle On and Fifth gear Transmit Telemetry from the main system and set the MultiScope to receive it by clicking the 'Receive' button! Adjust the engine operating conditions to 4000 rev/min, 50% load, 90C, 14V, lambda 1 and knock normal. Click the Fuel used button on the Trip computer (no. 7). Wait for the car to pass the start/finish line and click the Reset button on the Trip computer. Make a note of the fuel used to complete one lap (do not change settings during the lap) Change the operating conditions	How different operating conditions affect the economy of the system Detailed effects of the changes in sensors How full throttle changes the consumption	State the fastest lap time possible whilst still using the minimum amount of fuel Describe the conditions that use most fuel State when full load enrichment occurs

(full throttle for example) and repeat the above process. Try this with several different operating conditions such as low temperature or low engine load		

Diagnostics

Tasks:	What you should know when the tasks are completed:	Questions:
Click the Spanner button to open the diagnostics screens Use the top database control to select a vehicle system (e.g. Engine Management) then use the second database control to choose the most appropriate routine for the symptoms observed. Click File and then Print to send the current routine to the printer. Study the routine and note how it is used to trace a fault that is causing symptoms You must follow the OK routine top to bottom in order, and only move across to the Not OK action is the OK routine test is not met Take care though as some of the OK routine statements have had to be written in the	How to operate the diagnostic database The meaning of key diagnostic terminology How to print a diagnostic routine for workshop use Key diagnostic techniques and how to apply them	Define each of the following terms: Symptom Fault Diagnostics Describe how to select the best diagnostic routine from the database Explain what is meant by 'Black box faultfinding'

negative (e.g. Check the voltage does NOT read xxxV) **This allows the routine to flow logically (the key to good diagnostics) in two simple columns.**		

Advanced Diagnostics

Tasks:	What you should know when the tasks are completed:	Questions:
Make sure the ECU is being displayed on the engine management screen Start MultiScope and set it to show waveforms. Drag and drop some of the connection points, actuators and sensors on to the Connection Terminal. Make sure you know what the waveforms from various parts should look like Select a system fault, or get your instructor to choose one, at random from the list relating to engine management (1 to 30). You need to login from the file menu and enter a password to see what the numbered faults relate to... Run the engine if possible and then operate the scanner. This should indicate the area where the	Set a fault in the system Make judgments based on observed symptoms Call up a diagnostic procedure from the database Work through a diagnostic procedure in a logical way Check the operation of components and connections Explain the process you went through to find a particular fault...	State the effect of an open circuit lambda sensor Describe the symptoms of a break in the connection to a temperature sensor List FIVE critical faults (engine will not run) Explain why an over pressurized fuel supply can result in a richer than normal mixture

fault exists. **Check the symptoms by running the system through a 'road test' or cranking test procedure if it will not start** **Choose a procedure from the database by first clicking on the 'Spanner' button, selecting the System, and then the Symptoms. Follow the test procedure and carry out tests using MultiScope - until the fault is found** **Repeat the above until you can find ANY fault!**		

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AT Electronics Registration:

Name:

Reg. No.: