L-Jetronic Fuel Injection Systems for BMW E12's

Peter Florance

Introduction

- This seminar will describe the L-Jetronic system fitted on E12's
- It will also cover trouble shooting and performance tips

Seminar Topics

- Basic Engine Combustion Process
- Combustion Requirements
- Fuel Delivery Implementations
- Electronic Fuel Injection System Components
- L-Jetronic System
- Troubleshooting
- Conversion to Lambda Control
- Performance

Basic Engine Combustion Process

- Fuel and Air intake
- Compression
- Combustion
- Exhaust
- And so on and so on…..

Combustion Requirements

- Compression
- Air
- Fuel
- Spark
- Air and fuel need to be in 14.7 to 1 ratio for efficient combustion
- Understanding these requirements will help explain the L-Jetronic components and their role in the injection system

Implementations

- Carburetors
- Fuel Injection
  - Mechanical
    - Kugelfisher - 2002tii
    - K-Jetronic - 320i
  - Electronic
    - L-Jetronic (Electronic - fuel injection only) 530i 528i
    - Motronic (Computerized with ignition) 535i 528e
- Most modern fuel injection systems are computerized

Electronic Fuel Injection System Components

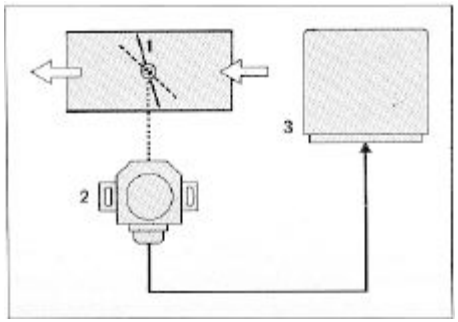
- Throttle and idle/WOT switches
- Air Mass Measurement
- Fuel Pump
- Fuel Injectors
- Pressure regulation
- Control Unit (some with O2 control)
- Combo Relay
- Cold Start
- Warm up enrichment
- Warm up Idle compensation

L-Jetronic System - Throttle and idle control

- Throttle opens to allow more air to sucked in to engine
- Small amount of air bypasses the throttle so the engine gets air and will idle. Screw on side of throttle adjusts idle speed.
- Auxiliary air valve bypasses more air during warm-up to compensate for thicker oil.
- Air conditioned cars have another bypass valve that operate when compressor is running to compensate for load of AC.
- Aux Air Valve DOES NOT control mixture.

L-Jetronic System - Throttle and idle/WOT switches

- Switches on throttle tell ECU what special position the throttle is in
  - Idle, off-idle, wide open throttle (WOT).
  - ECU has special mixtures for these two conditions

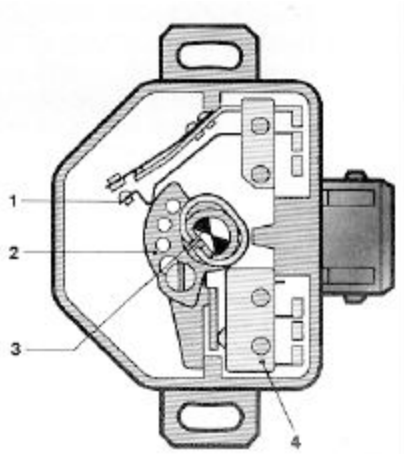


1 Full load contact

2 Contact path

3 Throttle valve shaft

4 Idle contact



L-Jetronic System – Throttle and Idle/WOT switches

•Idle switch is used for coasting fuel-cutoff on later models(E12 79-81). When switch is closed (throttle closed), fuel is cut until engine rpm drops below ECU specified value.

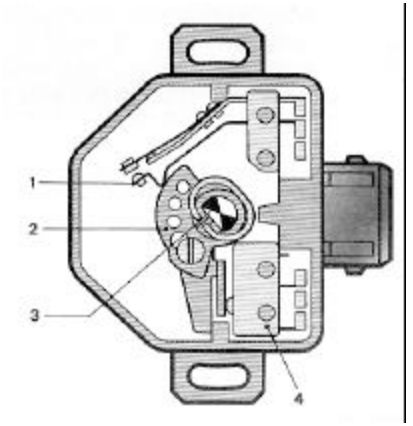
•If idle is set too high, the coasting fuel-cutoff with cause the idle to cycle up and down as the ECU cuts fuel until idle drops below spec, then fuel resumes, RPM rise above spec and fuel is cut again. To test, unplug throttle switch or idle switch on units with separate switches. If idle is above spec (1400 for US 528i set it too spec and re-connect the switch

1 Full load contact

2 Contact path

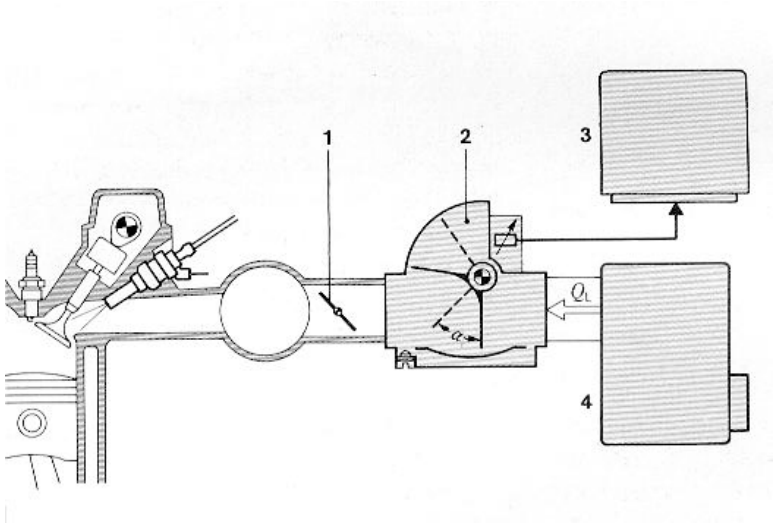
3 Throttle valve shaft

4 Idle contact



L-Jetronic System - Air Mass Measurement

- Fuel Injection System has to know mass of air
- Airflow meter provides air mass flow information
  - Mass is calculated by volume (flow) and density
    - Need device to determine flow air
      - Flap on airflow meter
    - Need temperature to determine density
      - Temperature sensor in air flow meter (AFM)



1 Throttle plate

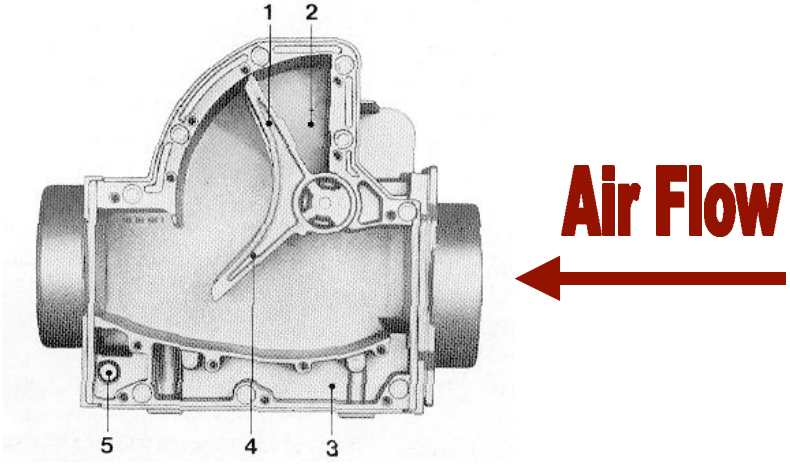
2 Air Flow Meter (with temperature sensor)

3 ECU

4 Air cleaner box

L-Jetronic System - Air Flow Meter - Mechanical Components

- AFM measures flow by spring loaded flap (door)
- Greater flow forces flap open.
- Compensation flap and damping chamber act like shock absorber allowing door to settle quickly and to make it insensitive to vacuum pulsation's from cvlinders



1 Compensation Valve

2 Damping Chamber

3 Air Bypass (idle mixture)

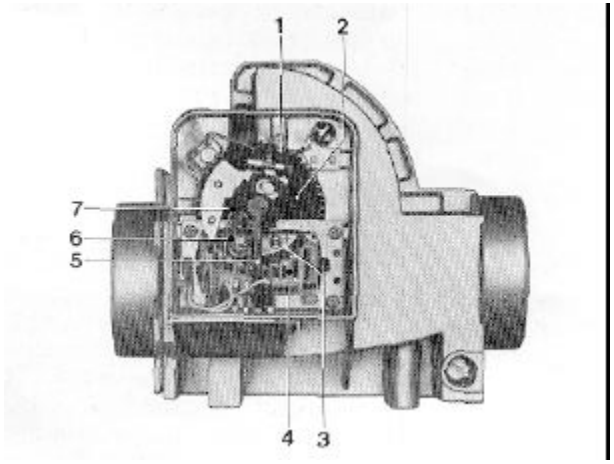
4 Air Sensor Flap

5 Idle mixture adjusting screw

L-Jetronic System - Air Flow Meter - Electrical Components

- Spring loaded flap causes wiper to move along resistance track.
- Resistance track has constant voltage applied to it.
- As wiper moves with flap, wiper voltage varies with amount of opening
  - full open - max voltage, full closed - min voltage
  - Voltage is proportional to fuel. More voltage, more fuel.

Air Flow



1 Gear for door spring load

2 Return Spring

3 Wiper Track

4 Resistance Element on ceramic substrate

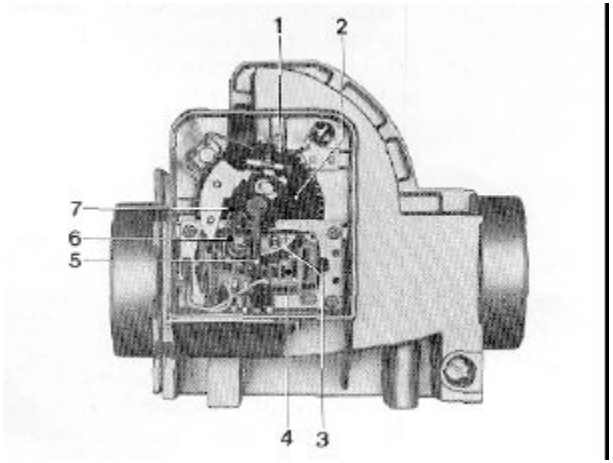
5 Wiper tab

6 Wiper

7 Fuel Pump Switch

L-Jetronic System - Air Flow Meter - Electrical Components

- Spring can be adjusted. Looser, door opens easier, causing mixture to be richer. Tighter door, requires more force (more air) , therefore leaner.
- Fuel pump switch activates when door opens. When engine quits, fuel pump will not run for safety (accident).



1 Gear for door spring load

2 Return Spring

3 Wiper Track

4 Resistance Element on ceramic substrate

5 Wiper tab

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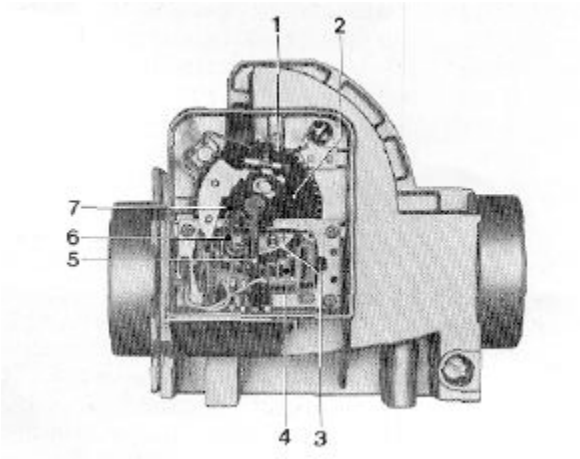
7 Fuel Pump Switch

L-Jetronic System - Air Flow Meter - Electrical Components

- Voltage is sent to ECU
- AFM contains temperature sensor (not shown). Temp info is sent directly to ECU for mass calculation.



1 Gear for door spring load

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4 Resistance Element on ceramic substrate

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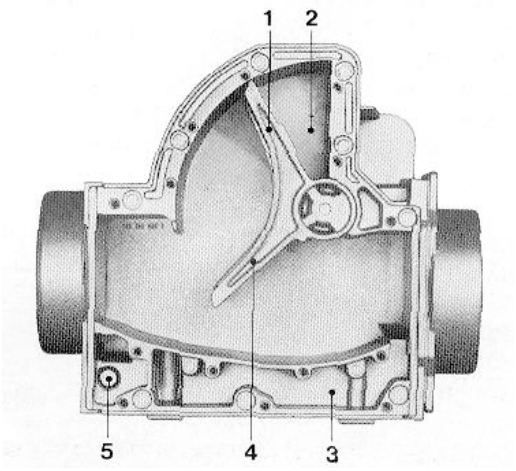
7 Fuel Pump Switch

L-Jetronic System - Air Flow Meter - Fuel Calculations

- The ECU uses mass measurement to meter fuel through injectors.
- When accelerating, the door will overshoot slightly.
  - This overshoot causes extra fuel to be delivered through injectors
  - This serves as accelerator pump similar to carburetors

L-Jetronic System - Air Flow Meter - Idle Mixture

- Idle mixture is adjusted by adding additional air to fixed idle mixture. Idle screw (underneath AFM adjusts amount of bypassed air (not measured by AFM). This way mixture can be adjusted.
  - Note effect of idle screw is not significant at higher airflow, only idle



1 Compensation Valve

2 Damping Chamber

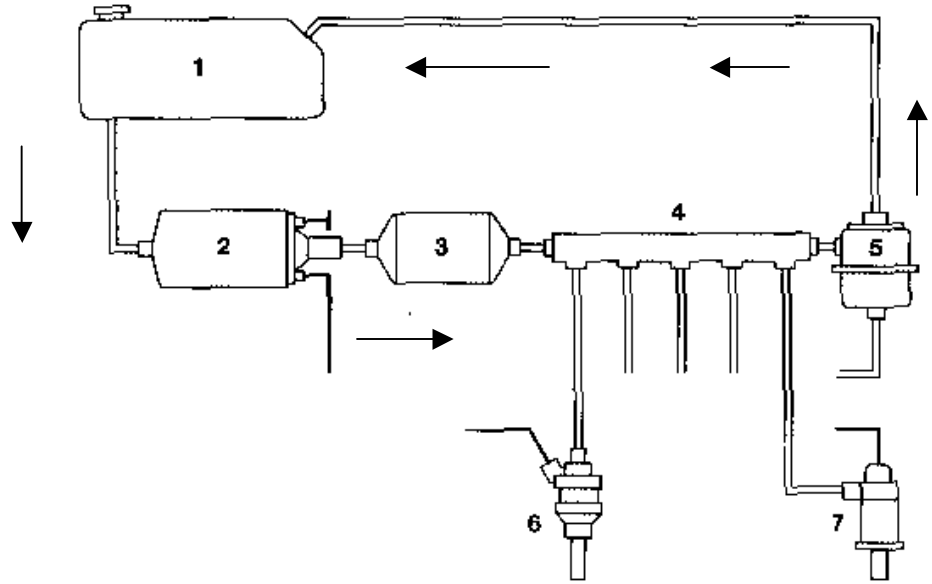
3 Air Bypass (idle mixture)

4 Air Sensor Flap

5 Idle mixture adjusting screw

L-Jetronic System - Fuel Flow

- Fuel is pumped up to fuel rail and excess returned to tank
- Because so much fuel is circulated, filter is quite large.
- Fuel lines are at high pressure (> 35psi), use BMW factory hose for replacement
- Inspect lines regularly, fuel under pressure can cause LARGE fire.



1 Fuel Tank

2 Fuel Pump w/ Check Valve

3 Fuel Filter

4 Fuel Rail

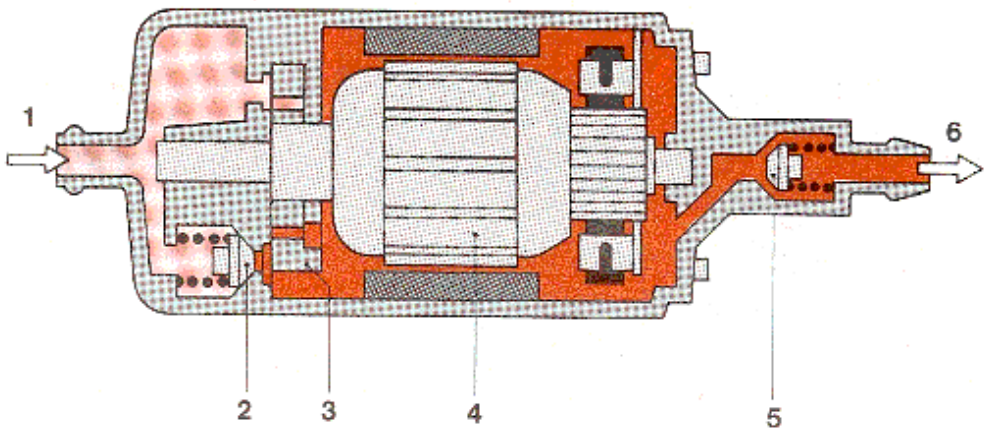
5 Pressure regulator

6 Fuel Injector

7 Cold Star Valve

L-Jetronic System - Fuel Pump

- Uses positive displacement roller pump.
- Electric motor is in fuel stream and uses fuel to cool it.
  - Because there is no air, it won't explode.
- It's important not to run low on fuel as the pump can overheat and fail if fuel starved.
- Check fuel pump fuse (fuse #1, 16 amp) for corrosion - common no start or stall failure. I replace every 2 years and clean the fuse holder contacts.



1 Suction Side (inlet from tank)

2 Pressure relief valve

3 Roller pump mechanism

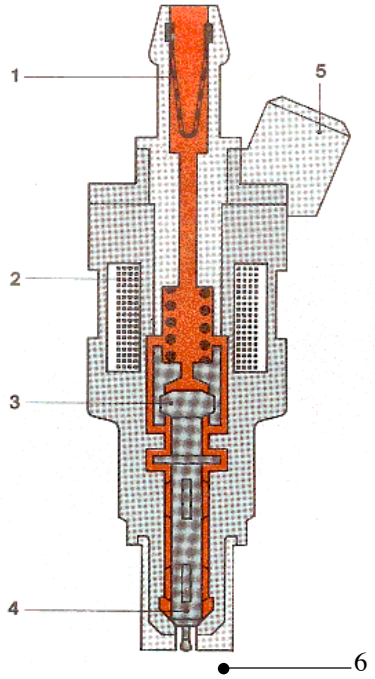
4 Motor

5 Check valve

6 Pump discharge (outlet to filter)

L-Jetronic System - Fuel Injectors

- Open when energized by ECU- not continuous as K-Jetronic.
- Current through windings causes magnetism pulling armature and attached needle valve up and way from valve seat allowing fuel to flow. Can test with magnet on a stick.
- All injectors are wired together and fire simultaneously,
- Flow is determined by pressure across injector and time (dwell) of opening.
- Normally more reliable than K-Jetronic type. See Rowe[4].



1 Screen mesh filter

2 Solenoid Winding

3 Solenoid Armature

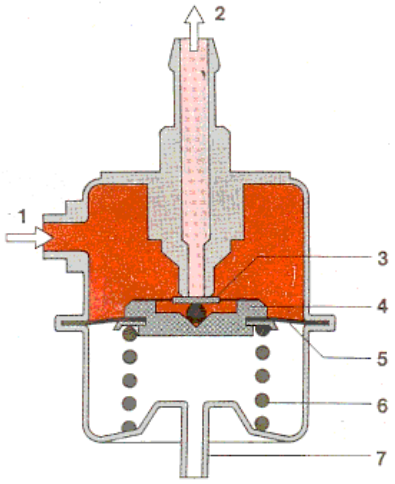
4 Needle Valve

5 Electrical Connection

6 Valve Seat

L-Jetronic System - Pressure Regulator

- Provides constant pressure across fuel injector valve
- Fuel *1* under pressure from fuel pump enters and pushes against valve holder *4* and spring *6* which opens valve *3* at regulated pressure; allowing excess fuel *2* to escape back to tank
  - All the fuel between the pump and this valve are at the regulated fuel pressure.
- Vacuum diaphragm *5* works against spring to create less pressure when intake *7* is under vacuum so *net* pressure is constant



1. Fuel inlet (from fuel injectors and pump)

2. Fuel Outlet (to return line back to fuel tank

3. Valve Plate (blocks return line)

4. Valve Holder

5. Vacuum Diaphragm (compensates for intake manifold vacuum)

6. Compression Spring (sets regulation pressure)

7. Vacuum connection (from intake manifold)

L-Jetronic System - Control Unit

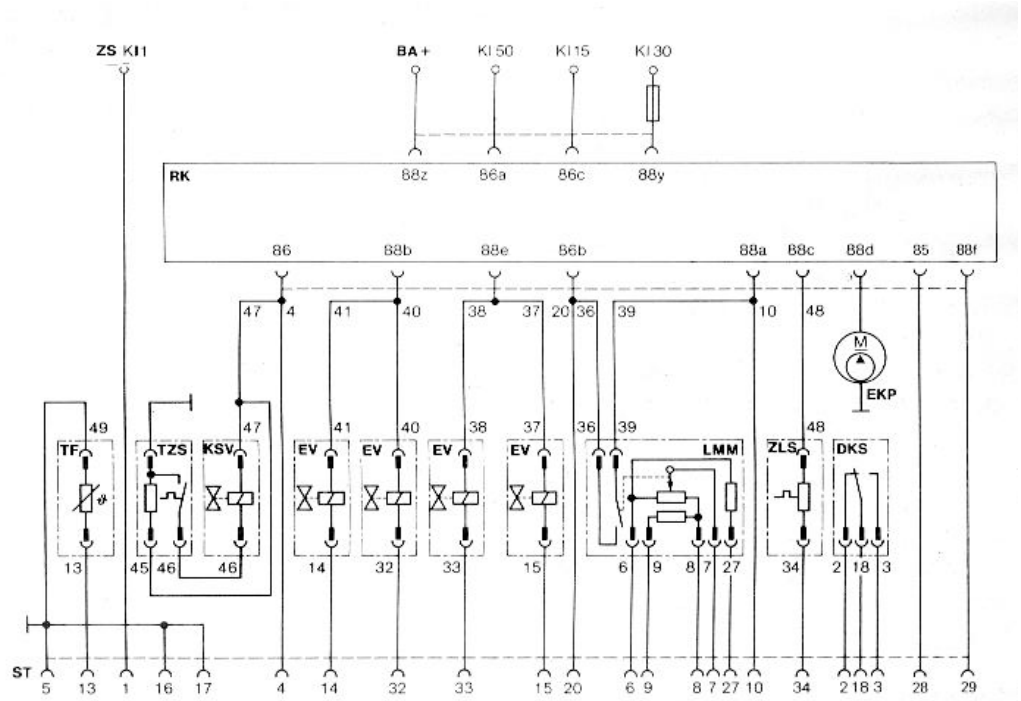
- Control unit (ECU) takes sensor information:
  - AFM flow and temperature
  - Engine RPM (from ignition)
  - Warm up information (from coolant temperature sensor)
  - Throttle mode (idle and WOT switches)
  - O2 sensor in Lambda systems
- ….and calculates opening duration of injectors
- This ‘map’ is hardwired into system (there’s no chip available to modify)
- Some users have adjusted value of internal components[5].

L-Jetronic System - Control Unit - Throttle Operating Modes

- Idle
  - Throttle is closed
  - Idle switch is closed, ECU supplies idle mixture (a little rich) for smooth idle
- Off - idle
  - Both switches are open. ECU reads AFM signal and O2 sensor (where installed) and determines how long to open injectors for proper mixture.
- Wide Open Throttle (WOT)or ‘Yeeeehaaaa! zone’
  - WOT switch is closed
  - Injector open time is fixed amount. Somewhat rich for added power.

L-Jetronic System - Control Unit, Basic Schematic

- This is a generic system schematic.
- Haynes diagram is good, but owners manual shows more internal component detail



TF Coolant Temp Sensor

TZS Thermo-time switch

KSV Cold Start Valve

EV Fuel Injector

LMM Air Flow Meter (AFM) with pump switch and air temperature sensor

ZLS Auxiliary Air Valve

DKS Throttle Switch (idle, WOT)

EKP Electric Fuel Pump

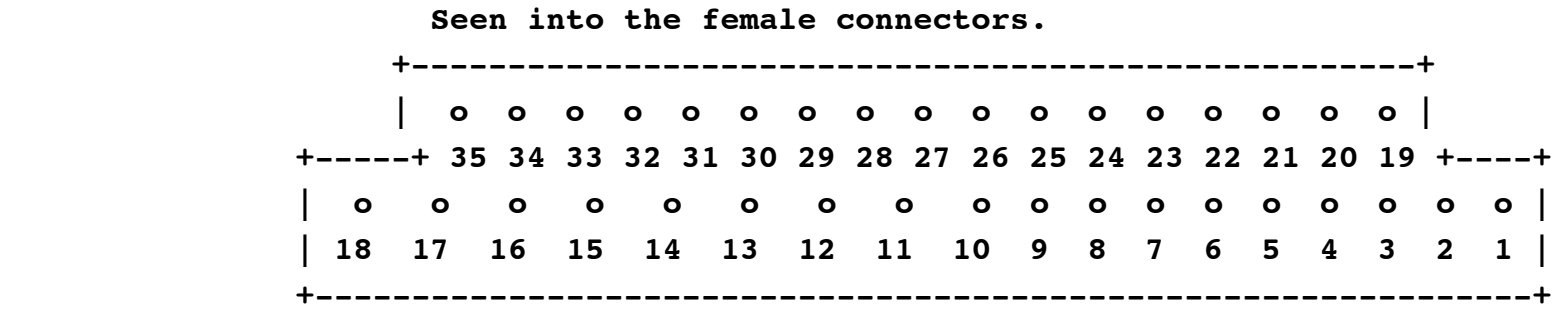
RK Fuel Injection Combo Relay

ZS Ignition Coil

BA Battery

ST Multi-pin connector to ECU

L-Jetronic System - Control Unit Pin out



1. Ignition coil
2. Throttle switch, idle ?
3. Throttle switch, WOT ?
4. Pin 50 via main relay
5. Earth connection
6. Air flow sensor + ?
7. Air flow sensor signal
8. Air flow sensor - ?
9. Air flow sensor air temp.
10. Main relay, pin 15
11. No connection
12. No connection
13. Coolant temperature sensor
14. Injectors
15. Injectors
16. Earth connection
17. Earth connection
18. Throttle switch +
19. No connection
20. Main relay + engine running
21. No connection
22. No connection
23. No connection
24. No connection
25. No connection
26: No connection
27. Air flow sensor
28. No connection
29. No connection
30. Injectors
31. Injectors
32. Injectors
33. Injectors
34. Auxiliary air valve, bimetal
35. Earth connection

L-Jetronic System - Lambda - Why?

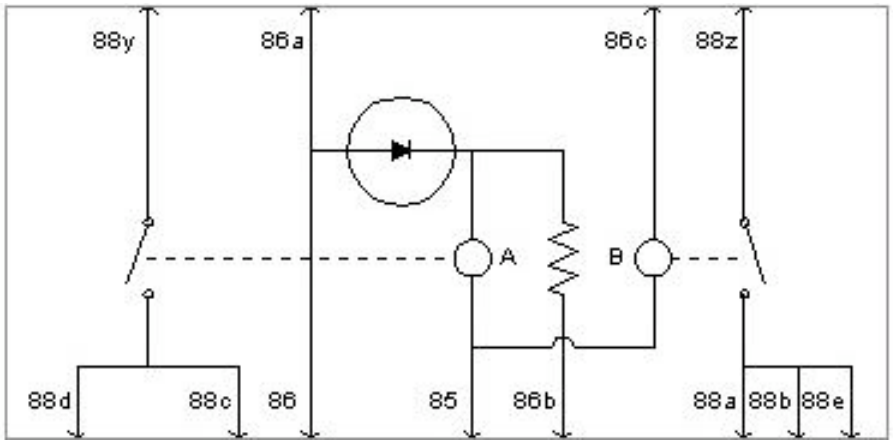
- Basic L-Jetronic System measures air mass and provides appropriate amount of fuel
- Note: although a precision system, there is no feedback for the system to know of any variances:
  - Aging components
  - Fuel characteristic differences
- Catalytic converters require precise mixture control for operation
- The air fuel ratio of standard L-Jetronic system is not accurate enough for proper catalytic converter operation

Combo Relay – Power and interface for the L jet system.

•Combo relay provides switched power to ECU and injectors

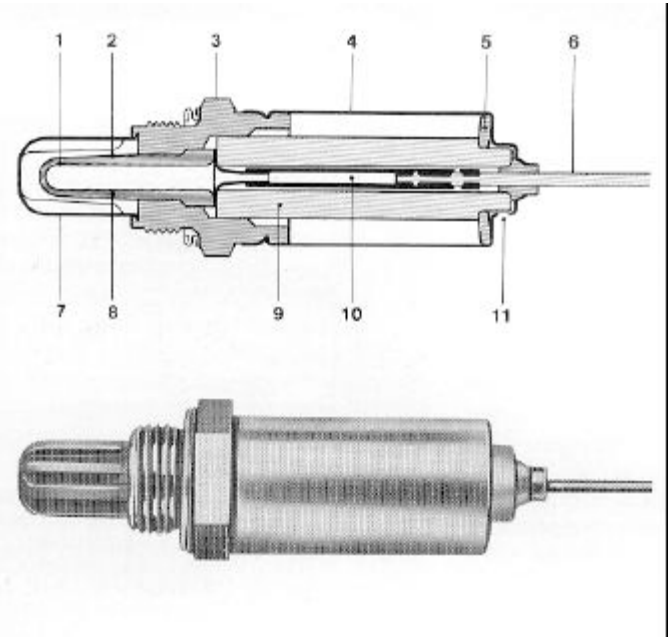
•Combo relay provides power to fuel pump (only when either air flow meter is open or engine is cranking)

•Combo relays are built on PC boards which can get bad solder joints



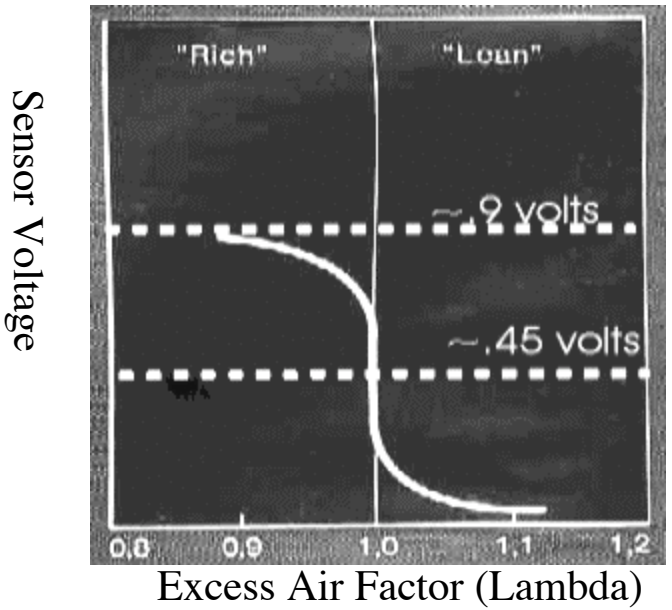
L-Jetronic System - Lambda - Components O2 Sensor

- O2 Sensor measures excess oxygen in exhaust gas. Sensors must be hot to work. Some have heating elements to start operating faster.



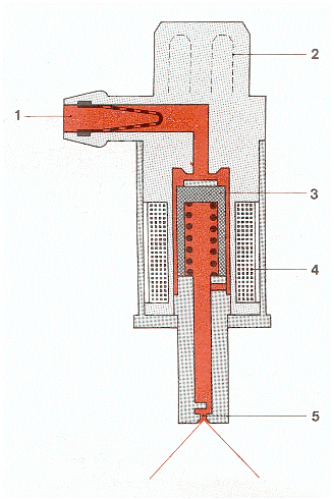
L-Jetronic System - Lambda - Components O2 Sensor Output Curve

- The sensors output changes rapidly around the 14.7 to 1 ratio. This provides a mixture with just enough oxygen to burn hydrocarbons in catalytic converter.
- The lambda system controls around this point. The ECU cycles mixture lean and rich slightly. It looks at the average of the lambda signal and adjusts the average of the mixture accordingly.

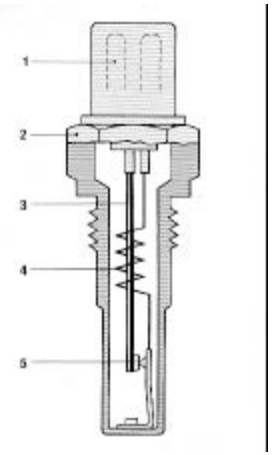


L-Jetronic System - Cold Start

- Extra fuel is required during cold start
- Cold start valve is operated for up to 30 seconds by thermo-time switch.
  - Switch is temperature and time sensitive.



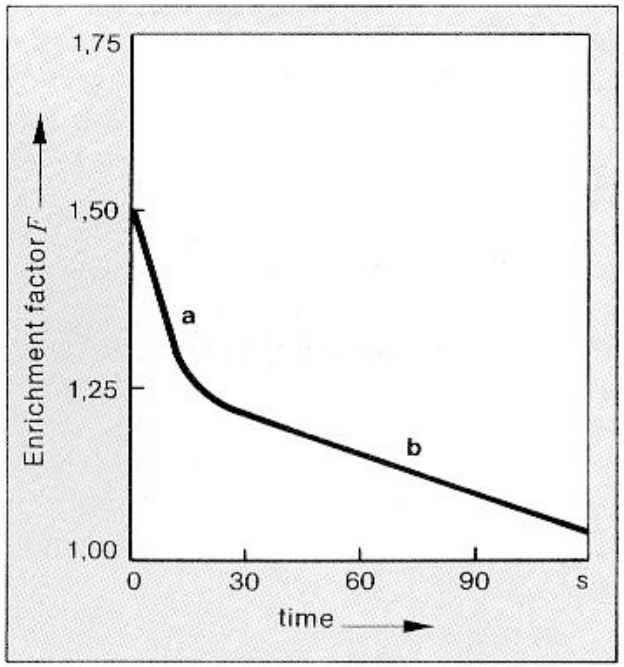
Cold Start Valve



Thermo time switch

L-Jetronic System - Warm up enrichment

- Once started ECU looks at coolant temperature to decide how much extra fuel to supply.
- Once at operating temperature, the warm up enrichment ceases.

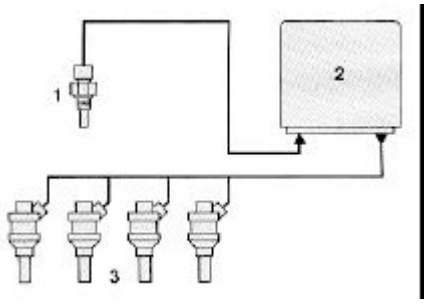


Warm up enrichment factor curve.

Curve a is cold start and warm up enrichment (extra fuel) combined. Note cold start valve and injectors are supplying fuel

Curve b is warm up enrichment only (thermo time switch opens and cold start valve ceases operation.

At right hand side, warm up is nearing completion and enrichment tapers off.



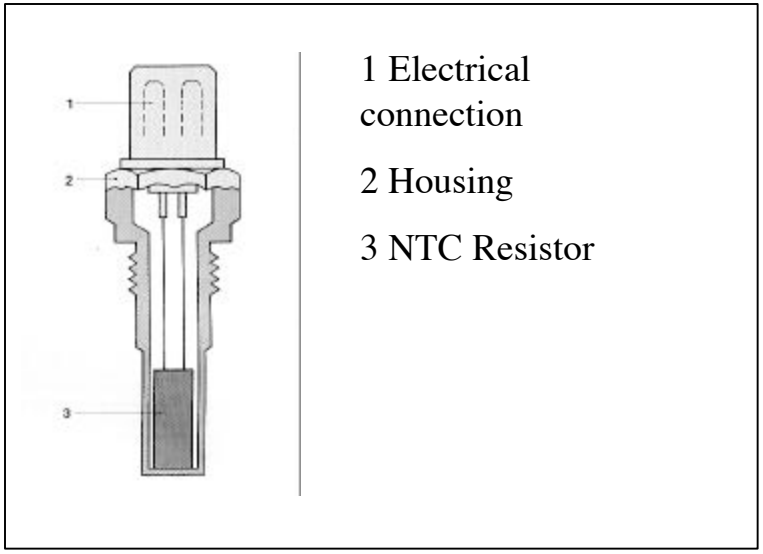
Enrichment fuel supply

1 Cold Start Valve

2 Injectors

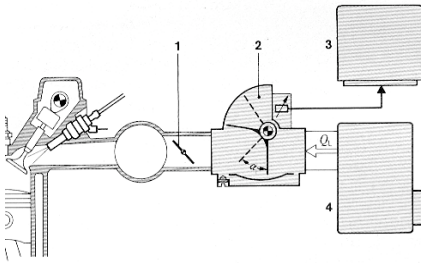
L-Jetronic System - Warm up enrichment Components - Coolant Temp Sensor

- Coolant temperature sensor mounted in thermostat housing.
- Sensor has high resistance when cold and low when warm.
- Connections do get intermittent - check for corrosion



L-Jetronic System - Warm up Idle compensation

- During Warm-up, engine oil is thicker adding load to engine
- Auxiliary air valve bypasses throttle for additional air (like mini - throttle) while warming up. This brings idle speed up to desirable level
- Electrical heating element inside valve combined with engine heat bend bi-metal strip causing valve to close. This happens gradually reducing amount of throttle ‘help’. Once warm, valve is closed



1 Blocking Plate

2 Bi-metal strip

3 Electric heating element

4 Electrical connection

Troubleshooting

Ask us questions!!

Conversion to Lambda Control

By Scott Stewart - First Fives Registry

Greg's note:

If you have a 528i, you don't have to worry about this, but if you have a 530i, keep reading. The following describes the process of converting your fuel injection system to the later style Bosch L-Jetronic with lambda control.

The object here is to assemble a FI system that is properly tuned, provides good driveability, low fuel consumption, and has minimal emissions.

I had my 530i checked for emissions after I retrofitted my L-jet with Lambda control FI system from a 528i. It's emissions are lower without a catalytic converter than what the original specs call for on a 1977 530i. The L-jet with lambda control FI system is leap years ahead of the one on your car now because it actually monitors the fuel/air (stoichometric) ratio rather than assuming it is OK. My performance is up, driveability is much better (my car would flood at high rpm's when it was cold before I changed to the new system) better fuel consumption, and of course the lower emissions.

Following is a quick list of the components I assembled for the conversion. Any questions, additions, or comments are welcome from those that currently drive "the real thing" 528i or from others who have done this conversion (Marty Roach).

Conversion to Lambda Control - Continued; Parts List

All parts were removed from a running 1981 528i:

- 122 extension ECU, same connection as the 106 original model in the 530i. Make sure you plug in the single spade terminal at the ECU that is not part of the FI wiring harness. I think this plug is the distributor pickup or Pin #1 on the ECU (help here from those in the know).
- Complete FI and engine wiring harness from the 528i
- 528i valve cover
- 528i throttle body with 4 contact limit switches
- 528i AFM
- auxiliary air valve and AC bypass valve off of 528i
- exhaust manifold down-pipe with threaded port for 02 sensor
- 528i combo relay
- later style vacuum advance/retard distributor with transistorized ignition, ignition module, resistor bank etc. Mount it on inside of uni-body behind the windshield washer bottle with heatsink grease (resistor bank gets pretty hot). Don't forget the engine wiring harness coming from the ignition module to the distributor, ignition coil, temperature sending unit, alternator (power and spade terminal for idiot light), and oil pressure sending unit. This harness will have a plug that plugs right into your fuse box.
- 528i thermostat housing with fittings for vacuum retard during cold running, temp time switch, temp sending unit for gauge and FI (this makes the FI wiring harness much easier to fit)
- 528i plenum chamber
- 528i fuel rail, fuel pressure regulator, injectors.

Conversion to Lambda Control - Continued; summary

I am sure you are saying WHAT!! by now but believe me it is worth the hassle. I don't know if the exhaust manifold from a 528i is necessary, my car had headers on it so I never saw the original 530i exhaust manifold.

OK. Thanks to Peter Florance I just happen to know the only mods that are necessary to the wiring in your car once the FI and engine wiring harness are in place are:

Remove the purple/green and yellow/green wires from the Fuel pump side plug in your combo relay (easily done with a knife that will flatten the tab that holds the terminal in the plug). Remove these same two wires from the Fuel pump side plug of the combo relay that came on the new 528i wiring harness and replace these wires with the two out of your harness. Tie wrap everything down and tape up the old combo relay plug with electrical tape (the main power, red, wire still has power to it)and start the car.

I hope some of this helps you or anyone else brave enough to perform the upgrade.

Scott Stewart

Peter's note: We are trying to see if this can be done w/out the harness swap.

Bibliography and Suggested Reading

[1] Technical Instruction L-Jetronic - # VDT-U 33 En - Robert Bosch GmbH

[2] Owners Workshop Manual BMW 528i & 530i - Haynes Publishing Group ISBN 0 85696 632 0

[3] Bosch Fuel Injection and Engine Management - Charles O. Probst, SAE - Robert Bently Publishers #GFIB; ISBN 0-8376-0300-5

[4] BMW Fuel Injection - Jim Blanton & Jim Rowe - Metric Mechanic Kansas City, MO 816-842-7232

[5] First Fives Web Site Technical FAQ - htpp://www.firstfives.org