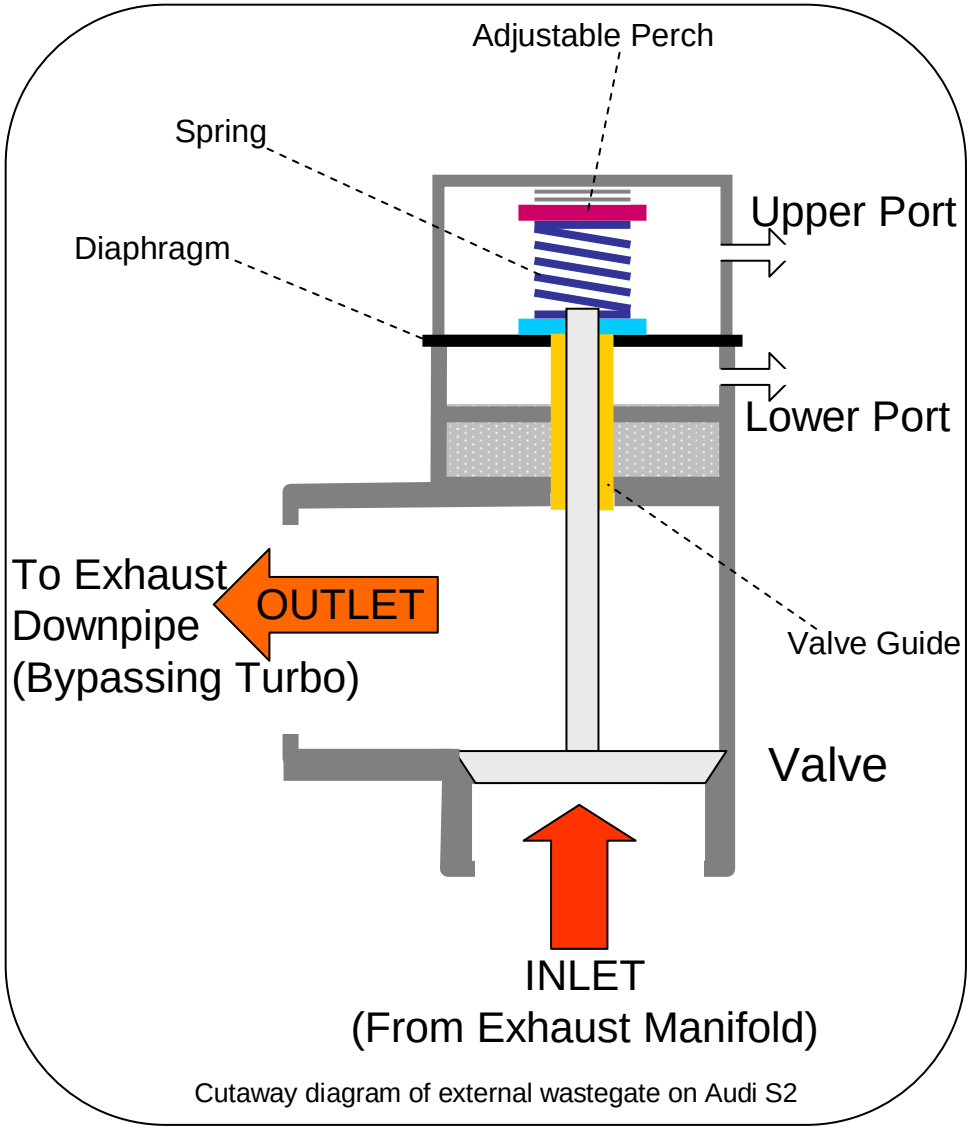
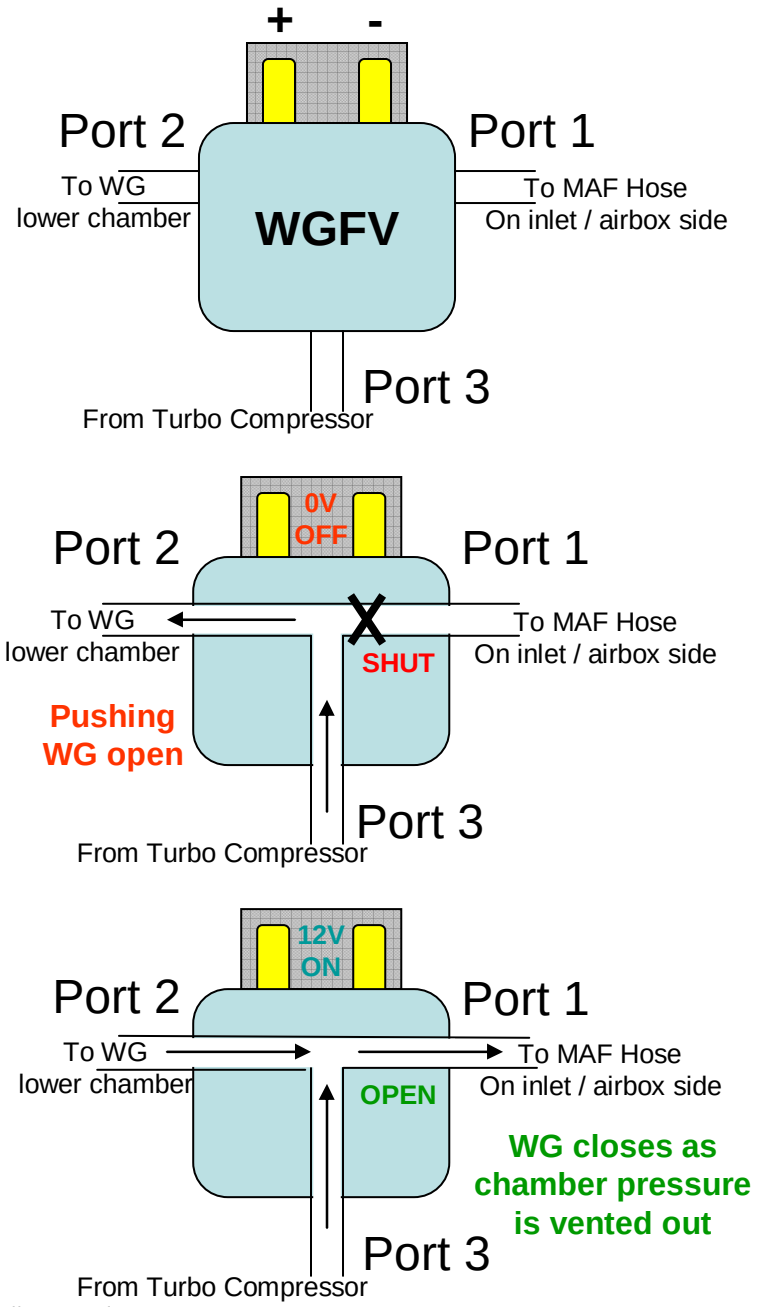
Audi S2 Wastegate Fundamentals



Cutaway diagram of external wastegate on Audi S2

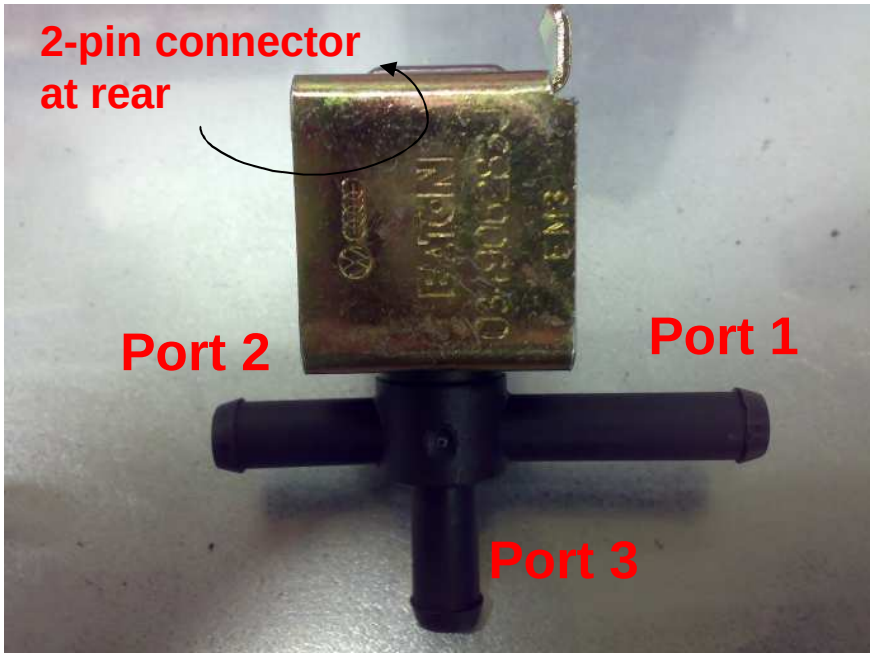
- The primary function of the wastegate (WG) is to control the boost pressure produced by the turbocharger.
  - The turbo cannot regulate itself
  - Providing safe levels of boost in the engine
  - The WG directs exhaust gas away from the turbine (hot side) when target boost pressure is achieved
- A mechanical spring in the uppermost chamber of the WG controls how much force tries to keep the WG valve closed
  - The factory fitted WG spring in the Audi S2 provides for 0.4bar boost when the lower port of the wastegate's control chamber is connected up as normal. See below on the WGFV.
  - This spring can be made tighter by adjustment within limits… Making it stiffer can improve turbo spool and reduce lag, but ECU reprogramming may be required for this to work smoothly.
  - The mechanical boost spring pressure must not be set so high that it exceeds the capability of the turbo at maximum load. Audi was very conservative with 0.4bar when the turbo could run to 0.8bar on max load (at sea level – not high altitude).
  - **WARNING**: If this lower port is left unconnected, then the WG valve will not start to open until sufficiently high **exhaust** gas pressure is able lift the WG valve… assuming the engine doesn't blow up first with ever increasing levels of boost & detonation !
- Control of the pressure applied to the lower port (LP) of wastegate control chamber provides boost levels higher than the mechanical spring limit alone
  - Upper Port (UP) is ambient air pressure on the Audi S2 WG
  - An airtight diaphragm separates the upper and lower chambers
  - When forces below the diaphragm exceed the forces above it, the WG valve opens
  - When forces above the diaphragm exceed those below it, the WG valve closes
- On the Audi S2, the force or pressure presented to the LP is ECU controlled by a wastegate frequency valve (WGFV)
  - By electronic control of the WGFV, it is possible to reduce the pressure presented to the LP below that of the mechanical spring pressure in the upper chamber so that the valve closes.
- Two main drawbacks with this approach on the Audi S2
  - Reliability of WGFV is vital for continued engine health. A faulty WGFV can kill an engine if the turbo is allowed to run 'open loop'
  - The WG valve can 'creep' open earlier than planned with this regulation of pressure via the WGFV. As soon as boost is applied to the LP it helps crack open the WG and causes slower spool times for the turbo to make maximum boost.

Audi S2 Wastegate Frequency Valve (WGFV) – N75



- The wastegate frequency valve (WGFV) is referred to as N75 on the Audi schematics for the Bosch Motronic ECU
- The purpose of the WGFV is to control the pressure presented to the lower chamber of the wastegate so that electronic boost control can provide higher levels of boost than with the mechanical spring.
- The WGFV is essentially a three port T-piece with an electrically controlled gate on one of the ports. It is a solenoid device which provides two possible paths for air to travel across the T-piece. The two air paths are selected by turning the solenoid on or off by means of a 12V control signal.
- On the Audi S2, the three ports on the WGFV are connected thus:
  - Port 1 : To the MAF hose where air enters the turbo compressor via airbox
  - Port 2 : To the wastegate lower chamber
  - Port 3 : To the turbo compressor outlet
- When the WGFV is in the OFF position (or disconnected from the ECU) the air path is from Port 2 to Port 3. This means that, with the ECU not being involved, the WGFV 'steers' boost pressure directly to the lower portion of the WG chamber. As such, the wastegate will provide boost control at the limit set by the mechanical spring.
- When the WGFV is in the active or 'ON' position, it **also** provides an air path from Port 2 to Port 1. In this scenario then ambient (or slight vacuum) air pressure is presented to the lower WG chamber and so the mechanical spring continues to keep the WG closes. Another way to think of this is that Port 1 provides the path of least resistance for air to travel out of the lower WG chamber.
- In operation, a rapidly repeating ON-OFF-ON-OFF control signal is applied by the ECU to the WGFV. The 'duty cycle' of this voltage is what controls the pressure in the lower chamber of the WG. It essentially modulates between full boost and ambient pressure.
- This 'active boost control' operates by means of ECU software. It provides a programmable boost profile across the engine's dynamic range with much greater elegance than simple mechanical control. With Motronic there is also the ability to provide safety mechanisms that can reduce the boost profile when running at high altitude or if excessive knock or very high water temperature is detected.
- An important aspect of the WGFV is that it in itself fails safe. If the solenoid sticks in the OFF position, then the mechanical spring in the WG provides for early opening – as long as it is setup to never allow the turbo to make more boost than it is capable of. Similarly, should the WGFV stick in the ON position then some boost pressure is also applied to the lower chamber of the WG.
  - NOTE: If Port 3 on the WGFV is blocked then the WG will not be opened by pressurised air from the turbo. This is a dangerous condition.

Audi S2 Wastegate Frequency Valve (WGFV) – N75

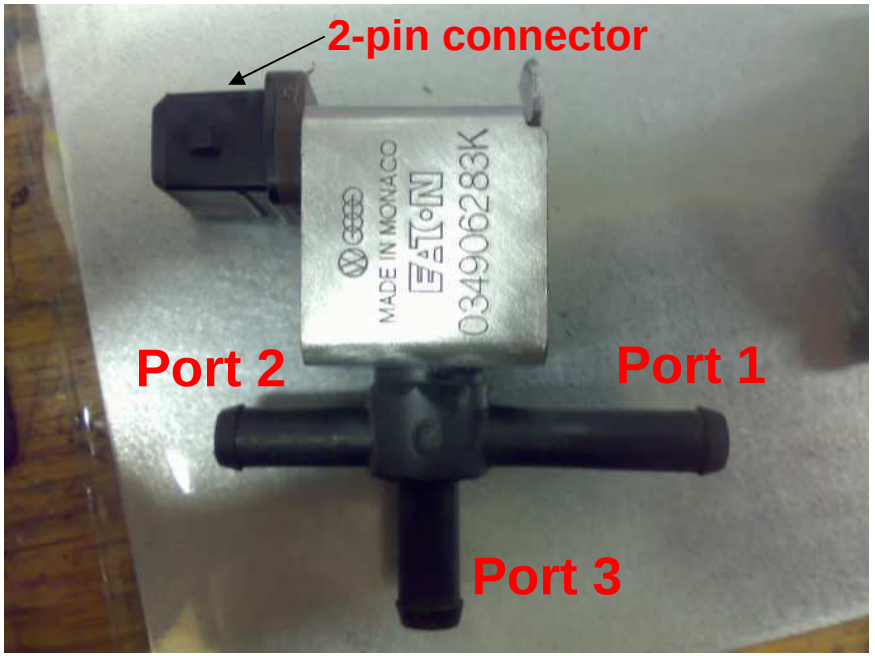


034 906 283 J – as used on 3B Engine

These two valves operate identically.

Only difference is the orientation of the 2-pin electrical connector.

Other more recent turbocharged Audi engines have similar setups.

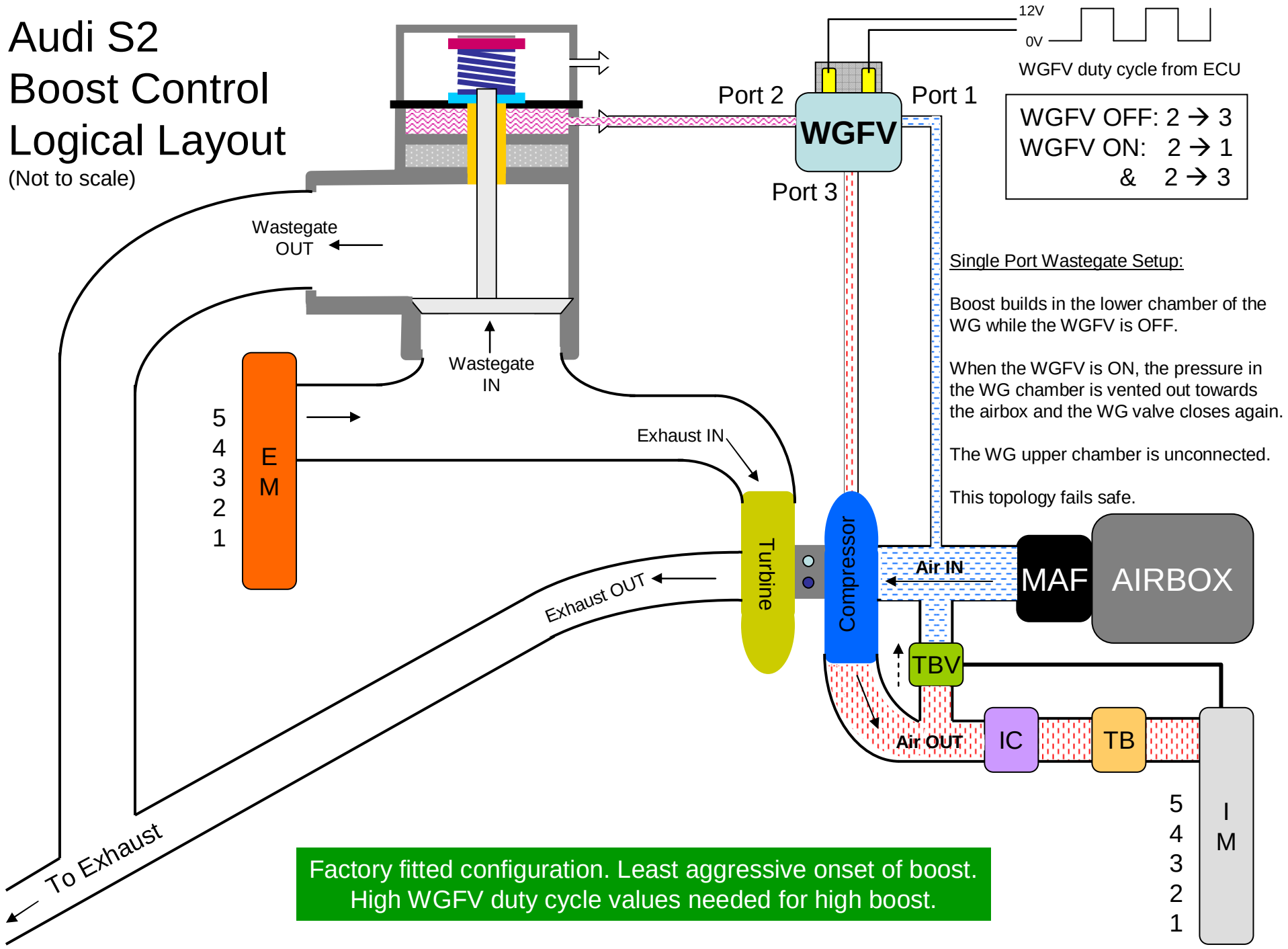


034 906 283 K – as used on ABY/ADU Engine

Port 1 – Inserted into the MAF hose
Port 2 – Connects to lower chamber of wastegate
Port 3 – Connects to turbo compressor outlet

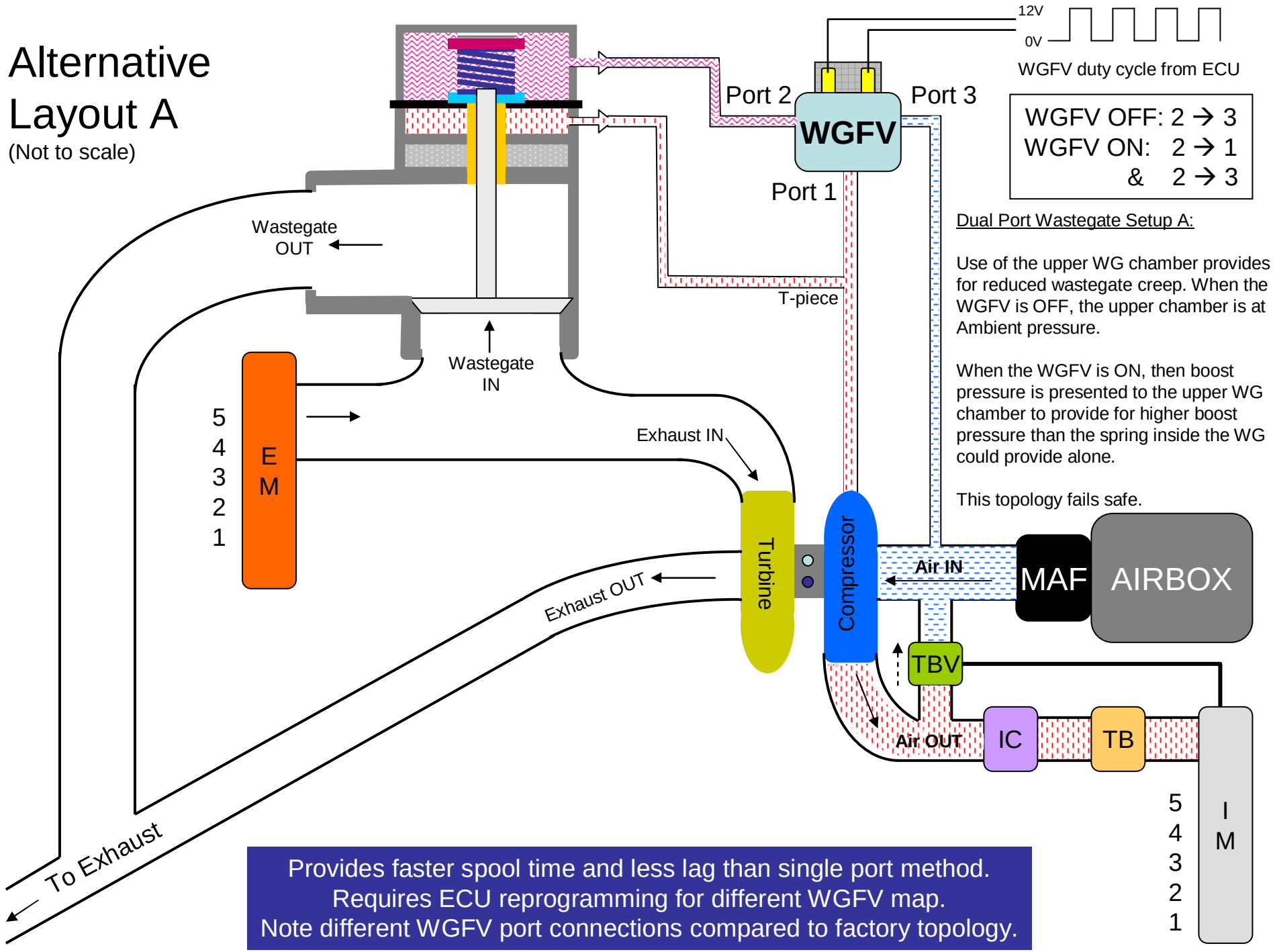
Audi S2 Boost Control Logical Layout

(Not to scale)



Alternative Layout A

(Not to scale)



Dual Port Wastegate Setup A:

Use of the upper WG chamber provides for reduced wastegate creep. When the WGFV is OFF, the upper chamber is at Ambient pressure.

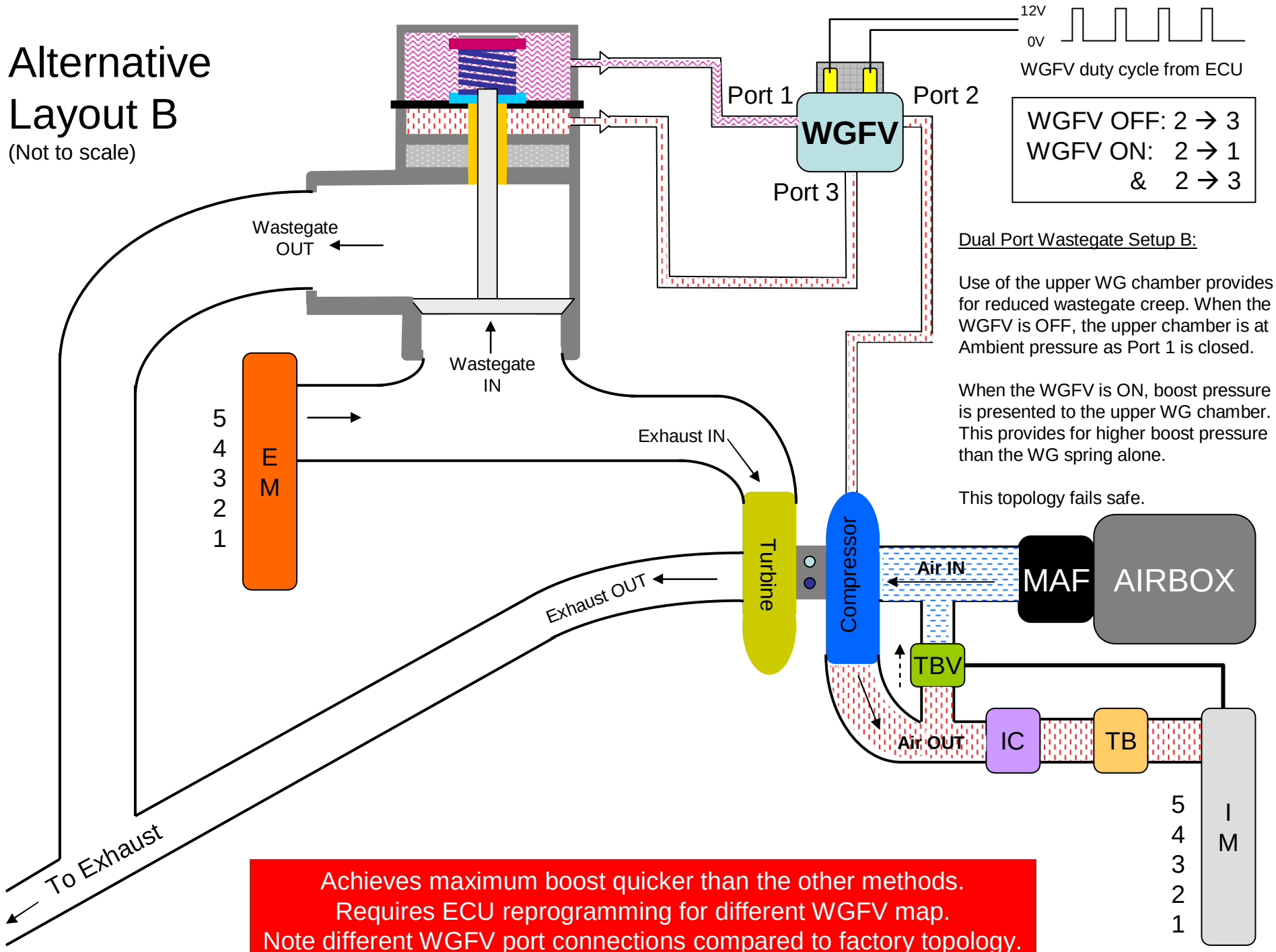
When the WGFV is ON, then boost pressure is presented to the upper WG chamber to provide for higher boost pressure than the spring inside the WG could provide alone.

This topology fails safe.

Provides faster spool time and less lag than single port method.
Requires ECU reprogramming for different WGFV map.
Note different WGFV port connections compared to factory topology.

Alternative Layout B

(Not to scale)



Dual Port Wastegate Setup B:

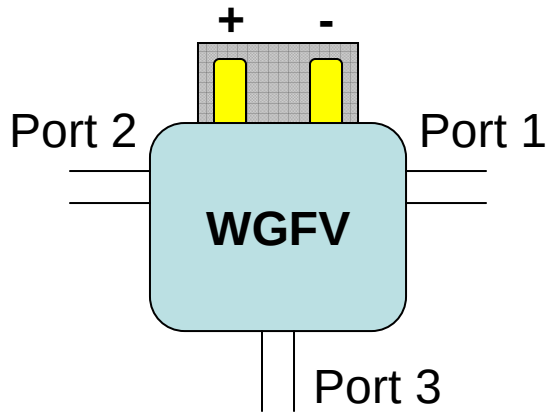
Use of the upper WG chamber provides for reduced wastegate creep. When the WGFV is OFF, the upper chamber is at Ambient pressure as Port 1 is closed.

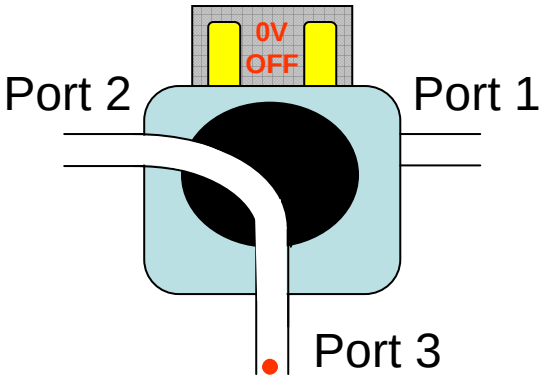
When the WGFV is ON, boost pressure is presented to the upper WG chamber. This provides for higher boost pressure than the WG spring alone.

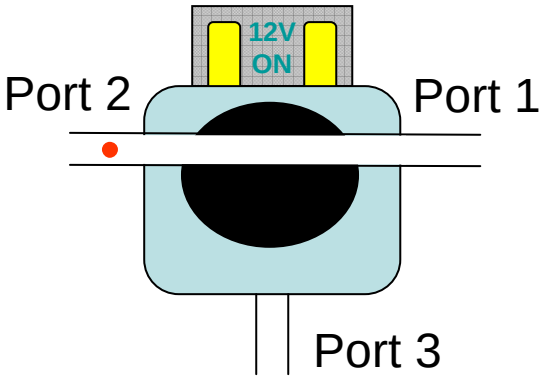
This topology fails safe.

Achieves maximum boost quicker than the other methods.
Requires ECU reprogramming for different WGFV map.
Note different WGFV port connections compared to factory topology.

Turbosmart eBoost Solenoid Valve (TBSV)







- Consider this aftermarket device, as sold with the Turbosmart eBoost kits. It is an alternative to the factory solenoid. The principles of operation are largely the same but the pneumatic toplogy is **NOT** identical to the factory item.
- Consider the function of the TBSV in the normal ‘single port’ topology for wastegate control on the S2.
- When the TBSV is in the OFF position (or disconnected from the ECU) the air path is from Port 2 to Port 3. This means that with the ECU not being involved, the TBSV ‘steers’ boost pressure directly to the lower portion of the WG chamber. As such, the wastegate will provide boost control at the limit set by the mechanical spring. ***Identical to factory WGFV when OFF.***
- When the TBSV is in the active or ‘ON’ position it provides an air path from Port 2 to Port 1. In this scenario then ambient (or slight vacuum) air pressure is presented to the lower WG chamber and so the mechanical spring continues to keep the WG closes. ***This is significantly different from the factory WGFV when ON.***
- For this reason, care is required to program an ECU in the more aggressive dual port topologies. Essentially a much reduced duty cycle is needed to achieve target boost. Additionally, a weaker WG spring may be advantageous so that a useful dynamic range of modulation control is provided under software control.