THE EXPERT
STEWART SANDERSON

Having worked as a tuner for 17 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business. A Level 5-trained fuel-injection technician, Stu has worked for a Ford Rallye Sport dealer, a well-known fuel-injection specialist and various tuning companies.

Eight years ago he joined forces with Kenny Walker and opened up Motorsport Developments near Blackpool (01253 508400, **www.remapping.co.uk**), specialising in engine management live remapping, as well as developing a range of Evolution chips which are now sold all over the world.

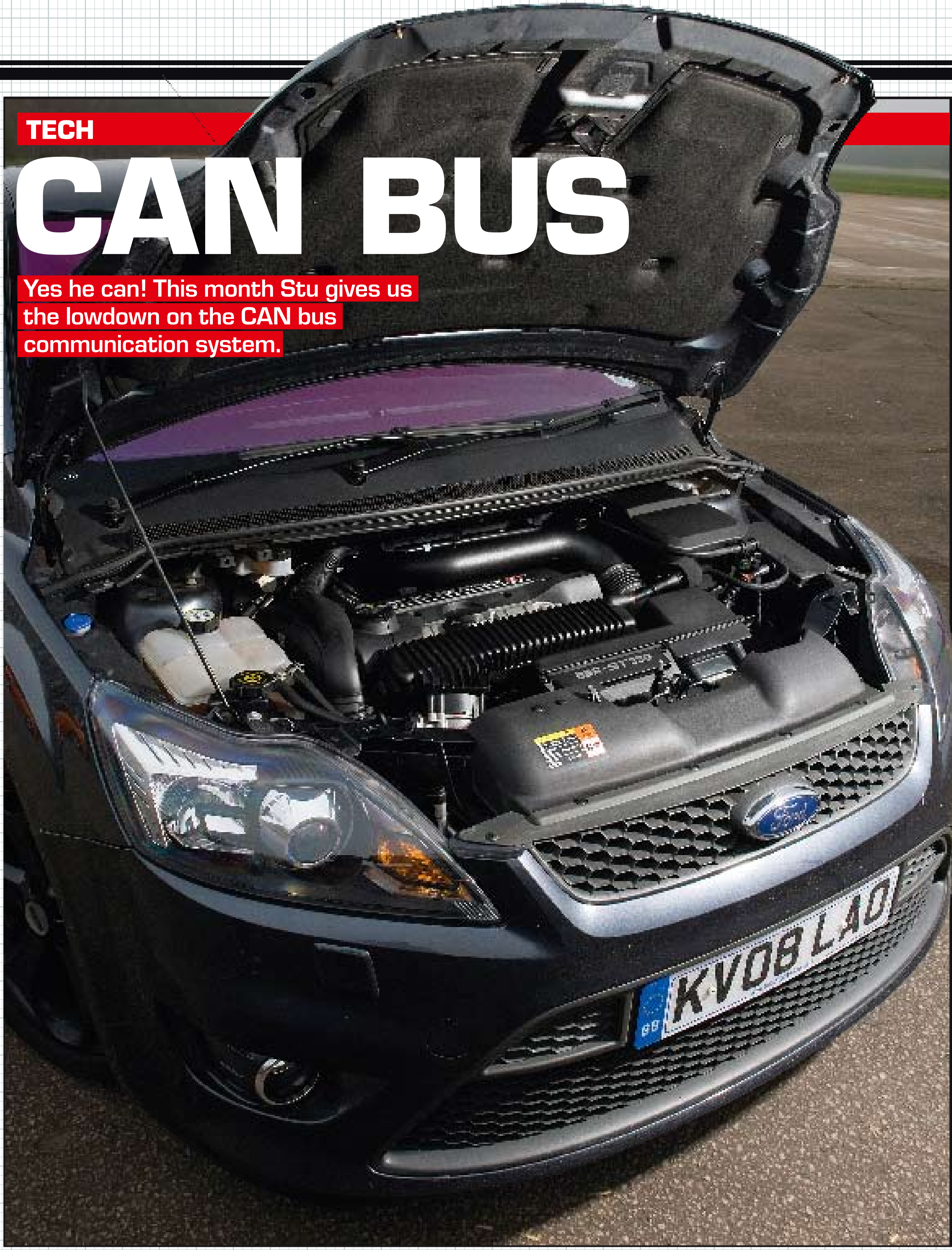
He is the creator and administrator of **www.passionford.com**, which he started in 2003. It has grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web.

Stu's enviable knowledge of the workings of modern-day Ford performance engines means that every month he's just the man to explain how and why things work, and importantly how they can be improved.

TECH

CAN BUS

Yes he can! This month Stu gives us the lowdown on the CAN bus communication system.



Inspiration for this article came from one of the Sun diagnostics courses that everyone at Motorsport Developments regularly attends to keep us up to speed with current technology. The latest one got me thinking about how many Ford owners are unaware of the latest communications systems built into a modern vehicle.

We regularly talk about technologies that relate to all cars and especially older ones, but I thought this month it would be good to look at one that relates more to the modern Fords as many Fords from 2003-onwards are fully equipped with such technologies as CAN bus.

WHAT IS THE CAN BUS?

The CAN (Controller Area Network) bus is an automotive communications system developed by Robert Bosch specifically for data exchange between electronic control units, switches, sensors and actuators in vehicles. CAN is also used in industrial microcontroller networks. For example as a bus system that connects machine tools with the computers that control them. It allows for data supply between measurement, control and display functions and superordinate computers, as well as for connecting sensors, actuators and controls.

In motor vehicles, the CAN bus replaces heavy and expensive wiring harnesses with a simple data line, and was tailored for automotive applications by Bosch engineers. On one hand, it is essential for managing the increasing number of electronic functions in automobiles, on the other it is scaled for those typical data quantities and operates with the extremely high transmission reliability that is required for safety-relevant features such as the electronic anti-skid system. The CAN bus allows automotive components to communicate on a single or dual-wire networked data bus at up to 1Mbps.

NETWORK

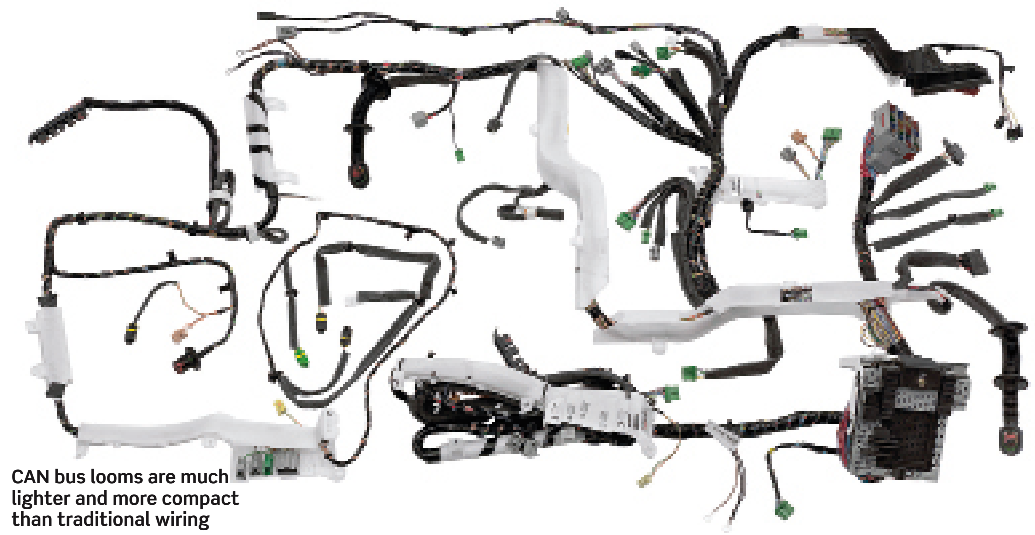
A network is a collection of connected devices that can talk to each other. In automotive applications this is usually a collection of vehicle control units for controlling items such as engines, airbags, anti-lock brakes, traction control, security, sound systems, central locking and a whole host of other things. In a CAN bus network the signals are usually multiplexed too.

MULTIPLEXING

This is the term given to the process of sending out multiple signals or streams of different information on a single carrier at the same time, all in the form of one single, complex signal and then recovering the separate signals from the individual one as required at the other end by the receiving unit. If one controller asks for a specific piece of information, let's say wheel speed, the sending ECU can send it out with other data for other receivers and the receiving unit that requested wheel speed will take the data it needs and ignore the rest. Conversely the others will just ignore the wheel speed data they didn't ask for and

CAN bus is used to control all manner of systems, including ABS

"IN MOTOR VEHICLES, THE CAN BUS REPLACES HEAVY AND EXPENSIVE WIRING HARNESSES."



CAN bus looms are much lighter and more compact than traditional wiring

Modern technology has made diagnostics much more user friendly

retrieve what they did ask for.

WHY CAN BUS WAS DEVELOPED

Since the 1940s vehicle manufacturers have strived to improve the technology within their vehicles. As a result they have started to use more electronic components. Consequently, electronics have slowly but surely taken over the role of many mechanical subsystems, and are designed to provide additional comforts, convenience and safety features.

> "BY 2010, IT'S ESTIMATED OVER 98 PERCENT OF VEHICLES SOLD IN EUROPE WILL USE CAN BUS TECH."

The problem is, or was, to talk to each other and do their jobs these systems needed immense amounts of wiring necessary to interconnect all the various electronic components to allow them to communicate with each other and external devices, such as our diagnostics equipment that we plug into the OBD port.

The release of CAN bus meant wiring savings were incredible. Traditionally, if a component needed information from the engine management ECU, the dashboard speedometer, the gearbox ECU, the airbag ECU and the anti-lock braking ECU it would have had have three wires for each ECU, so 15 wires just for those components to interact with one other component. If each ECU also needed to talk to each other you could double that. A modern Mondeo has no less than 40 computers so will give you some idea of the amount of wiring we are talking about!

The amount of wiring could be truly vast and has always been a headache to work on, made worse by the fact the vehicle wiring differs between vehicle years, makes and even models. Technicians need to be highly knowledgeable and perform intensive and expensive labour for the most trivial of installation or troubleshooting procedures.

HOW LONG HAS CAN BUS BEEN AROUND?

The BMW 850 coupe is widely accepted as the first CAN bus vehicle to enter the market in 1986. By reducing the vehicle's wiring by an incredible two miles, its overall weight was significantly reduced by over 50kg and required under half the amount of connections. For the first time ever each of the vehicle's systems and sensors were able to communicate at very high speeds (up to 1Mbps) on a single or dual wire communication line, as opposed to the previous multi-wire looms.

DOWNSIDES

There are no huge negatives to the CAN bus other than the sort of teething problems any new technology will introduce. In the case of CAN bus that is usually the fact it has increased the vehicle's complexity in some areas. This has rendered many aftermarket installations even more difficult and in many cases totally impossible to perform as they rely on the fact older cars had some wire to attach things to.

By 2010, it is estimated that over 98 percent of all vehicles sold in Europe will use CAN bus technology. There are already a great many aftermarket devices available that use the CAN bus protocol, so technology will overcome the initial difficulties that it has introduced.

HOW IT WORKS

The CAN network is a broadcast type of bus which means that all the receivers will hear the information that is transmitted and will decide themselves whether to use what's received. This means there is no way to target a specific receiver. The CAN bus is connected together by a twisted pair of wires and is divided into two separate subsystems – a high- and low-speed bus, so be aware that the system runs at two different speeds.

The networks are linked by units called gateway nodes. These gateways allow the signal to transfer from the low-speed bus onto the high-speed bus where required. Incidentally, if these gateways develop any errors they can cause one network to stop working and the other to continue to work fine. Special relays called bus cut relays are now employed in vehicles specifically to stop catastrophic failures of the entire CAN bus. These are fitted into individual ECUs.

The CAN bus works in the following way:

- Data supply: The originating control unit provides a data output to the CAN controller for transfer out onto the CAN bus.
- Sending the data: The CAN transceiver receives data from the CAN controller and converts it into electrical signals and sends them onto the bus as multiplexed data.
- Receiving the data: All other control units on the CAN bus network become receivers and start to receive the multiplexed information that was transmitted by the host.
- Checking the data: Each control unit checks whether they require the data they have received from the host.
- Accepting the data: If the data received is important to the unit, it is accepted and processed, if not itis simply ignored. CAN uses the multi-master principle of sending, where each module can send and receive data on the bus numerous times. A signal may be sent up to six times before logging a fault if no acknowledgement was received from a receiving controller.
- Priority of data: There is a function built into CAN bus that allows two messages to be released at the same time to be tagged with priority, This means important signals can be processed by the receivers first, for example when an airbag activation signal has been triggered by a body control module that has sensed an impact. This signal obviously needs priority over any other no matter how busy the network.

All info is sent into the network and the relevant receiver takes what it needs

SIGNALS

The CAN bus carries a great deal of data that is required by various units around the car. We have the obvious sensor outputs such as engine speed, water temperature, air temperature, fuel temperature, air flow meter feedback, throttle position, exhaust temperature, manifold pressure etc coming from the engine itself. These signals are travelling to the ECU to allow it to process this data and keep the engine running optimally.

We also have various other systems such as anti-lock braking wheel speed sensors, security key codes for security systems, lighting feedback information from bulbs etc so we can have some info on the dash when one blows. We also control some electro-mechanical-type devices via the CAN bus. Two common examples are as follows:

Electronic throttle control (Fly By Wire)
The fly by wire system eliminates the mechanical element of a throttle control cable to transfer your pedal commands to the throttle body and substitutes it with some fast responding electronics to reduce the number of moving parts (and associated wear). As a result it requires minimum adjustments and maintenances.

When the pedal is moved we transmit a signal to the ECU via the CAN bus. The ECU processes this information and sends out signals to the throttle motor telling it how fast and how far to move. This is done via the high-speed CAN bus as the data speed and accuracy are critical to the engine responding properly to your request.

Adaptive cruise control
Cruise control is now a common automotive driver assistance system. Combining the electronic throttle and ABS system with cruise control on a network it is possible to implement adaptive cruise control. This allows the system to sense changes in road speed, inclines, declines etc and act accordingly. Nowadays a cruise control system is very intelligent and its complexity of programming should not be taken for granted.

Soon we will have mainstream systems that can take action against impending collisions. The technology is here, tried and tested it just hasn't found the right route to market yet.

> "WHEN THE PEDAL IS MOVED WE TRANSMIT A SIGNAL TO THE ECU VIA THE CAN BUS."

VEHICLE STABILITY PROGRAMS

The onset of CAN bus really has brought this technology forward. These new stability control programs are looking not only at all wheel speeds but also at yaw rates in many cases and can take over throttle control if you are deemed to not be doing the right thing to avert disaster. They can also apply individual brake calipers to try and restore control to the driver.

OTHER COMMUNICATIONS SYSTEMS

It is very important to note that there are a few similar systems in existence and it's not uncommon to see a vehicle with more than one of these systems on board at any one time. Of the other multiplex capable network systems in use today, the most notable are:

Ford SAP SCP
Standard Corporate Protocol

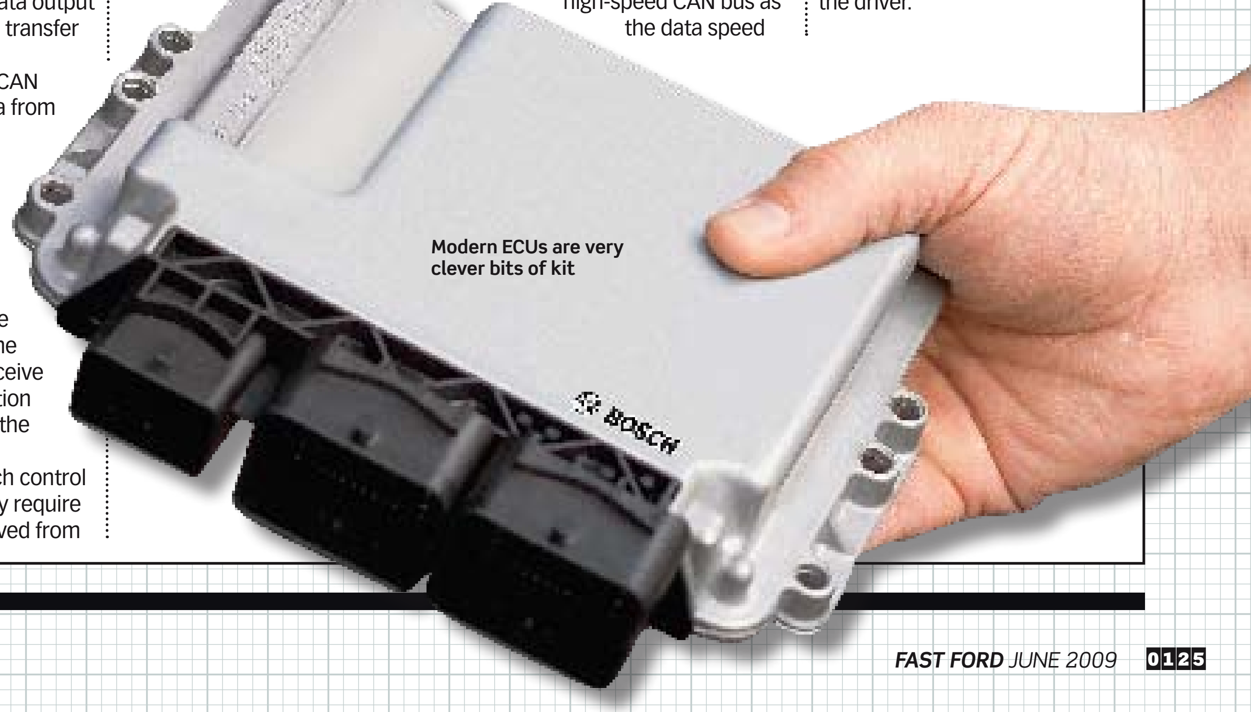
Peugeot/Citroën VAN
Vehicle Area Network

Vauxhall GM-CAN LIN
Local Interconnect Network
This is a less costly option to CAN and is widely used, often alongside CAN.

FLEXRAY
This is a new automotive network communications protocol under development by Flexray Consortium that comprises of VW, BMW, DaimlerChrysler, GM, Robert Bosch GmbH, NXP semiconductors and Motorola.

MOST
Media Oriented Systems Transport
This system is intended to replace the bulky and expensive wiring in vehicles and is used mainly for multimedia connectivity requirements.

Optical fibres are used because signals travel along them with less loss, and they're immune to electromagnetic interference. MOST is best suited to pass huge volumes of data. This is a requirement of Infotainment system.



Modern ECUs are very clever bits of kit