Searching and finding the root causes of the TCT gearbox.

All information is only intended for DIY's who have sufficient experience with car mechanics and electronics. If you have little or no experience, do not start and go to a certified Alfa Romeo 4C center.

Always bear in mind that misinterpretation and/or actions can lead to the destruction of components that can lead to dangerous situations.
The manufacturer's instructions for use and maintenance must be followed at all times. The service manual is the guiding document.

All actions you do yourself are at your own risk.
This information is purely informative!

Safety first!

Introduction:

Since 2015 I am the happy owner of an Alfa 4C and now have more than 70,000 km on the clock.

A few months ago I started having problems with the TCT and code P294D-18 – "salespeed electric pump – current too low/below threshold". This error code only occurred in manual mode and not in automatic mode. Because we had planned a holiday shortly afterwards, I replaced the electric motor, the hydraulic pressure accumulator and the electric control module of the pump. After more than 1000 Km without problems, I got the same error again, however, only in manual mode. When I got home I started reading all the reports on this forum related to gearbox and TCT problems.

And, it drove me crazy, because apparently no one managed to find the real cause of the various problems…

WWW : Why? What? Where?

Plan of action:

Troubleshooting is always a combination of knowledge and art. Actually, there are two methods to find an error. Try and error or (quick and dirty). Replace certain parts and then see if the problem is solved. Sometimes this is a good method and if you have a whole stock of parts this can be the quickest solution, but you also need a lot of luck. However, if there are several causes, this can become a very expensive solution and you still don't know "the why" at the end of the story.

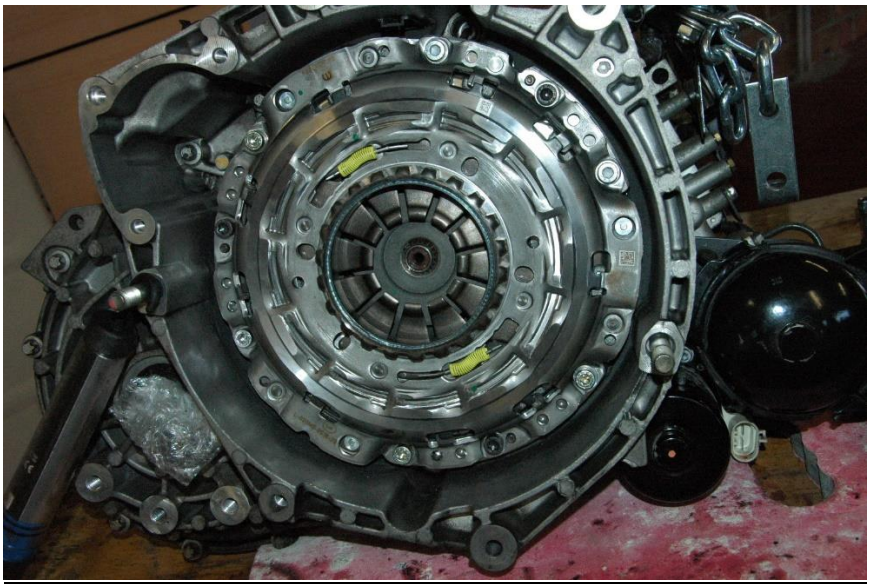
A second method of finding errors is the elimination method. Targeted testing of parts and then possibly repairing or replacing parts. This is not the fastest method and you also need the knowledge and the tools to test the different parts.

To avoid going round in circles, you need a good plan of action.

The first step in my plan was the clutch.

With 70,000 Km on the clock, it seemed a good idea to check the health of the current clutch and replace it if necessary. This is quite an operation because the engine has to be removed and replacing this clutch is not easy either.

The working method is already well and sufficiently described in the service manual and on this forum. So, I'm not going to go into that here.



New installed clutch.

Recommendations:

Replace not only the clutch but also the master cylinder (even gear CSC) and the clutch position actuator (odd gear CSC) PDF page 697 - 698. These can only be replaced when the engine has been removed. The clutch and both CSCs are also sold together in one kit. The odd gear CSC is on the outside and also has the clutch position sensor, which can be replaced and/or tested separately if necessary. See also my other contribution on this forum,
"Testing and repair of clutch position sensor"

Those who regularly ride on the track can consider an upgrade clutch,

Brand:	AlfaWorks
Description:	CLUTCH. *Lightened clutch kit for manual gearboxes* *(**to be used with flywheel 1750MFLYW**)* *• Includes x6 mounting bolts* *• Can take over 750nm so will be able to take the power output of even the most powerful 2.0 litre engine conversions*

Alfa Romeo 4C Clutch (alfaworkshop.co.uk)

I used the standard clutch kit.

After successfully replacing the clutch, it turned out that the problem was still present and I kept getting the same error codes.

What are the other possible causes?

Since the error only occurs in manual mode, the steering wheel controls, DNA switch, AUT/Manual – 1 N – R switches and CAN bus connections between Body computer – TCU and ECU were checked.

Everything was in order and so I came closer and closer to the TCT or as it is called in the service manual, The Complete Actuation system (CAS)

The Complete Actuation System – CAS:

Since I was lucky enough to get my hands on a complete unit that the seller said had been repaired in Italy, I was able to completely disassemble my unit to see what could be wrong.

It actually consists of 3 components:

1. TCU the transmission control unit the Magneti Marelli TCT computer CFC 8TDW.01
2. The hydraulic power unit
3. The Complete Actuation Module (CAM)

1 .The TCU:

- Magneti Marelli TCT computer HW version CFC 8TDW.01. The hardware version of this computer has never been changed.
- The SW version has been changed several times. The latest version in Europe is EF16L188 V.000

2. The hydraulic power unit: **“A device is only as good as its power supply”**

• The electric motor.

This is connected to the mechanical oil pressure pump. The error code P294D-18 therefore points in this direction. The oil pressure in the system must be between 44 and 55 bar. The electric motor does not rotate constantly but is connected to the TCU through an electronic circuit and is PWM controlled. It is the TCU that determines, based on pressure sensors, when and for how long this pump should run.

This can be tested by connecting it to the battery 12V DC and measuring the current in free-run. This current is then around 1.8A - 2.2A. (current is different when reversing the connections, measured value is the lowest one. The sound the motor makes says nothing about the condition. A new one will make even more noise because the contact brushes brand new.

• The accumulator

So the black sphere actually functions as a storehouse of hydraulic pressure.
This black sphere has an internal membrane with the oil on one side and a space with nitrogen on the other side at a pressure of about 2 bar. The latter was done to better absorb the pressure fluctuations in the hydraulic circuit. This membrane could eventually pulverize or rupture. The component itself is difficult to test and it is therefore best to replace it every 5 to 8 years…?

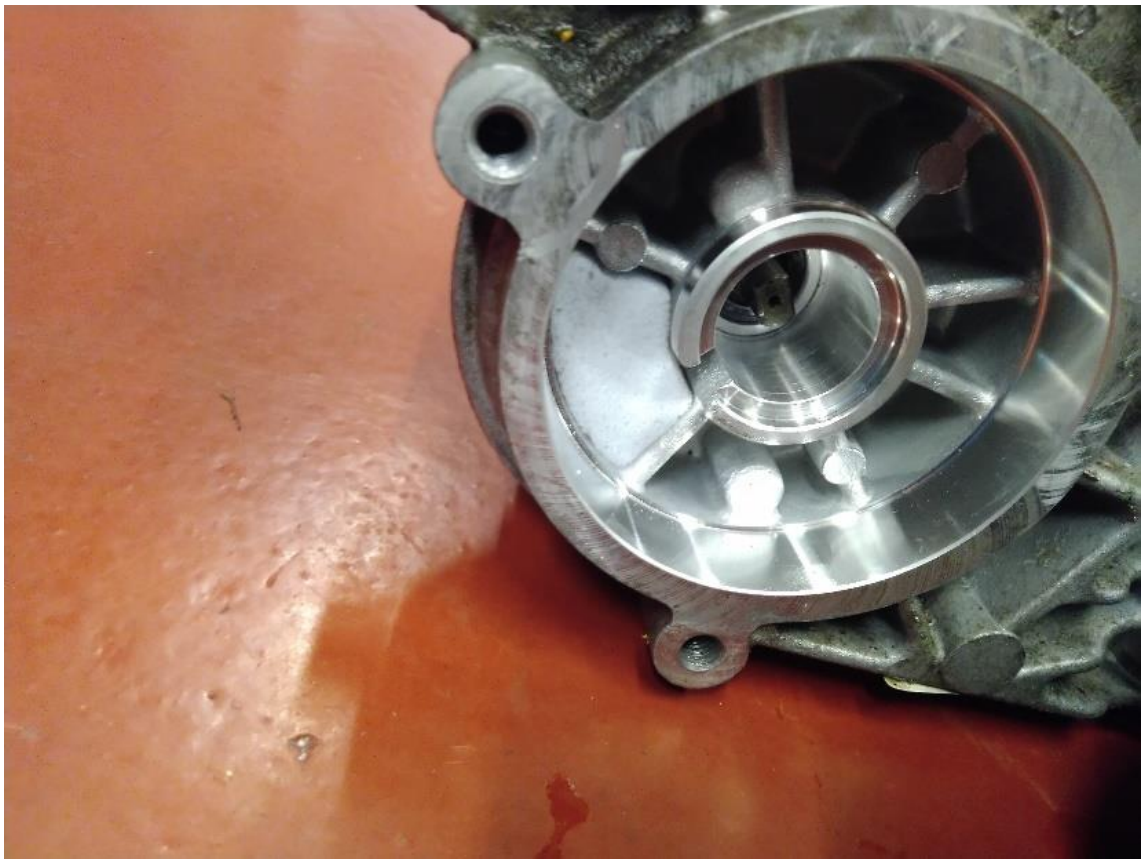
• And then there's the filter.

This filters the oil coming from the reservoir before it enters the hydraulic pump. This system is therefore at low ambient pressure, +- 1 bar.

This filter is available separately and can be easily replaced. According to the service manual, it should only be replaced every 120,000 km. This is downright ridiculous. My suggestion is to replace it at least every 30,000 Km.

• And then there is a second oil filter.

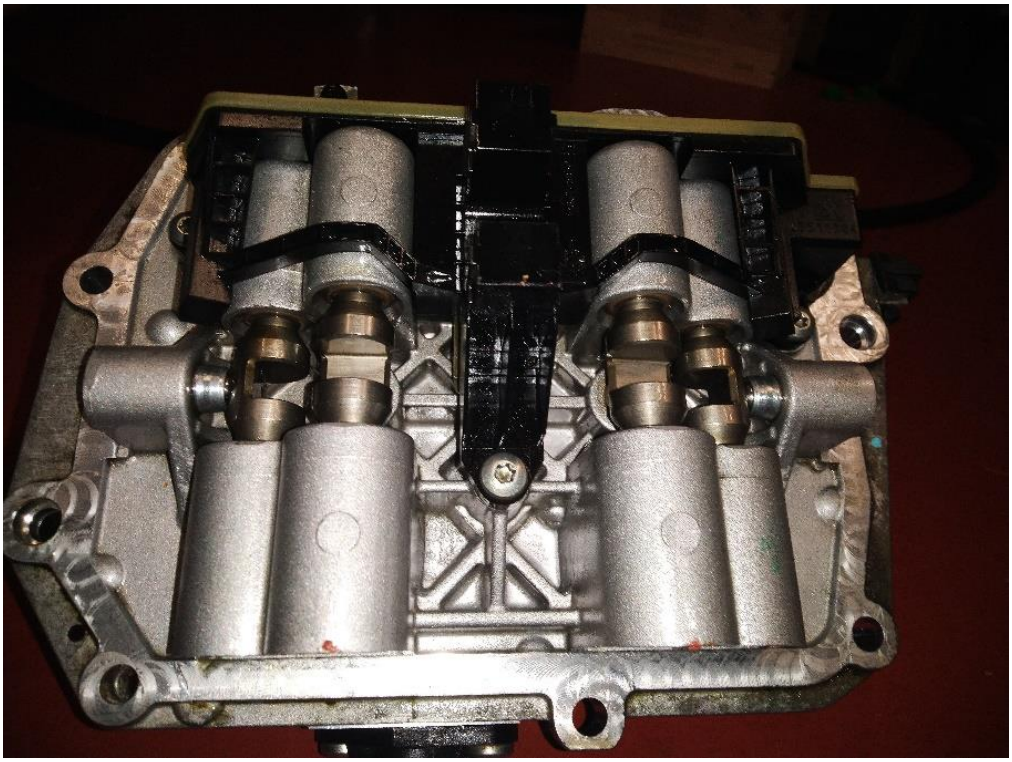
This is well hidden behind the mounting connection of the electric motor. When disassembling this electric motor, you will see a small white moose on the chassis. You can easily remove this and use it again after cleaning.



3.The Complete Actuation Module (CAM)

This is the most complex module. The operation of this module is described in detail in the manual.

I will go into more detail below about how the individual parts work and how they can be tested.



Measuring is knowing!

Pressure sensors: External

The hydraulic kit line pressure sensor and the K2 CSC pressure sensor are two identical sensors. Apart from an ordinary resistive Ohm measurement, you can't really test much because it is difficult to generate a pressure of 44 - 55 bar somewhere. However, these are available separately, but my suggestion is to first exchange them and check the parameters of the OBD tool to see if the pressure measurement is OK.

Shifter selector position sensor: External

This sensor measures the position of the clutch using a so-called Hall effect sensor. This is actually a chip that generates electrical pulses under the influence of a magnet and more specifically the position of this magnet in relation to the chip. These pulses are PWM, pulse width modulated. The computer then converts these pulses and makes the necessary calculations that are recognizable to the software in the ECU. Apparently the sensor is not available separately as a spare part from Alfa Romeo.

- Manufacturer: TE connectivity's

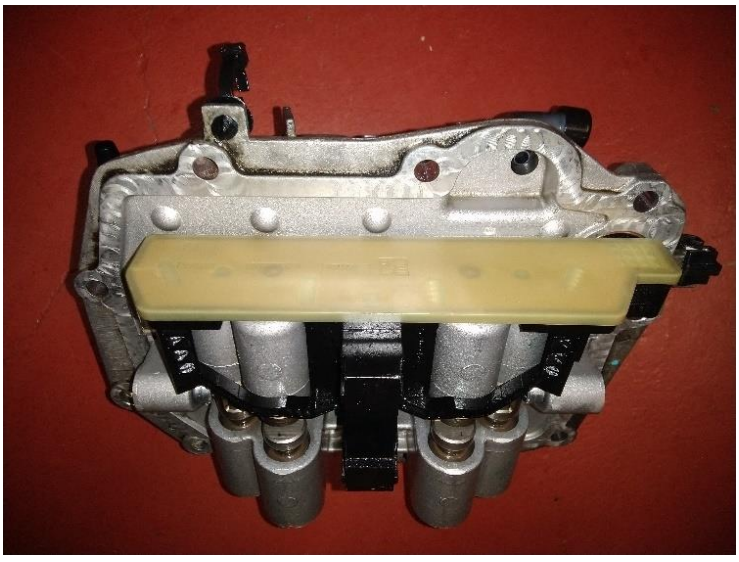
This sensor can also be tested as already described in my other article under the name:
It is a different sensor but the principle is the same.

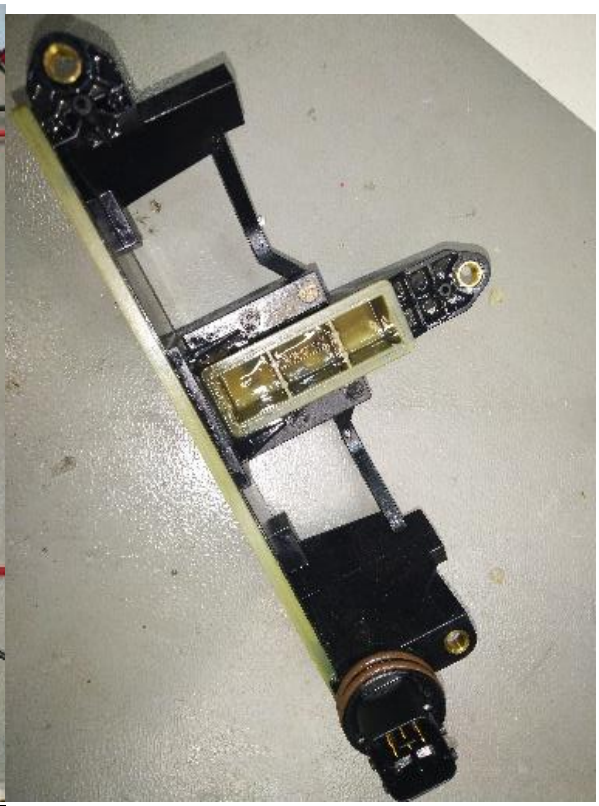
"Testing and repair of clutch position sensor"

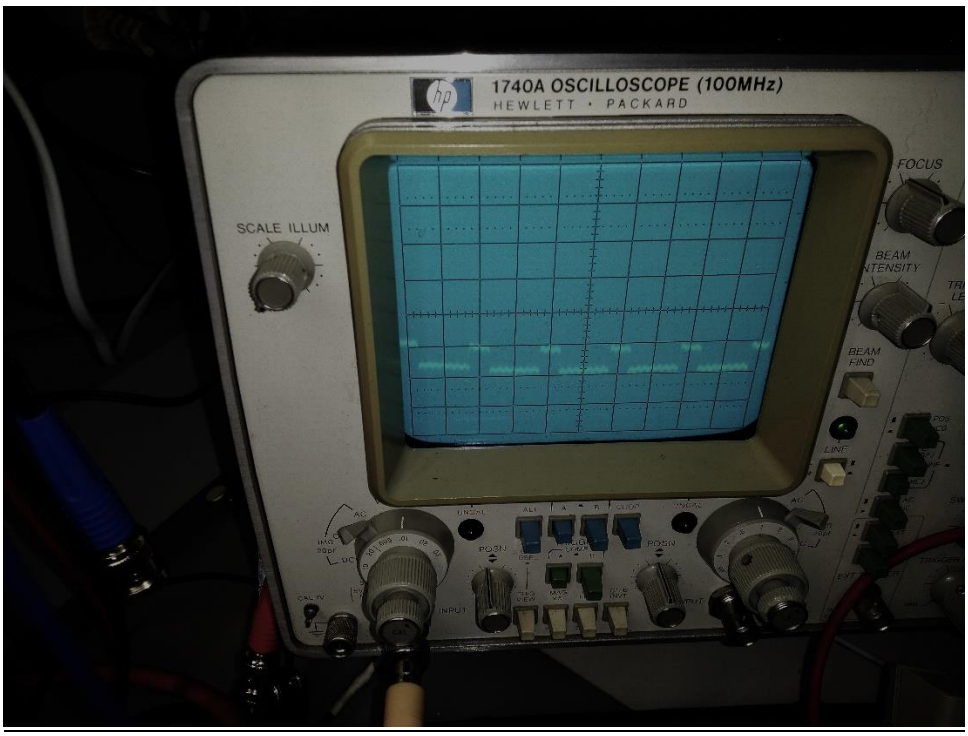
Integrated sensor module: Inter

• 5 position sensors for the different gears
• Even and Odd clutch speed sensors
• Temperature sensor.
• Manufacturer: TE connectivity's.

1308086-3-transmission-sensors.pdf (te.com)







This complete module cannot be obtained separately. The position sensors also work on the basis of Hall effect and can also be tested. You do NOT have to disassemble the module and therefore also the CAM. You can test them along the connector on the CAM. Connections are described in the service manual. PDF page no. 714.
Electrical wiring see PDF pages 578 – 579.

Attention errors in the manual!

• The designation of Pressure solenoid valve L114 and L113 has been switched on the schematic.

• Pressure sensor names K223 and K222 have been switched on the schematic.

Please note, it is only the names that are incorrectly indicated on the diagram. The numbers of the connections are correct and therefore the complete cabling is also correct. However, if you were to check the connections according to the schematic, this would cause confusion!

The supply voltage for testing these sensors is 5V DC and therefore NOT 12 V DC!

For the testing itself you need an oscilloscope, a 5V DC adjustable power supply and a normal magnet. If you move the magnet near the sensor you will see the PWM, Puls width will change. You will notice that this is sensitive to interference, you will see the signal on the oscilloscope dancing up and down sensitively. However, this is normal as it is taken care of by the TCU.

You can also test the RPM speed sensors with a normal magnet. By moving it near the sensor you will see the dc voltage of the signal change.

This simple test therefore indicates whether the sensors respond, but does not indicate whether they respond accurately. The threshold levels are also adjusted by the TCU during calibration.

In my estimation, these sensors and the entire internal module are very reliable and unlikely to be the cause of the various problems.

<u>The solenoid valves:</u>

I've noticed in the various discussions on the 4C forum that there is a lot of confusion with the naming. The service manual describes the CAM, Complete Actuator Module. This is the actuator unit with a total of **5 separate actuators**.

In the description of the CAM in the manual, however, one speaks of the **solenoid valves instead of actuators.**

<u>Below I describe the operation and testing of the solenoid valves.</u>

Important to know is that these valves are **NOT ON – OFF types** but they work **proportionally**. The relationship between the electric current passing through the solenoid and the opening of the valve is described on pdf page 718 of the manual.

<u>There are two different types. Manual pdf page 718</u>

• Capacity solenoid valve: K1 (odd gears) only one.
Electrical resistance of the winding +/-2.5 Ohm.
This is a valve that controls the flow of the oil. So it is not a pressure control valve.

• Pressure solenoid valves: Four valves, K2 even gear clutch, V1 gears 3-2-R, V2 gears 1-6-4-5 and VS shifter.
Electrical resistance of the winding +/-2.6 Ohm.

These valves are built by Magneti Marelli. They are **very specific to the Alfa 4C** and to this day are **not available separately from Alfa, nor from Magneti Marelli!**

Although they are very similar to eg. those used in different Fiat cars with TCT (Punto, 500, Abarth) are therefore **not compatible**!

To better understand how these valves work I used some valves from a **Fiat 500** and completely disassembled them.

You can see the different parts in the photos. It actually consists of a cylinder with an internal piston. This piston moves up and down in the cylinder under the influence of a force. The control of flow or oil pressure is therefore created by more or less closing off the flow holes. The force required to move the cylinder is generated by a solenoid, which in turn is controlled by the TCU. There are small springs on both sides of the pistons.

It is very important to understand that these valves are **mechanically calibrated in the factory**. This is done by turning a screw on the end of the cylinder in or out more. This regulates the force on the internal springs. The calibration point used is to control the amount of electrical current passing through the solenoid so that the valve is properly centered. For example, if you know that the calibration point is 0.5 A DC, then with an adjustable DC power supply you can set the voltage, and therefore the current, to 0.5 A and then adjust the adjusting screw so that the valve is in the middle. By controlling the current through the solenoid you can also see if the piston can move up and down nicely without bumping or faltering. You can check the other 4 pressure solenoids and compare the current value. If the difference is more than eg. 50 mA, there is a problem.

Below is a picture of the valves used on the 4C

On the end of the cylinder you can see the calibration screw that is sealed.

What could go wrong here??

• Mechanical hitches due to wear of the cylinder and/or piston.

• Staggering due to dirt, the polluting particles can be very small!

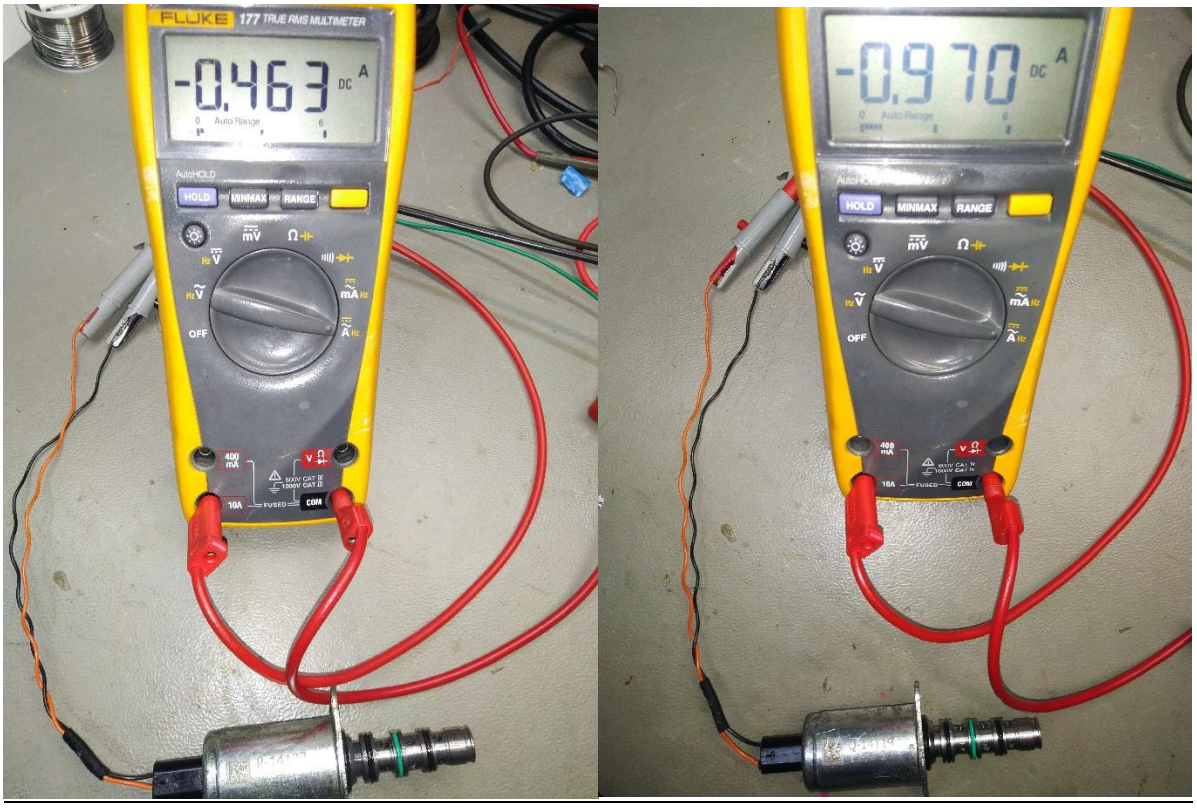
• Due to wear, the internal springs have aged and the mechanical calibration is no longer correct.

• Solenoid coil is burnt out.

• The external O rings no longer close properly.

You can also test the solenoids with an Ohm measurement, but then you don't know anything about the calibration or hitches.

When testing different valves coming from a TCT 4C I can conclude that the calibration current of the pressure types is +/- 470 mA and that of the capacity type is +/- 950 mA. However, these are guide values, but according to the curves in the manual, they can be correct.



The Shifter: pdf page 710.

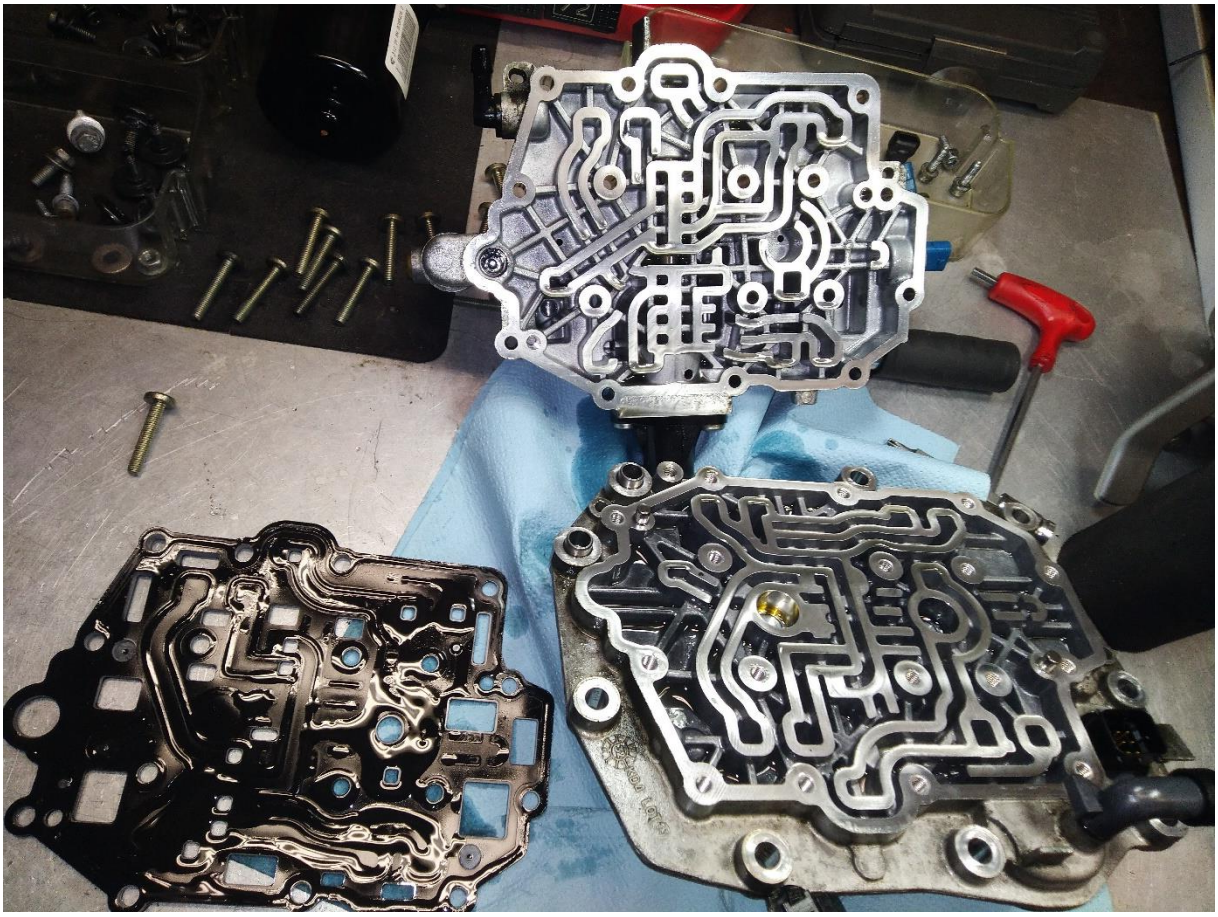
This is actually a piston that moves in a cylinder under the influence of high oil pressure. The external spring ensures that the piston is pushed back to its starting position if the pressure drops.

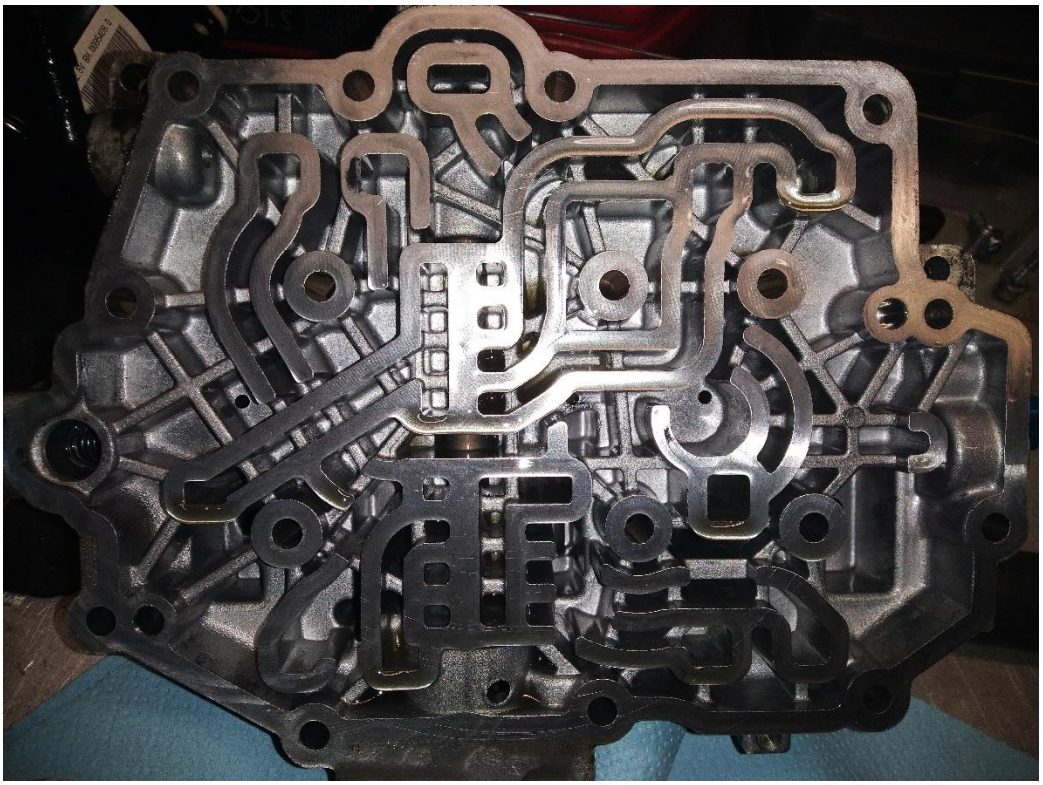
There are no o-rings or other seals around the piston. Only extreme dirt or heavy mechanical damage can block the shifter. However, a weak spring can affect proper operation.

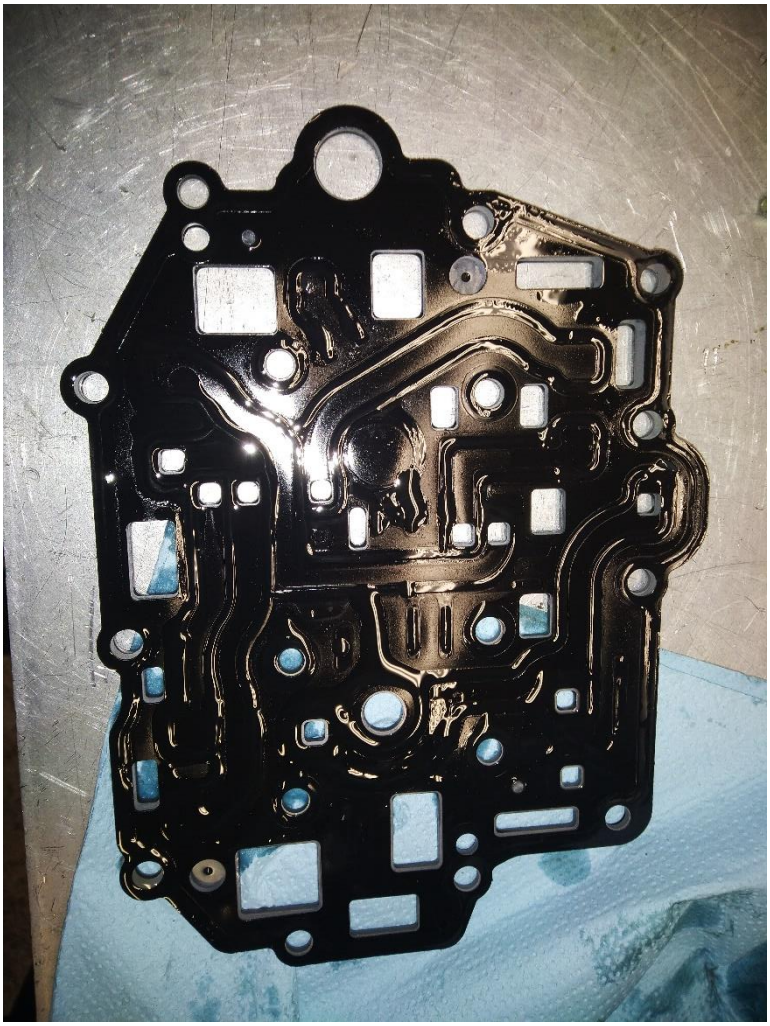
The Labyrinth: pdf page 710 - 711

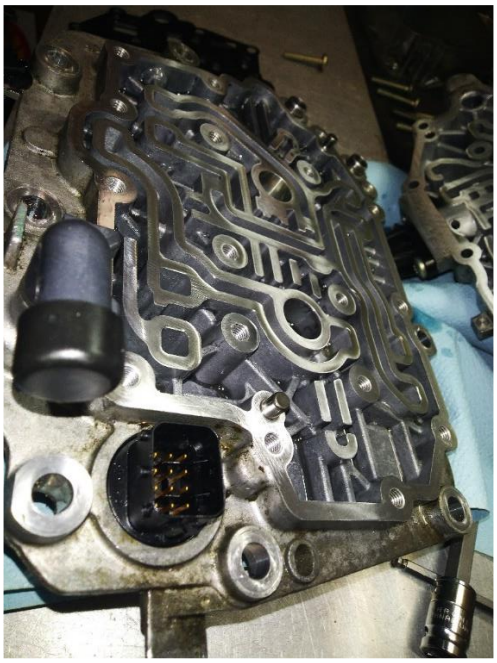
This is the complete housing consisting of two parts joined together by a double gasket. The channels in this labyrinth are sufficiently large and accumulation of dirt is less likely. A bad gasket can cause problems. The screws with which the two parts are screwed together can be checked. My suggestion is to tighten it to 18 – 20 Nm max.

The screws are not secured in any way, so be sure to check whether they are all still tight.

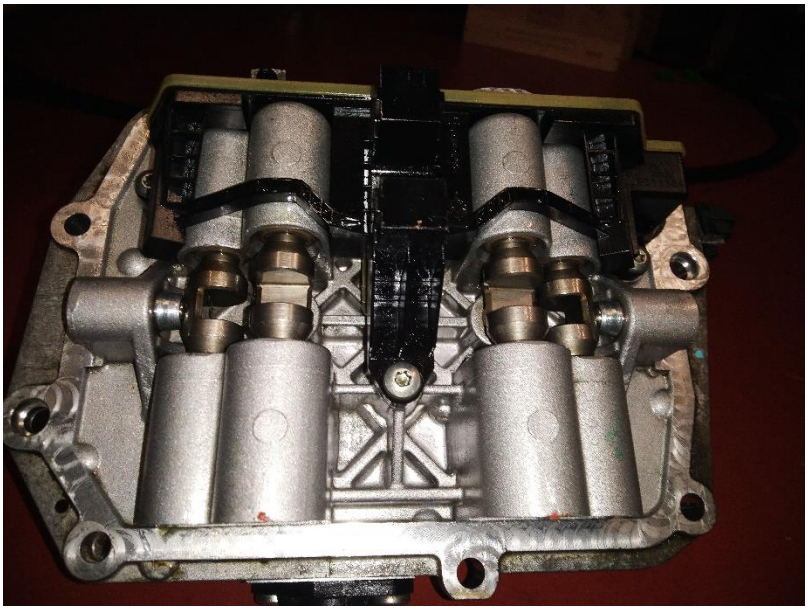








Gear engagement actuators:
See service manual Pdf page 711



This is the mechanical control of the gearbox. Each activator consists of a piston that moves left and right in a cylinder. These cylinders are driven under high pressure along the labyrinth. The principle is that if one side is under high pressure, the other side will decrease the pressure and switch over. This is all controlled by the pressure solenoids.

Pressure loss can occur in these cylinders due to wear. It is more difficult to disassemble it and I would not disassemble it with a normal inspection. In addition, the parts for an overhaul are not available at this time.

OBD Tools and calibration software:

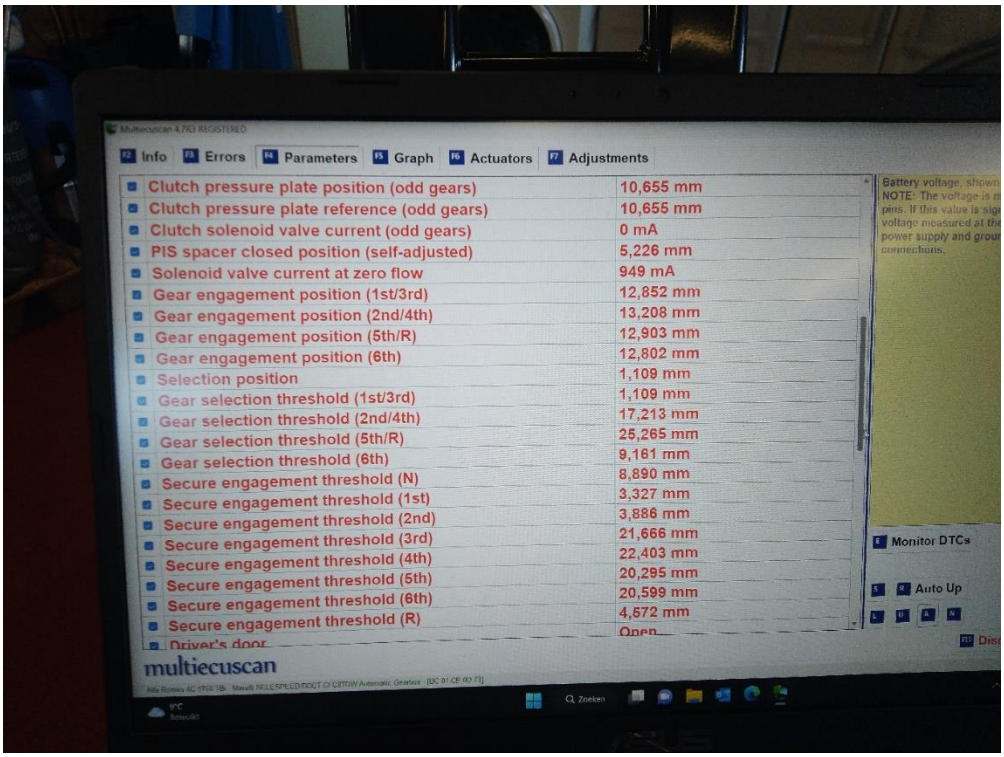
I use the Multiecuscan 4.7 and have had very good experiences with it so far. Despite the criticism of this tool on this forum, it is a very good tool. One needs to understand how these (and also other OBD tools) work.

This software is actually an MMI, human-machine interface to the TCU, transmission control unit. That is, the tool uses the software present in the TCU, the on-board TCU SW. It is therefore very important that you have the latest factory software update in order to perform a correct calibration. The latest version of the SW in Europe is EF16L188 version 0000. (The numbers are different in the US.)

So, to clear up a big misunderstanding, the calibration software is NOT located in the OBD tool, but in the flash EPROM of the TCU!

The HW version CFC8TDW.01 has never been changed. Alfa service centers use the wi TechPlus and connect it to Alfa's database in Italy or the main distributor in the country of sale. The latter is very important because it is the only guarantee that they will also see all updates when they connect to the OBD bus! So a service center using other tools will never see the latest version of the TCU SW update and will not be able to upload! Once you are sure that you have the correct version, you can calibrate perfectly with the Multiecuscan.

The most important parameters related to the clutch, after an initial "end of line calibration" with the Multiecuscan OBD tool.



Prevention is better than cure!

Yes, we all know that, it is remarkable that nowhere in the manual does Alfa's service program mention maintenance of the CAM. Just replace the oil of the robot at 120,000 Km…?

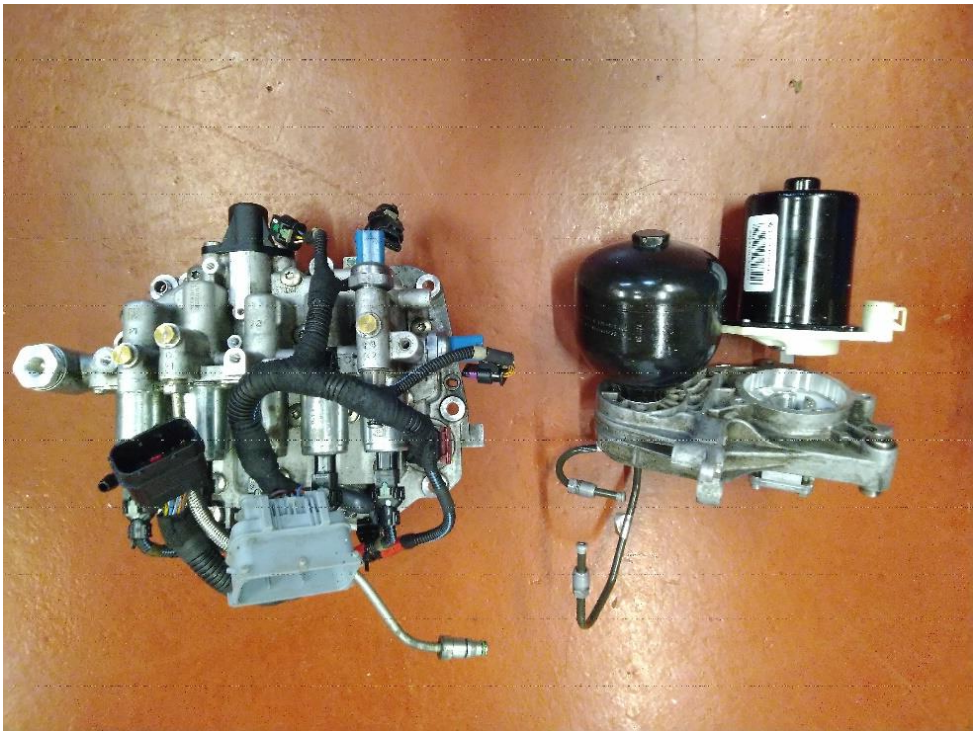
At least it is clear to me that many problems can arise from pollution of the oil, let alone that pollution can come in when refilling this oil.

My suggestion is to change oil and filters at least every 30,000 km.

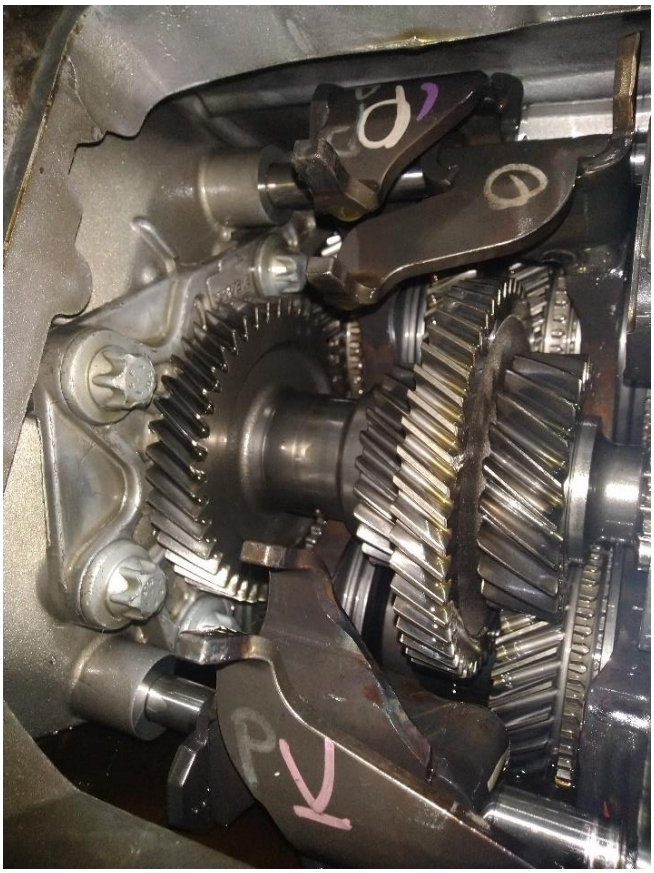
Even better would be to give the CAM a full service at the first indication of errors. Ultrasonic cleaning of the cylinders of the Pressure and Capacity solenoid valves seems to me to be a good option. It would be even better to simply replace the solenoids with new ones in the long term, but that is wishful thinking for now.

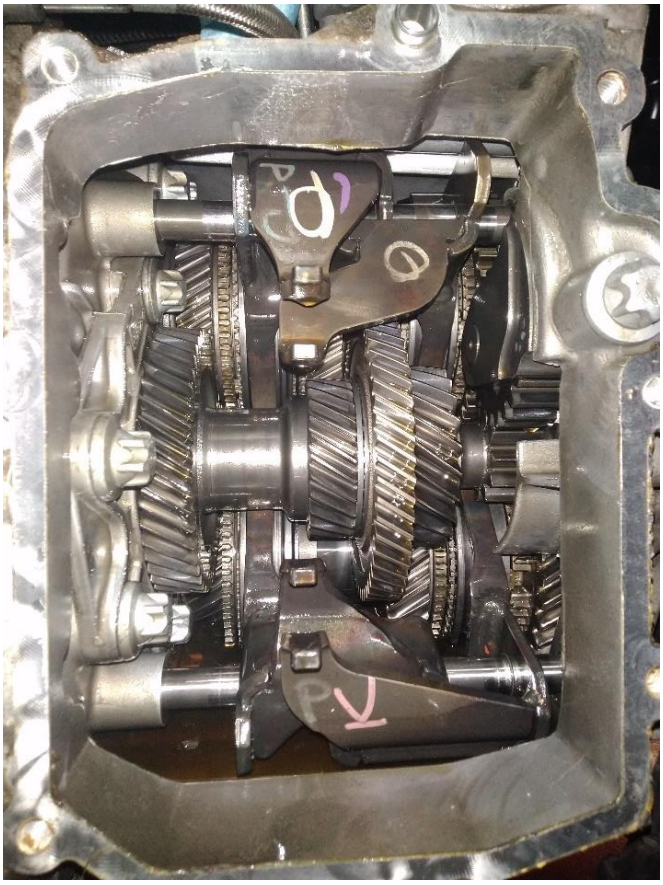
A completely new TCT Unit consisting of the hydraulic power unit and a complete actuator unit, CAM. (Picture 4C Forum member)

Left side the CAM, Right side the Hydraulic power unit.



Once the CAM or Robot has been dismantled, you can also easily view the gearbox and check for any damage.





Why did I get the errors only in Manual mode and not in AUT?

I don't have a definitive answer to that yet. I assume that in AUT mode the TCU only gives a shift command when all conditions, speed and pressure are optimal.

There are also other elements that determine the proper functioning of the CAM that most of us do not think about….

Accelerator pedal position:

When we press the throttle quickly, there is always a delay in the response of the engine. The TCU also receives information about the position of the accelerator pedal and therefore knows in advance and therefore faster what the driver is planning. This allows it to respond and switch faster, so it can anticipate what is to come.

The position of the accelerator pedal sensor can also be calibrated. I would say do it!

Lateral and longitudinal acceleration sensor:

This is located in the ABS module and also provides information about the angle the vehicle is making. This is important for the TCU to know if you are riding uphill or downhill. This is very important to calculate the correct switching moments.

My understanding is that as a driver in manual mode we give the shift command whenever we feel like it, whatever the circumstances. Especially on the circuit, I can imagine that we like to play with the flaps and enjoy the sensation and the sound as children 😊

Do you also do this in Race mode…. then this can sometimes cause damage.

Conclusions: (couple of)

• To fully and thoroughly test a complex system such as this TCT gearbox, more is needed than just an OBD analysis.

I also fully understand that FIAT and therefore Alfa Romeo advises its service centers to replace the entire unit. Their goal is to ensure that the customer is helped quickly and reliably.

• With all due respect to the technicians, not everyone has received thorough training. In Europe, as a main dealer, you must be 4C certified. This is a condition to be recognized as a 4C service center.

• Replacing a complete TCT Unit, which quickly costs EUR 3000 plus working hours here in Belgium, is relatively easy. You should not disassemble the engine, and very good chances are that the problem or problems are solved.

• We as DIYs are less satisfied with this. For some, the high cost in particular is also the reason why we keep looking for what is wrong. As described above, this can sometimes be a long search and the question is whether you have saved a lot at the end of the ride ...

• If you opt for a complete replacement of the TCT, ask your dealer if you can **keep the old unit!**

I am sure that there are good technicians who are willing to do a restoration of such systems for a reasonable price. In Italy there are already and if you search a bit on YouTube you can find several videos of technicians doing pressure valve restorations and full TCT of the Fiat Abarth, 500 or Punto….
(See links hereafter.)

• We can hope that Alfa will release the various parts of the TCT in due course.

• For those who regularly have fun on the track, a spare TCT unit is the message!

• I now have a spare unit that I will also completely overhaul. Based on the knowledge gained and with what is available of parts on the market.

Suggestions before you start replacing parts, and whatever error code you get related to the TCT:

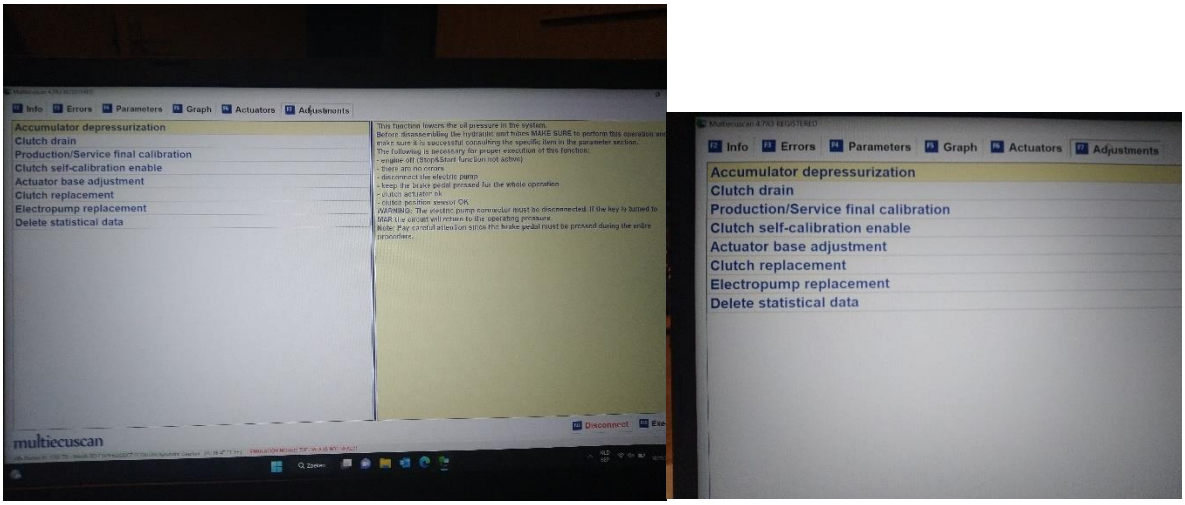
- The battery:
  So far I have not said anything about the battery. I read on this forum that many problems were already solved by simply installing a new battery. Certainly a good idea, but I want to say something more about this. “A device is only as good as its power supply” is certainly the most important law!
  But what happens and what can go wrong?
  The supply voltage is assumed to remain stable at 12 V DC. All computers have internal voltage stabilizers for 12V and 5V on board. As long as the voltage of the battery remains above 12 VDC, there is actually no problem for the proper functioning of the computers. This voltage can drop due to bad contacts and therefore loss.

When you start the engine , the voltage will drop and the loss will depend on the condition of the battery and the possible losses due to bad contacts. During this short time, the computers will detect and store various errors in their memory. Most error codes disappear after a few seconds, at least if there really are no errors. As a result, you may see errors during the OBD error analysis that were actually generated by the starting process and a possible bad battery. Check also the condition of the alternator by measuring the charging current!

That is why it is very important that you are sure that the battery is in good condition during an OBD analysis**.**
It is even recommended that you connect a battery charger during an OBD analysis and certainly during the calibration process or installing a SW update!

- OBD analysis
  Since I use the Multiecuscan myself, I can't say much about the other tools. It is important to use a tool WITH an official license. What I find particularly useful with the Multiecuscan is the possibility to dynamically monitor certain parameters and error codes. You can choose these parameters yourself and then record them during a test drive.
  Afterwards you can make a detailed analysis.
  Look ahead during the test drive and don't look at your computer screen!
  If you succeed in reproducing the error afterwards, you can monitor certain parameters and error codes (depending on the problem) during the test drive.
- Check parameters such as Hydraulic pressure (must be between 44 and 54 bar)
- **Before you start working on the hydraulic unit and change any parts, do the accumulator depressurization!**
- Use the oil recommended from Alfa as described in the manual or use a better one.
- Replace the hydraulic oil and filters.
- Do a complete new calibration as if the complete CAM , the clutch, actuators, electric motor, have been replaced. This will reset all parameters and set new reference levels. It is important that this is done with the latest SW update in the TCU. Don't forget to delete all data in the TCU first. A regular calibration will not write down the old data in the TCU.
- If the same error codes still appear afterwards, one should remember to replace the entire CAM or have it overhauled.

Some screenshots Multiecuscan OBD Tool:



For those who think this is a typical Italian Alfa Romeo problem…. Well those are wrong!

- Principle was invented by the French engineer Adolphe Kégresse in 1939
- First introduced on the Hillman Minx in 1961
- Applied to the Porsche 956 in 1983 on the Le Mans circuit
- Applied in 1985 to the Audi Sport Quattro S1
- First mass production by Borg Warner (USA) and applied to the Volkswagen Golf series in 2003

I certainly don't want to pretend to be “The expert” after this experience.
My intention is to share this knowledge and experience with those who have the Alfa Romeo **“Quadro folio” heart in the right place.**

I hope to have succeeded or at least made a small contribution for those DIY's who want to take on this challenge themselves...

Good luck and have fun… especially if you succeed!

Erik Van de Voor

Rikiduc

Sources and additional info:

Revisione Mecatronica e gruppo idraulico cambio automatico doppia frizione GiuliettaTCT - YouTube

Ajuste de solenoide EV0 Com a Queridinha GPP - YouTube

1308086-3-transmission-sensors.pdf (te.com)

Dual-clutch transmission - Wikipedia

BorgWarner - Wikipedia

FPT C635 DDCT transmission - Wikipedia