Unit 11: Vehicle Engine Management Systems

NQF level 3: **BTEC National**

Guided learning hours: 60

Unit abstract

Modern motor vehicles continue to make use of the rapid advances in electronics technology in a wide range of vehicle applications. This unit considers how electronics are used in engine management systems (EMS) and in particular the use of engine control units (ECU), which control different aspects of an engine's operation.

As a minimum, a simple ECU may just control the quantity of fuel injected into each cylinder during each engine cycle. However, advanced ECUs (found on most modern cars) also control the ignition timing, variable valve timing, the level of boost maintained by a turbocharger (if fitted) and may also control a range of other engine system peripherals. Increasingly, the EMS also plays an important part in environmental controls, fuel economy, safety and the various legislative requirements placed upon modern engines.

This unit will enable learners to gain an understanding of the systems and operating principles of an engine management system. Learners will also consider the interaction between the engine management system and the functions and performance of a modern motor vehicle engine. They will also carry out a series of engine management system tests and will select and use equipment to carry out a diagnostic test to determine EMS faults.

Learning outcomes

On completion of this unit a learner should:

1 Understand the operating principles and characteristics of an engine management system

2 Understand the operating principles of engine management system sensors and actuators

3 Understand the interrelationships and interaction of engine management systems and components

4 Be able to undertake tests on an engine management system to locate a system fault.

Unit content

1 **Understand the operating principles and characteristics of an engine management system**

Operating principles and characteristics: systems modelling eg diagrammatic representation of system input/process/output, characteristics of open and closed-loop system control strategies used in engine management systems; control systems eg analogue, digital, programmable, non-programmable; main elements of a digital processing system eg central processing unit (CPU), memory devices (such as volatile, non-volatile), buses, input/output ports; principal functions of a digital processing system eg multiplexing, controller area network (CAN) systems; characteristics eg purpose and applications of the system, operating conditions (conditions in which the system is operative or inoperative, 'fail-safe' features), system features (benefits, cost, performance, safety, convenience, efficiency)

Engine Management systems: integration developments eg fuel, mechanical to full electronic; interaction between other vehicle systems eg sport mode on gearbox selection; fuel management (spark and combustion ignition) systems; ignition control and combined fuel/ignition control; emission control eg active to reactive such as use of lambda system and knock sensor control; vehicle performance monitoring eg throttle position, driver selection

2 **Understand the operating principles of engine management system sensors and actuators**

Operating principles of sensors/transducers: types eg electro-magnetic, Hall-effect, photo-electric, resistive, inductive, piezo-electric element effect, capacitive; factors affecting performance and application eg sensitivity, accuracy, linearity and stability; influence of environmental factors eg heat, vibration, moisture, contaminants

Operating principles of actuators: eg ignition components such as coils, high tension (HT) components (individual coils, spark generators), fuel components (idle control valves, cold start devices, electronic injectors), variable valve timing control

3 **Understand the interrelationships and interaction of engine management systems and components**

Interfacing and signal processing: compatibility between components and systems eg temperature and speed sensors, throttle position/drive by wire actuators; characteristics of devices which give rise to the need for signal processing (inductive pick-ups, analogue to digital (AD) and digital to analogue (DA) conversion); control of output devices eg energy transfer, power output stages, buffer circuits

Functional interrelationships: location eg units and components within the vehicle, position/location of components relative to others in the system; functional relationships between the elements of the system eg data input from sensors and ECU process to affect actuation; impact of a component's failure on other components within the system, the operation of the system and on external systems eg the effect of speed sensor failure, Lambda sensor fault

System interactions: eg integration fuel and emission control and/or vehicle performance control, achieved by common data sources and actuator responses

4 **Be able to undertake tests on an engine management system to locate a system fault**

Test components/circuits for satisfactory operation: test equipment eg on-board diagnostics, test instruments, voltage drop tester, electronic control unit (ECU) tester, spark advance and retard tester; safe working practice eg common rail fuel pressures, working with ECU, HT voltage; components and circuits eg fuses, wiring, connectors, injector, coil, ECU, pulse generator, sensors/transducers (such as crankshaft, camshaft, knock), actuators, pressure check (fuel pump), break out box; checking for faults eg moisture, dirt, corrosion, fault code reading, gap, data link connection, output and resistance, condition, ignition timing, sensor output, sensor operation

Grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all of the learning outcomes for the unit. The criteria for a pass grade describe the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the operating principles and characteristics associated with an engine management system P2 explain the operating principles and application of three different types of engine management system sensors/ transducers P3 explain the operating principles and application of three different types of engine management system actuators P4 describe the interfacing and signal processing requirements of two engine management system components P5 explain the functional interrelationships and system interactions of the units and components of an engine management system	M1 compare the relative advantages and disadvantages of two different engine management systems M2 compare the performance of three engine management system sensors in terms of their sensitivity, accuracy, linearity and stability M3 explain the benefits of an integrated control system on engine performance.	D1 justify the comparative benefits of dedicated diagnostic equipment and procedures employed with engine management systems D2 evaluate an engine management system diagnostic procedure and make recommendations for improvements.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P6 explain the effect of different engine management functions during fuel, emission and performance control P7 use appropriate equipment to carry out tests on five different engine management system components/circuits to establish their serviceability P8 select test equipment, carry out a diagnostic check, record results and locate an engine management system fault.		

Essential guidance for tutors

Delivery

When delivering this unit centres should focus on providing learners with opportunities to explore the operating principles and characteristics of as wide a range of engine management systems and components as possible. Learners should be shown how to use block diagrams and should be encouraged to use them to represent system inputs/outputs and characteristics and break complex systems down into their sub-systems and components.

Videos, pictures and actual system components can be used to help explain the function and operation of sensors, actuators and circuits.

Block diagrams, circuit diagrams and simulation software can be used to give learners an appreciation of the digital principles used for engine systems. The conversion of circuit signals (ie AC to DC, DC to AC) should form an integral part of this explanation.

The use of 2D and 3D engine maps can help explain the relevance of the different scales/comparisons used. Fault recording can be explained with fault codes and the use of dedicated equipment (eg scanner).

The operation of the engine management system can be shown by the use of engine rigs, appropriate vehicles or simulation equipment/software (eg signal interface unit).

When covering system integration, emphasis should be placed on the effect that other systems have on the engine management system. Although it is not expected that the operation of other associated systems (eg anti-lock braking systems) is covered in detail, it is advisable to cover how a speed sensor could be utilised across different systems.

The importance of working safely should be emphasised throughout the practical activities used for diagnosis and routine maintenance activities. Maintenance and diagnostic procedures will need to be undertaken on vehicles incorporating the relevant systems and should be completed to national occupational standards.

Learners should be provided with opportunities to compare the characteristics of integrated systems with other designs (ie SI and CI). It may be advantageous to design investigative exercises around separate elements of the systems (eg investigating and comparing the characteristics and operation of various types of sensors for a particular application). Similarly, opportunities should be provided to compare associated diagnostic techniques and test equipment available for a particular system.

Assessment

Assessment of this unit could be through the use of three assignments and evidence is likely to be in the form of written work resulting from learner investigations and tutor observation records of practical work.

The first assignment could be designed to cover the requirements of P1, P2, P3, M1 and M2. The evidence to be produced should show that learners can explain both the operating principles and characteristics associated with an engine management system (P1). The assessment task should ensure inclusion of systems modelling, the control system used and their principle functions and characteristics. The evidence should also show that learners have understood the relevant aspects of the engine management system considered. This should include integration developments, the interaction between other vehicle systems, fuel management systems, ignition control and combined fuel/ignition control, emission control and vehicle performance monitoring. The assessment task used could also include a natural link to M1, by asking learners to consider two different engine management systems.

Learners could then consider relevant engine management system sensors/transducers to cover P2 (engine sensors/transducers such as engine temperature, speed and position) and actuators to cover P3 (such as idle control or ignition components). It would be natural to put the sensors/transducers (input) and actuators (output) within three different vehicle contexts (possibly across the two different engine management systems). The learner's evidence should identify for each specific application the type of sensor/transducer being used (eg electro-magnetic, Hall-effect, photo-electric, resistive, inductive, piezo-electric element effect, capacitive), the factors that may affect its performance and application and the influence of environmental factors. It would be possible to generate evidence for P2 and P3 through a practical investigation of the outputs and inputs from sensors/transducers and actuators using scanner/oscilloscopes or other dedicated equipment. For the actuators, learners must show comprehension of the principles of how individual actuators operate, such as spark generation and idle control valve (eg include how electromagnetic effect is used to create linear movement). Learners should be given opportunities to link the work done for P2 with the requirements of M2.

A second assignment could be used to cover P4, P5, P6 and M3. This will need to include a task requiring learners to describe the interfacing and signal processing requirements of two engine management systems (P4) and explain the functional interrelationship and system interaction of one of these (P5). A separate task could then require learners to explain the effect of different engine management functions during fuel, emission and performance control. Finally, a task to explain the benefits of an integrated control system on engine performance would cover M3.

The third assignment will require learners to carry out practical activities to cover P7 and P8. It would also provide the best opportunity to cover D1 and D2.

For P7, learners will need to use appropriate equipment to carry out tests on five different engine management system components/circuits to establish their serviceability. The evidence for this criterion should be gathered over time and collected together in a portfolio/report, including results of the test, relevant descriptive work and tutor observation/oral questioning records. The evidence should include the results of tests on both components and circuits, and clearly identify which system(s) and components are affected and are serviceable.

The evidence for P8 may also be used for some (or all if appropriate) of the testing carried out for P7. Although this would be ideal in terms of integration, it would need to be managed carefully to ensure full coverage of both criteria. An additional

task could be included to give learners an opportunity to work towards D1 and D2 during the testing/diagnostic activities. This should result in a separate written report including the justification and evaluation required by these two criteria.

It is expected that all the tests and procedures should be completed to national occupational standards and within health and safety guidelines.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit covers some of the knowledge and understanding associated with the Automotive Skills National Occupational Standards in Vehicle Maintenance and Repair, particularly:

- MR01: Carry Out Routine Vehicle Maintenance
- MR02: Remove and Replace Engine Units and Components
- MR03: Remove and Replace Auxiliary Electrical Units and Components
- MR07: Diagnose and Rectify Vehicle Engine System and Component Faults.

The unit supports and can be linked to other units in the qualification, such as *Unit 1: Operation of Vehicle Systems*, *Unit 3: Vehicle Fault Diagnosis and Rectification* and *Unit 6: Vehicle Electrical and Electronic Principles*.

Essential resources

A range of components, vehicles, diagnostic equipment and software will be required for the delivery of this unit. This will need to include manufacturer/vehicle-specific maintenance and test equipment and non-specific equipment such as measuring instruments, meters and pressure gauges. A variety of data sources will also be required for the vehicles, systems and procedures used.

Indicative reading for learners

Bonnick A — *Automotive Computer Controlled Systems* (Butterworth-Heinemann, 2001) ISBN 0750650893

Bonnick A — *Vehicle Electronic Systems and Fault Diagnosis* (Butterworth-Heinemann, 1998) ISBN 0340706309

Denton T — *Advanced Automotive Fault Diagnosis* (Butterworth-Heinemann, 2006) ISBN 0750669918

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of level 3 key skill evidence are given here. Staff should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• researching and selecting information about engine management operating systems and principles • preparing technical reports to explain engine management operating systems and principles • recording diagnostic results and reporting faults.	C3.2 Read and synthesise information from at least **two** documents about the same subject. Each document must be a minimum of 1000 words long. C3.3 Write **two** different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.
Information technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• researching and selecting information about engine management operating systems and principles • preparing and presenting technical reports to explain engine management operating systems and principles • preparing and presenting diagnostic results and fault reports.	ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case. ICT3.2 Enter and develop the information and derive new information. ICT3.3 Present combined information such as text with image, text with number, image with number.

Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• selecting test equipment, undertaking diagnostic procedures and locating engine management system fault.	PS3.1 Explore a problem and identify different ways of tackling it. PS3.2 Plan and implement at least one way of solving the problem. PS3.3 Check if the problem has been solved and review your approach to problem solving.