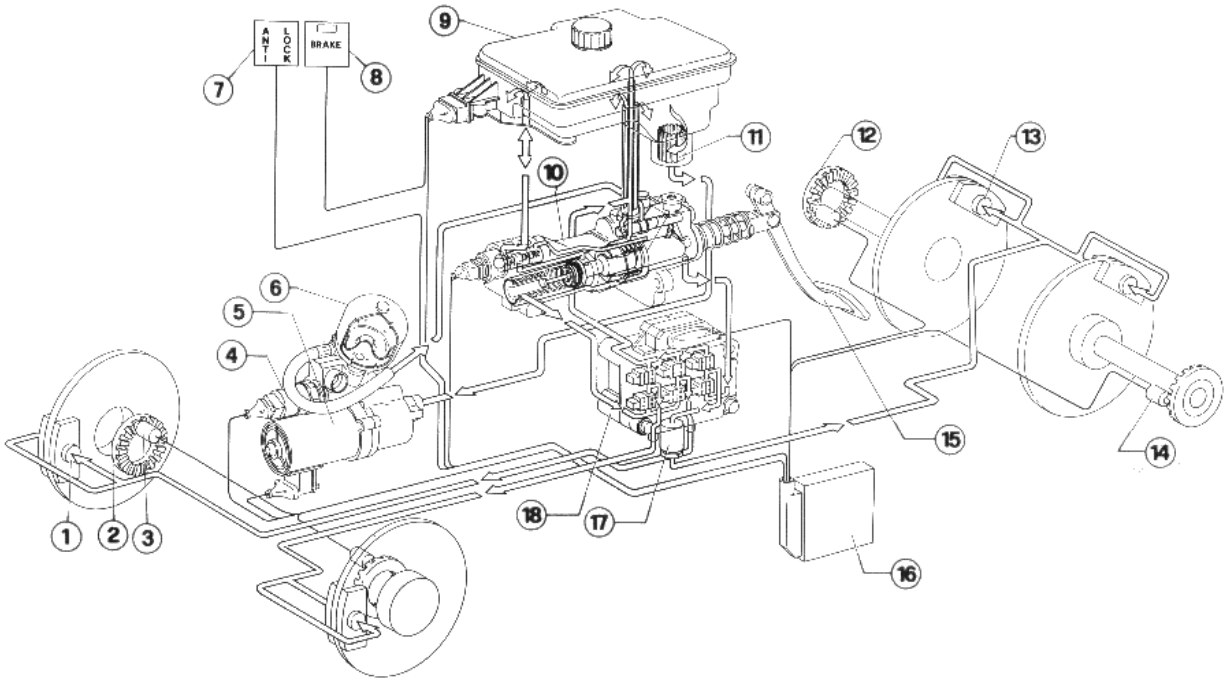
Debugging the ABS system

by Shiv Sikand, John Fox and Rich Hirsch

The 75/Milano uses a Mark II ABS system from Alfred Teves in Germany, commonly known as ATE. It is an excellent system, and a "true" ABS system. It is used by SAAB, Mercedes-Benz, Jaguar and also in the Merkur Scorpio and some years of the Lincoln Town Car.



1 Front brake caliper
2 Front impulse emitting wheel
3 Front impulse pickup
4 Min/max pressure switch
5 Electropump unit
6 Accumulator
7 ABS MARK II system warning light (antilock system failure)
8 Brake fluid minimum level and brake pad wear warning light on AR CONTROL electrovalve unit
9 Brake fluid tank
10 Brake master cylinder and hydraulic operating cylinder
11 Filter
12 Rear impulse emitting wheel
13 Rear brake caliper
14 Rear impulse pickup
15 Brake pedal
16 Antilock system control unit
17 Brake pressure adjusting valve
18 Braking pressure modulating

Figure 1. Alfa's ABS brake system

ABS systems use a combination of electronic and hydraulic systems to modulate the brakes individually to prevent them from locking. Antilock systems basically consist of wheelspeed sensors, a hydraulic control unit (HCU), and an electronic control unit (ECU) - see Figure 1. During braking the wheelspeed sensors measure the rotational speed of the wheels and forward this information to the ECU. If the ECU determines that one wheel is decelerating at a much greater rate than another (indicating that the brake is about to lock), the ECU directs solenoid valves in the

HCU to open to release hydraulic pressure to the brake until the rotational speed of the errant wheel matches the others.
The problem with this system in the 75/Milano implementation is that Alfa did not implement all the diagnostic and self-test features that were available, just the brake functions - so testing the system requires some external measurements, rather than reading out an electronic "trouble code". ATE is now on to MKIV, but the guts are pretty similar. Because of the complexity of the system, when the engine is started, a self-test sequence occurs. If the check is successful, the **ANTILOCK** light will extinguish in around 2 seconds. If some component fails to check out, one or both lights will remain lit or take longer than 2 seconds to go out. One or both warning lights may also come on while driving, also indicating a problem. If just the **ANTILOCK** warning light comes on, some ABS component gone out of spec, but the car still has power-assisted brakes. If both the **ANTILOCK** and **BRAKE** lights come on, the car is without power-assisted brakes, which is very dangerous. If just the **BRAKE** warning light comes on, this may be caused by low brake fluid or worn brake pads.
The ABS system Alfa uses is of the 3-channel variety. This means that hydraulic pressure is supplied to both rear brakes as if there were only one, although wheel speed is measured at all four wheels. One of the more interesting aspects of the ATE ABS system is how power-assist is provided to the brakes. The ATE ABS system uses an electric pump to pressurize brake fluid to provide power assist. and this is the source of many problems with the system. The pressurized brake fluid is stored at 180 bar (2650 psi) in a reservoir known as the accumulator. From the accumulator the high pressure fluid is supplied to the hydraulic operating cylinder in the master cylinder assembly. When the brakes are applied, a lever connected to the brake pedal lets in varying amounts of the high pressure fluid to assist in stopping the car.

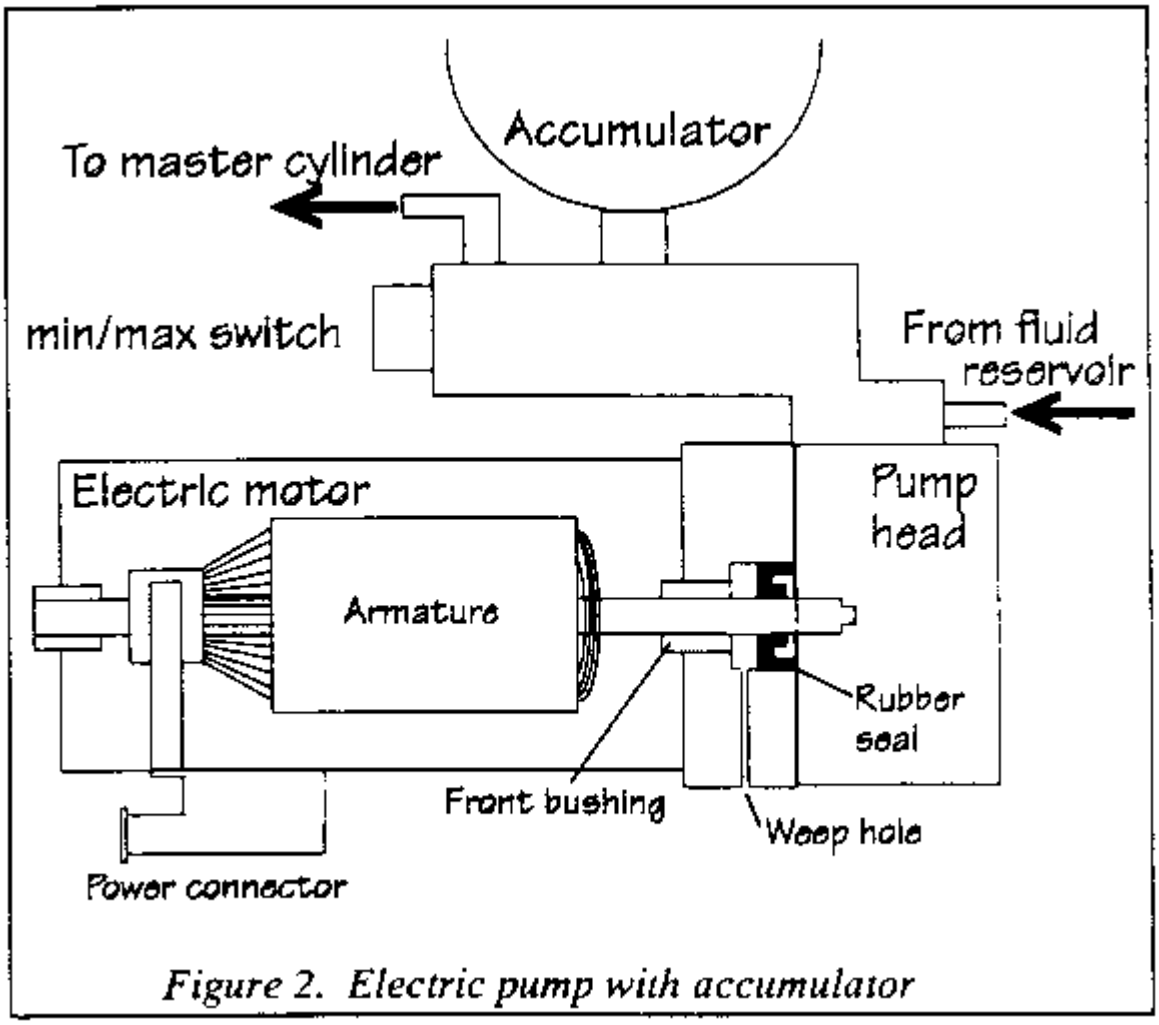


Figure 2. Electric pump with accumulator

As mentioned earlier, Alfa's ABS system consists of three hydraulic brake circuits. Each of the circuits is controlled by two solenoid valves - a load valve, normally open, and a drain valve, normally closed. When the ECU detects one wheel decelerating at a rate much greater than the others, the ECU closes the load valve and opens the drain valve for that wheel to bleed off hydraulic pressure and prevent lockup. Once the imbalance is corrected and the wheel is decelerating at roughly the same rate as the others, pressure must be reapplied to the brake caliper to help stop the car. This is accomplished by closing the drain valve and opening the load valve. But we have a problem here. If we have to depressurize and pressurize a brake caliper repeatedly, the brake pedal would eventually reach the floor. That is, unless there is some mechanism for raising the pedal after pressurization. There is, and this results in the odd and somewhat unsettling sensation of having the brake pedal pulsate beneath your foot.

ABS failure modes

Note: If you bought your car used, check that somebody has not removed the bulb for the ABS lamp. This is a very common practice. The light should come on when you turn the key and then go out a few seconds later.
There are two failure modes that cause the ABS light and the BRAKE light to come on. The first type are transient errors and the second are permanent errors that will only reset after a power cycle. The transient errors are typically pressure related and are caused by: Pressure drop below 140 bar (ABS light) Pressure drop below 110 bar (ABS and/or BRAKE light). Overheating (pump runs continuously, ABS and/or BRAKE light). Low brake fluid level
The permanent errors are usually caused by one of the following:
Wheel speed sensor DC failure (shorts, opens) Wheel speed sensor AC failure (inconsistent rotational data) Sensor amplitude inconsistencies Continuity failures in the master cylinder solenoids Power supply failures in the controller

Pressure failures

The pressure system can have the following failures: Accumulator failure Burnt out pump Leaking pump Pump power supply failure Incorrectly calibrated pressure switch
Pressure drop failures will usually cause the ABS light to come on when you press the brake pedal. Accumulator failure is the most common failure mode. The accumulator is divided into two sections separated by an elastic diaphragm. One section is preloaded with gas at a pressure of 80 bar, the other at the pressure of the brake fluid. This diaphragm fails with age quite regularly. This is usually manifested by the following behaviour:
The pump runs every time you press the pedal, or the pump runs for a few moments when you start the car from cold. A good accumulator will hold pressure for a fairly long period of time. Accumulators tend to fail over a period of time so the performance tends to drop of gradually. A good system should allow you to press the pedal 5-8 times before the pump runs. If the pump runs every time you hit the pedal and your pump is not leaking, replace the accumulator. Accumulator failure will result in a high duty cycle for the pump and may cause premature failure of this expensive unit. This is also a dangerous condition: if the pump fails during driving, there will be no pressure storage in the system and you will be left with an instantly hard pedal rather than the 5-8 press capacity of the accumulator. Accumulators are thankfully quite cheap to replace. At last count, they were about $166 from Alfa Parts in Berkeley, CA. If the brake light blinks when you start the car after a night's rest, the pump runs and then the brake light goes out, you have accumulator failure.
As a side note, if you have a leak in the master cylinder, this will also cause the same behaviour, but there is a significant difference: your braking will be severely limited and you will know about it very quickly. You can keep your master and solenoids in good condition by flushing the brake fluid once a year. Long pedal travel after an accumulator replacement is one sign of master cylinder failure. People have had bad accumulators in their cars for months without realizing it. A burnt out or leaking pump should be fairly obvious. I suggest replacing the accumulator at this time anyway. Don't buy a used accumulator under any circumstances, it is a waste of money unless you know it to be only a few months old. Pressure switch problems are also common, but are hard to debug without a pressure gauge.
Overheating is a problem reported by a few owners. If the temperature in the engine compartment rises considerably (high ambient temperatures in traffic, high A/C duty cycle, fan failure, poor cooling system performance etc) there is the possibility that the pump will run for a long period of time and never be able to recover pressure. If this condition occurs, you should pull over immediately and wait for the system to cool down. However, overheating of the ABS system is often caused by accumulator failure or master cylinder pressure leaks that raise the duty cycle of the pump causing it to run excessively.

Wheel speed sensor failures

The first check on your sensors is a simple DC check. The resistance on the connectors should be 1100 +- 300 Ohms. If you find a short or an open, replace the sensor. You MUST replace the sensor with the correct front/back left/rear item. They are NOT interchangeable. If you buy them used, make sure that you know which side and if they are front/rear. This is critical to the operation of the system. If your sensors pass DC, and your ABS light comes on shortly after the car starts rolling, you may have an AC problem. These can be caused by a bad sensor, an incorrect clearance between the sensor and speed wheel or a bad wheel bearing. The front sensor cables are very susceptible to heat damage from the manifold. The driver's side sensor is the usual culprit since it is attached to the bottom of the master cylinder with a plastic tie that snaps off and thus drops the cable down near the exhaust manifold. I suggest you remove both the front sensors and examine them very carefully and replace them if they show any kind of damage to the insulation. Check the speed wheel clearance using a brass feeler since the pickup is magnetic and set it to factory specs. The fronts should be 0.7 mm and the rears 1.1 mm. You can check the AC behaviour of the sensor by lifting a wheel and spinning it. You can use an oscilloscope or a multi-meter and you should see a small AC voltage being generated. At 1 rev/second you should see an AC voltage of between 0.15-0.7V
Wheel bearing clearance is also critical to the operation of the system. If there is excessive play in the system, the amplitude drop off will cause the ABS system to disconnect. The correct measurement technique for determining this is described in the shop manual, but if you can feel play in the bearing by pulling on it or it is noisy, I suggest replacement. After you have replaced it, be sure you check the backlash as described in the manual.

Continuity and power failures

Power supply failure to the controller can cause the diagnostic to fail. Check that there is 12V on the connector to the controller which is located on the left side of the luggage compartment. (Pin numbers to follow). Check the main ground. There is a small blade fuse on the left of the engine compartment, near the coil. This can corrode or fail. Check the connectors into the master cylinder and pump. I have seen damaged/broken plastic here which causes the ABS light to come on when the car hits a bump.
If you have not managed to isolate the problem so far, you could have a sticking solenoid or other failure in the master cylinder. These usually require a rebuild or replacement master but are rare failures.

A note on rebuilding by Scott Shadle

I'd like to pass on some additional info that I received from my source at Teves. Milano owners will note that the service manual shows how to disassemble the ABS hydraulic unit, but the parts microfiche does not show the parts as being available separately.
Well, it turns out that if the 'valve body' (the hydraulic part of the ABS control system) fails on your Milano, it can be replaced by the valve body from a '88-'90 Buick Regatta. (there may also be other US cars for which the valve body would work on a Milano, but this was the one that seemed to be the most obvious substitution), but there may be one minor modification necessary - that is the studs that screw into the master cylinder unit onto which the valve body mounts may need to be replaced with longer studs, but you won't know until you get the new valve body (the guy at Teves said that he does not know when and for what model that used the Mark II ABS the 'upgrade ' to the thicker cover plate on the valve body was implemented).
I also spoke to him about the recent AD posting about someone in Texas rebuilding the MC portion of the ABS. (Robert at Shade Tree in Texas). I asked whether or not it is advisable to try to rebuild them (he and I have spoken about this in the past and he said that Teves does not rebuild Mark II systems for any of the applications - including the much larger volume applications on GM and Ford cars, because it is not an easy job).
His answer was that it can be done, but ONLY for the 'regular master cylinder part' NOT the booster portion of the unit. He said that he has tried to rebuild these himself (just for 'fun?' and edification) and has not succeeded - he always broke or bent something. The problem is that you must remove and disconnect the booster portion of the unit to get at the MC pistons/seals. The 'scissors' mechanism and other control linkages of the booster portion are somewhat delicate and if bent may be nearly impossible to repair. Also, regarding rebuilding the booster section - DON'T - DON'T - DON'T!!!!!!!!!
This section is a very delicate force balance mechanism and the spool valve in this section has a tolerance of +-0.00010 to +-0.000.15!! A SINGLE FIBER OF COTTON FROM A SHOP TOWEL OR A 'THIN' HUMAN HAIR COULD LEAD TO A FAILURE, AND EVEN THOUGH THE VALVE PISTON IS MADE OF HARDENED STEEL, DROPPING IT ONTO A RUBBER OR VINYL TILED FLOOR FROM WORKBENCH HEIGHT ONTO THE EDGE OF ONE OF ITS ENDS COULD DEFORM IT ENOUGH TO CAUSE A FAILURE. THESE ARE ORIGINALLY ASSEMBLED IN A 'CLEAN ROOM' ENVIRONMENT.

Luckily, they very rarely fail. The most common failures of these ABS systems as they age (8 years or more/over 100K miles or lots of urban stop and go driving) are the high pressure pump/motors, accumulators and the MC seals. He said that he does know where the Texas people are getting the rebuild parts, but he is almost sure that there was no agreement between the German company from whom Teves originally bought the pistons and seals that prevents them from selling service parts.
I also mentioned the $400 rebuild price. He said that that sounded a little high to him, but after reflection, he said that given his 0 for 2 record trying the rebuild them himself (and he has any technical info that exists available to him) they may be recouping their 'development' costs for the unit that they broke until they got the procedure right. So far I've only had to replace an accumulator on one of my Milano's, but knowing that at least for some failures there is an alternative to a $2000 new replacement unit is somewhat comforting. Good luck!!
(Thanks to John Fox for his technical insight and to Rich Hirsch for his article published in i Saluti in May 1992)