dataTaker®

Intelligent Data Logging Products

CANgate™

User's Manual

A guide to:

- programming
- wiring
- communications

www.datataker.com

CANgate User's Manual

UM-0086-A2

Warranty

Thermo Fisher Scientific Australia Pty Ltd ("Thermo Fisher") warrants the instruments it manufactures against defects in either the materials or the workmanship for a period of three years from the date of delivery to the original customer. This warranty is limited to, and purchaser's sole remedy for a breach of this warranty is, the replacement or repair of such defects, without charge, when the instrument is returned to Thermo Fisher or to one of its authorized dealers pursuant to Thermo Fisher's return policy procedures.

The obligations set forth above shall be void with respect to any damage to the instrument resulting from accident, abuse, improper implementation or use, lack of reasonable care, loss of parts, force majeure, or any other third party cause beyond Thermo Fisher's control. Any installation, maintenance, repair, service, or alteration to or of, or other tampering with, the instruments performed by any person or entity other than Thermo Fisher without its prior written approval, or any use of replacement parts not supplied by Thermo Fisher, shall immediately void and cancel all warranties with respect to the affected instruments.

Thermo Fisher shall not be liable for any incidental, indirect, special, punitive or consequential loss or damages resulting from or arising out of the use of the instrument, In no event shall Thermo Fisher's liability with respect to the instrument, the use thereof, this warranty statement or any cause of action related thereto, under any circumstances exceed the purchase price of the instrument actually paid by purchaser.

Where Thermo Fisher supplies to the customer equipment or items manufactured by a third party, then the warranty provided by the third party manufacturer shall pass through to purchaser, but only to the extent allowed by the original manufacturer or third party supplier.

EXCEPT AS EXPRESSLY PROVIDED IN THIS WARRANTY STATEMENT, THERMO FISHER DISCLAIMS ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE INSTRUMENTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. THERMO FISHER DOES NOT WARRANT THAT THE INSTRUMENTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT. ANY ADVICE OR ASSISTANCE FURNISHED BY THERMO FISHER IN RELATION TO THE INSTRUMENTS SHALL NOT GIVE RISE TO ANY WARRANTY OR GUARANTEE OF ANY KIND, AND SHALL NOT CONSTITUTE A WAIVER BY THERMO FISHER.

The Purchaser shall be solely responsible for complying with all applicable local, state and Federal laws with respect to the installation, use and implementation of the equipment.

Trademarks

dataTaker is a registered trademark of Thermo Fisher Scientific Australia Pty Ltd

CANgate is a trademark of Thermo Fisher Scientific Australia Pty Ltd

All other brand and product names are trademarks or registered trademarks of their respective holders.

CE

Regulatory Notices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

CANgate Firmware Covered in This Manual

This version of the *CANgate User's Manual* (UM-0086-A2) applies to CANgate products running **version 1.28 (or later)** firmware.

WARNING

dataTaker products are not authorized for use as critical components in any life support system where failure of the product is likely to affect the system's safety or effectiveness.

Contents

Introduction

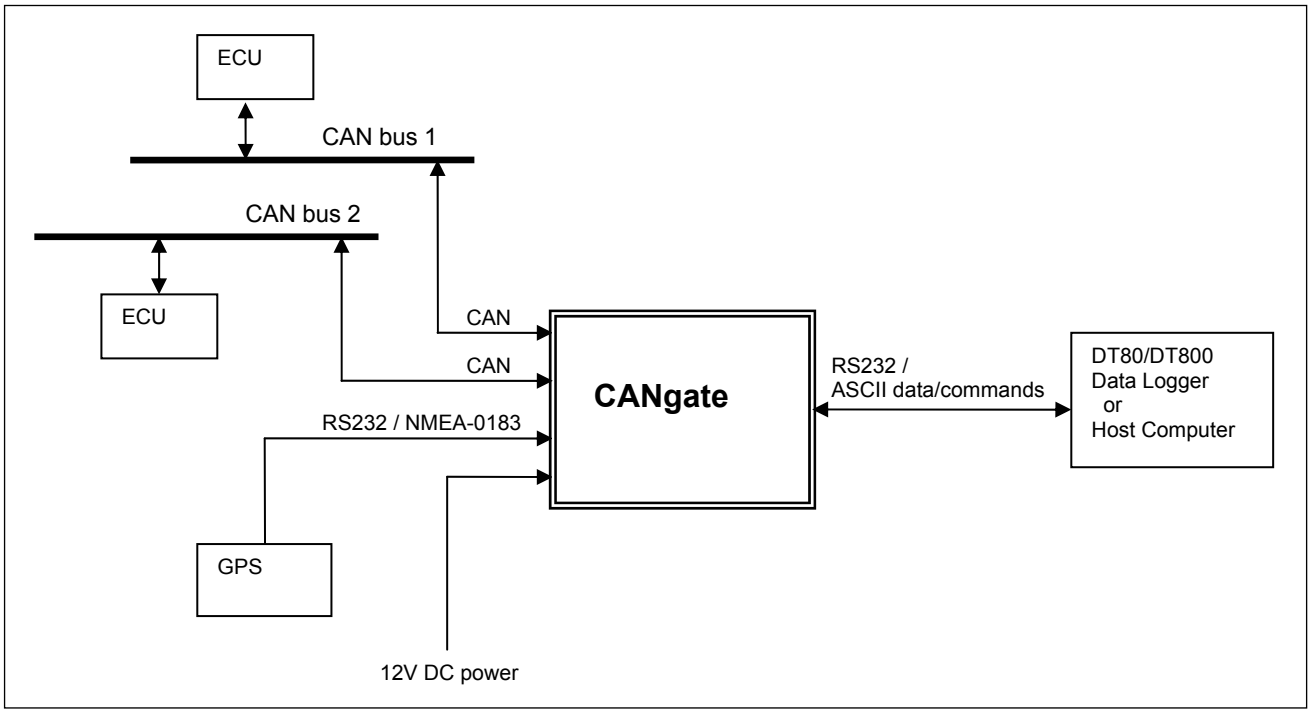
About CANgate

CAN (Controller Area Network) is a data communication system widely used in the automotive industry.

The dataTaker **CANgate** allows a data logger (such as the dataTaker DT80) or a host computer to be interfaced to a CAN network. CANgate is equipped with two standard CAN interfaces, plus a serial interface for connecting to an NMEA-0183 compatible device such as a GPS unit. Data may then be returned to the host computer or data logger via a second RS232 interface.

CANgate is capable of performing a range of functions; such as sending and receiving raw CAN messages or performing higher-level functions to interface with ISO-14230/OBD-II and SAE-J1939 compatible devices.

The CAN ports are "hot-pluggable" and all CANgate settings are saved in non-volatile flash memory so that the unit will resume its configured tasks following a power interruption.



Typical CANgate application

About This Manual

This document is primarily a reference manual which describes the commands used to configure the CANgate. It is assumed that the reader has some familiarity with the operation of CAN-based systems and the various communication protocols which operate over CAN.

Note that dataTaker *DeLogger* software provides an easy-to-use "front end" which will generate the required logger and CANgate commands in order to monitor and record the parameters of interest from the CAN bus. If DeLogger is used then detailed knowledge of the CANgate commands described in this manual is not required.

Acronyms

Abbreviation	Meaning
CAN	Controller Area Network
CRLF	Carriage Return, Line Feed
ECU	Electronic Control Unit
GPS	Global Positioning System
ID	Identifier
ISO	International Standards Organisation
NMEA	National Marine Electronics Association
OBD	On Board Diagnostics
PGN	Parameter Group Number
PID	Parameter Identifier
SAE	Society of Automotive Engineers
SPN	Suspect Parameter Number
OBD	On Board Diagnostics
DTC	Diagnostic Trouble Code
PDU	Protocol Data Unit

CANgate Hardware

Connectors and LEDs

CANgate consists of a small aluminium box with a DE9 connector on each end and six LEDs on the top face.

Host RS232 Port

The female DE9 is used to connect to an RS232 port on a host computer or data logger. The pin-out follows the standard DTE (Data Terminal Equipment) layout as used on a PC. That is:

Pin	Signal	Function
1	-	
2	RXD	Receive Data input
3	TXD	Transmit Data output
4	-	
5	GND	Ground
6	-	
7	RTS	Request To Send output
8	CTS	Clear To Send input
9	-	

Note that the RTS and CTS pins are only used if hardware handshaking is selected (see *Configuration* *(P11)*)

CAN/GPS/Power Port

The male DE9 is used to:

- supply power to CANgate (10-30V DC)
- connect to two separate CAN buses
- connect to the RS232 interface (and possibly power) on a GPS unit

The pin-out is as follows:

Pin	Signal	Function
1	5V out	+5Vdc output (200mA max)
2	GND	Ground
3	CAN1-HI	CAN port 1 – high (+)
4	GPS RXD	GPS port – Receive Data input
5	CAN1-LO	CAN port 1 – low (–)
6	CAN2-HI	CAN port 2 – high (+)
7	CAN2-LO	CAN port 2 – low (–)
8	GPS TXD	GPS port – Transmit Data output
9	POWER in	+10-30V DC power input

LEDs

The LEDs are used to indicate activity on the various ports:

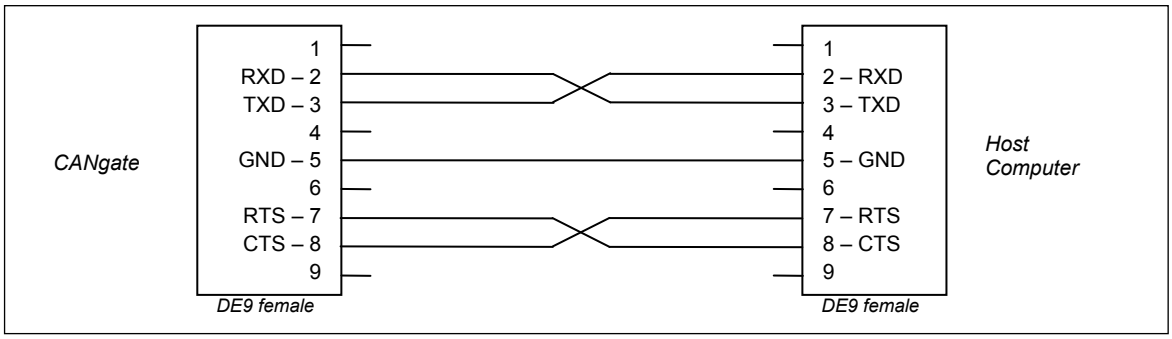
LED Label	LED Colour	Function
Power	red	on while CANgate is powered
RS232 Tx	red	flashes when characters are transmitted to host port
RS232 Rx	green	flashes when characters are received from host port
CAN 1 Rx	blue	flashes when a CAN frame is successfully received from CAN port 1
CAN 2 Rx	red	flashes when a CAN frame is successfully received from CAN port 2
GPS Rx	green	flashes when characters are received from GPS port

Note that the CAN LEDs will only flash on receipt of CAN frames which match CANgate's current hardware filter settings. If CANgate has not yet been programmed to receive CAN data then the LEDs will not flash, even if there is traffic on the connected bus.

Connecting CANgate

Host Computer Connection

The supplied host computer serial cable is wired as a standard "null modem" cable:

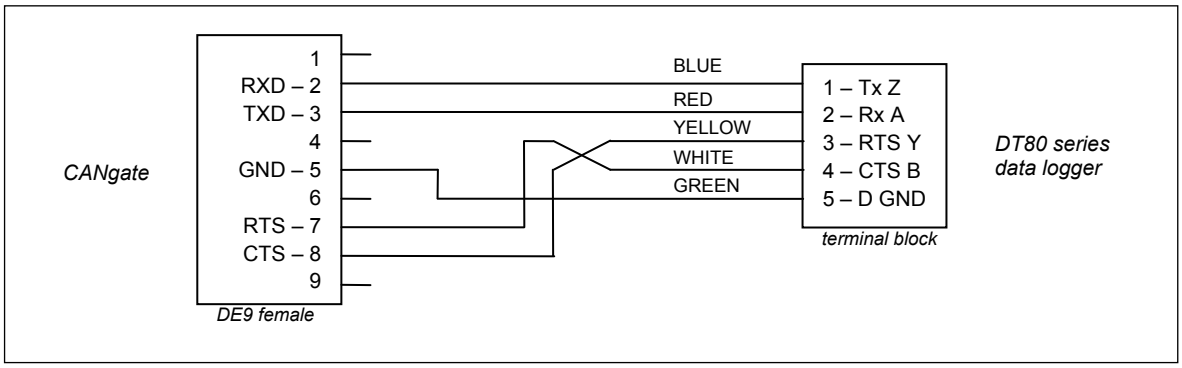


Host computer serial connection wiring diagram

If the host computer does not have an RS232 port then a USB to serial adapter may be used.

Data Logger Connection

The supplied data logger serial cable is designed to connect to the serial sensor port on a DT80 series logger.



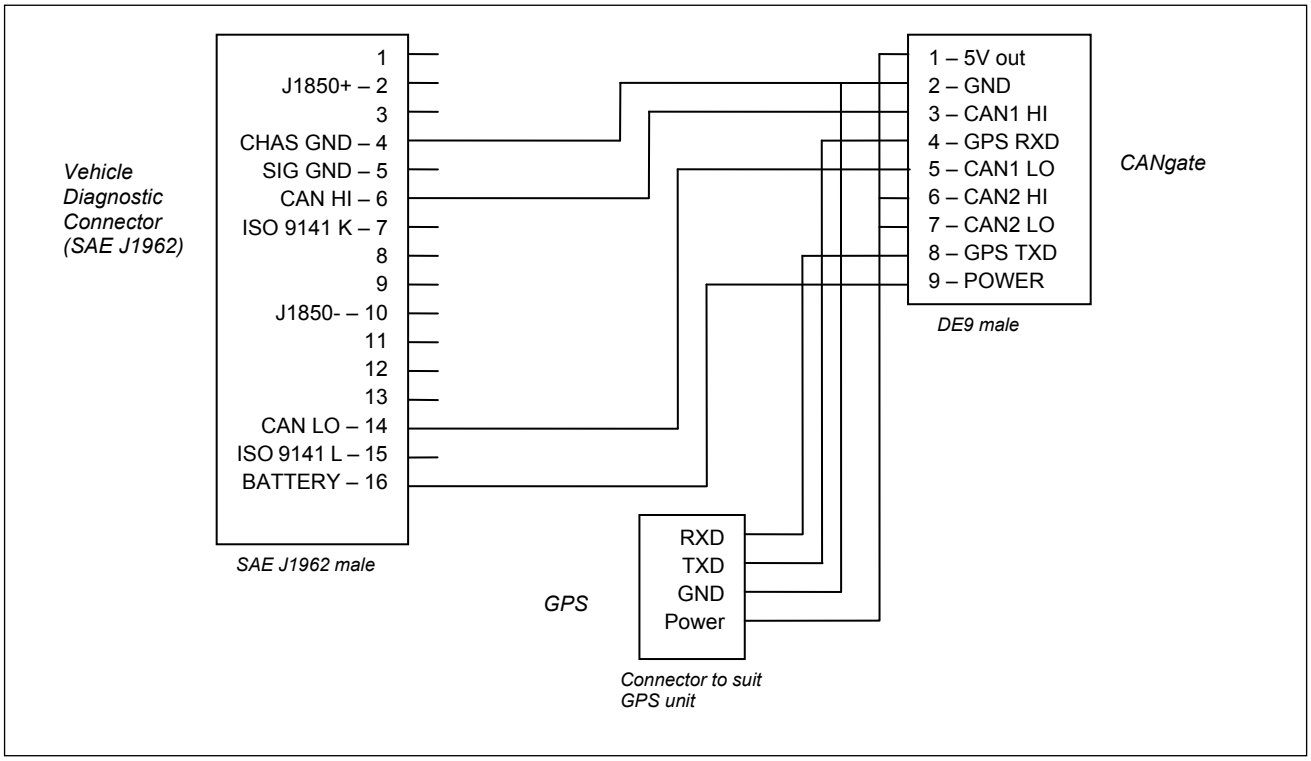
Data logger serial connection wiring diagram

Note: By default, the CANgate host port operates at a high baud rate (57600 baud). At this speed, the maximum cable length for the host computer or data logger connection is approximately 5 metres, assuming good quality shielded cable is used. If a longer cable is required, the CANgate baud rate should be reduced (see *Configuration* *(P11)*), eg. at 9600 baud a cable length of 40m is normally possible.

CAN/GPS/Power Connections

The supplied terminal adapter plug (DE9 male to 9-way terminal block) provides convenient screw terminal connections to the CAN/GPS/POWER connector. Alternatively, a custom cable can be made up using a conventional DE9 plug.

A typical wiring configuration is shown below:



Diagnostic connector and GPS wiring diagram

Note A vehicle with an SAE J1962 diagnostic connector may not necessarily use a CAN network. If CAN is not used then the indicated pins will either be not connected or in some applications may have a different function. Ensure that the vehicle does actually use high speed CAN before connecting CANgate to the diagnostic connector.

CAN Bus Type and Termination

The CAN protocol can operate over a number of different **physical layers**. A physical layer is a specification defining the low level electrical characteristics of the network, eg. allowable bit rates, voltage levels, cable type and so on.

It is important to note that CANgate only supports the **high speed** CAN physical layer, as defined in ISO 11898-2 / SAE J2284. This is by far the most widely used physical layer. The important characteristics of this standard are:

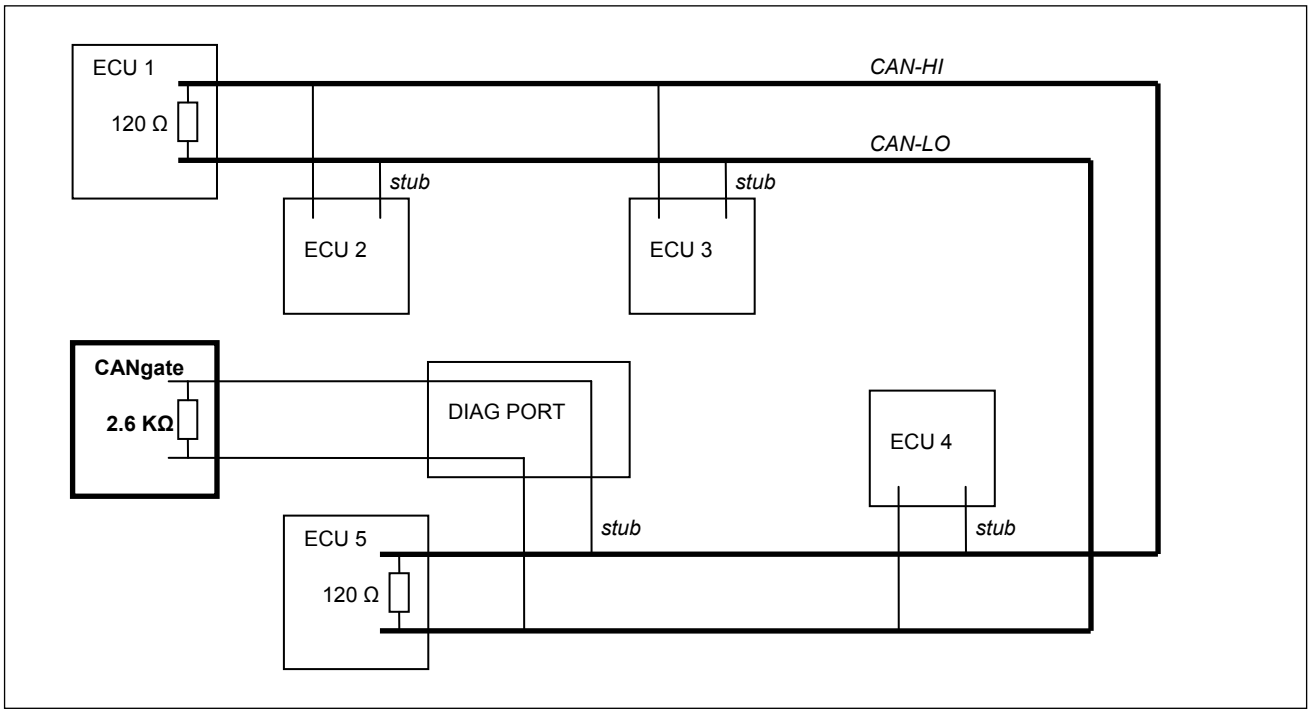
- two wire, 5V differential signalling
- bit rate 10kbps – 1Mbps
- twisted pair cable, 120 Ω characteristic impedance

A high speed CAN network is required to have a linear topology. There is a single twisted pair "backbone" cable which can be up to 40m long. Electronic control units (ECUs) are then connected to the bus using short **stub** connections (max length 0.3m). (These limits are for 1Mbps operation and can be increased somewhat for lower bit rates.)

At each end of the bus, correct **termination** is required. This typically consists of a resistor (wired across the two bus lines) that matches the impedance of the cable (ie. 120 Ω). The termination resistance provides the correct DC load for the CAN output drivers, and minimises signal "reflections", which can distort the CAN signals and cause errors.

Connecting to an Existing CAN Network

A typical CAN network might be wired as follows:



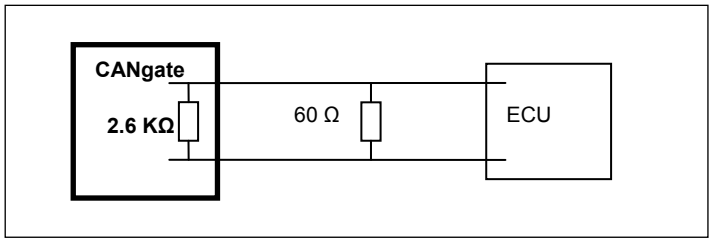
Typical layout of a vehicular CAN network

In this case the vehicle has five ECUs connected to the CAN bus, plus a diagnostic connector. ECUs 1 and 5 are at the ends of the main bus, so they incorporate termination resistors. ECUs 2, 3 and 4 connect to the bus via short stub connections and do not include a termination resistor.

Notice that CANgate incorporates **weak termination** (2.6k Ω). This value is high enough so as not to significantly increase the DC load on the already terminated bus, yet low enough to provide some damping of reflections on CANgate's stub connection to the bus. This allows the length of the stub to be extended to around 2-3 metres. Note that some of the ECUs may also include weak termination to allow their stub connections to be extended slightly.

Connecting to a Single ECU

If CANgate is connected to a single ECU (eg for laboratory testing) then an external termination resistor may be required



Direct connection to a single ECU

In this case a short (1m) cable is used so the two 120 Ω resistors are combined into one 60 Ω resistor. If a long cable is used then 120 Ω resistors should be placed at each end. This assumes that the ECU is not terminated (or weakly terminated). If the ECU includes its own 120 Ω termination then an external 120 Ω resistor is only required at the CANgate end of the cable.

Note that if the cable is short and the bit rate moderate then you may well get away with no external termination, ie. CANgate's internal weak termination may be adequate.

Inside CANgate

Accessing CANgate Internals

If it is necessary to alter the settings on the internal DIP switch then CANgate will need to be disassembled, as follows:

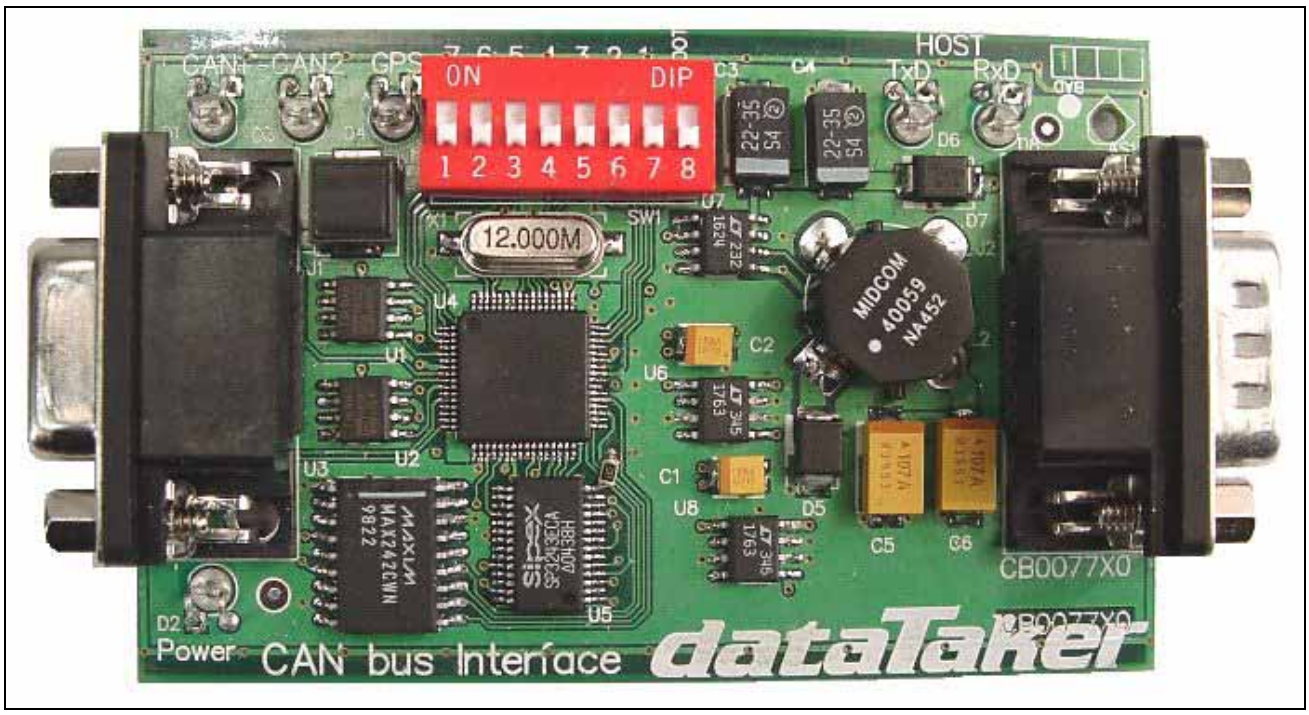
1. Disconnect any cables from the CANgate connectors.
2. Remove the two Philips-head screws on the right hand ("Host RS232") end of the case.
3. Remove the aluminium end plate and plastic surround.
4. Push on the connector at the other end of the case. The printed circuit board (PCB) should slide out.

To reassemble:

1. Slide the printed circuit board into the topmost slot in the case (the one closest to the front panel label). The male DE9 should be at the right hand ("Host RS232") end of the case.

   Note: It is normal for one of the solder connections on the PCB near the male DE9 connector to make contact with the case.

2. Replace the plastic surround, then the end plate.
3. Fasten the two screws



CANgate internal view

Configuration Switches

By default, the CANgate's host RS232 port is configured for 57600 baud, hardware flow control (RTS/CTS), 8 data bits, no parity, 1 stop bit. This should be suitable for most applications, however these settings can be changed by setting the internal DIP switch, as shown below. The factory default is all switches OFF.

		Switch 1	Switch 2	Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8
Host port baud rate	57600	off	off	off	x	x	x	x	off
	38400	off	off	ON	x	x	x	x	off
	19200	off	ON	off	x	x	x	x	off
	9600	off	ON	ON	x	x	x	x	off
	115200	ON	off	off	x	x	x	x	off
Host port flow control	hardware	x	x	x	off	x	x	x	off
	software	x	x	x	ON	x	x	x	off
Factory Defaults		ON	ON	ON	ON	ON	ON	ON	off
Bootstrap Mode		x	x	x	x	x	x	x	ON

Note: Switch numbers refer to the numbers printed on the switch itself. Ignore the labels marked on the printed circuit board.

Note: The switch settings are only checked immediately after power up. Changing the switches during operation has no effect.

The **Factory Defaults** setting can be used to force CANgate to revert to a factory default state, ie. verbose mode off, both CAN ports disabled, GPS baud rate 4800, all memory slots cleared. Set the switches as indicated above (ie. switches 1-7 ON), then cycle the power – all LEDs should illuminate briefly – then return the switches to their normal setting and cycle the power again.

The **Bootstrap Mode** switch provides an alternative way of entering Bootstrap Mode, which is only used when upgrading CANgate firmware.

Using CANgate

Memory Slots

By default, CANgate will not send or receive any CAN messages. In order to do anything useful, it must first be programmed.

CANgate is programmed by sending commands to set up one or more **memory slots**. Each memory slot can be configured to perform one of the following functions:

Slot type	Class	Action
RECV **RECVE**	passive	receive CAN messages with a specified **identifier** value, extract the specified data field and return its value as a formatted ASCII value
RECVJ	passive	receive CAN messages relating to a specified **J1939 PGN** number, extract and return the specified data field
GPS	passive	receive **NMEA-0183** messages of the specified sentence type, extract and return the specified data field
SEND **SENDE**	active	send a CAN message
RQST	active	request an **ISO-14230** parameter, wait for the reply, extract and return the specified data field
RQSTJ	active	request a **J1939 PGN**, wait for the reply, extract and return the specified data field

As can be seen, there are two classes of slots: **passive** and **active**.

For RECV, RECVE, RECVJ and GPS slots, CANgate passively receives all matching messages then returns the last known data value either at a fixed rate, or when requested by the host (data logger or computer). Statistical calculations can optionally be performed, resulting in a min/max/average value being returned instead of an instantaneous value.

For SEND, SENDE, RQST and RQSTJ slots, CANgate will take the specified action (ie. transmit a message and possibly wait for a reply) either at a fixed rate or when requested by the host.

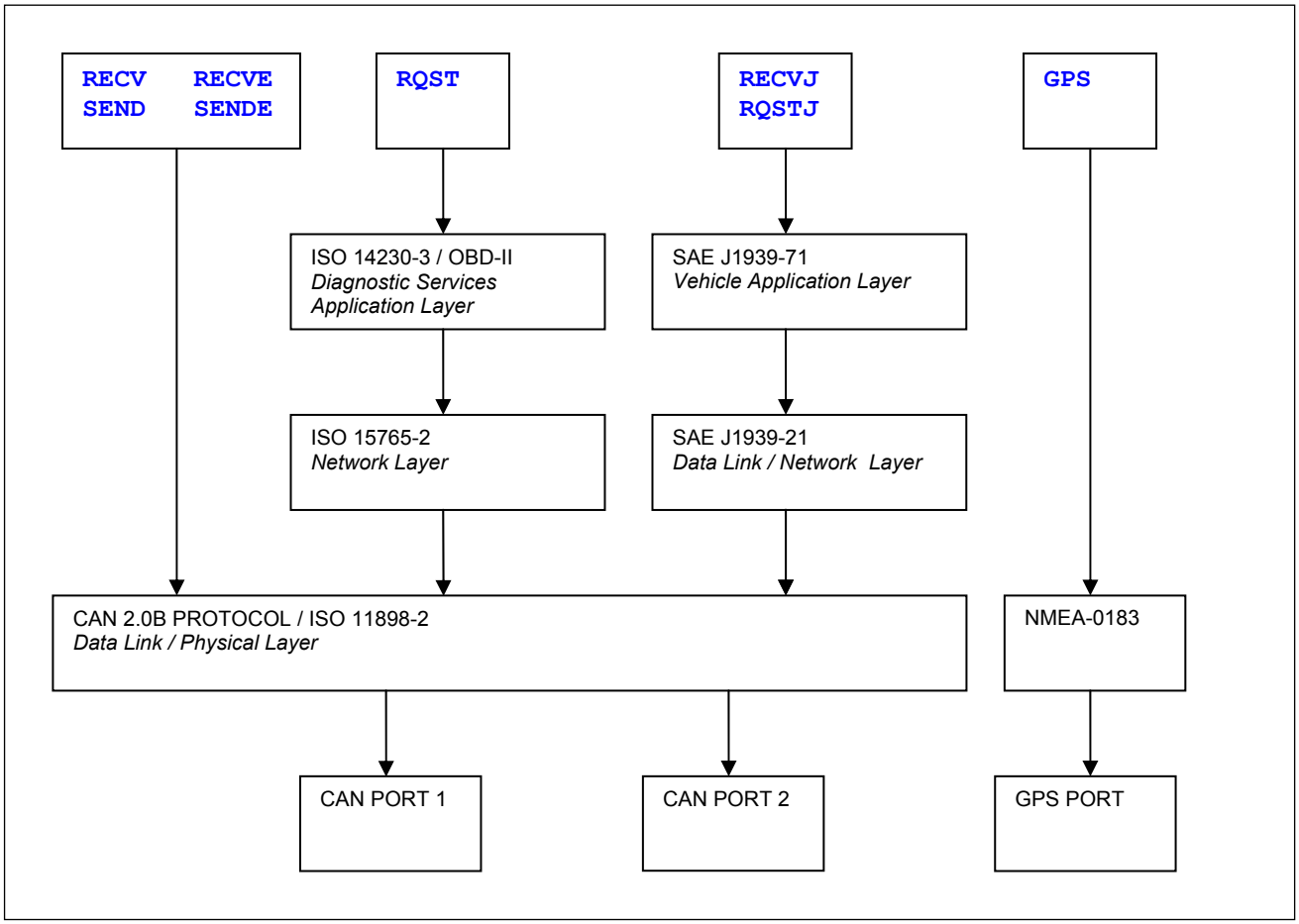
In all cases, one memory slot corresponds to one data value of interest. So if a particular type of CAN message contains six separate values packed into its data area, of which four are of interest, then you would set up four memory slots – each one configured to extract a different subfield.

Up to 150 memory slots (which are referred to by number, 1-150) can be set up. Slot configurations are automatically saved to flash memory so that operation will automatically resume following a power interruption.

One further memory slot, **Slot 0**, is provided. This is intended to be used as a "scratch pad" for one-off requests, ie. it may be reprogrammed many times during operation. This slot's configuration is not saved to flash.

Memory Slot Commands and Protocol Hierarchy

CAN networks can use a number of different higher level communications protocols. The following diagram illustrates the protocols used by each type of memory slot.



CANgate protocol hierarchy

As can be seen, the RECV, RECVE, SEND and SENDE memory slot types operate on raw CAN messages. A raw CAN message consists of an 11 or 29 bit identifier, plus 8 bytes of data.

RQST memory slots allow parameters to be requested using standard automotive OBD (On Board Diagnostics) requests. The ISO 15765-2 network layer protocol is responsible for breaking up the request and response messages into multiple CAN frames, if required.

RECVJ and RQSTJ memory slots allow broadcast and requested parameters to be read from a J1939 network. J1939 also incorporates a network layer which can break long messages up into multiple CAN frames.

Finally, GPS memory slots allow fields of interest to be extracted from the NMEA-0183 data stream produced by a GPS device.

Entering Commands

CANgate memory slots and other settings are configured by sending textual **commands** via the host port. The available commands are detailed in the *Command Reference* *(P16)*.

If CANgate is directly connected to host computer then these commands can be entered using a terminal program (eg. *DeTransfer*).

If CANgate is connected to the serial sensor port on a DT80/DT800 series data logger then the logger would be programmed to transmit commands and receive data using the **`1SERIAL`** channel type. Refer to the logger User Manual for more details.

CANgate commands are not case sensitive.

Most commands have a set number of space-separated **parameters**. All parameters must be specified, unless a parameter is marked as optional.

A parameter's data type will be specified as either:

- **floating point** – enter a decimal value, eg. **`1.25`**, **`-4`**, **`0.9907`**
- **integer** – enter a decimal or hexadecimal value, eg. **`2309`**, **`0xff07`**, **`-10`** (hexadecimal values are prefixed by **`0x`**)

- **hex data** – enter a string of hexadecimal digits, eg. **`12ff09270045db08`**. To make long strings easier to read, one or more underscores (or any other non-hex, non-whitespace character) can optionally be inserted between bytes, eg: **`12ff0927_0045db08`**. The hexadecimal prefix **`0x`** can also be included if desired.
- **string** – enter an ASCII string inside quotation marks, eg. **`"big top"`**, **`"\007Alert "`**, **`"\r\n"`**

Control characters may be inserted into strings using a backslash followed by three decimal digits representing the ASCII code, eg. **`\013`** will insert a carriage return. To insert an actual backslash character, use **`\\`**. As a shortcut, carriage return, newline (CR-LF) and tab characters may be inserted using **`\r`**, **`\n`** and **`\t`** respectively.

Note: If *DeTransfer* is used to send commands to CANgate then each backslash must be entered as **`\\`** in the DeTransfer Send window. So if you want the string to contain an actual backslash character you would need to enter **`\\\\`** in DeTransfer.

Commands must be terminated by a carriage return or a semi-colon (**`;`**) character.

Comments may be included using an apostrophe (**`'`**) character. All characters after the apostrophe up until the end of the line will be ignored.

Run Mode and Program Mode

CANgate has two operational modes.

Run Mode is the normal mode of operation. Following power-up, CANgate always starts in Run Mode.

In Run Mode, all configured memory slots will receive and/or transmit their programmed CAN or GPS messages, and return data to the host system as required.

Whilst in Run Mode, any of the commands described in the Command Reference *(P16)* may be entered. However, only Memory Slot #0's configuration may be changed. Commands that attempt to modify any of the other memory slots will be ignored – the only way to update these slots is to switch to Program Mode.

Program Mode is entered by sending the **`BEGIN`** command. This command will erase all existing memory slots and prepare CANgate for receiving new definitions.

In Program Mode, the CAN and GPS ports are not active. The only commands that are accepted in this mode are the slot definition commands – **`RECV`**, **`RECVE`**, **`SEND`**, **`SENDE`**, **`RECVJ`**, **`RQST`**, **`RQSTJ`** and **`GPS`**.

These commands are prefixed by the number of the memory slot to define, eg:

```
12 RECV 1 0x712 1 2
```

will define memory slot #12.

When all required memory slots have been defined, the **`END`** command will save all memory slot details (except Slot #0) to non-volatile flash memory and return to Run Mode.

Command Summary

{ slot } **RECV** *CANport RxID { startByte{.bit} endByte{.bit} sampleRate } { FORMAT options }*

{ slot } **RECVE** *CANport RxID { startByte{.bit} endByte{.bit} sampleRate } { FORMAT options }*

{ slot } **SEND** *CANport TxID hexData { sampleRate }*

{ slot } **SENDE** *CANport TxID hexData { sampleRate }*

{ slot } **RQST** *CANport hexData { startByte{.bit} endByte{.bit} ECUaddr sampleRate } { FORMAT options }*

{ slot } **RECVJ** *CANport PGN { startByte{.bit} endByte{.bit} ECUaddr priority sampleRate } { FORMAT options }*

{ slot } **RQSTJ** *CANport PGN { startByte{.bit} endByte{.bit} ECUaddr priority sampleRate } { FORMAT options }*

{ slot } **GPS** *"header" fieldNum { option sampleRate } { FORMAT options }*

… **FORMAT** *{ rawFormat } { scale offset } { "formatString" } { stats }*

BEGIN

END

RP *{ slot1 slot2 }*

CONNECT *CANport bitrate*

VERBOSE *state*

VERSION

RESET

SNOOP *CANport* | **GPS** *{ snoopTime }*

SNOOPJ *CANport { snoopTime }*

NETLOAD *{ CANport }*

SETADDR *CANport address*

GPSBAUD *baudRate*

GPSSEND *"text"*

STATUS

STATS *{* **CLEAR** *}*

DIAG *mode*

Command Reference

Commands and Parameters

In this section, **literal text** (to be entered exactly as shown) is shown thus: **RECV**.

Variable **parameters** are shown as: *CANport*.

Optional parameters are surrounded by braces. If multiple parameters are surrounded by braces, eg.

CMD *param1 param2 { param3 param4 }*

then one or more of the parameters may be omitted, starting with the rightmost parameter. That is, you can specify either:

CMD *param1 param2* or

CMD *param1 param2 param3* or

CMD *param1 param2 param3 param4*

If parameters have their own individual braces, eg.

CMD *param1 param2 { param3 } { param4 }*

then each optional parameter can be either specified, or not. So as well as the above choices you could also specify:

CMD *param1 param2 param4*

All optional parameters have a defined default value, which is what will be used if the parameter is not specified.

Remember that CANgate commands are not case sensitive, so **recv** is equivalent to **RECV**.

Slot Definition Commands

RECV – Receive Standard-ID CAN Messages

{ slot } **RECV** *CANport RxID { startByte{.bit} endByte{.bit} sampleRate } {* **FORMAT** *formatOptions }*

where:

- *slot* is the memory slot being defined (integer, **0-150**). If not specified then **0** is assumed. If CANgate is in Run Mode then zero is the only value that can go here.
- *CANport* is the CAN port to use (integer, **1-2**)
- *RxID* is the 11-bit CAN identifier to listen for (integer, **0-0x7FF**)
- *startByte{.bit}* is the starting bit position of the field of interest within the 8-byte CAN data field. Bytes are numbered from 1 to 8, bits are numbered from 8 (MSB) down to 1 (LSB). If *startByte* is not specified then **1** is assumed. If *.bit* is not specified then **.8** is assumed.
- *endByte{.bit}* is the ending bit position (inclusive) of the field of interest within the 8-byte CAN data field. If *endByte* is not specified then **8** is assumed. If *.bit* is not specified then **.1** is assumed.
- *sampleRate* is the rate at which to return values to the host (integer, in ms, must be multiple of 100ms). May also be **ALL**, in which case a value is returned on receipt of every matching CAN message. If this parameter is **0** or not specified, the memory slot will only return data when it is polled by the host system (using the **RP** command).
- *formatOptions* specify how the data value is to be formatted when it is returned to the host system; see *FORMAT Sub-command* *(P21)* for more details. if not specified, data will be returned in raw hexadecimal format.

A **RECV** memory slot captures all messages on the specified CAN port with the specified standard identifier, and extracts the required data field. When polled (using the **RP** command), or at the intervals specified by the *sampleRate* parameter, the slot will return the most recent value for the data field. If no messages have been received, nothing will be returned (other than the configured static formatting text, which is specified by the **FORMAT** sub-command and by default is just CRLF).

The **SNOOP** command *(P24)* can be used to determine which CAN identifiers are being broadcast on a CAN network.

Note: If the *sampleRate* parameter is set to **ALL**, it is not guaranteed that every CAN message will be returned. Many CAN networks operate at high speed, and some parameters are broadcast at very frequent intervals. The rate at which these messages arrive may exceed the bandwidth of the host RS232 connection, or the processing capabilities of the CANgate.

Examples

```
RECV 1 0x220
```

Receive messages on CAN port 1 with ID 0x220. When polled, return all 8 data bytes (in hexadecimal) of the most recent message.

```
RECV 1 0x603 1 2 FORMAT "P1:%d\n"
```

Receive ID 0x603 messages. When polled, return the first two data bytes as a single decimal integer, prefixed by **P1:**.

Remember – if *DeTransfer* is used to send the above command then it would need to be entered as

```
RECV 1 0x603 1 2 FORMAT "P1:%d\\n"
```

RECV 1 0x603 3.8 3.5 ALL FORMAT .25 "%f,"

As each ID 0x603 message is received, return the value of the upper 4 bits of data byte 3 (0-15). This is then scaled by a factor of 0.25 and returned as a floating point number (range 0-3.75) followed by a comma.

RECV 1 0x112 4 8 1000

Once per second (1000ms), return the most recent values of data bytes 4-8 of received ID 0x112 messages.

RECVE – Receive Extended-ID CAN Messages

{ slot } **RECVE** *CANport RxID { startByte{.bit} endByte{.bit} sampleRate } { FORMAT formatOptions }*

This command is exactly the same as **RECV**, except that the CAN identifier is an **extended mode** (29 bit) identifier, as opposed to a standard mode (11 bit) identifier.

The allowable range for *RxID* is therefore **0-0x1FFFFFFF**

SEND – Transmit Standard-ID CAN Message

{ slot } **SEND** *CANport TxID hexData { sampleRate }*

where:

- *slot* is the memory slot being defined (integer, **0-150**). If not specified then **0** is assumed. If CANgate is in Run Mode then zero is the only value that can go here.
- *CANport* is the CAN port to use (integer, **1-2**)
- *TxID* is the CAN identifier to include in the transmitted message (integer, **0-0x7FF**)
- *hexData* is up to 8 bytes of hex data to include in the transmitted message. Non hex characters (eg. **_**) may be inserted between bytes to make the string easier to read.
- *sampleRate* is the rate at which to send messages (integer, in ms, must be multiple of 100ms). If this parameter is **0** or not specified, the memory slot will only send a message when it is polled by the host system (using the **RP** command).

When polled, a **SEND** memory slot transmits a raw CAN message. No data is returned to the host system.

Note that it is not possible to set up a RECV slot on the same CAN port to monitor messages sent by CANgate. If this is required, connect the two CAN ports together and set up the RECV slot on the other port.

Examples

SEND 2 0x302 1122FF07; RP

This will immediately send a CAN message on CAN port 2. The message's identifier will be 0x302 and the data field will be 1122FF07. The DLC (data length code) field in the CAN frame will be set to 4.

SEND 2 0x119 FF110203_040599CC 2000

Every 2000ms, send the indicated 8-byte data field with CAN ID 0x119.

SENDE – Transmit Extended-ID CAN Message

{ slot } **SENDE** *CANport TxID hexData { sampleRate }*

This command is exactly the same as **SEND**, except that the CAN identifier is an **extended mode** (29 bit) identifier, as opposed to a standard mode (11 bit) identifier.

The allowable range for *RxID* is therefore **0-0x1FFFFFFF**

RQST – Request OBD Data

{ slot } **RQST** *CANport hexData { startByte{.bit} endByte{.bit} ECUaddr sampleRate } { FORMAT formatOpt }*

where:

- *slot* is the memory slot being defined (integer, **0-150**). If not specified then **0** is assumed. If CANgate is in Run Mode then zero is the only value that can go here.
- *CANport* is the CAN port to use (integer, **1-2**)
- *hexData* is 1-39 bytes of data to include in the transmitted request message. The first byte is the ISO-14230 **mode byte**, the remainder of the data are parameters. The number and meaning of the parameters vary depending on the mode byte. Non hex characters (eg. **_**) may be inserted between bytes to make the string easier to read. See *OBD-II Modes and PIDs* *(P40)* for more details on some common OBD request messages.
- *startByte{.bit}* is the starting bit position of the field of interest within the received message. Bytes are numbered from 1, bits are numbered from 8 (MSB) down to 1 (LSB). If *startByte* is **0** or not specified, a default value is chosen based on the mode byte. If **.***bit* is not specified then **.8** is assumed.
- *endByte{.bit}* is the ending bit position (inclusive) of the field of interest. If *endByte* is **0** or not specified then this will be the last received byte in the message. If **.***bit* is not specified then **.1** is assumed.

- *ECUaddr* is the address of the ECU to which to send the request (integer, **0-7**, or **256**). If **256** is specified (which is the default), a non-specific request is made. For ECUs which do not use the standard OBD-II CAN IDs, you can alternatively specify an explicit CAN ID here, in hexadecimal (e.g. **0x220**); this is discussed further below.
- *sampleRate* is the rate at which to send messages (integer, in ms, must be multiple of 100ms). If this parameter is **0** or not specified, the memory slot will only send a message when it is polled by the host system (using the **RP** command).
- *formatOpt* specify how the data value is to be formatted when it is returned to the host system; see *FORMAT Sub-command* *(P21)* for more details. if not specified, data will be returned in raw hexadecimal format.

A **RQST** memory slot transmits a request message to an ISO-14230/OBD-II compatible ECU, and waits for a reply. Then:

- if a reply is forthcoming, the required bytes are extracted from the reply message, formatted if required, and returned to the host.
- if an ISO-14230 negative reply code is received, this is reported to the user (if the Verbose flag is on), and no data is returned.
- if nothing is received then CANgate will time out after approximately 400ms and abort the request.

The request will be sent using CAN ID (0x7E0 + *ECUaddr*). If *ECUaddr* = 256, this indicates a "functionally addressed request", which will instead be broadcast using CAN ID 0x7DF.

The message data consists of a single **mode byte** (or **service identifier**), followed by a variable number of parameters. Modes 0x01-0x0F are standardised ("legislated") OBD-II modes (defined in SAE-J1979 or ISO-15031), while modes 0x10-0x3F are manufacturer extended modes (specified in ISO-14230, although details of data and parameters are manufacturer specific).

CANgate will then listen for a response with CAN ID 0x7E8-0x7EF (ECU #0 will reply using ID 0x7E8, ECU #1 with ID 0x7E9, and so on). The response message's mode byte will be either:

- a copy of the request mode byte with bit 6 set – this is a **positive response** and the mode byte will generally be followed by one or more data values, or
- the value 0x7F – this is a **negative response** and indicates that an invalid request was made.

All messages are transmitted using the **ISO-15765** network layer protocol. This protocol fragments long messages into multiple CAN frames and then reassembles them.

CANgate recognises a few of the common ISO-14230 mode byte values and sets the default *startByte* value appropriately, so that header information in the response is skipped. In particular:

Mode	default *startByte*	Comment
0x01, 0x02, 0x33	3	skip first 2 bytes (mode, PID) in response
0x22	4	skip first 3 bytes (mode, ID-hi, ID-lo) in response
other	2	skip first byte (mode) in response

All received data, from *startByte* through to the end of the message (or *endByte* if specified), will be returned to the host.

Note: The response time for ISO-14230/OBD-II commands depends upon the particular ECU and can vary greatly. CANgate will only send out one request at a time; if it is asked to make many requests simultaneously then the requests will be placed in a queue and executed sequentially. If no reply is received within 400ms then CANgate will assume the ECU is dead and make the next request.

Note: Some ECUs do not use the standard CAN identifier range (0x7E0 – 0x7E7). In this case an arbitrary CAN ID (0x000 – 0x7F7) can be specified explicitly as the *ECUaddr*. This should be specified in hexadecimal. CANgate will then send the request using the specified CAN ID, and expect a response with CAN ID *ECUaddr* + 8. The following two commands are therefore equivalent:

```
RQST 1 010C 3 0 1
RQST 1 010C 3 0 0x7E1
```

In both cases the request will be sent with CAN ID 0x7E1 and the response will be expected to have CAN ID 0x7E9.

Examples

```
RQST 1 010D FORMAT "%d\n"
```

When polled, send a message on CAN port 1 requesting the current value (mode = 0x01) of Parameter ID (PID) 0x0D, which is vehicle speed (see *OBD-II Modes and PIDs* *(P40)*). The speed will be returned as a single decimal integer (0-255 km/h) followed by CRLF.

```
RQST 1 1800FF00 2 2 0; RP
```

This will immediately send a message on CAN port 1 to ECU #0 to ReadDTCByStatus (mode = 0x18), returning all currently active fault codes (parameter byte 1 = 0x00) for all fault code groups (parameter byte 2-3 = 0xFF00). The ECU will return a mode byte, fault code count, and a variable length string of 3-byte SAE-J2012 format fault codes. The slot selects just fault code count (byte 2) and returns it in the default format (hexadecimal).

RECVJ – Receive J1939 Messages

{ slot } **RECVJ** *CANport PGN { startByte{.bit} endByte{.bit} ECUaddr priority sampleRate } { FORMAT fmtOpt }*

where:

- *slot* is the memory slot being defined (integer, **0-150**). If not specified then **0** is assumed. If CANgate is in Run Mode then zero is the only value that can go here.
- *CANport* is the CAN port to use (integer, **1-2**)
- *PGN* is the J1939 Parameter Group Number (integer, **0-131071**)
- *startByte{.bit}* is the starting bit position of the field of interest within the received message. Bytes are numbered from 1, bits are numbered from 8 (MSB) down to 1 (LSB). If *startByte* is **0** or not specified then **1** is assumed. If **.***bit* is not specified then **.8** is assumed.
- *endByte{.bit}* is the ending bit position (inclusive) of the field of interest. If *endByte* is **0** or not specified then this will be the last received byte in the message. If **.***bit* is not specified then **.1** is assumed.
- *ECUaddr* is the address of the ECU (source address) from which to receive messages (integer, **0-255**, or **256**). If **256** is specified (which is the default), messages are received from any source address.
- *priority* (integer, **0-7**, default:**6**) specifies the expected value of the priority field (bits 28-26 in the CAN ID)
- *sampleRate* is the rate at which to return values to the host (integer, in ms, must be multiple of 100ms). May also be **ALL**, in which case a value is returned on receipt of every matching CAN message. If this parameter is **0** or not specified, the memory slot will only return data when it is polled by the host system (using the **RP** command).
- *fmtOpt* specifies how the data value is to be formatted when it is returned to the host system; see *FORMAT Sub-command* *(P21)* for more details. if not specified, data will be returned in raw hexadecimal format.

A **RECVJ** memory slot operates in a similar way to a **RECVE** slot. That is, it listens for CAN messages with a particular extended identifier, extracts the required data field then returns it to the host when polled (or at regular intervals, or after every message is received). The difference is in the way the identifier is specified.

The SAE-J1939 protocol assigns meaning to various parts of the 29-bit CAN identifier, as follows:

CAN ID bit	J1939 interpretation
28-26	Priority
25	Reserved
24	Data Page, which is effectively bit 16 of the PGN
23-16	Parameter Group Number (PGN) MSB (bit 15-8) – if < 240 then this identifier has **PDU1** (directed message) format, otherwise it has **PDU2** (broadcast message) format
15-8	if PDU1 format: destination address (implied PGN LSB = 0) if PDU2 format: PGN LSB, or "group extension" (implied destination address = 0)
7-0	source address

CANgate will receive messages where:

- the Priority field matches *priority*, and
- the 17-bit PGN/Datapage fields match *PGN* (for PDU1 format, any destination address will be accepted), and
- the source address field matches *ECUaddr* (if *ECUaddr* = 256, any source address will be accepted).

PGN numbers, and the layout of the data fields therein, are defined in the SAE J1939/71 (Vehicle Application Layer) standard.

The **SNOOPJ** command *(P24)* can be used to determine which J1939 PGNs are being broadcast on a CAN network. See also *J1939 PGNs & SPNs* *(P28)*.

The J1939 protocol also supports **multi-packet** broadcast messages. These messages use a fixed PGN value in the CAN identifier (PGN 59904, 60160 or 60416); the actual PGN is embedded in the CAN data field. CANgate will receive multi-packet broadcasts where the embedded PGN value matches *PGN*.

Note that there are some special considerations to be aware of regarding multi-packet transfers; see *Multi-Packet J1939 Messages* *(P30)*.

Examples

```
RECVJ 2 61444 1 8 256 3
```

Receive messages on CAN port 2 (from any ECU) which relate to PGN 61444 – which contains various engine controller parameters – and return the entire message to the host when polled. Only messages with priority 3 will be received.

RQSTJ – Request J1939 Data

{ slot } **RQSTJ** *CANport PGN { startByte{.bit} endByte{.bit} ECUaddr priority sampleRate } {* **FORMAT** *fmtOpt }*

The parameters for a **RQSTJ** slot are the same as for a RECVJ slot (except that **ALL** is not a valid setting for *sampleRate*), but they are used in a somewhat different way.

When a RQSTJ slot is polled, CANgate will send a message to request a particular parameter group (PGN). The format of this request message is defined in SAE J1939/21 (Data Link Layer). The request will be sent to destination address *ECUaddr*, or to the broadcast address if *ECUaddr* = **256**. The source address will be set to CANgate's configured address (see *SETADDR – Set CANgate Address* *(P25)*).

CANgate will then listen for a response with an appropriate CAN identifier, the same as a RECVJ slot.

Some PGNs have more than 8 bytes of data (which is the limit of a single CAN frame) associated with them. In this case the ECU will respond with a multi-packet transfer. This may take the form of a multi-packet broadcast, or it may be a point-to-point transfer using the J1939 transport protocol. CANgate will accept either type of response.

Note that there are some special considerations to be aware of regarding multi-packet transfers; see *Multi-Packet J1939 Messages* *(P30)*.

See also *Request PGNs* *(P29)*.

Note: As is the case with ISO-14230 (RQST slots), the response time will depend upon the particular ECU. J1939 requests are queued in the same way as ISO-14230 requests – CANgate will only send out one request at a time, and will time out after approximately 400ms if there is no response.

Examples

```
RQSTJ 2 65254 1 1 0 6 1000 FORMAT .25
```

Once per second (1000ms), send a request on CAN port 2 for PGN 65254 (time/date) to the ECU with address 0, and expect a reply with priority 6. The first byte of the response (seconds x 4) is extracted and returned.

GPS – Receive NMEA-0813 Messages

{ slot } **GPS** *"header" fieldNum { option sampleRate } {* **FORMAT** *formatOptions }*

where:

- *slot* is the memory slot being defined (integer, **0-150**). If not specified then **0** is assumed. If CANgate is in Run Mode then zero is the only value that can go here.
- *header* is the NMEA-0183 sentence header string, without the leading **$** character (string, eg.**"GPGLL"**)
- *fieldNum* specifies the data field of interest in the NMEA-0183 string (integer, **1-19**). The field immediately following the sentence header is field #1.
- *option* (single character: **D** or **M** or **N**, default:**N**). If **N** (normal) is specified then the indicated field is returned as is. Otherwise, the indicated field and the next field are interpreted as a latitude or longitude value with format *DDDMM.mmmmm,h* – *DDD* = degrees, *MM.mmmmm* = minutes, *h* = hemisphere (**N**, **S**, **E** or **W**). If *option* = **D** then the **degrees** component is returned, ie. *DDD*, which will be prefixed by a minus sign if *h* = **S** or **W**. Similarly, if *option* = **M** then the **minutes** component is returned, ie. *MM.mmmmm*, which will also be prefixed by a minus sign if *h* = **S** or **W**.
- *sampleRate* is the rate at which to return values to the host (integer, in ms, must be multiple of 100ms). May also be **ALL**, in which case a value is returned on receipt of every matching GPS message. If this parameter is **0** or not specified, the memory slot will only return data when it is polled by the host system (using the **RP** command).
- *formatOptions* specify how the data value is to be formatted when it is returned to the host system; see *FORMAT Sub-command* *(P21)* for more details. Note that GPS data is always treated as a string; scaling options will be ignored. The **FORMAT** clause is therefore only useful for adding before and after text.

If a GPS receiver is connected to CANgate then positional data (latitude, longitude, elevation, etc.) can be returned along with measured CAN parameters.

A GPS receiver will transmit position messages via its RS232 interface, typically about once per second. These messages are formatted according to the **NMEA-0183** protocol. NMEA-0183 defines many different **sentences**, each of which consists of an identification string followed by a number of comma separated data values. For example, the sentence:

```
$GPGLL,3749.1965,S,14458.9940,E,073510.22,A
```

provides a basic positional fix, containing the current latitude (37° 49.1965' S, 144° 58.9940' E), and the time the fix was taken (07:35:10.22 UTC). Other sentence types (eg. **$GPGGA**) provide more detailed information, including elevation, accuracy, number of satellites in view, etc.

A CANgate **GPS** memory slot is used to parse incoming NMEA-0183 data and then return specific fields to the host. This will capture all messages with the specified ID string, and extract the required data field. When polled (using the **RP** command), or at the intervals specified by the *sampleRate* parameter, the slot will return the most recent value for the data field. If no messages have been received, or if the specified field does not exist in the received messages, then nothing will be returned (other than the configured static formatting text, which is specified by the **FORMAT** sub-command and by default is just CRLF).

Examples

```
GPS "GPGLL" 1 D 5000
```

Receive NMEA-0183 "GPGLL" sentences. Every 5 seconds, return the current degrees component (`-37` for the above input data)

```
GPS "GPGSV" 3
```

When polled, return the number of satellites in view (the third field in a "GPGSV" sentence).

FORMAT Sub-command

As indicated above, all slot definition commands that return a data value may include a **FORMAT** clause to specify how the data value should be formatted – otherwise the data will be returned in raw hexadecimal form. The format of a **FORMAT** sub-command is as follows:

FORMAT *{ rawFormat } { scale offset } { "formatString" } { stats }*

where:

- *rawFormat* specifies how the raw bit field is to be interpreted. It consists of two letters, one being **U** or **S** (unsigned or 2's complement signed; default: **U**), the other **M** or **N** (Motorola (MSB first) or Intel (LSB first); default: **M**). Note that for J1939 memory slots (RECVJ, RQSTJ), Intel format is always used. The byte swapping options are ignored if the size of the data field is not a multiple of 8 bits.
- *scale* is a floating point scaling factor which will be multiplied by the raw bit field value (default: **1.0**).
- *offset* is a floating point offset which will be added to the scaled bit field value (default: **0.0**).
- *formatString* is a string which specifies: the output type (raw hexadecimal, integer, floating point, string, etc.), formatting options (eg. number of decimal places) and any leading or trailing text. Default is **"%f\n"** (output floating point value, 2 decimal places, followed by CRLF) See below for more details.
- *stats* is a statistical operation (**MIN**, **MAX** or **AVE**). If set, all matching CAN messages are received and processed. When the slot is polled, the calculated minimum, maximum or average value (since last poll) is returned. If not specified (which is the default), the most recent instantaneous data value is returned. **Note:** statistical operations are only valid for passive CAN slot types (RECV, RECVE, RECVJ)

Format String

A format string consists of three text elements:

- some text to display before the data value (default: none)
- a **conversion specifier**, which begins with a **%** character and specifies the data type (integer, floating point etc.) and possibly some other formatting details. If no conversion specifier is present (which is the default), the data value will be output in raw hexadecimal format, exactly as it appears in the CAN message (in this case the *rawFormat*, *scale*, *offset* and *stats* parameters will be ignored.)
- some text to display after the data value (default: **\n**). If no conversion specifier is present, all text in the format string will be returned after the data value.

The format of the conversion specifier is as follows (there are no gaps between the various elements):

% *{ flag } { width }{ .precision } type*

where:

- **%** marks the start of the conversion specifier
- *type* is a single character which specifies the data type: **f** (floating point), **d** (signed decimal integer), **u** (unsigned decimal integer), **x**/**X** (unsigned lower/upper case hexadecimal integer) or **s** (ASCII string)
- *flag* is a single character which alters the way the other elements work, as described in *width* below (default: none)
- *width* is an integer, the minimum number of characters to output. If the converted data value is longer than *width* then all characters will still be output. If the data value is shorter then it will be padded on the left with spaces (or zeroes, if *flag* = '**0**') so that a total of *width* characters are output. If *flag* = '**–**' then the data value will instead be padded on the right with spaces if it is shorter than *width*. The default value for *width* is 0, ie. no padding characters will be inserted.
- *precision* is an integer which specifies different things depending on the data type. For floating point, it is the number of digits displayed to the right of the decimal point (default: 2). For integers, it is the minimum number of displayed digits; if the data value has fewer digits it will be prefixed by zeroes (default: 0). For strings, it is the maximum number of characters to display, If the data string is longer then it will be truncated (default: no maximum).

Note that following points about format strings:

- An integer (**d**/**u**/**x**/**X**) or floating point (**f**) conversion specifier will be ignored if the data field is larger than 32 bits. In this case the value will be returned in raw hexadecimal format.
- Integer or floating point conversion specifiers are ignored for GPS slots. For a GPS slot, all data values are treated as strings.

- The floating point conversion only supports values in the range -16777216 to 16777216. Values outside this range will be returned as **99999.9**.
- If an integer conversion type is specified, the *scale* and *offset* parameters will be converted to integers.
- The format strings **"%X\n"** and **"\n"** do different things. The former will output the scaled data value as a hexadecimal number; the latter will output the raw data value as it appears in the CAN message (no byte reversal, scaling, etc.)
- To include a literal **%** or **** character, enter **%%** or **** respectively.

Defaults

To summarise the rules regarding default formatting behaviour:

- if **FORMAT** is present, with a *formatString*, and the format string contains a conversion specifier, then the data will be formatted according to the conversion specifier. (Numeric conversion specifiers will only work if the data size is 32 bits or less, if it is longer then the data will be returned in raw hexadecimal format.)
- if **FORMAT** is present, with a *formatString*, and the format string does not contain a conversion specifier, then the data will be returned in raw hexadecimal form (or ASCII string form for GPS slots), followed by the format string text.
- if **FORMAT** is present, without a *formatString*, then a default format string will be used: **"%f\n"** for CAN slots, or **"%s\n"** for GPS.
- if **FORMAT** is not present, then a default format string will be used: **"\n"** for CAN slots (ie. raw hexadecimal followed by CRLF), or **"%s\n"** for GPS.

Examples

The following examples assume that the last matching CAN message had the data: **01234567AABBCCDD**.

RECV 1 0x100 1 2 – returns **0123** CR LF.

RECV 1 0x100 1 2 FORMAT 100 – returns **29100.00** CR LF. (0123 hex, scaled by 100)

RECV 1 0x100 1 2 FORMAT ";" – returns **0123;**

RECV 1 0x100 1 2 FORMAT "%d %%\n" – returns **291 %** CR LF. (0123 hex)

RECV 1 0x100 1 2 FORMAT N "x=%d Pa\n" – returns **x=8961 Pa** CR LF. (2301 hex)

RECV 1 0x100 1 8 FORMAT "%d\n" – returns **01234567AABBCCDD** CR LF. (no conversion if > 32 bits)

RECV 1 0x100 1 2 FORMAT .5 10 "%9.3f\n" – returns **155.500** CR LF. (2 leading spaces)

RECV 1 0x100 1 2 FORMAT .5 10 "%09.3f\n" – returns **00155.500** CR LF. (2 leading zeroes)

RECV 1 0x100 1 2 FORMAT .5 10 "%-9.3f\n" – returns **155.500** CR LF. (2 trailing spaces)

RECV 1 0x100 1 2 FORMAT .5 10 "%f," – returns **155.50,**

RECV 1 0x100 4.8 4.6 FORMAT "Z\t%d" – returns **Z** TAB **3** (byte 4 = 67 hex, bits 8:6 = 011 binary = 3)

The following assume that the last received GPS string was: **$GPGLL,1244.98,S,11102.09,E**

GPS "GPGLL" 2 FORMAT ">%3s<" – returns **> S<**.

GPS "GPGLL" 3 M FORMAT ">%.4s<" – returns **>02.0<**. (truncate minutes (**02.09**) to 4 chars)

Other Commands

With the exception of **END**, all of the following commands are only valid in Run Mode.

BEGIN – Begin Program Entry

BEGIN

This command erases all memory slots and switches CANgate to **Program Mode**. In Program Mode, the only commands that are accepted are numbered slot definition commands. The CAN and GPS interfaces are disabled in Program Mode and no memory slots are processed.

END – Finish Program Entry

END

This command saves all defined memory slots to flash memory, then switches to **Run Mode**. Once in Run Mode, no more numbered memory slots can be defined. However, Slot 0 (which is not saved to flash) may be defined and re-defined any number of times by entering an unnumbered slot definition command.

RP – Poll Memory Slot

RP *{ slot1 slot2 }*

where:

- *slot1* is the first memory slot to poll (**0-150**, default:**0**)
- *slot2* is the last memory slot to poll (**0-150**, default:**0**)

This command will **poll** memory slots *slot1* to *slot2* inclusive. If no parameters are specified then Slot 0 is polled.

What does polling a slot mean?

- For a **passive** memory slot (RECV, RECVE, RECVJ or GPS), the most recent received value is formatted and returned to the host. Alternatively the minimum, maximum or average (calculated since the last poll) may be returned instead, if the **FORMAT** clause specifies to do so. If no data at all have been received then no value will be returned.
- For an **active** memory slot (SEND, SENDE, RQST, RQSTJ), CANgate will transmit the required CAN message. In the case of the request types, CANgate will then wait for a response and return the required data to the host.

If no response is received to a request, or if no data at all have been received at the time that a passive slot is polled, then no value will be returned. If there was text specified in the format string then that text it will still be returned.

If any slots in the specified range have not been defined then they will be skipped (nothing will be returned for the undefined slots).

Note: When passive slots are polled, the data is returned instantly, while for RQST/RQSTJ slots the data will only be returned when a response is received from the ECU. This means that if a mixture of "receive" and "request" slots are polled all at once then the order of responses may not match the order of the memory slots.

Examples

```
RP 1 150
```

Poll all defined memory slots.

```
RQSTJ 2 65226 3 6 FORMAT "%f\n"; RP
SEND 1 0x142 112233; RP
```

The **RP** command is often appended when defining an active memory slot in Slot 0. This usage is not applicable to passive slots because at the point where the **RP** command is executed it is unlikely that any data has been received since the slot was defined, so nothing will be returned.

CONNECT – Set CAN Bit Rate

CONNECT *CANport bitrate*

where:

- *CANport* is the CAN port to use (integer, **1-2**)
- *bitrate* is the CAN bitrate in kbps (integer, **0**, **10**, **20**, **50**, **125**, **250**, **500**, **1000**)

Before a CAN port can be used it is necessary to specify the bitrate using the **CONNECT** command.

Initially, the bitrate is set to **0**, which will disable the port. If the bitrate is set incorrectly, bus errors will result and the port will be disabled for a period of two seconds, after which CANgate will re-attempt connection.

The currently selected bitrate setting is saved to flash memory, so it will automatically be set if CANgate restarts following a power interruption.

Examples

```
CONNECT 2 250
```

Configure the CAN port 2 for connection to a 250kbps CAN network. (Note that J1939 based CAN networks always use a bitrate of 250kbps.)

VERBOSE – Enable Extended Messages

VERBOSE *state*

where

- *state* is either **ON** or **OFF**. Default is **OFF**.

In **Verbose** mode, CANgate will return error and confirmation messages as required. Also, all received commands will be echoed back to the host computer. This is useful for troubleshooting.

In **Normal** (non-verbose) mode, no unsolicited messages are returned to the host. Data values are returned, as is text that is generated in direct response to a command (eg **VERSION**). Commands are not echoed.

Verbose mode should normally be switched on when manually entering CANgate commands and slot definitions. Once you are confident that the slots are working as expected, Verbose mode can be turned off.

When CANgate is being controlled by a DT80/800 data logger, Verbose mode is normally switched off. This avoids any parsing complications which may occur due to unexpected messages returned by CANgate.

The current Verbose mode setting is saved to flash memory so it will be restored following a power interruption.

VERSION – Display Firmware Version

VERSION

This command will return the version number of the CANgate firmware, eg. **1.24**, followed by CRLF.

In Verbose mode, the product name is also included.

The **VERSION** command is a useful check that the host port communications are correctly configured and CANgate is responding, as it should always return some text in response to this command.

RESET – Clear Memory Slots

RESET

This command will clear all defined memory slots. It does not affect the currently configured CAN/GPS bit rates, or the current verbose mode setting.

SNOOP – Report CAN/GPS Activity

SNOOP *port { snoopTime }*

where

- *port* is either the CAN port number (**1** or **2**), or **GPS**.
- *snoopTime* is the time to spend listening (integer, in ms, must be multiple of 100ms). Default is **10000** (10 seconds).

This command may be used to determine which CAN identifiers are being broadcast on a CAN network. During the specified snoop time, all incoming CAN messages on the specified port are received. For each distinct CAN identifier that was received, the following information is displayed:

- identifier type: standard 11 bit (**STD**) or extended 29 bit (**EXT**)
- identifier value, in hexadecimal
- the 64-bit data value from the first received message with this identifier

If **GPS** is specified instead of a CAN port number, this command will display all NMEA strings that are received during the snoop period. This is useful for verifying that the GPS unit is sending the expected strings.

Examples

```
SNOOP 1
EXT  18FEF000 FFFFFF0000F0CCFF
EXT  18F0000F C07DFFFF0FFFFFFF
EXT  18EBFF00 0115FF5E0004016F
EXT  18ECFF0F 20130003FFE1FE00
EXT  18EBFF0F 010306602254A041
EXT  18FEEE00 17FF0020FFFFFFFF
END SNOOP
```

This shows that 6 different extended identifiers were captured on CAN port 1 during the default 10 second snoop time.

```
SNOOP GPS 5000
$GPGLL,5330.25,N,00215.31,W,134531,A
$GPGLL,5330.25,N,00215.31,W,134532,A
$GPGLL,5330.25,N,00215.32,W,134533,A
$GPGLL,5330.24,N,00215.32,W,134534,A
$GPGLL,5330.23,N,00215.32,W,134535,A
```

This shows the strings received from a GPS unit over a 5 second period.

SNOOPJ – Report J1939 Activity

SNOOPJ *port { snoopTime }*

This works in exactly the same way as **SNOOP**, except that the results are interpreted in terms of the J1939 protocol. That is, the PGN, priority, source address and destination address components of the CAN identifier are decoded.

This command also recognises J1939 multi-packet messages. For such messages the displayed PGN is extracted from the data field, not the identifier. (For multi-packet messages, the PGN encoded into the CAN identifier relates to the transport

protocol used to break up and reassemble long messages, not the actual data parameters.)

Examples

```
SNOOPJ 2
EXT   0CF00400 FE7D7D000000FFFF   PGN:61444 PRI:3 SA:0 DA:0
EXT   18FEF000 FFFFFF0000F0CCFF   PGN:65264 PRI:6 SA:0 DA:0
EXT   18F0000F C07DFFFF0FFFFFFF   PGN:61440 PRI:6 SA:15 DA:0
EXT   0CF00300 F9FE00FFFFFFFFFF   PGN:61443 PRI:3 SA:0 DA:0
EXT   18FEF100 FF000050000000C0   PGN:65265 PRI:6 SA:0 DA:0
EXT*  18ECFF00 202E0007FFCAFE00   PGN:65226 PRI:6 SA:0 DA:255 LEN:46
EXT   18FEFF00 FDFFFFFFFFFFFFFF   PGN:65279 PRI:6 SA:0 DA:0
EXT*  18ECFF00 20220005FFE3FE00   PGN:65251 PRI:6 SA:0 DA:255 LEN:34
EXT*  18ECFF0F 20130003FFE1FE00   PGN:65249 PRI:6 SA:15 DA:255 LEN:19
END SNOOP
```

In this example six different single-packet parameter group messages were observed. For each, the PGN, priority, source address and destination address are returned.

There are also three different multi-packet messages, indicated by **EXT***. These include an additional display item: the length of the data message in bytes. Note that the displayed 64-bit data field does not contain any actual message data; it contains transport protocol information including PGN and data length.

NETLOAD – Measure CAN Traffic Load

NETLOAD *{ CANport }*

where

- *CANport* is the CAN port to measure (integer, **1-2**). If not specified, both CAN ports are measured.

This command measures the traffic load on one or both CAN ports, and reports it as a percentage of the theoretical maximum for the bit rate in use. It should be noted that a network with a load approaching 80% is close to the practical maximum load possible on a CAN network.

Examples

```
NETLOAD
CAN1 0.0 %
CAN2 7.8 %
```

In this case nothing is connected to CAN1, and a single ECU is connected to CAN2. 7.8% of the available bus bandwidth is being consumed by the regular broadcasts from this ECU.

SETADDR – Set CANgate Address

SETADDR *CANport address*

where

- *CANport* is the CAN port (integer, **1-2**)
- *address* is the protocol address which CANgate should use when communicating on the specified CAN network (integer, **0-255**, default:**0**)

For some CAN protocols, each device on the network needs to have a unique address assigned. This command allows you to assign an address to the CANgate. Currently this will only have an effect for the J1939 protocol. Note that in most cases the default address (**0**) can be used.

GPSBAUD – Set GPS Port Baud Rate

GPSBAUD *baudRate*

where

- *baudRate* is the required baud rate to use on the GPS port (integer, **300-115200**, default:**4800**)

Most NMEA-0183 devices operate at 4800 baud, however some newer high speed devices operate at a faster rate. This command allows the GPS port baud rate to be set to match that of the connected device.

The current GPS port baud rate setting is saved to flash memory so it will be restored following a power interruption.

GPSSEND – Send Commands to GPS

GPSSEND "*text*"

where

- *text* is a text string to send to the GPS port. Escape sequences eg **\n**, **\009** will be translated into the appropriate control characters.

Some GPS devices can be configured – for example to switch certain NMEA-0183 strings on or off – by sending commands to them via their serial interface. The **GPSSEND** command allows you to send arbitrary command strings to the GPS. If the GPS requires that commands be terminated by a CRLF then include **\n** at the end of the string.

Examples

GPSSEND "$PGRMO,GPVTG,0\n"

This command will configure a Garmin GPS unit to not output the GPVTG sentence type.

STATUS – List Memory Slot Status

STATUS

This command returns a summary of all defined memory slots. The information returned includes:

- memory slot number (**0-150**)
- type of memory slot (**RECV**, **RQST**, etc.)
- port number (**CAN1** or **CAN2**)
- CAN identifier and 8-byte data field to use in transmitted message (SEND, SENDE, RQST, RQSTJ only)
- CAN identifier to look for in received message (RECV, RECVE, RECVJ, RQST, RQSTJ only)
- GPS header and field number to look for (GPS only)
- Start and end byte/bit number of field of interest (RECV, RECVE, RECVJ, RQST, RQSTJ only)
- Internal status information ("flags")
- sample period

This command can be useful for verifying that all required memory slots have been created successfully. Recall that in non-verbose mode no error messages will be issued if an invalid slot definition is entered.

Example

```
STATUS
****** CHANNEL TABLE ******
 0:  RQST (CAN1) - TxID:0x07df  TxData:041800ff 00000000  RxID:0x07df
RxBytes:2.8-end  Flags:c0820000  Sample:0 ms
 1:  RECV (CAN1) - RxID:0x0001  RxBytes:1.8-1.1  Flags:c0020000  Sample:0 ms
 2:  RECV (CAN1) - RxID:0x0002  RxBytes:1.8-1.1  Flags:c0020000  Sample:0 ms
 3:  RECV (CAN1) - RxID:0x0003  RxBytes:1.8-1.1  Flags:c0020000  Sample:0 ms
 6: RECVE (CAN1) - RxID:0x0006  RxBytes:1.8-1.1  Flags:c0220000  Sample:0 ms
 7: RECVE (CAN1) - RxID:0x0007  RxBytes:1.8-1.1  Flags:c0220000  Sample:0 ms
**************************
```

STATS – Display Communications Statistics

STATS {**CLEAR**}

This diagnostic command displays communications statistics for each port (host, GPS, CAN1, CAN2). These include:

- volume of traffic sent (**Tx**) and received (**Rx**), measured in bytes for the serial ports, and in frames for the CAN ports
- number of transmit bytes/frames that could not be sent (**Dropped Tx**). This may occur if the slot sample rates are set too fast, so that the volume of traffic required to be sent exceeds the available bandwidth on the port.
- number of bytes/frames that could not be received and/or processed (**Dropped Rx**). This may occur if the slot sample rates are set such that CANgate cannot keep up with the rate of incoming messages.
- number of bytes/frames which were discarded due to errors. These may be due to electrical noise or incorrect bit rate settings. Note that for CAN ports, "arbitration lost" (**ArbLost**) errors are a normal part of operation and simply indicate that a CANgate transmission was delayed by a higher-priority message.
- number of CANgate system errors, including RQST/RQSTJ queue overflows and processing overflows (occasions when the configured slot sample rates could not be met due to excessive processing load)
- an indication as to whether an exception (serious CANgate error that required a firmware restart) has occurred.

If the **CLEAR** parameter is specified then all statistics values are reset.

Example

```
STATS
HOST: Tx:218408 Rx:1255 bytes   Dropped Tx:0 Rx:0   Errors:0
GPS:  Tx:0 Rx:0 bytes   Dropped Tx:0 Rx:0   Errors:0
CAN1: Tx:44 Rx:272042 frames   Dropped Tx:0 Rx:9
      Errors Warning:0 Bus:0 ArbLost:5
CAN2: Tx:0 Rx:273096 frames   Dropped Tx:0 Rx:220
      Errors Warning:0 Bus:0 ArbLost:0
Sys:  RQST dropped:0   Proc ovfl:0   Except: 0/0
```

DIAG – Set Diagnostic Mode

DIAG *mode*

This command enables certain diagnostic functions. Each bit of the *mode* parameter enables a particular function, as follows:

- if bit 0 = 1 then all CAN messages sent by CANgate will be displayed, eg:
  CAN2 TX> 18EC00FF 132C0007 FFEBFE00
  which shows that a message has been sent on CAN2 with identifier 0x18EC00FF and the indicated data value.
- if bit 1 = 1 then all CAN messages received by CANgate will be displayed, eg:
  CAN2 RX< 18EBFF00 07A50403 12FFFFFF
  Note that only those messages which match the current filter criteria (as specified by the defined memory slots) will be received and displayed. So if there are no memory slots defined then nothing will be displayed.

To switch on display of both transmitted and received messages you would therefore use:

```
DIAG 3
```

and to switch off all diagnostic displays use:

```
DIAG 0
```

This command can be useful when troubleshooting ISO-14230 and J1939 multi-packet request sequences.

Notes and Examples

Extracting and Formatting Bit Fields

In the following example two 16-bit fields plus four 4-bit fields are packed into the CAN message with identifier 0x118. The most recent value for each of these fields will be returned when polled by the host.

```
CONNECT 1 500   'Enable CAN port 1 at 500kbps
BEGIN
12 RECV 1 0x118 1 2 FORMAT "P1:%d\n"
13 RECV 1 0x118 3 4
14 RECV 1 0x118 5.8 5.5
15 RECV 1 0x118 5.4 5.1 FORMAT 10 -40
16 RECV 1 0x118 6.8 6.5 FORMAT .25 "Gibble Freq. %6.3f Hz\n"
17 RECV 1 0x118 6.4 6.1
END
```

So if the last message that CANgate received (with CAN ID 0x118) happened to have the following 64-bit data field:

```
019266401A9F0000
```

and the above six memory slots were polled, for example using the command:

```
RP 12 17
```

then the following data would be returned:

`P1:402`	(bytes 1-2 = 0x0192 = 402)
`6640`	(bytes 3-4 = 0x6640)
`01`	(byte 5 = 0x1A, bits 8-5 = 0x1)
`60.00`	(byte 5 = 0x1A, bits 4-1 = 0xA, scaled by 10 with offset -40 = 60)
`Gibble Freq.  2.250 Hz`	(byte 6 = 0x9F, bits 8-5 = 0x9, scaled by 0.25 = 2.25)
`0F`	(byte 6 = 0x9F, bits 4-1 = 0xF)

In this case three of the memory slots use the `FORMAT` specifier to return their values in scaled engineering units, rather than raw hexadecimal. Slot #15 uses the default format string of `"%f\n"`, ie. floating point, 2 decimal places, followed by CRLF.

J1939 PGNs & SPNs

Broadcast PGNs

J1939 based systems typically have a multitude of SPNs (Suspect Parameter Numbers), each representing an individual measured quantity or status. A group of related SPNs will be broadcast over the CAN network under a particular Parameter Group Number (PGN), which is specified as part of the 29 bit identifier.

Each 29 bit identifier carries with it one 64 bit packet of CAN data. Some PGNs with a data length larger the 64 bits require several packets to send them. CANgate automatically uses the J1939 transport protocol to send or receive large PGNs. Refer to *RQSTJ – Request J1939 Data* *(P20)* or the SAE J1939/21 (Data Link Layer) standard for a more detailed description on PGN numbers and how they are encoded into CAN identifiers.

An example of a J1939 SPN would be “Engine Speed”. In order to capture engine speed using CANgate, it is first necessary to determine the PGN which contains this parameter. This can be found in SAE J1939/71 (Vehicle Application Layer), which specifies:

Electronic Engine Controller #1
Update rate: *Engine speed dependent*
Data length: *8 bytes*
Data page: *0*
PDU format: *240*
PDU specific: *4*
Default priority ***3***
Parameter Group Number: ***61,444*** *(0x00F004)*
Byte: 1 *Status_EEC1*
Bit: 8-5 *Not defined*
Bit: 4-1 *Engine/retarder torque mode*
Byte: 2 *Driver’s demand engine – percent torque*
Byte: 3 *Actual engine – percent torque*
Byte: 4-5 ***Engine Speed***
Byte: 6-8 *Not defined*

The precise format of each SPN is also specified in SAE J1939/71:

Engine Speed
Data Length: *2 bytes*
Resolution: ***0.125 rpm/bit gain, 0 rpm offset***

Data Range: 0 to 8031.875 rpm
Type: Measured
Suspect Parameter Number:190

The **SNOOPJ** command can now be used to verify that the PGN is in fact being broadcast by an ECU on the CAN network. This involves examining the returned data looking for the required PGN (61444). For example:

```
SNOOPJ 1
…
EXT  0CF00402 PGN:61444 PRI:3 SA:2 DA:0
…
```

This line indicates that the required PGN is being broadcast on the network, and decodes the CAN identifier (0CF00402) as follows:

- *priority* field is 3
- *PGN* field is 61444 (0x00F004)
- *destAddr* field is not applicable because this PGN uses PDU2 format (bits 15-8 of PGN >= 0xF0)
- *srcAddr* (ie. the address of the sending ECU) is 2.

Using this information, a memory slot can be initialised, for example:

```
RECVJ 1 61444 4 5 2 3 FORMAT 0.125 "%.3f rpm\n"
```

which will:

- receive J1939 messages
- on CAN port **1**
- with identifier 0x0CF00402 (PGN **61444**, source address **2**, priority **3**)
- and extract bytes **4**-**5** as an unsigned 16-bit value (byte 4 = LSB, byte 5 = MSB)
- then multiply by **0.125**
- and, when polled, return the result as a floating point value with 3 decimal places (**%.3f**)
- followed by the text " **rpm**" and a CRLF (**\n**).

Note that for J1939, multi-byte fields are always specified LSB first (Intel format). It is not necessary to specify the **n** option after the **FORMAT** for RECVJ/RQSTJ slots.

Request PGNs

Some PGNs are not broadcast; they are only returned when specifically requested. For example, if the above PGN was actually a "request-only" PGN, the engine speed would then be obtained using:

```
RQSTJ 1 61444 4 5 2 3 FORMAT .125 "%.3f rpm\n"; RP
```

which looks very similar to the RECVJ slot definition. The **RP** on the end causes the memory slot to be immediately polled, which will cause the request to be immediately sent. (Note that it doesn't make sense to poll a RECVJ slot immediately after defining it, because at that time it is likely that no matching messages will have been received, in which case nothing will be returned.)

Reusing Request Data

Often a J1939 PGN will contain several separate parameters (which is why it is called a Parameter Group Number). These parameters are typically extracted using a number of memory slots, all with the same PGN but with different start and end bytes specified. The same is true for certain OBD PIDs.

For requested PGNs, it is inefficient for each slot to send a separate request, particularly for multi-packet PGNs. Also, you may not get a consistent snapshot of all of a PGN's constituent parameters – that is, they may not have been measured at the same time (which may or may not be a problem).

For this reason, CANgate will attempt to reuse requested data where possible, ie. a RQST/RQSTJ slot will use previously received reply data rather than sending a new request. This will, however, only be done if:

- the most recently sent request message exactly matches this slot's request message (ie. it's a request for the same PGN, same source and destination address and so on), and
- this is a different slot to the one which sent the request (or, if this and the requesting slot are both slot #0, then the two slot definitions are different in some way, eg. they are extracting a different range of bytes), and
- the reply data was received less than 5 seconds ago.

The second condition means that if you repeatedly poll a group of slots, each of which extracts a different part of the same PGN, then only one request will be sent each time the group is polled – provided that the group is polled within 5 seconds.

Example

J1939 PGN 65254 may be used to request the current time setting from an ECU. This PGN contains separate fields for hours, minutes and seconds. It is important that this PGN be queried using a single request, otherwise the time may roll over to the next minute/hour between requests, leading to an incorrect reading.

The following group of slot definitions will, when polled (using **RP 1 3**), return the current time in hh:mm:ss format.

```
BEGIN
1 RQSTJ 1 65254 3 3 FORMAT "%02d:"      ' hours
2 RQSTJ 1 65254 2 2 FORMAT "%02d:"      ' minutes
3 RQSTJ 1 65254 1 1 FORMAT .25 "%0.f\n" ' seconds
END
```

Sending the following slot #0 definitions in quick succession would have the same effect:

```
RQSTJ 1 65254 3 3 FORMAT "%02d:"; RP
RQSTJ 1 65254 2 2 FORMAT "%02d:"; RP
RQSTJ 1 65254 1 1 FORMAT .25 "%0.f\n"; RP
```

Multi-Packet J1939 Messages

An ECU on a J1939 network may periodically broadcast **multi-packet** messages for one or more PGNs. These messages are used when the PGN contains more than 8 bytes of data. A message consists of a header CAN frame (containing the PGN number and message length), followed by one or more CAN frames, each containing up to 7 bytes of data.

It is possible for two or more broadcast messages to overlap, in which case some or all of their constituent CAN frames will be interleaved. CANgate can track a certain number of simultaneous multi-packet messages. Be aware of the following limitations:

- Only one RECVJ slot can reference a data field of size greater than 8 bytes.
- Multiple RECVJ slots can reference data fields up to 8 bytes in size within a multi-packet message.
- If there are RECVJ slots which reference data fields (up to 8 bytes) from three or more different multi-packet PGNs then this will work provided that the ECU does not transmit more than two of these PGNs at the same time.

There are no restrictions for RQST/RQSTJ slots, because only one request can be active at any one time.

Terminal Control

The following example is intended to be used with an ANSI/VT100 terminal or emulator. Two data values are extracted from received CAN messages with ID 0x212, and one from ID 0x444 messages. These values are displayed at particular row/column positions on the terminal (using the ANSI ESC**[***row***;***col***H** sequence), and are then updated once per second.

```
CONNECT 2 250
BEGIN
1 RECV 2 0x212 1 3 1000 FORMAT "\027[1;10HEngine Speed: %6f rpm"
2 RECV 2 0x212 4 5 1000 FORMAT "\027[2;10H        Temp: %6.1f degC"
3 RECV 2 0x444 1 3 1000 FORMAT "\027[3;10H        Gear: %3d"
END
```

This should display the data on the terminal as follows:

```
            Engine speed:   2310 rpm
                    Temp:   39.2 degC
                    Gear:   4
```

KWP2000/OBD-II/ISO-14230 Requests

Keyword Protocol 2000 (KWP2000) is a widely used poll-response protocol that allows diagnostic equipment to query and control ECUs on an automotive network.

As discussed in *RQST – Request OBD Data* *(P17)*, the basic structure of KWP2000 is defined in ISO 14230-3. This standard defines various request messages, each of which consists of a single byte **service identifier**, or **mode byte**, usually followed by a number of parameters. Reply messages also begin with a mode byte which is derived from the mode byte of the request.

KWP2000 modes 0x00-0x0F are reserved for standardised **legislated OBD** (on board diagnostics) functions, and are defined in SAE J1979 / ISO-15031. Modes 0x10-0x3F are functionally defined by ISO-14230-3, but the details of parameters and response data format tend to be manufacturer specific.

Each ECU parameter that can be requested or set is identified by a **PID** (parameter identifier) code. For the legislated OBD functions, the PID codes are standardised; for the ISO-14230-3 functions the PID definitions are manufacturer specific.

Example

In this example, the engine speed is requested. From ISO-15031 (or the Appendix, *OBD-II Modes and PIDs* *(P40)*, we know that the Engine RPM is PID 0x0C, and the returned value has a resolution of 0.25 rpm and an offset of 0. KWP2000 mode 0x01 indicates a request for the current value of a PID. The complete request message therefore contains two bytes: the

mode byte and the PID.

```
RQST 1 010C FORMAT .25; RP
```

In this case *ECUaddr* is not specified, so the message will be broadcast using CAN ID 0x7DF. The reply will be expected to have a CAN identifier in the range 0x7E8-0x7EF. In this case 4 bytes will be returned: mode byte, PID and a 16-bit data value (MSB first). CANgate knows the format of a mode 0x01 request, and will discard the first two bytes of the response and return all remaining bytes as the data value. (This behaviour can be overridden if *startByte* and *endByte* parameters are specified.) The data value will then by multiplied by 0.25 and returned in the default format (floating point, 2 decimal places, CRLF).

The above is equivalent to the following, which specifies every parameter explicitly:

```
RQST 1 010C 3 0 256 0 FORMAT UM .25 0 "%f\n"; RP
```

That is:

- CAN port 1
- 2-byte request message: 0x01, 0x0C
- data field of interest starts at byte 3 and continues to the end of the reply message (0)
- broadcast request to all ECUs (*ECUaddr* = 256)
- *sampleRate* = 0, ie. only when polled
- raw data format is unsigned, Motorola byte order (MSB first)
- scaling factor is 0.25, offset Is 0
- output format is floating point, 2 decimal places, then CRLF.

Reading Fault Codes

OBD-II

For an OBD-II compliant vehicle, stored fault codes can be read out using a Mode 03 request, as noted in the Appendix, *OBD-II Modes and PIDs* *(P40)*.

It is useful to first determine how many fault codes are stored, which can be done by sending a Mode 01 query for PID 01, eg:

```
RQST 1 0101; RP
81066060
```

The most significant 8 bits (**81**) of the 32-bit result contains the most pertinent information. In this case b31 is set, which indicates that the Malfunction Indicator Light (MIL) is currently on, and the next 7 bits indicate the number of fault codes, which in this case is 1.

The request for the actual codes can now be sent:

```
RQST 1 03; RP
013300000000
```

Fault codes are returned in 6-byte packets, each of which contains three 16-bit fault codes. In this case, there is only one fault code, **0133** so the remainder of the packet is padded with zeroes.

Referring again to the Appendix, this number 0133 decodes as fault code P0133. If you then look up this code in a list of OBD-II DTCs you find that it means "Oxygen Sensor Circuit Slow Response (Bank 1 Sensor 1)"

J1939

A J1939 ECU will normally periodically broadcast any active fault codes using a DM1 message (PGN 65226). These messages can be received using:

```
RECVJ 1 65226
```

The returned data consists of a 2-byte lamp status indicator, then one or more 4-byte fault code packets. Each packet consists of:

- the Suspect Parameter Number, which specifies what has failed
- the Failure Mode Indicator, which specifies what is wrong with the indicated parameter (eg. over voltage)
- the occurrence count, which is the number of times the fault has occurred

For more details, see SAE J1939/71

For example, the following slot definitions will return all data in hex format, then decode the MIL status plus the first two fault code packets:

```
BEGIN
1 RECVJ 1 65226
2 RECVJ 1 65226 1.8 1.7 FORMAT "MIL: %x\n"
3 RECVJ 1 65226 3 4 FORMAT 8 "SPN: %d  "
4 RECVJ 1 65226 5.8 5.6 FORMAT "FMI: %x  "
5 RECVJ 1 65226 6.7 6.1 FORMAT "Count: %x\n"
6 RECVJ 1 65226 7 8 FORMAT 8 "SPN: %d "
```

```
7 RECVJ 1 65226 9.8 9.6 FORMAT "FMI: %x "
8 RECVJ 1 65226 10.7 10.1 FORMAT "Count: %x\n"
END
```

When polled using **RP 1 8** this might return:

```
15FF 5E000401 6F000201 5B000401 61000301 6C000401
(lamp)(DTC 1)     (DTC 2)     (DTC 3)     (DTC 4)     (DTC 5)
MIL: 0
SPN: 752  FMI: 4   Count: 1
SPN: 888  FMI: 2   Count: 1
```

In this case five fault codes are active (spaces have been manually inserted in the hex data for clarity).

If CANgate is connected to a data logger then you would typically dispense with the decoding and just return the hex data, eg:

```
BEGIN
1 RQSTJ 1 65230 1 1   ' number of fault codes
2 RECVJ 1 65226       ' fault code data
END
```

The DT80 would then be programmed to regularly poll the slots using **RP 1 2**, then parse the returned hex string and log individual fault codes.

Using CANgate with a DT8x Data Logger

CANgate can be readily interfaced to a *DT80* series data logger. The supplied host port RS232 cable plugs directly into the *DT80's* **serial sensor** port.

The *DT80's* **1SERIAL** channel type can then be used to send commands to the CANgate host port and interpret the responses. Refer to the *DT80 User's Manual* for more information on programming the logger.

The logger program will generally consist of:

- a number of immediate schedule **1SERIAL** commands (channel definitions). These are executed once only and serve to configure CANgate's operating parameters and define the required memory slots.
- a number of **1SERIAL** commands within one or more logger schedules – typically one **1SERIAL** command per parameter of interest. These commands will normally send a poll command (**RP** *memslot*) then parse the response and either log it directly or assign it to a channel variable (CV). As well as polling the pre-defined memory slots, these commands may also set up a Slot 0 request then poll it and interpret the response.

A typical program structure would be:

```
BEGIN"CANNY"
' ***** Immediate Schedule (execute once only) *****
' Initialise DT80 port that CANgate is connected to
PS=RS232,57600,8,N,1,HWFC
' Initialise CANgate settings
1SERIAL("{VERBOSE OFF^M}",W)
1SERIAL("{CONNECT 1 250^M}",W)
1SERIAL("{GPSBAUD 9600^M}",W)
' define CANgate memory slots
1SERIAL("{BEGIN^M}",W)
1SERIAL("{1 RECVJ 1 61444 4 5 256 3 FORMAT .125^M}",W)
1SERIAL("{2 GPS \034GPGLL\034 1 D^M}",W)
1SERIAL("{END^M}",W)

' ***** "A" Schedule (execute once per second) *******
RA1S
1SERIAL("\e{RP 1^M}%f","EngSpd~RPM")
1SERIAL("\e{RP 2^M}%f","Lat-Deg~Degrees")
1SERIAL("\e{RQSTJ 1 65256 3 4 FORMAT 0.00390625; RP^M}%f","NavSpd~km/h")
LOGON
END
```

Escaping Control Characters

A frequent source of confusion when using *DeTransfer* (dataTaker terminal software), the DT80 serial sensor control language, and CANgate, is the process of "escaping" control characters. Each of these pieces of software parses input text strings and performs certain actions when particular characters are seen. For example, CANgate uses the backslash character to introduce special character sequences, eg **\n** is used to indicate that a CR, LF character sequence should be inserted into a format string, or **\003** for an ETX character.

The flip-side of this capability is that if you don't want special characters such as **** to be interpreted then they need to be "escaped". So if you actually want to output a **** followed by a **n** then the backslash would be **escaped** by entering it twice, ie. **\\n**.

Example

Suppose you are using DeTransfer to enter a DT80 logger program which requests a parameter from CANgate, and you want CANgate to return the parameter in the following format:

```
A\B 15.9 %
```
CRLF

The CANgate command to do this might be:

```
RQST 1 0199 FORMAT "A\\B %f %%\n";RP
```
CR

which is what you would type if you were directly connected to CANgate using a simple terminal program such as *HyperTerminal*. Note that where literal **** and **%** characters are required, they have been escaped so that they are not interpreted by CANgate.

To send the above command from the DT80 serial sensor port, the command would be:

```
1SERIAL("{RQST 1 0199 FORMAT \034A\\\\B %%f %%%%\\n\034;RP^M}")
```

Note that the DT80 firmware also treats **** and **%** characters as special. Consequently in order to output the required three backslash and three percent characters to CANgate, it is necessary to escape each of them, as shown. The **"** character is also special, so it too must be escaped. In this case the **\034** sequence is used to force the output of an ASCII 34 (**"**) character. (Later DT80 firmware versions also allow a double quote to be escaped using **\"**.)

But DeTransfer also interprets backslash sequences. So in order to send the above string to the logger, you would need to enter the following into the DeTransfer Send window:

```
1SERIAL("{RQST 1 0199 FORMAT \\034A\\\\\\\\B %%f %%%%\\\\n\\034;RP^M}")
```

Serial Sensor Direct Mode

When CANgate is connected to a DT80 series data logger, you may sometimes need to interact with the CANgate directly – for example to send a **SNOOP** command. To facilitate this, the DT80 series data logger incorporates a **serial sensor direct mode** (DT80 firmware version 6.08 or later).

To enter this mode, enter the following logger command:

```
SSDIRECT
```

A confirmation message should be displayed. Everything you send to the logger connection from now on will be ignored by the logger and will instead be forwarded to the serial sensor port, ie. to CANgate. Furthermore, all normal text output from the logger (eg. real time data returns) will be discarded and instead any output from CANgate will be returned.

To return the logger to normal operation, send the command:

```
ENDSSDIRECT
```

and the logger should return a message indicating that serial sensor direct mode has been cancelled.

Using CANgate with *DeLogger*

The dataTaker *DeLogger* software (Version 3 Release 5 and later) provides a way of easily configuring CANgate when it is used in conjunction with a DT80 series data logger.

DeLogger allows you to select parameters of interest from a database. It will then generate a logger program similar to that described in the previous section. The generated program will set up CANgate, then poll it at the specified rate (in conjunction with any other analog or digital measurements that may be required) and log the results.

DeLogger is supplied with pre-defined databases containing parameter definitions for J1939, OBD-II and NMEA-0183. These databases are in standard XML (Extensible Markup Language) format, and are readily expandable to cover other protocols or manufacturer-specific parameters.

For more details on using DeLogger with CANgate and a DT80, refer to the "*CANgate* and *DT80* ➡Start Here" guide and the DeLogger on-line help.

Troubleshooting

This section gives a few tips which may assist in resolving problems that may occur when using CANgate.

CANgate does not respond to commands from host computer

- Check that CANgate is powered (**Power** LED is on)
- Check that the supplied null modem cable is securely connected between CANgate and an RS232 port on the host computer.
- Check that the serial parameters for the DeTransfer (or other terminal program) connection match those set on the CANgate DIP switches (by default **57600 baud**, 8 data bits, no parity, 1 stop bit, **hardware** flow control)
- Confirm that you have selected the correct COM port (especially if you are using a USB to serial converter)
- When CANgate is in non-verbose mode (which is the default), many commands do not return anything to the host. The **VERSION** command should always return something, however.

- Watch the **RS232 Rx** and **RS232 Tx** LEDs when you send the **VERSION** command. They should both flash briefly to indicate reception of the command and transmission of the response.
- If you are using a USB to RS232 converter, check whether its Tx and Rx LEDs flash. If the converter's TX LED doesn't flash then either you are talking to the wrong COM port, or CANgate has signalled the host to stop sending. Double check the flow control settings on both devices, and try closing then reopening the connection in DeTransfer.

CAN Bus Errors are reported

- Check that the bit rate you have set using the **CONNECT** command matches the bit rate in use on the CAN network.
- Check that the polarity of the network connection is correct (CAN-HI signal connected to CAN1-Hi or CAN2-Hi on CANgate).
- Check that the CAN network is correctly terminated. This may require the addition of a terminating resistor, see *CAN Bus Type and Termination* *(P9)*
- Check that the CAN network you are connecting to is actually a **high speed** (ISO 11898-2) CAN network.
- If CANgate is configured to send CAN frames, verify that there is at least one other CAN device connected and operating at the correct bit rate. A bus error will result if a transmitted CAN frame is not properly acknowledged by the receiving device.

Errors occur when sending a large program to CANgate

- Check flow control settings on CANgate and host computer or data logger. Note that DT80 series data loggers with firmware version less than 6.08 do not support flow control on the serial sensor port. It is recommended that the logger firmware be upgraded to the latest available release.

Every command seems to generate an error message

- This may occur if you fail to send the **END** command following an earlier **BEGIN**. All commands other than numbered slot definition commands are invalid when inside a BEGIN-END block. Send an **END** command to restore proper operation.

SNOOP returns no data

- Verify that the ECU is correctly wired to the CAN port you specified in the **SNOOP** command
- Ensure that the bit rate has been set for the CAN port in use, using the **CONNECT** command
- Verify that the ECU is powered correctly. If you are talking to a single ECU on the bench then it may require one or more connector pins to be linked to indicate to it that the ignition switch is on.
- Check the LED for the CAN port. It should flash while the snoop is active as messages are received. (If the other CAN port is connected to an active bus then its LED may also flash during the snoop.)
- If the CAN LED gives a brief flash at two second intervals then this may indicate that bus errors are occurring, causing CANgate to disconnect from the bus then retry every 2 seconds. Switch on Verbose mode to see whether bus error messages are being returned. If so, refer to the Bus Errors section above.

Broadcast CAN data are not returned

In other words you have defined a RECV, RECVE or RECVJ memory slot but nothing is returned when it is polled

- Use the **STATUS** command to verify that the slot definition has been accepted by CANgate. Remember that in non-verbose mode no error messages are issued. If some slots don't appear in the status display or don't look right, switch on Verbose mode and send the slot definition(s) again to see if any error messages are reported.
- Double check all of the memory slot definition parameters, especially ECU address and priority (for RECVJ). Note that a given ECU will generally only implement a subset of the possible set of PGNs/PIDs.
- Is the specified CAN ID or PGN being broadcast by the ECU? Use the **SNOOP** or **SNOOPJ** command to verify this. If the ID/PGN doesn't appear in the snoop list then it's not being broadcast. Note that for infrequently broadcast parameters you may need to extend the snoop time (eg. **SNOOP 1 60000** to have CANgate listen for messages for 60 seconds)
- It is possible that at the time the slot was polled, no data had yet been received. Note that the **RP** command should not be appended to the end of a RECV/RECVE/RECVJ slot definition, because at that time it is almost certain that no messages will have been received in the time since the definition command was processed.
- Check the CAN LED. Once the memory slot has been set up, the LED should flash when matching messages are received. Note that if any J1939 slots are defined, the LED will flash on receipt of any multi-packet message. (Non matching multi-packet messages will be discarded by the CANgate firmware.)
- Only one memory slot can reliably receive a data field longer than 8 bytes from a multi-packet J1939 broadcast. If you define two or more slots which return more than 8 bytes of data then they may sometimes return no data, depending on the timing of the broadcast messages. If you need to receive data from multiple multi-packet PGNs then multiple slots should be used, each configured to return no more than 8 bytes.
- When receiving multi-packet messages using RECVJ, check that the specified start/end byte positions don't extend past the actual size of the message – if they do then no data will be returned. The value 0 can be used as the endByte parameter (in fact it is the default), which means the last byte received for a particular message.

Requested CAN data are not returned

- Use the **STATUS** command to check the status of the slot, and double check the slot definition parameters, as described above.
- Have you actually polled the slot? A common mistake is to simply enter a **RQST** command, which by itself will do nothing (unless the sample rate parameter is specified). Normally an **RP** command is required, which (for slot 0 definitions) can be appended to the end of the request command eg.
  RQSTJ 2 61444; RP
- Try switching on the diagnostic message display using **DIAG 3**, then poll the request slot. You should see a **CAN**x **TX>** message. Check whether there is any reply shown from the ECU – it is possible that the ECU does not implement this request.
- For J1939, it may be necessary to set the CANgate's network address (default is 0) to a value that is unique on the network. Use the **SETADDR** command for this. Note that CANgate does not implement the network address management protocol described in SAE J1939/81.

GPS data are not returned

- Use the **STATUS** command to check the status of the slot, and double check the slot definition parameters, as described above.
- Ensure that the GPS port baud rate (set using the **GPSBAUD** command) matches that of the GPS unit.
- Use **SNOOP GPS** to check the NMEA-0183 strings being sent by the GPS. If you don't see the string you want then you may need to send a command to the GPS (using **GPSSEND**) to enable it. Verify that the required data item within the string is present in the field number specified in the slot definition.

Data Logger reports timeouts or scan errors

In this case CANgate is connected to the serial sensor port on a DT80 series data logger.

- Check that the logger's serial sensor baud rate has been set to match that of CANgate, eg. **PS=57600**
- Check flow control settings – by default, CANgate uses hardware flow control, so the logger serial sensor port should also be set to hardware flow control, using **PS=HWFC**. If CANgate has been configured to use software flow control then the logger must be set likewise (**PS=SWFC**), otherwise the XON and XOFF characters may appear in the received data stream, which will probably disrupt the parsing of the returned data.
- With the logger in pass-through mode, verify that CANgate is configured for normal operation with no extraneous output (ie. **VERBOSE OFF;DIAG 0**).
- With the logger in pass-through mode, verify slot definitions using **STATUS**. Manually send some of the commands that the logger is sending in its **1SERIAL** channel definitions and check that CANgate is returning data. Check that the format of the data matches that expected by the input conversion in the serial sensor control string (eg. if CANgate is returning a floating point value then the serial sensor string should be set up to read a floating point value (**%f**) and not, for example, an integer (**%d**))
- Alternatively, enable diagnostic mode on the logger (**P56=1**), which will display data received on the serial sensor port in conjunction with the input conversions which are endeavouring to parse it. By examining these, it should be possible to determine why the input conversions are not working.

CANgate repeatedly resets

If CANgate detects a serious firmware problem then it will trigger a hardware reset. If this does not clear the problem then repeated resets may occur. If this is the case then to regain control it may be necessary to set the internal DIP switches to the Factory Defaults setting (see *Configuration* *(P11)*), and cycle the power.

Error Messages

If **Verbose mode** is selected, CANgate will return a descriptive message in the event that a problem is detected with any received command or operational situation. If verbose mode is switched off, no unsolicited messages will be returned; erroneous commands will be silently ignored.

Syntax Errors

If there is a problem with a command or parameter, a message is returned indicating where the error occurred. For example:

Error: [SWOOPJ<err> 2 5000]

In this case the problem is clear: a misspelt command; note that the **<err>** tag immediately follows the problematic command or parameter.

Error: [3 RECVJ<err> 2 61444]

Here the command name is OK but it is not valid in this context (eg. a slot number has been specified but CANgate is not in Program Mode, ie. **BEGIN** has not been seen.)

Error: [SNOOPJ <err>]

In this case the **<err>** tag is not attached to any particular parameter – so the problem here is a missing parameter (*CANport*).

Overload Errors

If CANgate is heavily loaded (many slot definitions, rapid slot poll rate, fast host/CAN baud rates), errors such as:

```
CAN1 RX OVERFLOW
```

may be issued, indicating that one or more incoming CAN messages have been dropped. Even though these events are not reported in non-verbose mode, they are still counted, and the event counts may be displayed using the **STATS** command *(P26)*.

In a similar vein,

```
PROC TIME OVERFLOW
```

indicates that CANgate may not have satisfied the requested slot sample rate. This error may sometimes occur if a diagnostic command is entered that produces a large volume of output text (eg **STATUS**).

Comms Errors

If a large number of communications errors occur on a CAN port, the port will be briefly shut down and the following message returned (if in verbose mode):

```
CAN1 BUS ERROR – DISCONNECTED
```

The most common cause for this is an incorrectly configured bit rate, although it may also be caused by noise or an intermittent electrical connection. After two seconds CANgate will re-enable the port and attempt communication again.

All comms errors on the CAN, host and GPS ports are counted and counts may be displayed using the **STATS** command *(P26)*.

Certain ECU responses will also be indicated via an error message (if in Verbose mode), eg.

```
ISO14230 NEGATIVE REPLY – 11
```

which in this case indicates that the requested service is not available.

Internal Errors

If the CANgate firmware detects a serious internal inconsistency it will force a hardware reset and display a message such as:

```
DATA ABORT EXCEPTION AT 000049F8
```

or

```
INTERNAL ERROR 1 (00000008)
```

Following the reset, CANgate will attempt to resume normal operation.

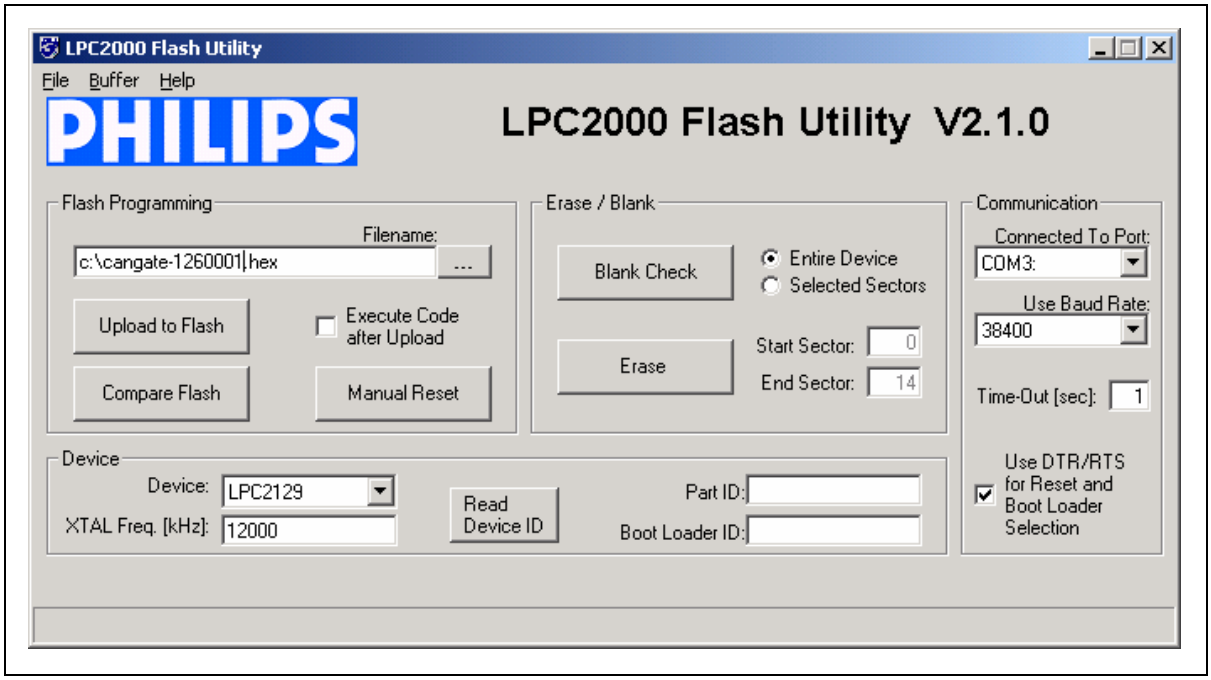
If one of these errors ever occur, please note the circumstances of the failure and contact dataTaker support.

Upgrading CANgate Firmware

From time to time dataTaker may make available new versions of CANgate's internal operating system, or **firmware**. These updates may include fixes for reported problems as well as new features and enhancements.

The procedure for upgrading CANgate's firmware is as follows.

1. Download the update package (a .zip archive) and extract the files therein to a convenient location on the host computer.
2. Read the release notes included in the package. These will describe what has changed and any special upgrade procedures that may be required.
3. Install the Philips LPC2000 upgrade utility on the host PC. This is included on the dataTaker resource CD, under "Utilities". Do not run the utility yet.
4. Connect power to CANgate and connect the serial cable between CANgate and the host PC.
5. Run *DeTransfer* or other terminal program. Type **VERSION** to confirm the current firmware version.
6. Type **RESET** to clear any existing CANgate configuration.
7. Type **VXVX**. All CANgate LEDs will turn on to indicate that the **bootloader** is active. Some random characters may be returned as the bootloader operates at lower baud rate (38400 baud).
8. Close the DeTransfer connection.
9. Run the Philips LPC2000 Flash Utility.



Flash Utility screenshot showing required settings

10. Set the **Filename** field to point to the firmware .hex file; set the **Connected To Port** field to the COM port in use; set all other options as shown above
11. Press **Read Device ID** to verify communications. This should fill in the **Part ID** and **Bootloader ID** fields.
12. Press **Upload to Flash** and wait for completion.
13. Close the Flash Utility.
14. Cycle the power on CANgate. The LEDs should return to their normal state.
15. Connect using DeTransfer. Type **VERSION** to confirm the new firmware version.

Note: An alternative method of entering the bootloader is to set DIP switch 8 ON and then cycle the CANgate power. This replaces steps 5-8 above. Note that the "all LEDs on" indication will not occur using this method. Return the switch to the OFF position prior to step 14.

Appendix

CANgate Specifications

CAN Interfaces

2 independent CAN ports

Physical Layer: ISO 11898-2 / SAE J2284 (High speed CAN, two wire)

Port Speeds: 10, 20, 50, 125, 250, 500 or 1000 kbit/s

Protocols: Raw CAN; SAE-J1939; ISO-15765-2 based protocols e.g. J1979/ISO-15031-5 (Legislated OBD), ISO-14230-3 (manufacturer diagnostics)

Maximum broadcast parameters: 150

Maximum polled parameters: No Limit.

Statistical functions for broadcast parameters: Average, Minimum, Maximum.

GPS Interface

1 RS232 port

Port Speeds: 300,1200,2400,4800 (default),9600,19200, 38400, 57600,115200 baud

Serial Parameters: No parity, 8 data bits, 1 stop bit

Flow Control: Not supported

Protocols: NMEA-0183

Host (Data Logger/Computer) Interface

1 RS232 port

Port Speeds: 9600, 19200, 38400, 57600 (default),115200 baud

Serial Parameters: No parity, 8 data bits, 1 stop bit

Flow Control: Hardware (RTS/CTS) or Software (XON/XOFF)

Protocols: ASCII

LED indicators

Power (red)

CAN1 Data Receive (blue)

CAN2 Data Receive (red)

GPS Data Receive (green)

HOST Data Receive (green)

HOST Data Transmit (red)

Connectors

1 DE9 male (Host) – standard PC/AT DTE pin-out

1 DE9 female (CAN1, CAN2, GPS, power)

Host Software

DeLogger supports use of CANgate with dataTaker DT80 range of data loggers. Includes built in parameter databases for J1939, OBD, NMEA-0183 and supports user developed custom parameter databases.

DeTransfer or any other ASCII terminal emulator may be used to program CANgate when directly connected to a host PC.

Power Supply

External Input Range: +10 to +30VDC

+5V power output (200mA max) is also provided, for powering GPS modules

Power Consumption

Idle: 0.75W (50mA @ 15V)

Maximum (CANgate only): 2.25W (150mA @ 15V)

Maximum (CANgate + external device drawing 200mA from +5V output): 3.75W (250mA @ 15V)

Physical

Construction: Anodised aluminium, plastic surrounds on ends (removable if required)

Overall Dimensions: 57.5 x 95 x 26 mm

Weight: 110g

Environmental

Temperature Range: -20 to +70°C

Humidity: 85% RH, non-condensing

OBD-II Modes and PIDs

OBD-II defines a standardised set of on-board diagnostic functions, which are described in the SAE J1979 and ISO 15031 standards.

Modes

The first byte of an OBD-II request message specifies the mode of operation. Modes 0x00-0x0F are reserved for standardised (legislated) functions, of which nine are currently defined:

Mode	Description
01	Show current value of specified PID
02	Show stored (freeze frame) value of specified PID
03	Show stored Diagnostic Trouble Codes (DTCs)
04	Clear DTCs and stored values
05	Test results, oxygen sensors
06	Test results, non-continuously monitored
07	Show pending DTCs
08	Special control mode
09	Request vehicle information

Modes 0x10-0x3F are defined in ISO 14230. The precise details of how these modes work (eg. parameter definitions) are manufacturer specific.

PIDs

For Modes 01 and 02, the second byte of the request message is the PID of interest. The table below lists some of the standard PIDs. Refer to the standards for more details.

The first byte of the reply message is the mode byte with bit 6 set (eg. 0x41 for a reply to a mode 0x01 request). The second byte is the PID, and the third and subsequent bytes are the actual data value.

PID (hex)	Data Size (bytes)	Description	Scale	Offset	Units
00	4	PIDs supported	b31..0 = PIDs 0x01..0x20		
01	4	(Mode 01 only) MIL (Malfunction Indicator Light) status, number of DTCs, test status	b31=MIL status, b30..24=num DTCs, b23..0=test status		
02	2	(Mode 02 only) DTC associated with freeze frame data, if 0 then there is no stored freeze frame data	DTC code, see below		
03	2	Fuel systems #1 and #2 status (1 byte each)	bit encoded		
04	1	Calculated engine load			
05	1	Engine coolant temperature	1	-40	°C
06	1	Short term fuel % trim – bank 1 (- lean, + rich)	0.7812	-100	%
07	1	Long term fuel % trim – bank 1 (- lean, + rich)			
08	1	Short term fuel % trim – bank 2 (- lean, + rich)	0.7812	-100	%
09	1	Long term fuel % trim – bank 2 (- lean, + rich)	0.7812	-100	%
0A	1	Fuel pressure	3	0	kPa (gauge)
0B	1	Intake manifold pressure	1	0	kPa (abs)
0C	2	Engine RPM	0.25	0	rpm
0D	1	Vehicle speed	1	0	km/h
0E	1	Timing advance	0.5	-64	degrees
0F	1	Intake temperature	1	-40	°C
10	2	MAF air flow rate	0.01	0	g/s
11	1	Throttle position	0.3922	0	%
12	1	Secondary air status	bit encoded		
13	1	Oxygen sensors present	b7..4=bank 2 sensors 4-1 b3..0=bank 1 sensors 4-1		
14	2	(byte 1) Bank 1 sensor 1, oxygen sensor voltage	0.005	0	V
		(byte 2) Bank 1 sensor 1, short term fuel trim (0xFF if sensor not used)	0.7812	-100	%

15-17	2	…as above for Bank 1 sensors 2-4			
18-1B	2	…as above for Bank 2 sensors 1-4			
1C	1	OBD standards this vehicle conforms to	bit encoded		
1D	1	Oxygen sensors present	b7..6=bank 4 sensors 2-1 b5..4=bank 3 sensors 2-1 b3..2=bank 2 sensors 2-1 b1..0=bank 1 sensors 2-1		
1E	1	Auxiliary input status	b0=power take off status		
1F	2	Run time since engine start	1	0	s
20	4	PIDs supported	b31..0 = PIDs 0x21..0x40		
21	2	Distance travelled with MIL on	1	0	km
22	2	Fuel rail pressure (relative to manifold vacuum)	0.079	0	kPa
23	1	Fuel pressure (diesel)	3	0	kPa (gauge)
24	4	(bytes 1-2) Sensor 1 WR lambda(1) Equivalence ratio	0.0000305	0	-
		(bytes 3-4) Sensor 1 WR lambda(1) Voltage	0.000122	0	V
25-2B	4	…as above for sensors 2-8			
2C	1	Commanded EGR	0.3922	0	%
2D	1	EGR error	0.7812	-100	%
2E	1	Commanded evaporative purge	0.3922	0	%
2F	1	Fuel level input	0.3922	0	%
30	1	Number of warm-ups since DTCs cleared	1	0	-
31	2	Distance travelled since DTCs cleared	1	0	km
32	2	Evaporative system vapour pressure	0.25	-8192	Pa
33	1	Barometric pressure	1	0	kPa (abs)
34	4	(bytes 1-2) Sensor 1 WR lambda(1) Equivalence ratio	0.0000305	0	-
		(bytes 3-4) Sensor 1 WR lambda(1) Current	0.00391	-128	mA
35-3B	4	…as above for sensors 2-8			
3C	2	Catalyst temperature: bank 1 sensor 1	0.1	-40	°C
3D	2	Catalyst temperature: bank 1 sensor 2	0.1	-40	°C
3E	2	Catalyst temperature: bank 2 sensor 1	0.1	-40	°C
3F	2	Catalyst temperature: bank 2 sensor 2	0.1	-40	°C
40	4	PIDs supported	b31..0 = PIDs 0x41..0x60		
41					
42	2	Control module voltage	0.001	0	V
43	2	Absolute load value	0.3922	0	%
44	2	Command equivalence ratio	0.0000305	0	-
45	1	Relative throttle position	0.3922	0	%
46	1	Ambient air temperature	1	-40	°C
47	1	Absolute throttle position B	0.3922	0	%
48	1	Absolute throttle position C	0.3922	0	%
49	1	Accelerator pedal position D	0.3922	0	%
4A	1	Accelerator pedal position E	0.3922	0	%
4B	1	Accelerator pedal position F	0.3922	0	%
4C	1	Commanded throttle actuator	0.3922	0	%
4D	2	Run time with MIL on	1	0	min
4E	2	Time since DTCs cleared	1	0	mins

Note: All multi-byte values are returned most significant byte first.

DTCs (Fault Codes)

OBD-II Diagnostic Trouble Codes (DTCs) are normally written as a letter followed by four decimal digits. The letter describes the category: **P** (powertrain), **B** (body), **C** (chassis) or **U** (network). For example:

- **P0118** - Engine Coolant Temperature Circuit High Input
- **P0203** - Injector Circuit Malfunction - Cylinder 3
- **U0003** - High Speed CAN Communication Bus (+) Open

When a DTC is returned it is encoded as a 16-bit value, as follows:

- b15..14 – first character (00=P, 01=C, 10=B, 11=U)
- b13..12 – second character (0-3)
- b11..8 – third character (0-9)
- b7..4 – fourth character (0-9)
- b3..0 – fifth character (0-9)