

## **What Tuning Can Do For You**

All of the engine tuning parameters for the LT5 engine are located in the engine control computer also known as the Electronic Control Module or ECM. The processor in the ECM is a Motorola MC68HC11A0. It's part of the Motorola M6800 family of 16 address bit and eight data bit processors. Dave McLellan has said that the ECM's development cost was \$1M. That's in roughly 1990 dollars.

### **GM issued program updates for stock engines**

GM was proactive about the performance of the engine control system. They monitored their internal sources and customer experiences. For the '90 to '94 models an improved version of the control program was issued via the parts department to replace the program installed at the factory. The program resides on a plug-in calibration package commonly referred to as a Chip. In the '90 to '93 service manuals it is called a Mem-Cal. In the '94 and '95 service manuals they refer to it as PROM. Programmable Read Only Memory. Versions of the calibration program are identified by four letter codes. For example AYBK.

For '90 cars GM issued AYBK with Product Service Bulletin 476503, dated February, 1994. It was released to address problems with idle fluctuation after a hot restart, increase in idle speed after a hot restart and excessive engine speed during coast down to a stop with the clutch disengaged. It reduces the idle step down time after the 1500 rpm coast down speed by about 50% or two seconds. It disables the 'Up Shift' light on the cluster.

For '91's GM issued BFXB also with Product Service Bulletin 476503 dated February, 1994. It was released to address hard starting during the restart of a hot engine. It reduces the engine speed during coast down to a stop with the clutch disengaged.

For '92's GM issued BPPA. GM did not release a Product Service Bulletin for it. I have noticed that the idle speed is 650 rpm like the '90 and '91 cars. The factory calibration idle speed for the early '92's is 575 rpm.

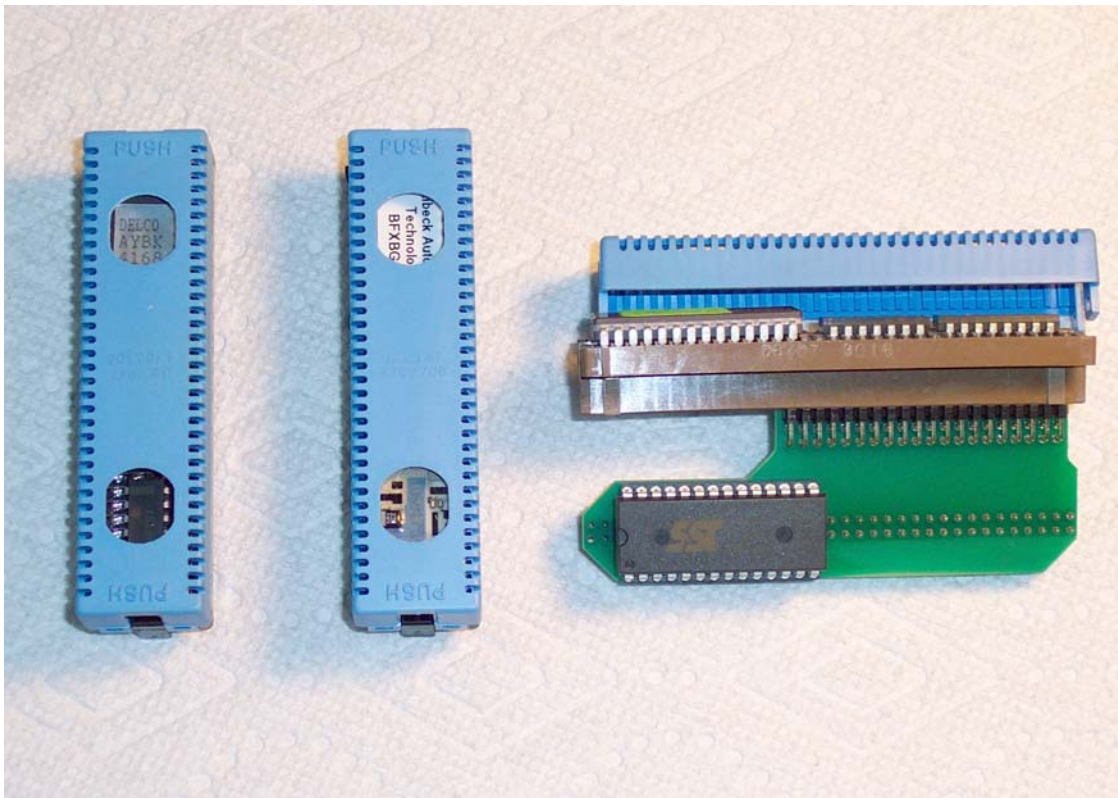
For '93 to '94's GM issued BMCB with Product Service Bulletin 576514 dated 18 September, 1995. It addresses a problem with a sag or surge on light throttle acceleration below 2500 RPM. It also corrects an intermittent ASR error that a few cars had.

For '95's BMCB was the factory installed calibration program.

Accessing the calibration chip. The ECM is the black box located above the power brake booster. Disconnect the negative battery cable. To remove the chip, remove the two 10 mm head nuts on '90 to '93's, or four nuts on '94 to '95's and turn the ECM over. Remove the four fasteners with 1/4" heads from the access panel. Carefully pry the panel off with a wide screwdriver. It may be stuck to the gasket fairly tight. Note the position of the chip so that it can be reinstalled with the same orientation. Pull out the socket's levers and the chip will eject.



### Identifying chip packages



Shown on the left, GM chips have silver foil labels with a four letter code. In the center, rewritten tuner chips commonly have white labels. The GM chips can be erased and reused. On the right, is a calibration adapter module. The adapter module is often used when the GM calibration package with the blue cover is not available. GM stopped making them about ten years ago. The tuner chip is on the green module; the GM calibration package is plugged into the header pins on top of the module. The blue cover needs to be removed for clearance to fit it in the ECM. The GM calibration

module needs to be piggy backed in-order to connect to the cylinder select logic and the white knock filter device on '91 and up cars.

### **Improvements can be made for stock engines**

The cooling fans can be turned on earlier. For '90 to '94 the GM fan control points are primary fan on at about 225 degrees and secondary fan on at about 234 degrees. For '95 both fans turn on at low speed at 225 degrees and both fans go to high speed at 234 degrees. This strategy causes the temperature gauge to swing to about 75% of the sweep before the primary fan goes on. These temperatures were probably selected for good emissions performance. A better strategy that reduces heat stress is to turn both fans on at 205 degrees and both off at 200 degrees. The turn off point must be higher than the thermostat control temperature or the fans will never be able to turn off. The thermostat is a 180 degree unit. The thermostat regulates the temperature at the inlet to the engine. The temperature sensor is at the outlet in the left injector housing. There is an approximately 15 degree temperature rise as the coolant passes through the engine. Therefore the lowest temperature that is possible is 195 degrees. If the fans are run at too low of a temperature they will conflict with the thermostat and will not be able to turn off. This can cause an over heating problem much farther down the road. The C4 radiator cooling system is a bottom breather and the fans can act as a vacuum cleaner and clog the radiator with debris. Running the engine cooler reduces heat induced power loss, so the engine feels stronger because power has not been lost due to the effect of the heat.

The ignition spark advance can be increased. GM uses a conservative spark advance. The owner's manual states that it is okay to use 87 octane Regular grade fuel. Most people use 91 or better octane fuel in their ZR-1. Then the spark advance can be increased at peak power from 25 to 28 degrees, which usually adds 10 hp. Adding spark advance at lower speeds adds about 10 lb.ft. of torque.

The fuel delivery at wide-open throttle is about 3% rich in the stock calibration. The unneeded fuel can be removed to add one hp or two.

The stock calibration retards the ignition spark advance when the intake air temperature is over 90 degrees F. This can be revised to 160 degrees and the amount of retard can be decreased.

The engine control system tends to sense false ignition spark knocks during fast throttle opening transitions at low engine speeds. This can result in a 10 lb. ft. torque reduction for about a second after the throttle transition. With Premium fuel this can be improved to a 5 lb. ft. loss for one half second.

The CAGS (forced 1 to 4 shift) can be disabled. This also turns off the "One to Four" lamp in the cluster.

Set the power key default to Full Power on '91 and up cars.

The Upshift light on the '90's can be changed to turn on at 6400 rpm. That's the highest value that is possible.

### How the chip is organized

The OE chip is a 27C256. The data space on the chip is divided into two halves. The program and the data. An analogy can be made to a spreadsheet. The program is like the spreadsheet software and the data is like the data in the spreadsheet. The data for spark advance and fuel is organized on an engine speed verses load basis. The engine idles at about 40 kpa manifold pressure and has about 100 kpa manifold pressure (atmospheric pressure) at wide open throttle.

This is the spark advance table with the secondary intake port throttles open for a stock '90 engine.

Spark Advance #1 (Port Throttles Open)

RPM	MAP (Kpa)															
	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
400	25.3	25.3	25.3	25.3	23.2	20.0	18.3	15.5	14.1	12.3	10.2	8.1	6.0	5.3	3.9	3.9
600	28.1	28.1	28.1	28.1	27.1	25.3	22.1	20.0	17.2	14.1	12.3	10.2	8.1	6.0	5.3	5.3
800	35.2	35.2	35.2	30.2	30.2	28.1	24.3	22.1	19.0	16.2	14.1	12.3	9.1	7.0	6.0	6.0
1000	35.2	35.2	35.2	35.2	33.0	30.2	25.3	23.2	20.0	17.2	15.1	13.0	11.3	9.1	8.1	7.0
1200	35.2	35.2	35.2	35.2	33.0	30.2	26.4	24.3	21.1	18.3	16.2	14.1	12.3	11.3	10.2	9.1
1400	35.2	35.2	35.2	35.2	33.8	30.2	27.1	25.3	22.1	19.0	17.2	16.2	14.1	13.0	12.3	11.3
1600	35.2	35.2	35.2	35.2	33.8	30.2	27.1	25.3	22.1	20.0	18.3	17.2	16.2	15.1	14.1	14.1
1800	35.2	35.2	35.2	35.2	33.8	30.2	27.1	25.3	23.2	21.1	20.0	19.0	18.3	17.2	16.2	16.2
2000	35.2	35.2	35.2	35.2	33.8	30.2	28.1	25.3	24.3	24.3	22.1	21.1	20.0	19.0	18.3	18.3
2200	35.2	35.2	35.2	35.2	33.8	30.2	28.1	26.4	25.3	25.3	24.3	24.3	22.1	21.1	20.0	20.0
2400	35.2	35.2	35.2	35.2	33.8	30.2	28.1	27.1	26.4	26.4	25.3	25.3	24.3	24.3	23.2	22.1
2800	35.2	35.2	35.2	35.2	33.8	32.7	30.2	30.2	28.1	26.4	25.3	25.3	24.3	24.3	23.2	23.2
3200	35.2	35.2	35.2	35.2	34.1	34.1	32.0	30.2	28.1	26.4	25.3	25.3	24.3	24.3	23.2	23.2
3600	35.2	35.2	35.2	35.2	35.2	35.2	33.8	31.3	28.1	26.4	24.3	23.2	22.1	22.1	22.1	22.1
4000	35.2	35.2	35.2	35.2	35.2	35.2	33.8	31.3	27.1	25.3	23.2	22.1	21.1	21.1	20.0	19.0
4500	32.0	32.0	32.0	32.0	32.0	32.0	28.8	28.1	27.1	25.3	24.3	23.2	22.1	21.1	21.1	21.1
5000	28.1	28.1	28.1	28.1	28.1	28.1	27.1	26.4	25.3	25.3	24.3	24.3	24.3	24.3	23.2	23.2
5500	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3
6000	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3
6500	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3
7000	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3
7500	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3

If the car was cruising at 2000 rpm and the plenum throttle was quickly opened to 100% the spark advance would use the table values as shown by the arrow. The table values can be modified with tuning software.

This is the fuel table with the secondary port throttles open for a stock '90 engine. The program controls fuel in proportion to the volumetric efficiency. Fuel can be added or removed by increasing or decreasing the VE values.

% Volumetric Efficiency #1 (Port Throttles Open)																	
RPM	MAP (Kpa)																
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
400	43.0	45.7	50.0	52.3	54.7	57.4	60.5	60.9	61.3	62.1	62.9	64.1	64.8	66.0	66.8	69.1	71.1
500	43.0	45.7	50.0	52.3	54.7	57.4	60.5	60.9	61.3	62.1	62.9	64.1	64.8	66.0	66.8	69.1	71.1
600	44.1	46.9	50.4	52.7	55.1	58.2	60.9	61.7	62.1	62.9	63.7	64.8	65.6	66.8	67.6	69.9	71.5
700	44.9	48.0	50.8	53.5	55.9	58.6	61.7	62.5	63.3	64.1	64.8	65.6	66.8	68.0	68.8	71.1	72.7
800	45.7	48.8	51.6	54.3	56.6	59.8	62.5	63.3	64.1	64.8	65.6	66.4	67.6	68.8	69.9	71.9	73.0
900	46.1	49.2	52.3	55.1	57.4	60.5	62.9	64.1	64.8	65.6	66.4	67.2	68.4	69.1	70.3	72.3	73.4
1000	46.9	50.4	53.5	55.9	58.6	60.9	63.3	64.5	65.6	66.4	66.8	68.0	69.1	69.9	70.7	72.7	73.8
1100	48.0	51.2	54.7	57.4	59.8	61.7	63.7	64.8	66.0	66.8	67.6	68.8	69.9	70.7	71.1	72.7	73.8
1200	50.0	52.7	55.9	58.6	60.5	62.5	64.1	65.2	66.4	67.2	68.0	69.5	70.7	71.1	71.5	73.0	74.2
1300	50.8	53.9	57.4	59.4	61.7	63.3	64.8	66.0	66.8	68.0	68.8	69.9	71.1	71.9	72.3	73.4	74.2
1400	51.6	54.7	58.2	58.6	62.5	64.1	65.2	66.4	67.2	68.4	69.1	70.7	71.9	72.3	72.7	73.8	74.6
1500	53.1	55.5	59.0	61.3	63.3	64.5	65.6	66.8	68.0	68.8	69.5	71.1	72.3	72.7	73.0	74.2	75.0
1600	53.9	56.6	59.8	61.7	63.7	65.2	66.4	67.6	68.4	69.1	70.3	71.9	72.7	73.0	73.4	74.2	75.0
1700	54.3	57.4	60.5	62.5	64.5	65.6	66.8	68.4	69.1	70.3	70.7	72.3	73.0	73.4	73.8	74.6	75.4
1800	54.7	57.8	60.9	63.3	65.2	66.4	67.6	68.8	69.9	70.7	71.5	72.7	73.4	74.2	74.6	75.4	75.8
1900	55.5	58.6	61.3	63.7	65.6	66.8	68.0	69.1	70.7	71.5	71.9	73.0	73.8	74.6	75.0	75.8	76.2
2000	56.6	59.0	61.7	64.1	66.4	67.6	68.4	69.9	71.1	71.9	72.7	74.6	77.0	77.7	78.5	79.3	81.3
2200	57.0	59.8	62.5	65.2	67.6	68.4	69.1	70.7	71.9	72.7	73.4	75.4	77.3	78.1	79.3	80.1	82.4
2400	57.8	60.5	62.9	65.6	68.4	69.5	70.3	71.5	72.7	73.4	74.2	76.2	78.1	78.9	80.1	81.3	84.4
2800	58.2	61.3	63.3	67.2	69.1	70.3	71.5	72.7	73.4	74.6	76.2	78.1	79.7	80.9	82.0	84.0	88.3
3200	59.0	61.7	64.1	68.0	69.9	71.5	72.7	73.8	75.4	76.6	79.7	80.1	82.0	83.6	85.2	87.5	92.6
3600	59.4	62.5	65.2	68.8	70.3	72.3	74.2	75.4	77.3	78.9	80.1	82.8	85.2	87.1	89.1	92.6	96.9
4000	60.5	63.7	67.2	70.7	72.3	74.6	76.6	78.5	80.1	82.4	84.4	86.3	87.9	90.2	92.6	96.9	102.3
4500	62.5	66.4	70.7	75.0	79.3	81.3	83.2	84.8	86.3	88.3	90.2	91.8	93.4	94.9	97.7	103.1	105.9
5000	66.8	72.7	78.9	83.2	86.3	88.3	89.8	91.0	91.8	92.6	93.8	94.5	95.7	96.9	98.8	100.4	103.9
5500	75.0	80.1	83.6	86.7	87.1	89.1	90.6	91.8	94.1	94.5	95.7	96.5	97.3	98.0	98.4	100.0	102.3
6000	67.6	74.2	82.0	85.2	86.3	88.3	89.8	91.0	94.9	95.7	96.1	96.9	97.7	98.0	98.4	99.2	100.0
6500	67.6	74.2	82.0	85.2	86.3	88.3	89.8	91.0	94.9	95.3	95.7	96.5	97.7	98.0	98.4	99.2	100.0
7000	67.6	74.2	82.0	85.2	86.3	88.3	89.8	91.0	94.9	95.3	95.7	96.9	97.7	98.0	98.4	98.8	99.6

### Useful modifications to the calibration

Headers add 25 hp. Fuel can be added to support the additional power. Also, running without catalysts tends to cause backfiring on low load shift. The deceleration fuel cut off mode can be turned off to prevent the backfires.

The GM rev limit is 7100 rpm. It can be changed to any desired value.

Low speed torque can be increased by adding spark advance at low loads.

The GM idle speed is 650 rpm. When upgrading to a lightweight flywheel 750 rpm idle speed often reduces the transmission gear rattle associated with the single mass flywheel.

The secondary intake port control system can be disabled.

The VATS security system fuel control can be turned off. The second part of VATS is the starter lockout. To remove the starter control, remove the starter relay and insert a jumper connecting relay socket pins 30 and 87.

### What can't be done

The AFR at idle cannot be changed. The oxygen sensor hardware physically sets a 14.7:1 AFR when the system is in closed loop mode.

A high idle speed cannot be reduced. A high idle speed is usually caused by a vacuum leak.

The speedometer cannot be adjusted on calibrations for the LT5 engine.