User's guide for DT-C003

Duty cycle actuators

EXOTEST® EDUCATION

Document no. 00297505-v1

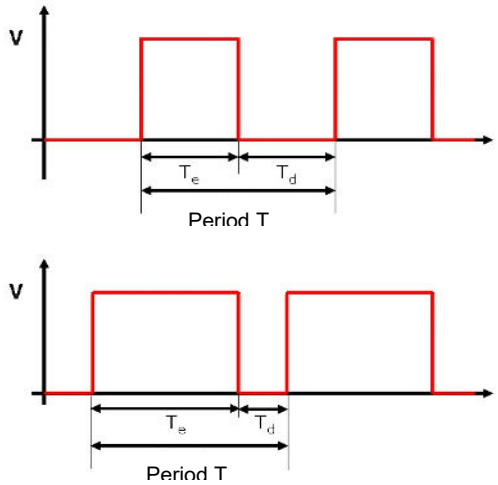
1. RESOURCE FILE

1.1 DUTY CYCLE

The Duty Cycle (in French: RCO) is a fixed-period signal. The period consists of a top and bottom edge. The height of the edges is defined and does not change. In a duty cycle the width of the edges varies within a given fixed period. The Duty cycle is often expressed as a percentage using the following formula:

$$Dutycycle = \frac{Controltime}{Periodtime} * 100$$

The mean voltage of the signal depends on this percentage.

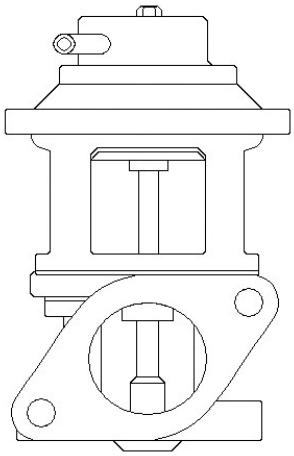


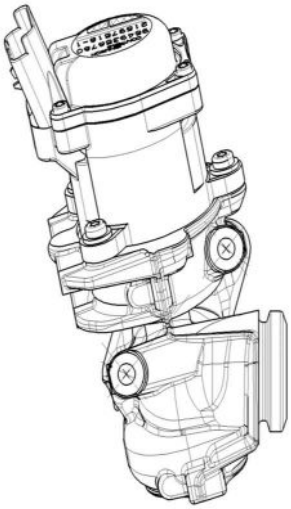
Te = Control time
Td = Rest time

1.2 EGR VALVE

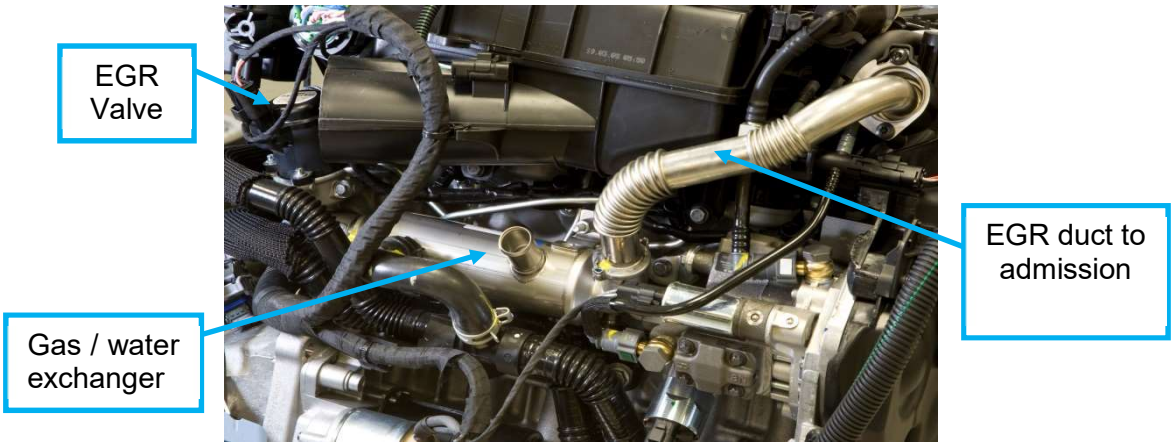
1.2.1 Assembly

There are two types of valves. One which functions pneumatically, the other which functions electrically.





Whatever its type, the recycling valve is connected to the exhaust manifold.



1.2.2 Role

Controls the volume of exhaust gas recycled.
The EGR exhaust gas recycling device serves to reduce the quantity of nitrogen oxide (Nox) discharged via the exhaust pipe.
The amount of nitrogen oxide is reduced by re-injecting part of the exhaust gases into the cylinders.
The recycling phases are memorised in the maps: injector calculator.

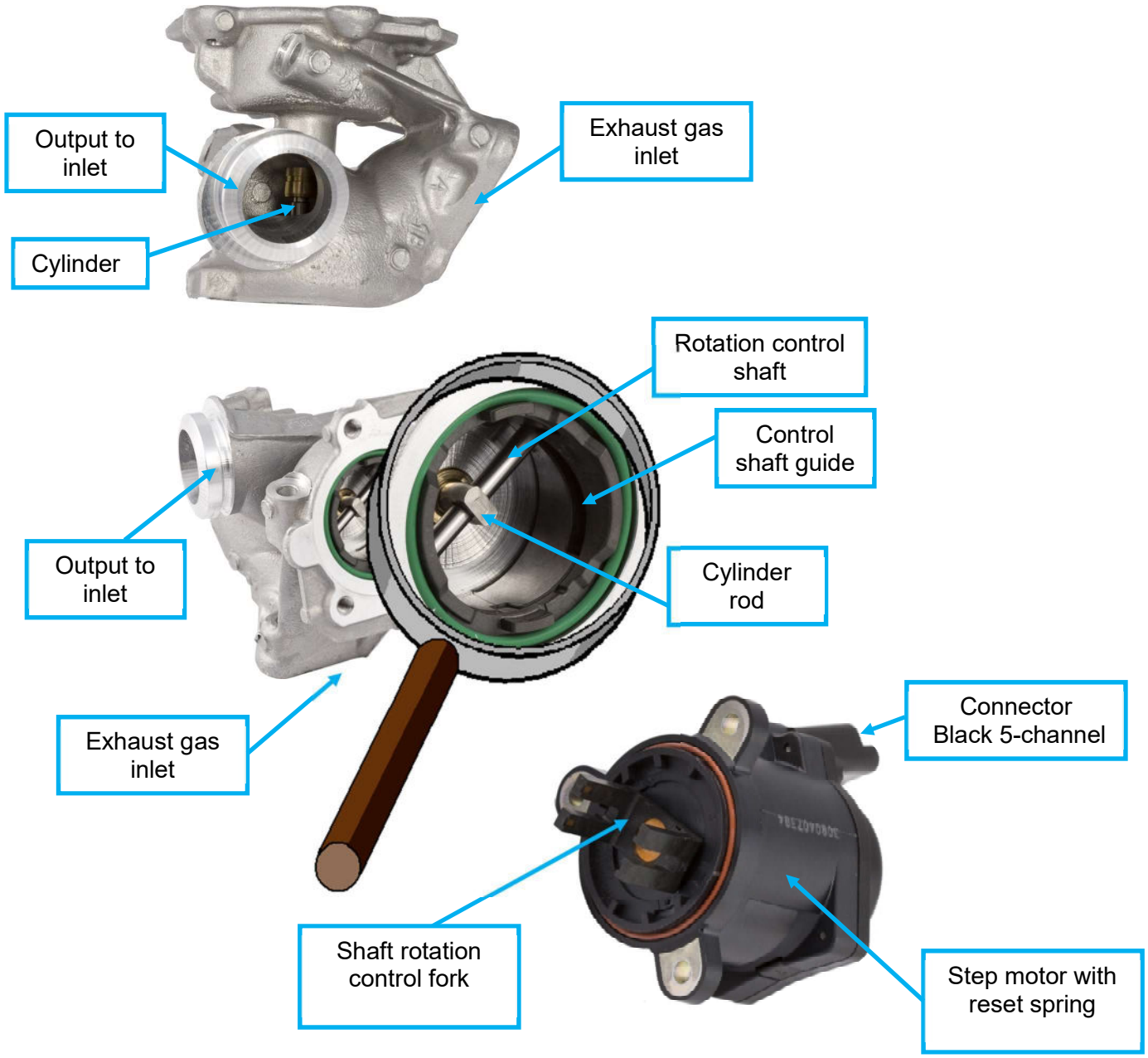
1.2.3 Description

When the control motor is powered by the injection calculator, the recycling valve opens the exhaust gas recirculation circuit. The opening process is progressive and controlled by an electric control, based on a duty cycle %. This serves to adjust the recirculation rate of exhaust gases according to the motor operation.

The EGR valve includes a Hall effect position sensor to control the valve.

NOTE: When not powered, the EGR valve is in the closed position.

1.2.4 Mechanical design



1.2.5 Electrical features

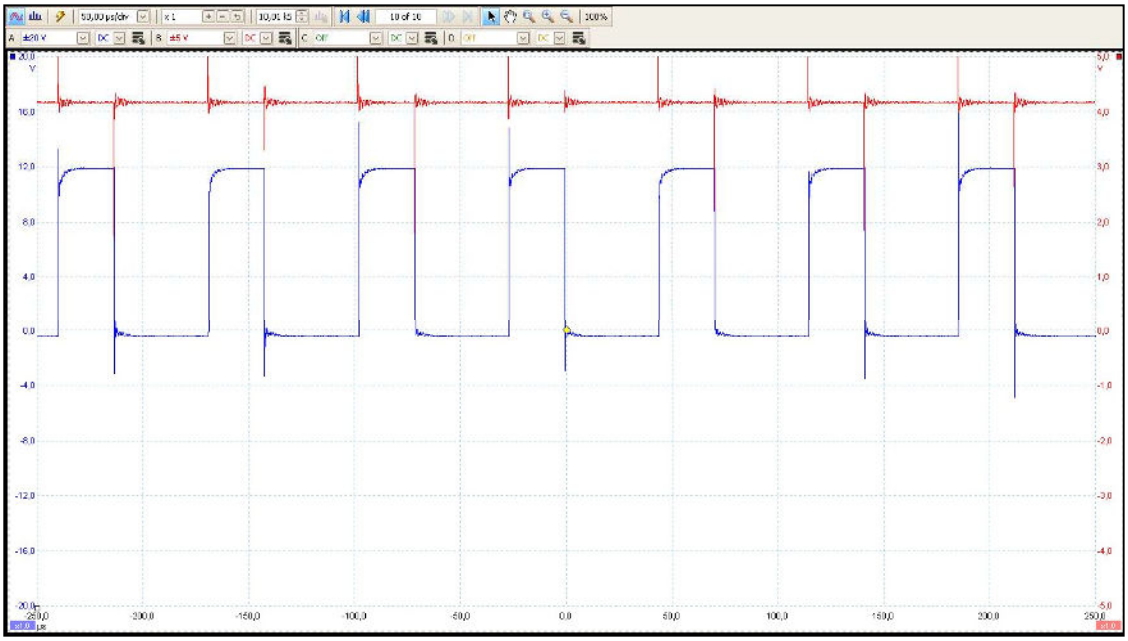
A. Allocation of connector channels:

Channel number	Signal
	+5 Volt
	Valve Earth (% duty cycle)
	+12 V Valve
	Sensor signal
	Sensor Earth

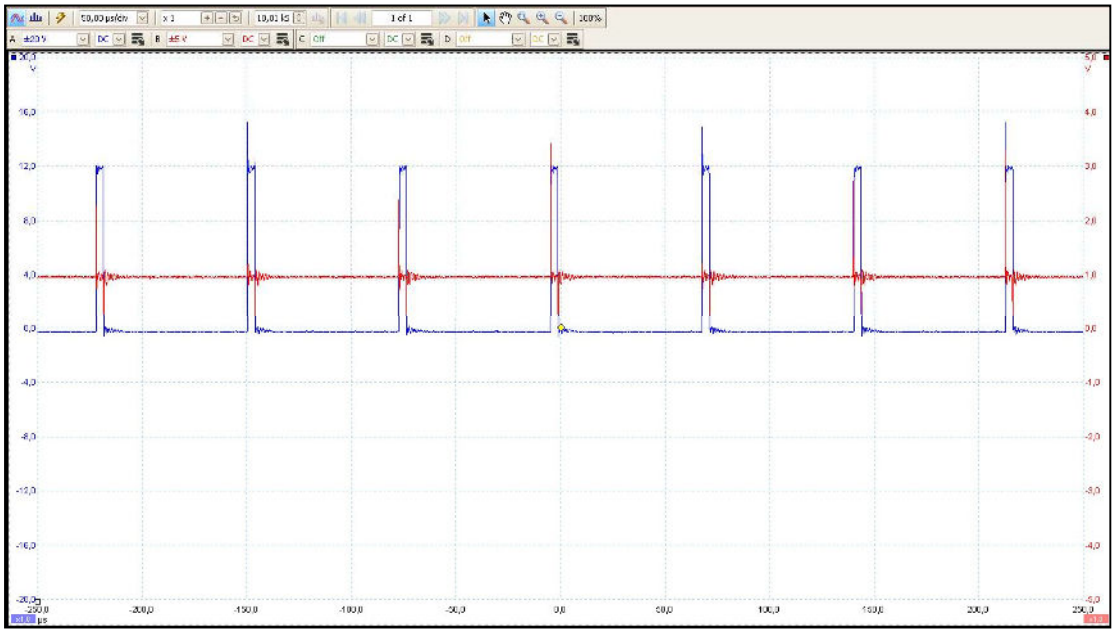
Note: It is powered with a 5 V supply and Duty cycle voltage by the injection calculator.

B. Characteristic curves:

EGR Valve + feedback at max



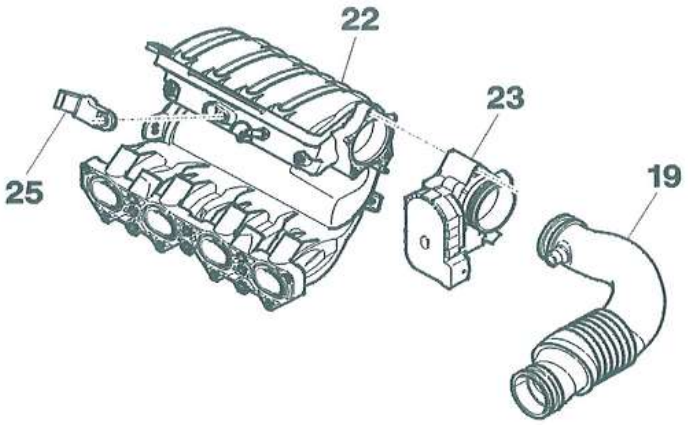
EGR Valve + feedback at min:



1.3 MOTORISED BUTTERFLY VALVE UNIT

1.3.1 Assembly

Located between the air filter and the inlet manifold, where it is fixed by 3 screws.



(19) Inlet tube
(22) Inlet manifold
(23) Motorised butterfly valve unit
(25) Inlet pressure sensor

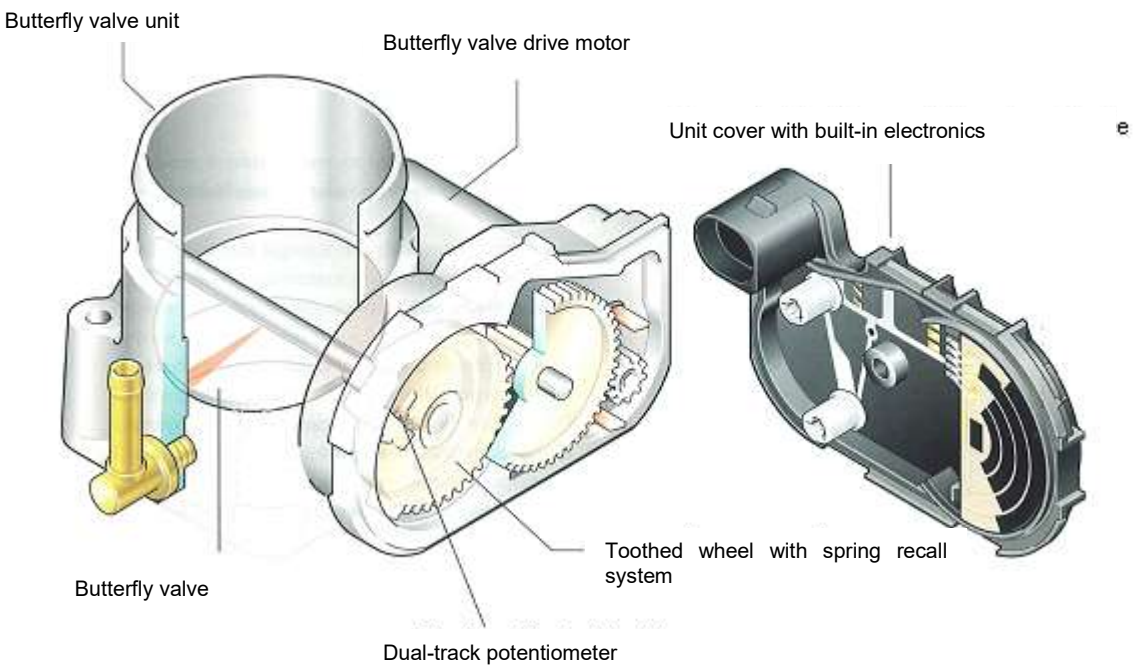
1.3.2 Role

The motorised butterfly valve unit serves to convey the driver's instructions via an accelerator pedal position sensor, which translates the driver's torque demand into a voltage, like a calculator or a function.

The unit is controlled by a duty cycle control. It enables more precise dosage depending on the operating phases.

1.3.3 Description

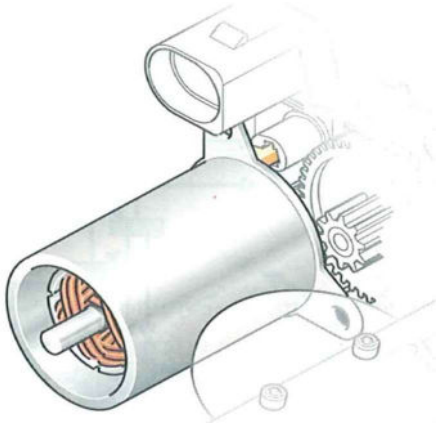
A. Butterfly unit



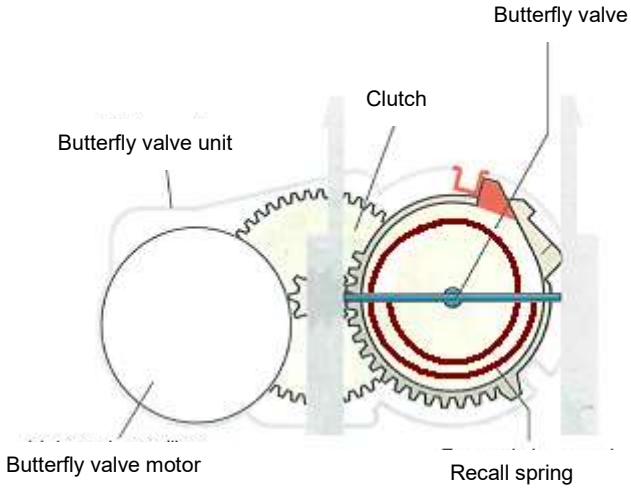
B. Butterfly drive part

The butterfly drive system is an electric motor, actuated by the motor control calculator via a duty cycle voltage.
It actuates the butterfly via a small clutch.
The regulation range is continuous, from idle to full load.
The motor modes are therefore managed by controlling the butterfly motor, which enables:

- supply of an additional airflow (cold start),
- regulation of idle speed according to temperature of motor, motor load, motor age, consumers,
- improvement of transient phases,
- improvement of idle returns (dashpot effect)

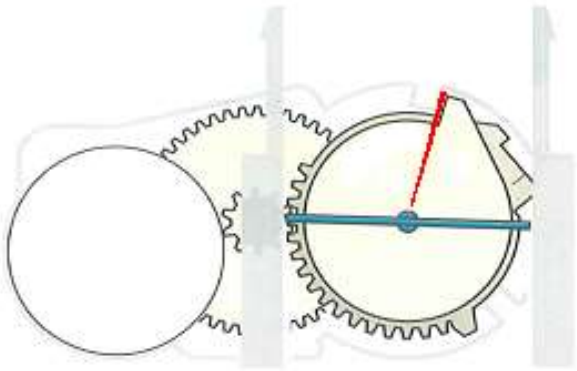


Note: As idling control is also done by this motor, the idle regulation solenoid no longer exists.



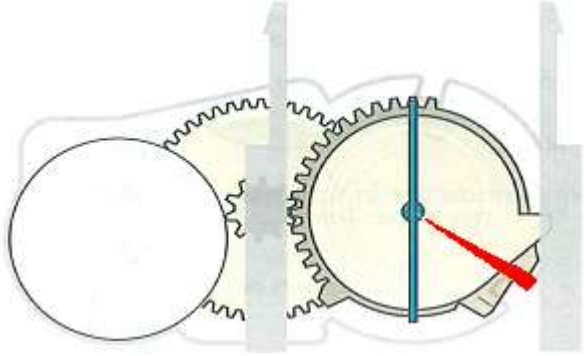
Lower mechanical stop:

When the butterfly is closed, it rests on its lower mechanical stop.
This serves to adjust the base of the butterfly unit.



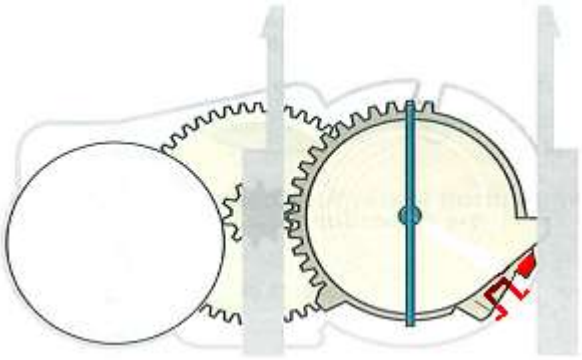
Lower electrical stop:

Configured in the motor control calculator and slightly above the lower mechanical stop.
During no-load operation, the butterfly is closed to the maximum, up to the lower electrical stop.
Therefore, the butterfly is prevented from penetrating the unit.



Upper electrical stop:

Configured in the motor control calculator and represents the maximum opening angle of the butterfly in operation.

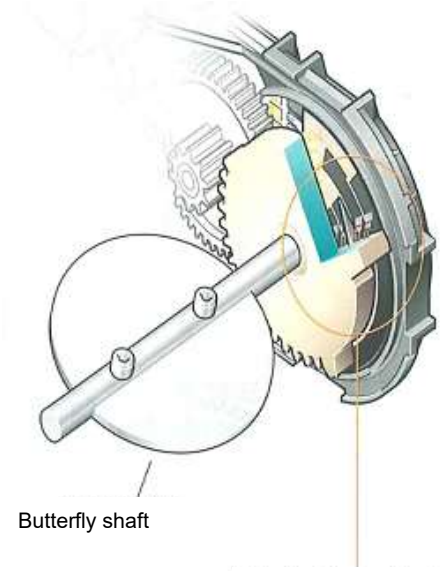


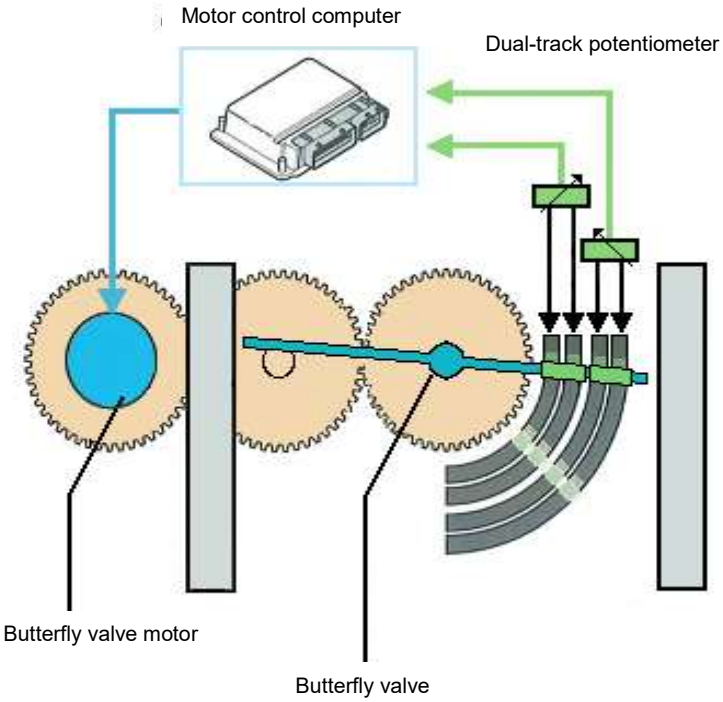
Upper mechanical stop:

Located above the upper electrical stop. Located 'in the shadow' of the butterfly shaft, i.e. in the area sheltered from the air inlet flow, it does not alter the characteristics of the inlet.

C. Dual-track potentiometer part

A dual track potentiometer positioned on the toothed wheel on the butterfly shaft provides the calculator with precise information about the position of the butterfly.
The potentiometer cannot be adjusted.
The information is used to recognize the zero driver input and full driver input positions.
The potentiometer is dual-track to enable the diagnostic of each track in relation to the other.





The position of the butterfly is determined by the motor action, which is controlled by the calculator.

The two tracks use the same power supply and each sends its own signal to the motor control calculator.

1.3.4 Electrical features

A. Assignment of connector channels

Channel number	Signal
	BUT POT EARTH
	BUT SGN POS 2
	CTL MOT -
	CTL MOT +
	BUT SGN POS 1
	BUT POT 5V PWR

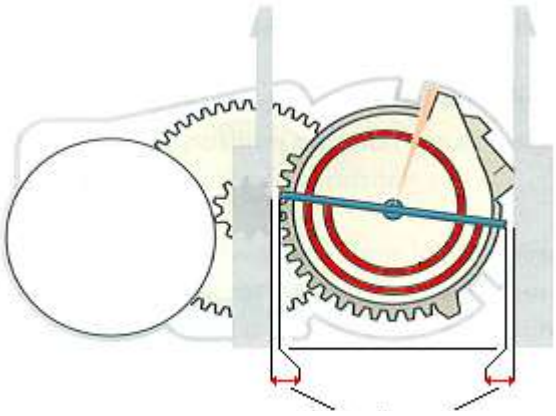
Note: The butterfly motor is powered with duty cycle voltage (controlled by Earth)

B. Configuration in event of failure

During operation, if the motor is not supply with a current, the butterfly is recalled to the degraded operation position by a spring system.

This position nonetheless enables an accelerated idling state with certain restrictions.

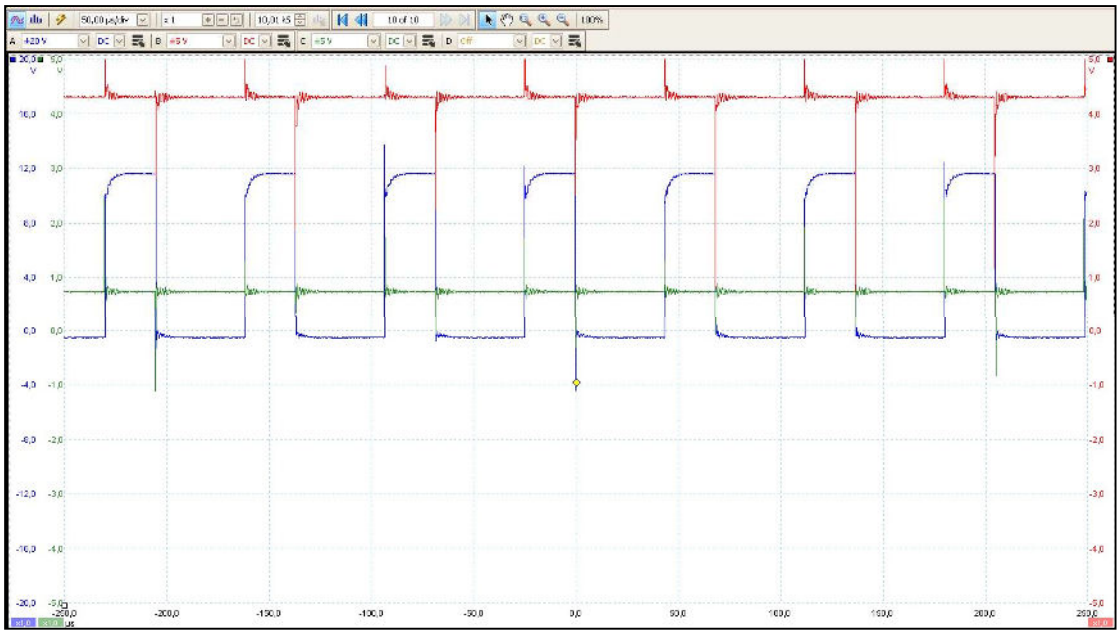
Note: During this phase the driver no longer has control over the load instruction.



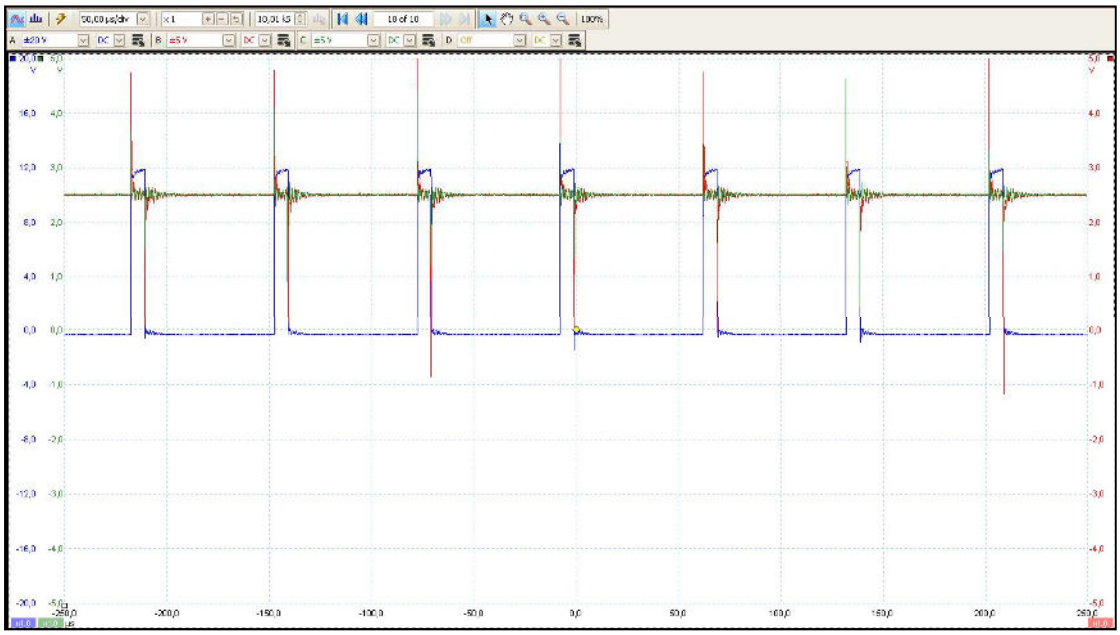
Emergency slot

C. Characteristic curves

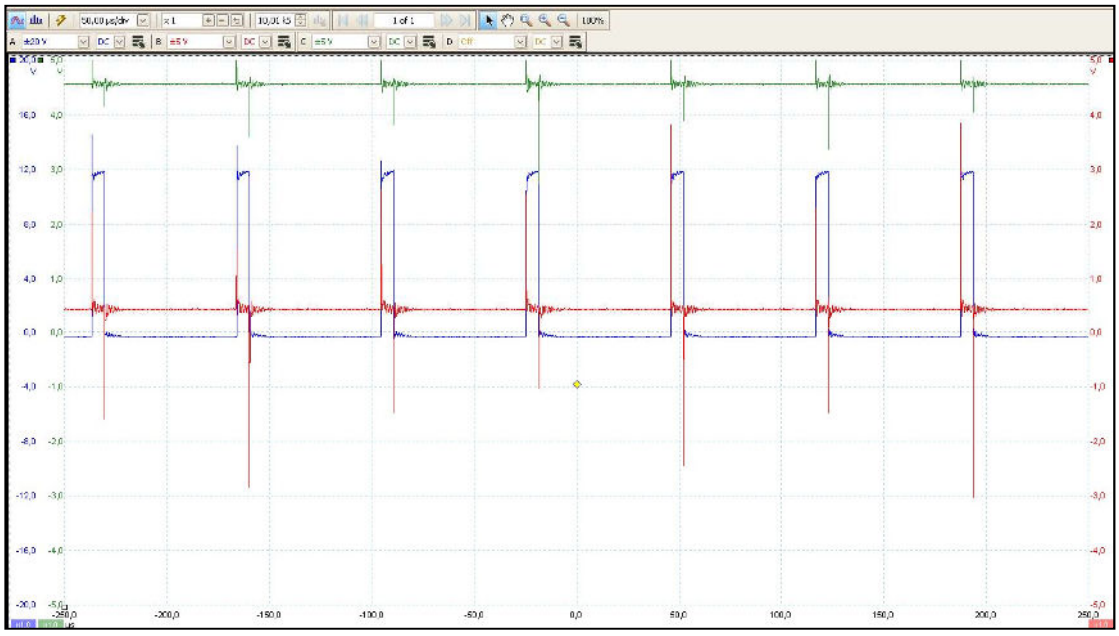
Motorised butterfly + feedback at max:



Motorised butterfly + feedback at medium:



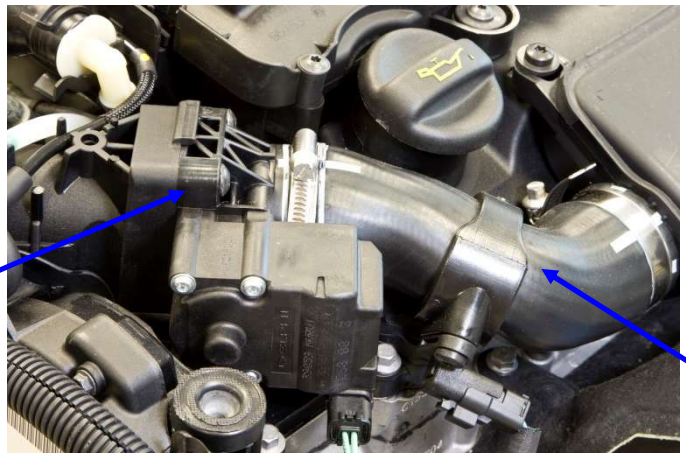
Motorised butterfly + feedback at min:



1.4 AIRFLOW REGULATOR BUTTERFLY VALVE

1.4.1 Assembly

The butterfly valve is located on the inlet before the exhaust gas return duct.



1.4.2 Role

The butterfly is a complement to the EGR solenoid to enable the enhancement of the recycling of the exhaust gases, by blocking the air inlet on the inlet manifold.

1.4.3 Description

The EGR butterfly, also called the airflow regulator butterfly, is controlled with a duty cycle voltage supplied by the motor control calculator.

When the butterfly motor is powered, the air quantity in the inlet is reduced.

1.4.4 Electrical features

A. Assignment of connector channels

Channel number	Signal
	Earth
	+12 V power

The motor control calculator powers it with a duty cycle voltage.
At full supply setting, the butterfly is in the closed position.
When inactive, the butterfly is open.

2. USER MANUAL

2.1 Installation and activation of DT-C003 module

Use the 12V 10A power supply provided. Connect the power to the 230V mains supply (check the position of the switch on the back of the power supply unit).
Connect the Earth and the power + to the DT-C003 module using the cables provided.
Activate the power supply. Then cable the module.
Moving devices are the EGR valve, the airflow regulator butterfly and the motorised butterfly valve.
Note: a protective device with buzzer informs you if the power voltage is greater than 12V or if the + and - are inverted.

2.2 Operational environment

The DT-C003 training module can be laid on a table.
It must be installed in a dry location protected from dust, steam and combustion gases.
The module needs ambient lighting between 400 and 500 lux.
It can be placed in a Practical Workshop room, its operating noise does not exceed 70 decibels.
The module is protected against possible errors by trainee users.

2.3 Calibration and maintenance of DT-C003 module

Calibration: Factory Settings.
Servicing interval: N/A
Cleaning: Use a soft, clean cloth with a window cleaning product.

2.4 Number of stations, user position

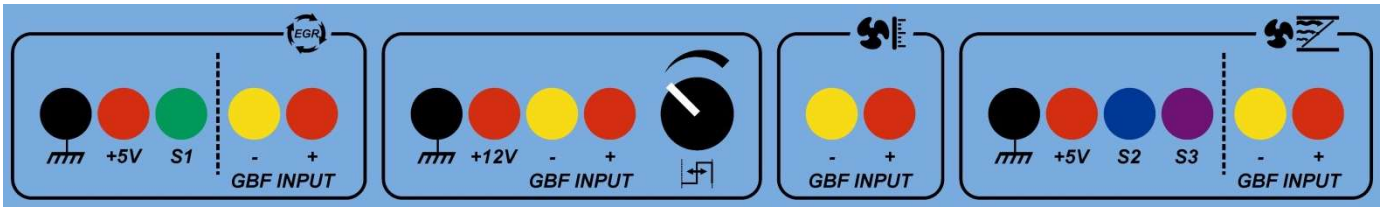
The DT-C003 module is considered as a single workstation.
The module user remains seated during the practical classes.

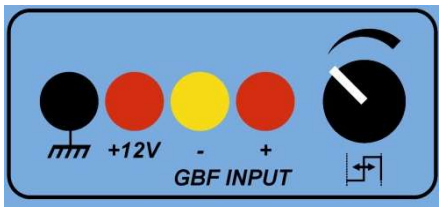
2.5 Locking out procedure

Move the power switch to 0.
Disconnect the 230V cable from the mains supply.
Remove all single-pin connector leads from the module.
The store the DT-C003 module and its accessories in a closed room or cabinet with a label attached to the front marked "**Equipment tagged-out**".

Access to the internal workings of the mock-up is reserved for qualified and authorised persons

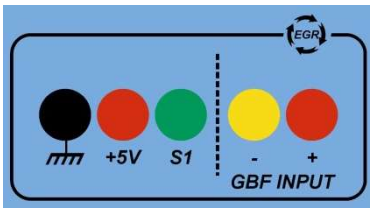
2.6 Details of front





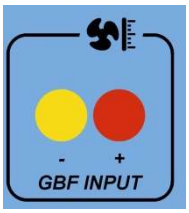
Low Frequency Generator (GBF):

- ⏚ → GBF Earth
- **+12V**→ GBF +12V power supply
- **-** and **+**→ GBF signal output terminal



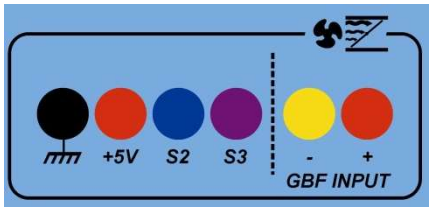
EGR valve:

- ⏚ → Feedback sensor Earth
- **+5V**→ Feedback sensor +5V power supply
- **S1** → Feedback sensor signal
- **-** and **+**→ GBF signal input terminal



Airflow regulator butterfly valve:

- and **+**→ GBF signal input terminal



Motorised butterfly valve:

- ⏚ → Dual track sensor Earth
- **+5V**→ Dual track sensor +5V power supply
- **S2** → Track 1 signal
- **S2** → Track 2 signal
- **-** and **+**→ GBF signal input terminal

3. PRACTICAL WORK

3.1 EGR Solenoid valve

A. What is its function?

It enables the injection of exhaust gases into the inlet circuit, to reduce the emission of pollutants.

B. Where is it situated on the motor system?

It is placed on the exhaust manifold.

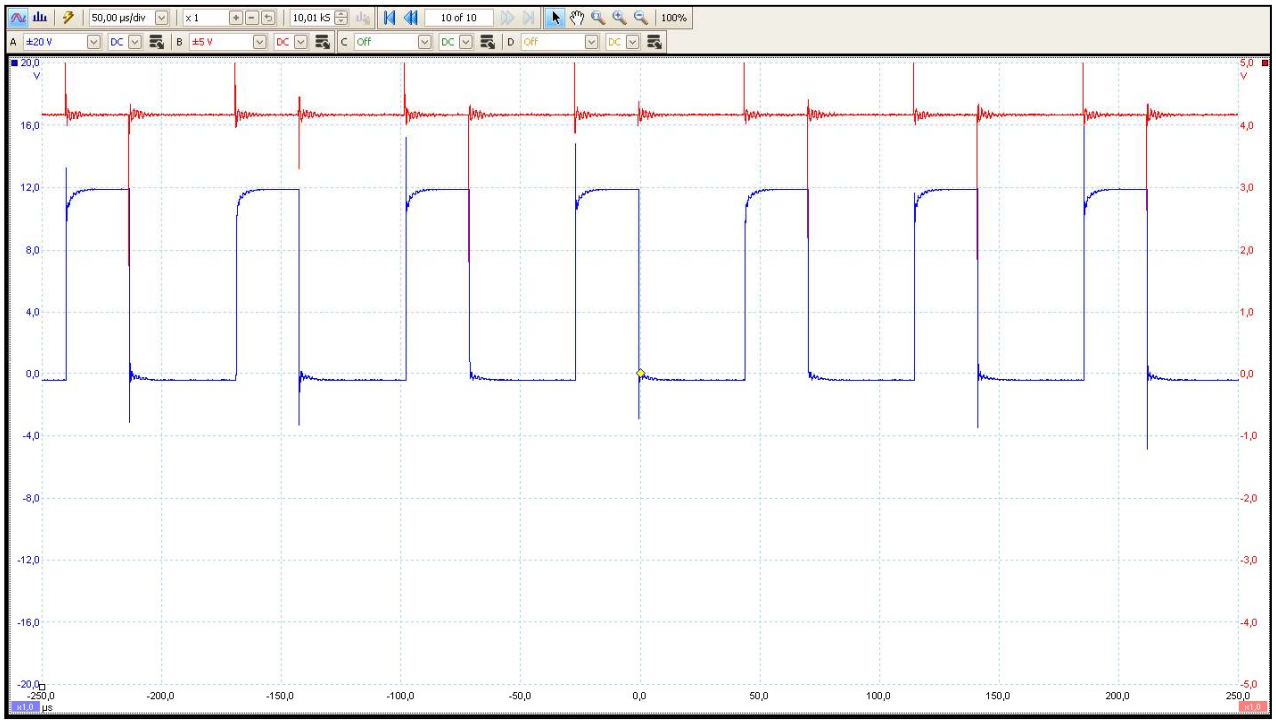
C. The solenoid valve is fitted with a feedback sensor. What is its purpose?

The purpose of the feedback sensor on the solenoid is to inform the injection calculator about the position of the valve.

D. Determine the operating range of the feedback sensor.

The voltage varies between 1 and 4 V.

E. According to the curve below, determine the duty cycle % applied.



The period is approx. 70 µs
The control time is approx. 25 µs.

$$\text{Duty cycle} = \frac{25}{70} \times 100 = 35.7$$

The duty cycle is approx. 35%

F. Using the curve below, determine the frequency used.

The period is approx. 70 µs, or 0.00070 s.
f=1/0.00070 = 1428.5
The frequency is therefore approx. 1430 Hz.

3.2 Motorised butterfly valve unit

A. What is its function?
It transmits the driver's instructions to increase the fill volume of the cylinders, therefore the engine speed.

B. Where is it situated on the motor?
It is fixed in place between the air filter and the inlet manifold.

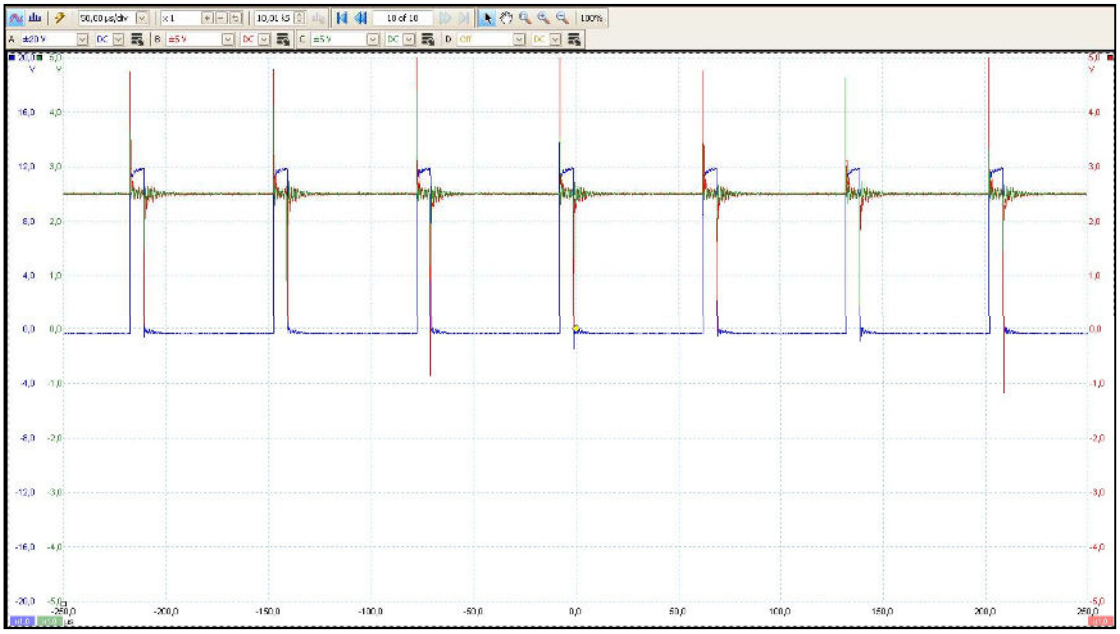
C. The motorised butterfly valve unit is equipped with a dual-track potentiometer. What is its function?
It enables the calculator to know the exact position of the unit.

D. Why does the potentiometer have dual tracks?
It has dual tracks to enable the diagnostic of each track in relation to the other.

E. Determine the operating range of the dual-track potentiometer. What do you observe?
$0.5 \geq S2 \geq 4.5V$ and $4.5 \geq S3 \geq 0.5V$
We observe that the two signals are inverted.

F. Determine the voltage value of S2 and S3 when the butterfly is in the centre position. What do you observe?
Voltages S2 and S3 are identical. S2 = S3 = 2.5V

G. Take readings of the control curve and the potentiometer when S2 = S3.



H. Determine the duty cycle percentage needed to be in the same case as above.
The period is approx. 70 µs
The control time is approx. 6.9 µs.

$$\text{Duty cycle} = \frac{6.9}{70} \times 100 = 9.8$$

The duty cycle is approx. 10 %

3.3 Airflow regulator butterfly valve

A. What is its function?

It facilitates the recycling of gases and blocks the airflow inlet to a defined amount.

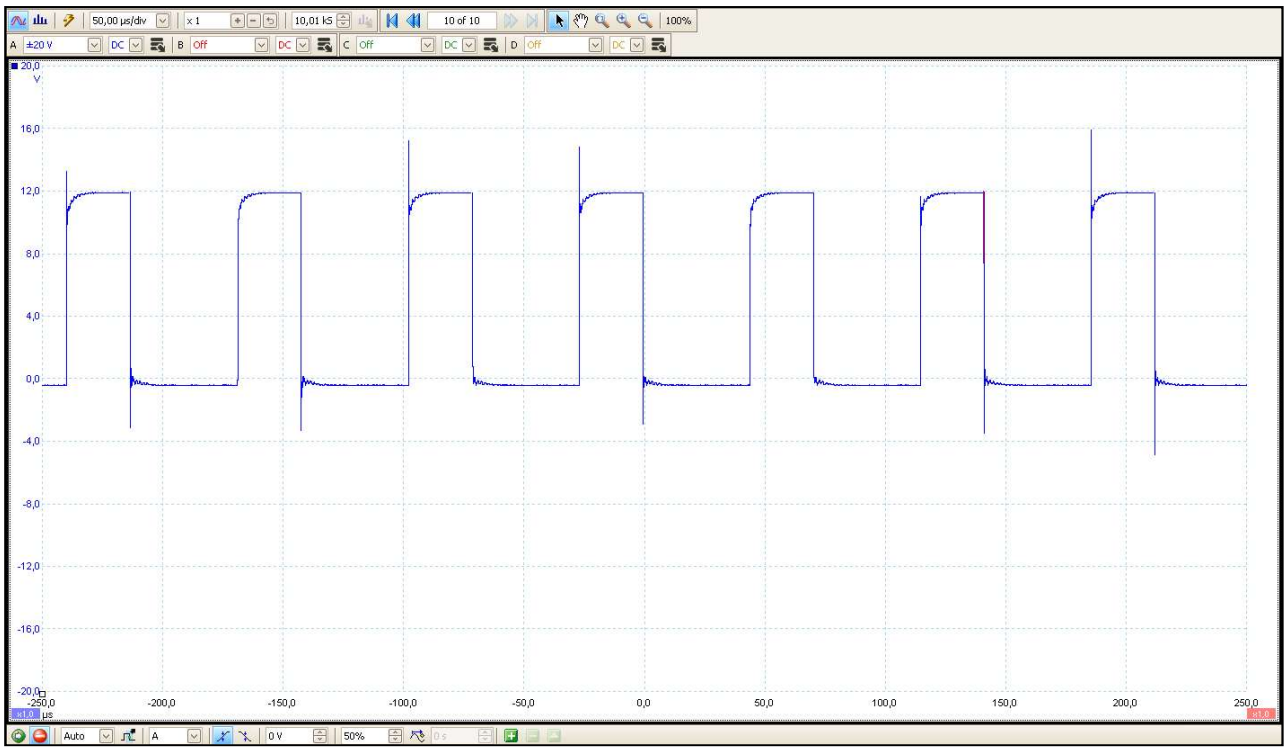
B. Where is it situated on the motor?

It is located on the inlet duct before the gas recycling duct.

C. How is it different from the motorised butterfly unit?

The airflow regulator does not have a position control device. The butterfly is open when inactive, contrary to the motorised butterfly valve.

D. Take a signal reading in the closed position.



E. What is the duty cycle % in this position?

The period is approx. 75 µs

The control time is approx. 25 µs.

$$\text{Duty cycle} = \frac{25}{75} \times 100 = 33$$

The duty cycle is approx. 33 %

F. As the control signal period is 75 µs, determine the control time for a duty cycle of 80%.

$$T_{ctrl} = \frac{\text{Duty cycle}}{100} \times T_{period}$$

$$T_{ctrl} = \frac{80}{100} \times 75 = 60$$

The control time is 60 µs.

CE DECLARATION OF CONFORMITY

By means of this declaration of conformity, as defined by the European Directive on Electromagnetic Conformity 2004/108/EC, the company:

S.A.S. ANNECY ELECTRONIQUE
Parc Altaïs – 1, rue Callisto
F-74650 CHAVANOD

Declares that the following product:

Brand	Model	Description
EXXOTEST	**DT-C003**	**TRAINING MODULE: Control duty cycle actuators**

I - Has been manufactured in accordance with the requirements of the following European Directives:

- LV Directive 2006/95/EC - 12 December 2006
- Machinery Directive 98/37/EC - 22 June 1998
- EMC Directive 2004/108/EC - 15 December 2004

and satisfies the requirements of the following standard:

- NF EN 61326-1 dated 07/1997 +A1 of 10/1998 +A2 of 09/2001
Electrical measurement, control and laboratory equipment, EMC-related requirements.

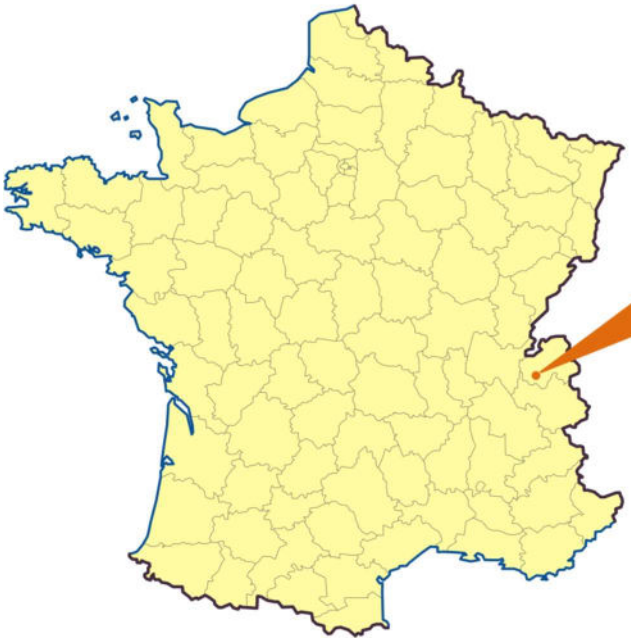
II - Has been manufactured in accordance with the requirements of the European Directives relating to EEE design and WEEE management for the EU. :

- Directive 2002/96/EC dated 27 January 2003 on Waste Electronic and Electrical Equipment (WEEE)
- Directive 2002/95/EC dated 27 January 2003 on the limitations for the use of certain hazardous substances in the construction of Electronic and Electrical Equipment (EEE).

Drawn up in Chavanod on 30 June 2009,

CEO - Stéphane SORLIN

Latitude: 45° 53' 49" / Longitude: 6° 4' 57"



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