VOLVO TECHNOLOGY REPORT VOLVO

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Volvo S80: Electrical system of the future

The Volvo S80 – the company's first model to be equipped with a completely new electrical system – has just been introduced. Instead of the individual electronic control modules used in today's cars, the system in the new model is based on a number of microprocessors interconnected by networks.
Volvo has thereby created a brand new platform for meeting the demands of the future in the area of on-board functionality. This latest technological advance places the company in the forefront among its competitors in terms of exploiting the opportunities now afforded by modern technology.

The modern car is equipped with a range of different functions in which electrical and electronic systems are used. Examples include the lights, windscreen wipers, brakes and locking system. It is estimated that the modern car is equipped with over 100 such functions, each operated in the 'traditional' manner by means of a small electronic module and its associated wiring. This has resulted in the installation of a large number of electronic modules in various locations throughout the car, together with a large quantity of wiring. The size of the system is increased by the addition of new functions year by year (see Fig. 1) and by the growing complexity of existing functions. It is estimated that total functionality increases by about 7-10 % per year, with the result that the existing method of designing an electrical system has reached the limits of its capacity. In other words, due to shortage of space, we can no longer keep adding electronic modules and increasing the volume of wiring.

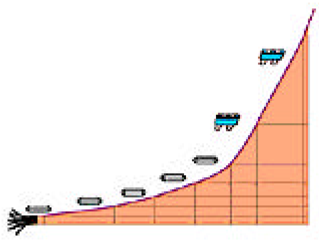

Fig. 1

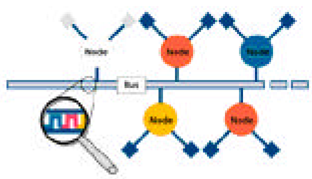

Fig. 2

The challenge

The challenges facing the designers of the S80 system included:

- limiting the steady growth of on-board electronics;
- achieving more integrated functionality;
- meeting higher demands for quality and reliability.

A technological advance of this magnitude would be extremely difficult to implement in an existing car, since it would entail a complete redesign of the component electronic modules and wiring. However, the development of the S80 and the new model platform provided a realistic opportunity of introducing new technology.

The solution

> “The various modules represent the nodes of the network, which is based on multiplex technology”

The solution was to develop a completely new electrical platform to meet these challenges, and to enable the same system to be used in the growing multiplicity of models and variants. In this context, the term ‘electrical platform’ refers to all electrical components and systems which share a commonality of any kind. This includes everything from common hardware, software, electrical architecture and communications, to development and production methods.
An electronic module is installed in every section of the car in which electronic hardware and software are required.
The objective is to ensure that all sensors, actuators, switches and loads in this defined section are connected to the nearest electronic module, irrespective of the function of which the component is part. When information transmitted to or from a given component is required by another electronic module, it is transmitted across a communications network. The various modules represent the nodes of the network, which is based on multiplex technology (see Fig. 2). As a result, information from a specific component is available to all of the modules in the car.
In the new electrical system, many of the functions are divided between several modules. Since the modules associated with one and the same function may be supplied by different makers, it is essential to specify the function to a high degree of accuracy.

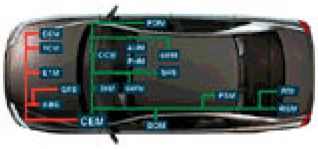

Fig. 3

Architecture

Fig. 3 illustrates the geographical location of the various electronic control modules (nodes) in the car and their interconnection with two different multiplex networks. The CEM module provides a ‘bridge’ between the two networks, enabling information to be exchanged between them.
As already noted, many functions are divided between several electronic modules. The alarm function, for example, is split between the CEM, REM, UEM, DDM, PDM and CCM units.

Communications

Since almost all of the system functions are dependent on the integrity of the communications between the modules, Volvo has devoted particular attention to this aspect. Basically, the system is designed in accordance with CAN (Controller Area Network), the standard which is by far the biggest and most widely used by European automakers. Other, earlier standards, such as VAN and ABUS, have now been superseded by CAN.
The CAN standard is supplemented by Volvo’s own requirements. The real-time characteristics of the communications network are controlled by the section of the system which is unique to Volvo. This means that Volvo has full control over the signals transmitted on the network and can fulfil all time delay conditions associated with them. The communications specification is known as Volcano, the features of which are described in detail in a separate article.
Volvo not only writes the specification, but defines its implementation in each control module to ensure that it cannot be interpreted differently by the various suppliers. This means that all of the communications software has been written by Volvo and is the same in every control module, since all suppliers have been provided with identical

copies for use in their individual products.

Signals

As many as several hundred signals may be transmitted back and forth over the communications networks. Thus, one electronic module can transmit a message while all of the others ‘listen’ simultaneously. However, every signal is coded to indicate which module or modules must listen to it. This enables the receiving modules to disregard the signals which they do not require, thereby reducing the load on them.
Subject to certain rules, every module can transmit its messages at a time determined by itself. All modules are of equal status; in other words, none is either a master or a slave. Since one of Volcano’s most important functions is to eliminate conflicts and queues on the networks, the priority and maximum permissible time delay of every message have been determined by the system designers. This affords full control over all signals transmitted over the networks.

Hardware

To minimise the number of costly variants, each electronic module is produced only in a single hardware version which is suitable for all cars based on the new electrical platform. The standardised hardware is used for all types of function. Although a range of microprocessors capable of handling CAN communications is available on the market, these are not optimised for Volvo’s Volcano communications specification. To overcome this problem, Volvo collaborated with semiconductor manufacturer Motorola to develop a type designed specifically for its requirements. Bearing the designation 68HC08, this device is now a standard Motorola product and is used in about ten electronic modules in various parts of the car.

Software

Since the hardware is fully standardised, all of the functionality is contained in the software. As a result, it is increasingly important for Volvo to master this area to maintain full control over the aspect of functionality in its cars.
Different options, variants and market adaptations are created by programming the electronic modules with different software. This is carried out on or alongside the production line. Almost all modules are equipped with a built-in flash memory; in other words, with a memory which is erasable and reprogrammable. This means that the module can also be reprogrammed by a service workshop if modification is required or when installing a new accessory.

EoL (End-of-Line) programming

Volvo has always used mechanical and electrical components with different part numbers in a variety of ways in its cars. From now on, different software programs will be handled in similar manner as part of the production process. In other words, every 'empty' electronic module and every program will be assigned a part number, and the programs will be delivered to the programming equipment in the assembly plant from Volvo's central software archives. This will involve the handling of 'virtual' parts which cannot be seen, and will apply equally to the company's production and computer systems. The software flow is illustrated in Fig. 4.

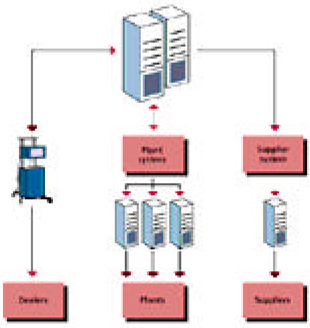

Fig. 4

Once programming has been completed, the car will be 'sealed' with a PIN code to prevent unauthorised persons from accessing and altering the program.

All part numbers programmed into the car are read out once more and stored in a central archive as an exact record of the car's software configuration when the vehicle leaves the assembly line.

Programming of the control modules as part of the production flow enables the wide variety of electronic modules used in previous models to be eliminated. As many as several hundred modules of similar appearance were used in earlier cars, the only difference being that the units were programmed differently.

PIE

Project PIE (Product Information Exchange) was undertaken to assure the reliability of software transfer throughout the entire chain, from the Volvo central archives to our production plants and service workshops.

This project deals with software transfer for both the new Volvo S80, and the 1999 Volvo S70, C70 and V70.

> "Once programming has been completed, the car will be 'sealed' with a PIN code"

Every Volvo workshop around the world is equipped with a VADIS station. Standing for Volvo Aftersales Diagnostic and Information System, VADIS is basically an industrial PC which can be connected to a Volvo car by means of a VCT2000 adapter unit, and can be used to read out diagnostic information from the vehicle and download new software to it.

Since VADIS itself does not incorporate any of the programs which can be downloaded in this manner, it must be connected directly to the Volvo central software archives. This is achieved by means of a TCP/IP protocol, which uses both the Volvo intranet (Violin) and the Internet.

Before any program can be downloaded, the database must be asked for the correct PIN code for the car. This is achieved by transmitting the car's identity to the database and receiving the PIN code in return. Once a new program has been downloaded, its part number is reported back to the central database so that the details of the on-board software configuration are kept updated at all times.

Working procedures

The new electrical system has had a major effect on working procedures at Volvo Car Corporation. Until now, the practice has been simply to specify a given function, and to appoint a sub-contractor to design the solution and supply a 'black box'. The more detailed procedure which has now been adopted is to specify both hardware and software, an approach which demands a type of expertise not previously possessed by Volvo.

The system designers are now required to divide the functions between the various electronic units and to configure the signal flow between the modules. Volvo has formulated a comprehensive set of rules governing software writing and produces a high proportion of the programs itself. ‘C’ programming language is used almost exclusively in the control modules.
Software management is something completely new to many departments at Volvo Car Corporation. Since all previous rules, schedules and procedures applied exclusively to the development and manufacture of mechanical products, many of them were not entirely appropriate to software management. As a result, a large number of new procedures has been developed to meet the needs of the new situation.

CONCLUSION

With the launch of the S80, Volvo now leads the world’s automakers in on-board electrical architecture, communications with real-time characteristics and software management. This has had a major influence on working methods and procedures within Volvo Car Corporation. Personnel at all levels of the company have received training in the new technology and the opportunities which it affords, while Volvo has also been obliged to train suppliers in many of its aspects. The state-of-the-art technology used in the Volvo S80 makes the model an ideal platform for meeting the demands of the information society of the future.

Kent Melin
graduated from Chalmers University of Technology, Gothenburg in electronic engineering in 1979, and joined Volvo Car Corporation the following year to work on electrical and electronic development projects. Since then, he has worked on a series of projects for most of the company’s design and development departments, and has been specialiced in advanced electrical system architecture since 1988. Since 1994, he has been responsible for the architecture, communications and systems integration aspects of the S80 project on behalf of Complete Electrical Systems.
