

GM Variable Valve Timing VVT Camshaft Actuator System (CAS)



By:

Randall D. Decker

&

James N. Knobloch

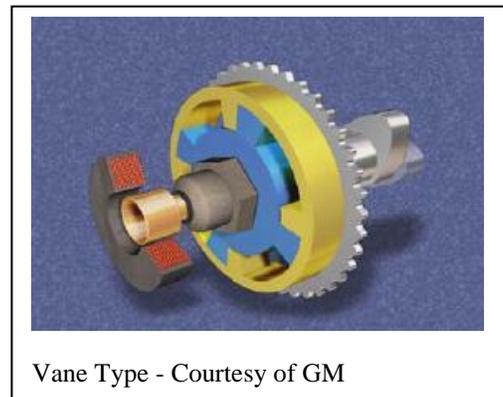
History

In September 1975, GM patented a system intended to vary valve lift. GM was interested in throttling the intake valves in order to reduce emissions. This was done by minimizing the amount of lift at low load. GM was successful but did not have a proper four cylinder motor to put the new technology in. GM put the technology to the side. Until 2004 when it was used on the Cadillac LH2 version of the Northstar in the STS, XLR, and SRX sport utility vehicle. The LH2 introduces a number of firsts for the Northstar engine. The compression ratio was increased for 10:1 to 10.5:1 and the intake and exhaust manifolds along with the cylinder head ports were designed to be less restrictive. A new air induction system was used designed to enhance engines volumetric efficiency. VVT was added and the EGR system along with associated emissions hardware was eliminated.

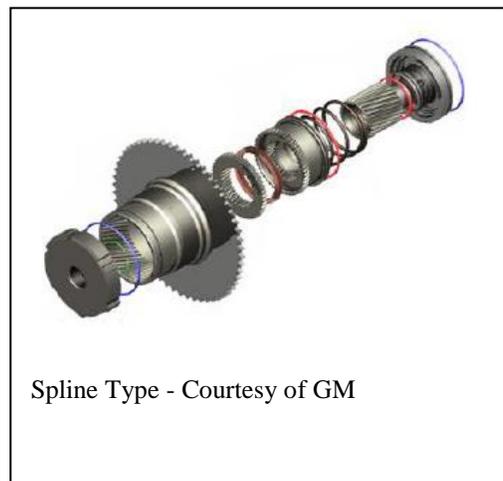
Description

Variable Valve Timing (VVT) is used to vary engine performance and enhancements. On dual cam systems, the PCM controls the amount of variance on both cams separately. There are two actuators in the system; one for the exhaust cam and one for the intake cam. The system is designed to lower emission output, give a wider torque range, improve gas mileage, and improve engine idle.

In 2004 and prior years, the GM 4.2L engine used the cam phaser on the front end of the exhaust camshaft. The camshaft is designed with a helical spline that allows the camshaft to change its position in its relationship to the camshaft drive sprocket, which changes the camshaft and crankshaft relationship, thus changing cam timing. This technology was replaced with the vane type, which is a more efficient set up.



Vane Type - Courtesy of GM



Spline Type - Courtesy of GM

Applications 2006 & 2007

- Buick – Allure, LaCrosse, Rainier, Rendezvous, Terraza
- Cadillac – CTS, Escalade, SRX, SRS, XLR
- Chevrolet – Avalanche, Cobalt, Colorado, HHR, Impala, Malibu, Monte Carlo, Suburban
- GMC – Canyon, Envoy, Yukon
- Hummer – H3
- Pontiac – G6, Solstice
- Saab – 9-3, 9-7X, Aero
- Saturn – Ion, Relay

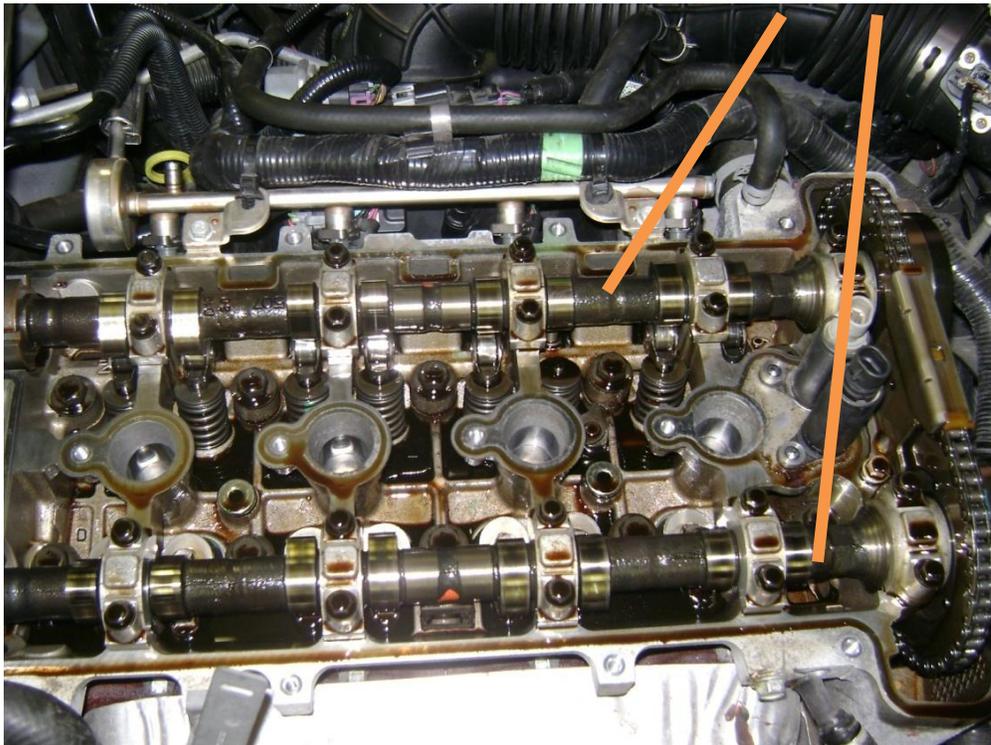
Components

Mechanical

- Cams
- Cam Phaser (Vane type)
- Camshaft Position actuator Solenoid

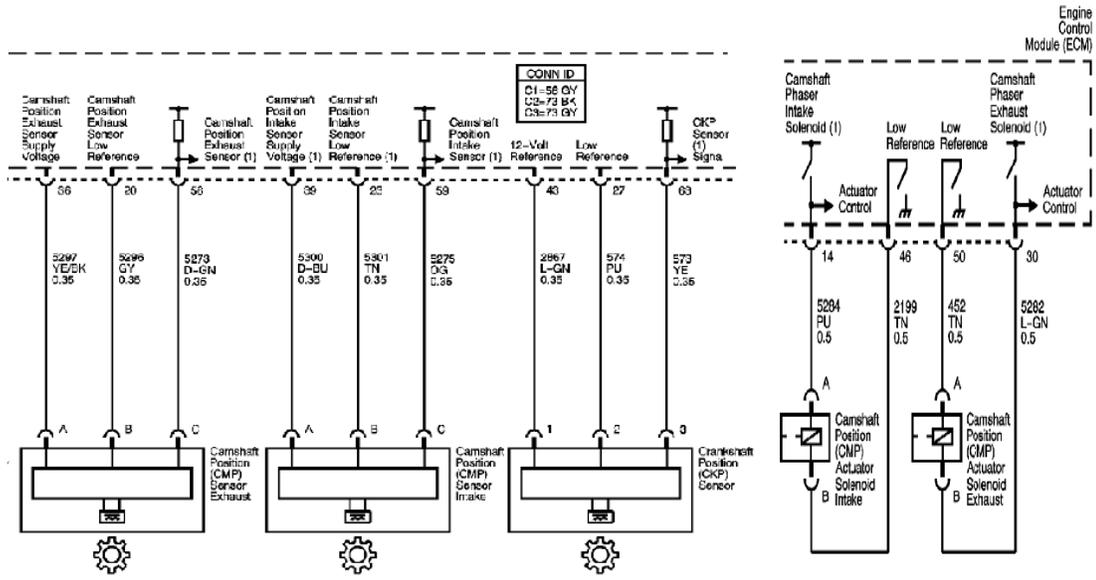
Electrical

- PCM
- Cam Sensors
- Crank Sensor



Camshafts

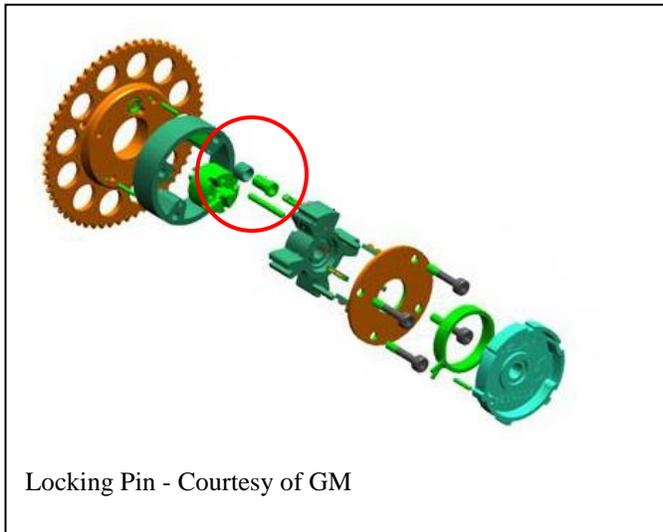
Wiring Diagram



Courtesy of Alldata

Current Phaser Description:

The benefits of the vane type cam phaser are a faster response time and a lighter, more compact design. The vane type VVT system utilizes the camshaft position solenoid actuators to manipulate oil pressure to the cam phasers. The Camshaft Position Actuator Solenoids are sent a 12v signal which is pulse width modulated. With the signal received from the PCM, the solenoids actuators open allowing engine pressure to enter either one of the two passages; camshaft advance or camshaft retard. Since the solenoid is pulse width modulated, the system can vary camshaft position between its two limits (25 or 50 degs depending on system). The solenoid is an electromagnet and would not function correctly without the ability of pulse width modulation. The cams actuators are hydraulically controlled. Pressure on one side of the cam actuator piston adjusts the cam to move the opposite way, and reverse for the other side. Cams can be varied as much as 50 degrees (depending on the system), from one extreme to the other.



The actuators are held in the 0 degree position by locking pins which help quiet valve train noise. The locking spring pressure is released once the pressure in the engine is high enough to overcome it. The exhaust actuators also have return springs to aid in returning to the home position.

There are two camshaft position sensors (CMP) which send signals to the PCM to verify cam

angle. The CMP sensor is very important in this system. If the CMP sensor doesn't read exactly what the PCM is requesting for the cam angle, a diagnostic trouble code (DTC) will set and the vehicle will default to base timing.

PCM Strategies

VVT can provide an EGR function. Whenever the PCM would normally command the EGR valve on (on a vehicle without VVT), the PCM of a VVT equipped vehicle would retard the exhaust camshaft. This will allow exhaust gas to reenter the combustion chamber with varying amounts of camshaft retardation. This action reduces combustion chamber temperature, thus improving NOX emission. On the intake camshaft, retarding the camshaft allows more air to enter the combustion chamber. This will provide a higher compression ratio, more horsepower, and improve gas mileage.

Advantages and Disadvantages

Advantages

- Increase horsepower and torque
- Improve gas mileage
- Improve emissions
- Eliminates the EGR system
- Eliminates AIR system

Disadvantages

- More parts to go wrong
- Very sensitive
- Destructive capabilities
- Expensive parts

Diagnostics Trouble Codes

Electrical DTC's	Description
P0010	Intake Camshaft Position Actuator Solenoid Control Circuit Bank 1
P0013	Exhaust Camshaft Position Actuator Solenoid Control Circuit Bank 1
P0020	Intake Camshaft Position Actuator Solenoid Control Circuit Bank 2
P0023	Exhaust Camshaft Position Actuator Solenoid Control Circuit Bank 2
P2089	Intake Camshaft Position Actuator Solenoid Control Circuit High Voltage Bank 1
P2091	Exhaust Camshaft Position Actuator Solenoid Control Circuit High Voltage Bank 1
P2093	Intake Camshaft Position Actuator Solenoid Control Circuit High Voltage Bank 2
P2095	Exhaust Camshaft Position Actuator Solenoid Control Circuit High Voltage Bank 2

Mechanical DTC's	Description
P0011	Intake Camshaft Position System Performance Bank 1
P0014	Exhaust Camshaft Position System Performance Bank 1
P0021	Intake Camshaft Position System Performance Bank 2
P0024	Exhaust Camshaft Position System Performance Bank 2

Correlation DTC's	Description
P0016	Crankshaft Position-Intake Camshaft Position Correlation Bank 1
P0017	Crankshaft Position-Exhaust Camshaft Position Correlation Bank 1
P0018	Crankshaft Position-Intake Camshaft Position Correlation Bank 2
P0019	Crankshaft Position-Exhaust Camshaft Position Correlation Bank 2

Diagnostics for the DTC's

Electrical

P0010, P0013, P0020, and P0023

Conditions for running the DTC's are that the engine is running more than 80 RPM. The EMC has commanded the Camshaft position Actuator solenoid on and off at least once during the ignition cycle. It is a continuous monitor.

Conditions for setting the DTC's are the ECM detects a open, short to ground, short to voltage on the high control circuit or an open in the low end for more than a ¼ second.

P2089, P2091, P2093, and P2095

Conditions for running the DCT's are that the engine is running more than 80 RPM. The EMC has commanded the Camshaft position Actuator solenoid on and off at least once during the ignition cycle. It is a continuous monitor.

Conditions for setting the DTC's are the ECM detects a short to voltage in the camshaft position actuator solenoid circuits and the conditions exists for more than 4 seconds.

Mechanical

P0011, P0014, P0021, and P0024

Conditions for running the DTC's are engine speed is more than 1000RPM, The engine is running for more than approximately 5 minutes, and the actuator system must move from the park position for at least 5 seconds and at least 4 times.

Conditions for setting the DTC's are if the ECM detects a difference of 5 degrees between the desired and actual cam position for more than 4 seconds or if the ECM detects a difference between actual camshaft position and locked position for more than 4 seconds.

Correlation

P0016, P0017, P0018, and P0019

Conditions for running the DTC's are the engine needs to be running for more than 5 seconds. The ECT reads between 32 and 203 degrees F. Engine oil

temperature is below 240 degrees F. Continuously ran once the conditions are met for approximately 10 minutes.

Conditions for setting the DTC's are the ECM detects one of the following conditions for more than 4 seconds: 1) a camshaft is too advanced or retarded in relationship to the crankshaft, 2) a deviation in the relationship between a camshaft and the crankshaft

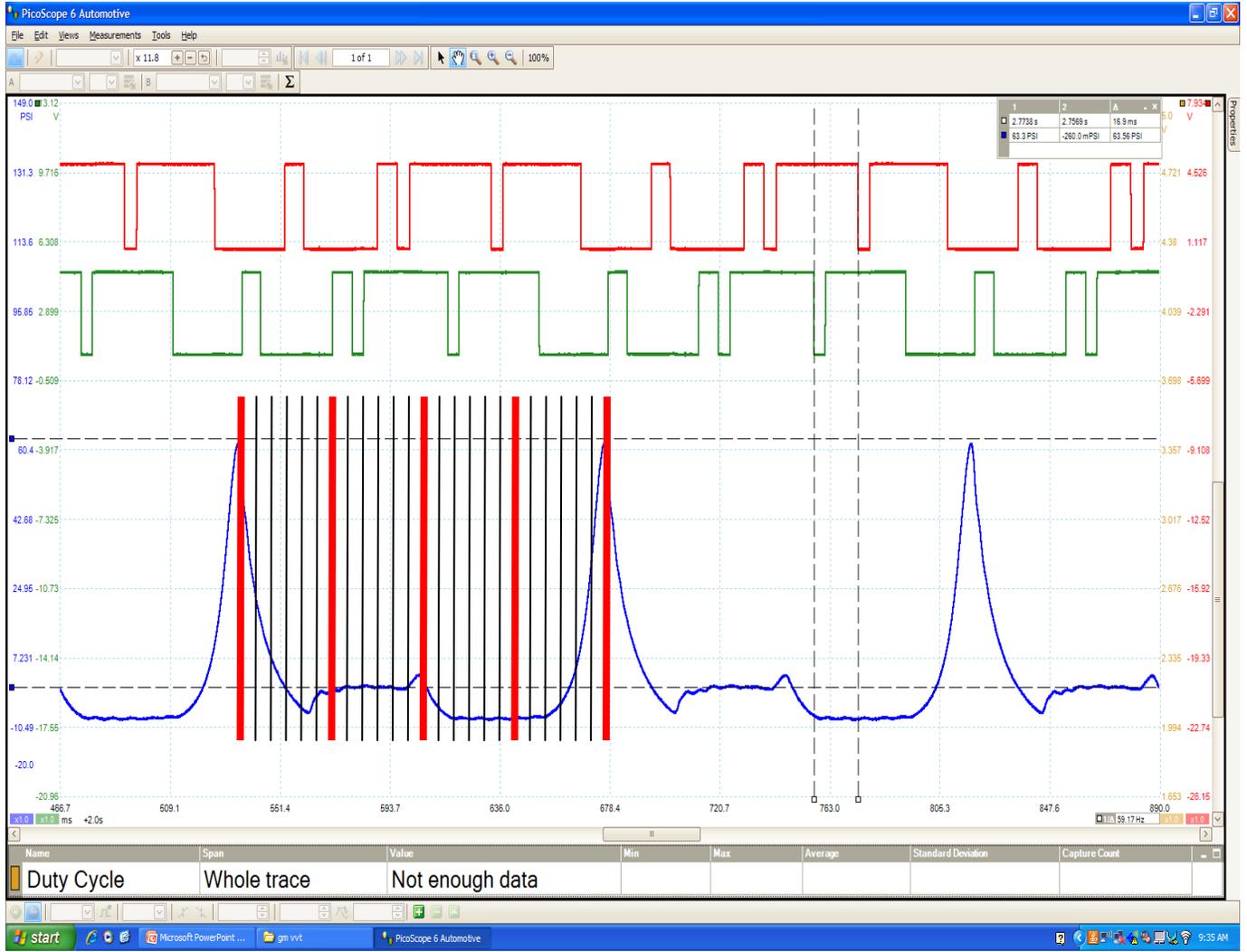
5 Gas Analyzer Data

All 5-gas tests were performed at 1500rpm, as required by the Tech2 scan tool.

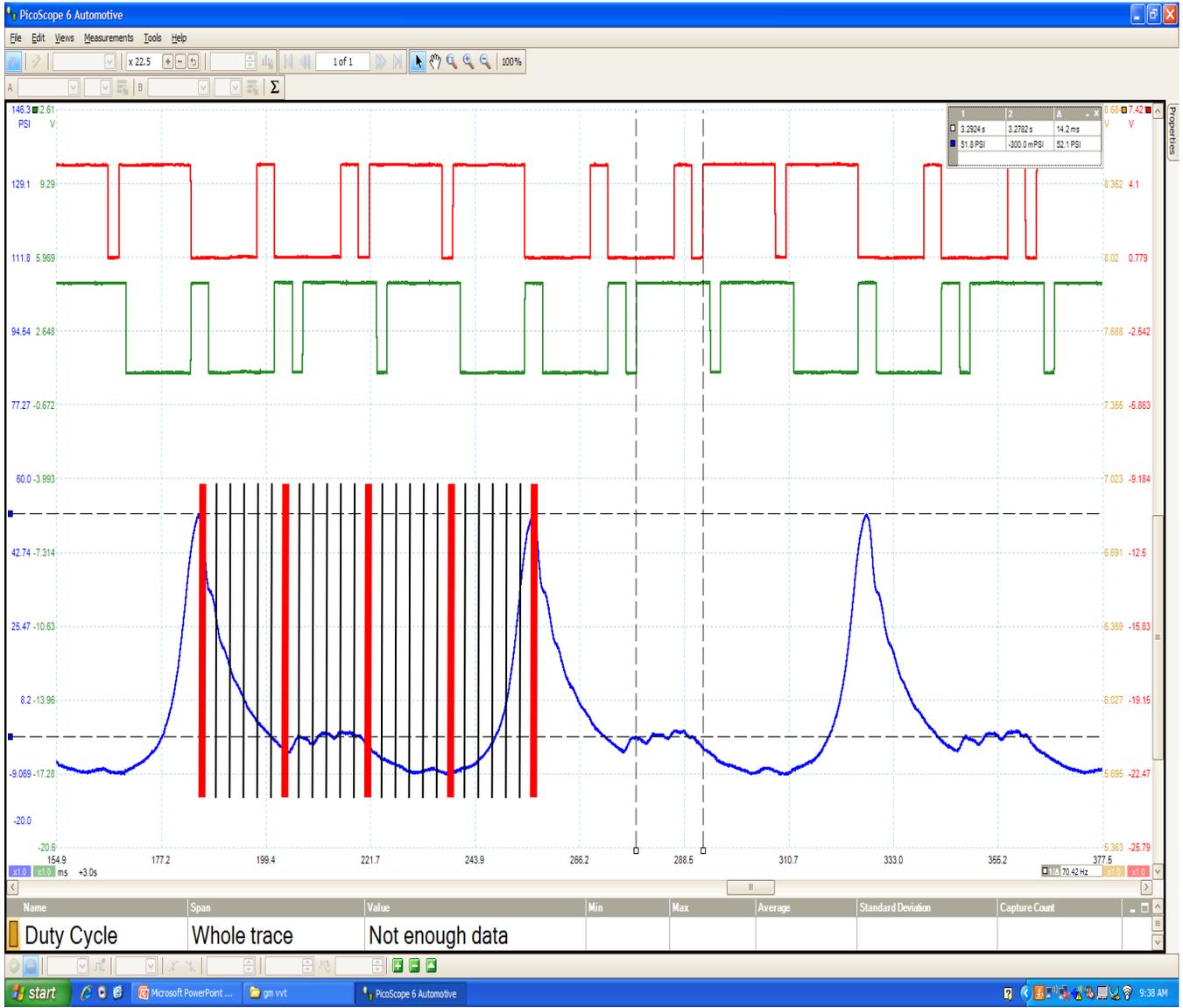
	HC	CO	CO2	O2	NOX
Normal	175 ppm	.6%	14.7%	.6%	250 ppm
5 Degree Intake	166 ppm	.5%	14.7%	.7%	300 ppm
15 Degree Intake	228 ppm	.4%	14.5%	.6%	360 ppm
25 Degree Intake	675 ppm	.9%	13.9%	1.3%	58 ppm
5 Degree Exhaust	190 ppm	.65%	14.5%	.7%	200 ppm
15 Degree Exhaust	150 ppm	.64%	14.7%	.5%	242 ppm
25 Degree Exhaust	160 ppm	.64%	14.5%	.6%	100 ppm

Pico scope Images

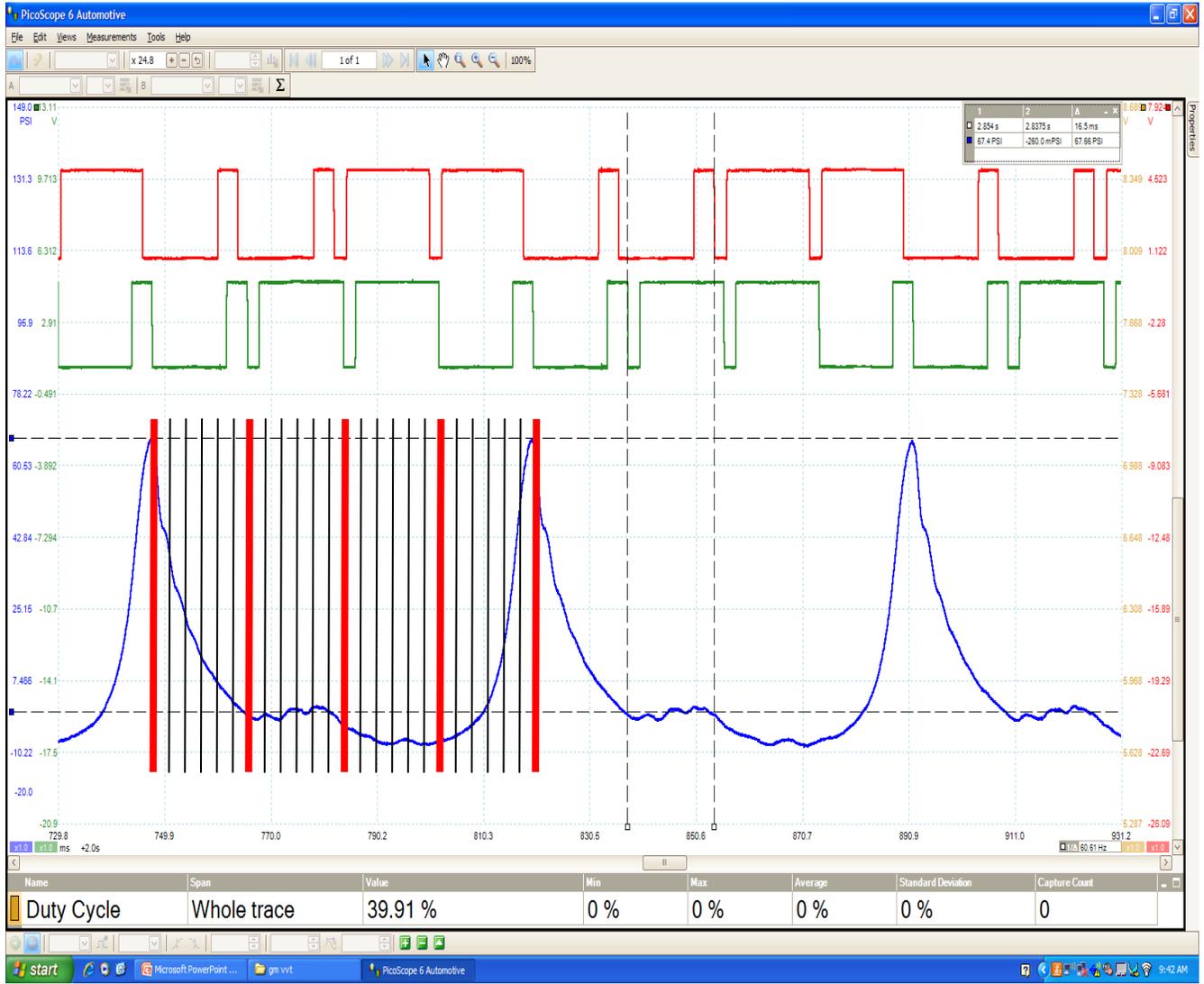
Normal



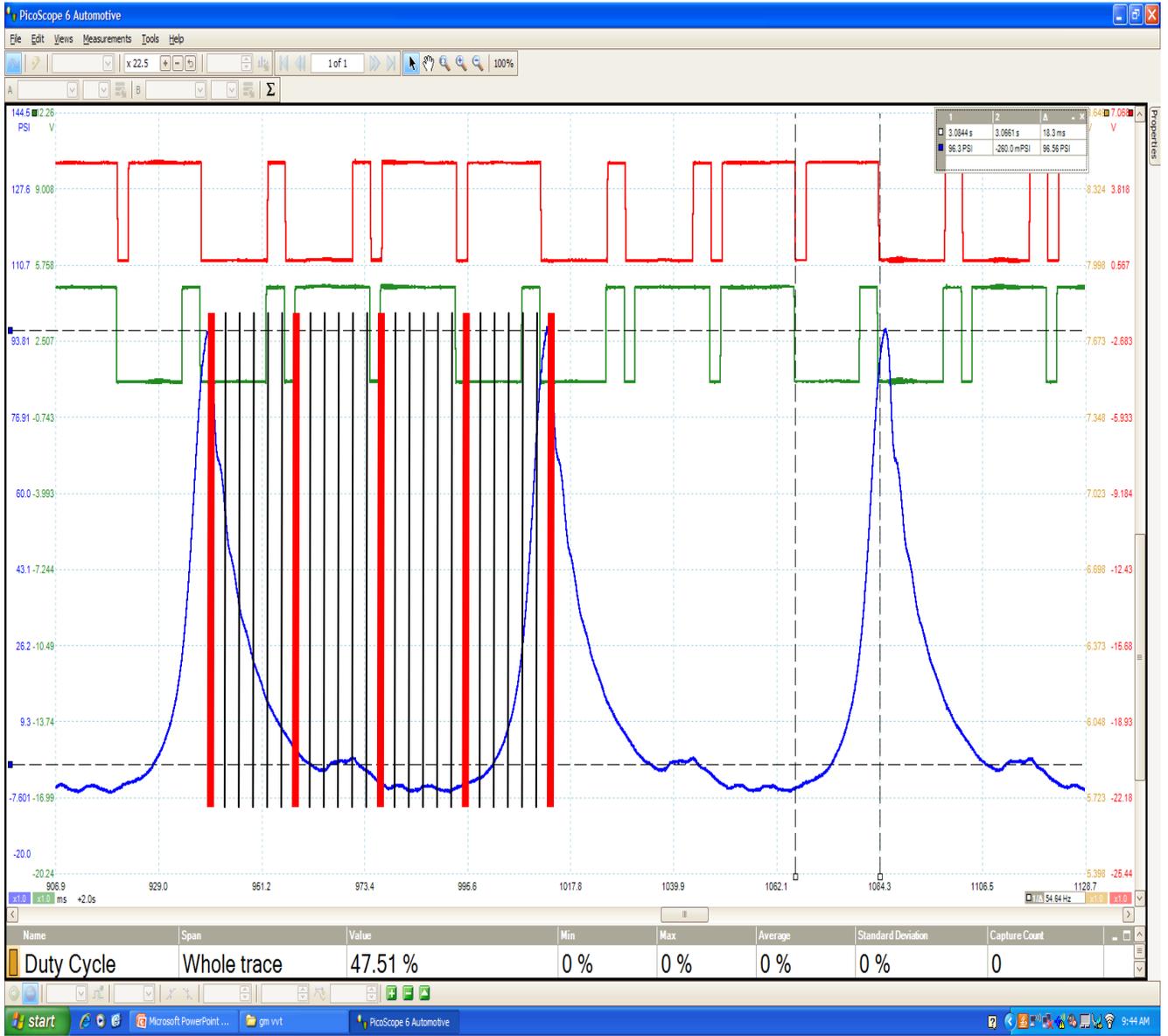
5 degree intake



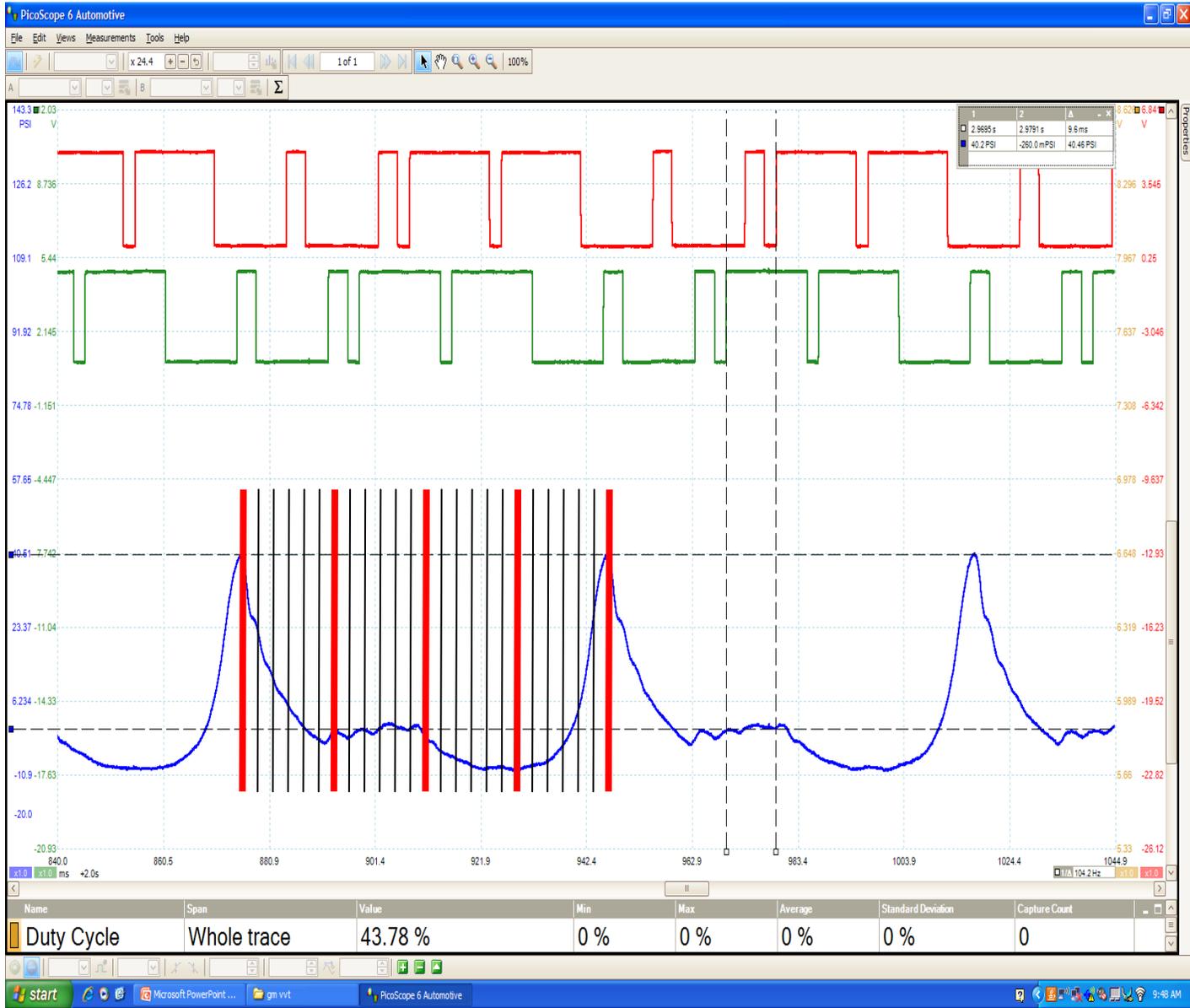
15 Degree intake



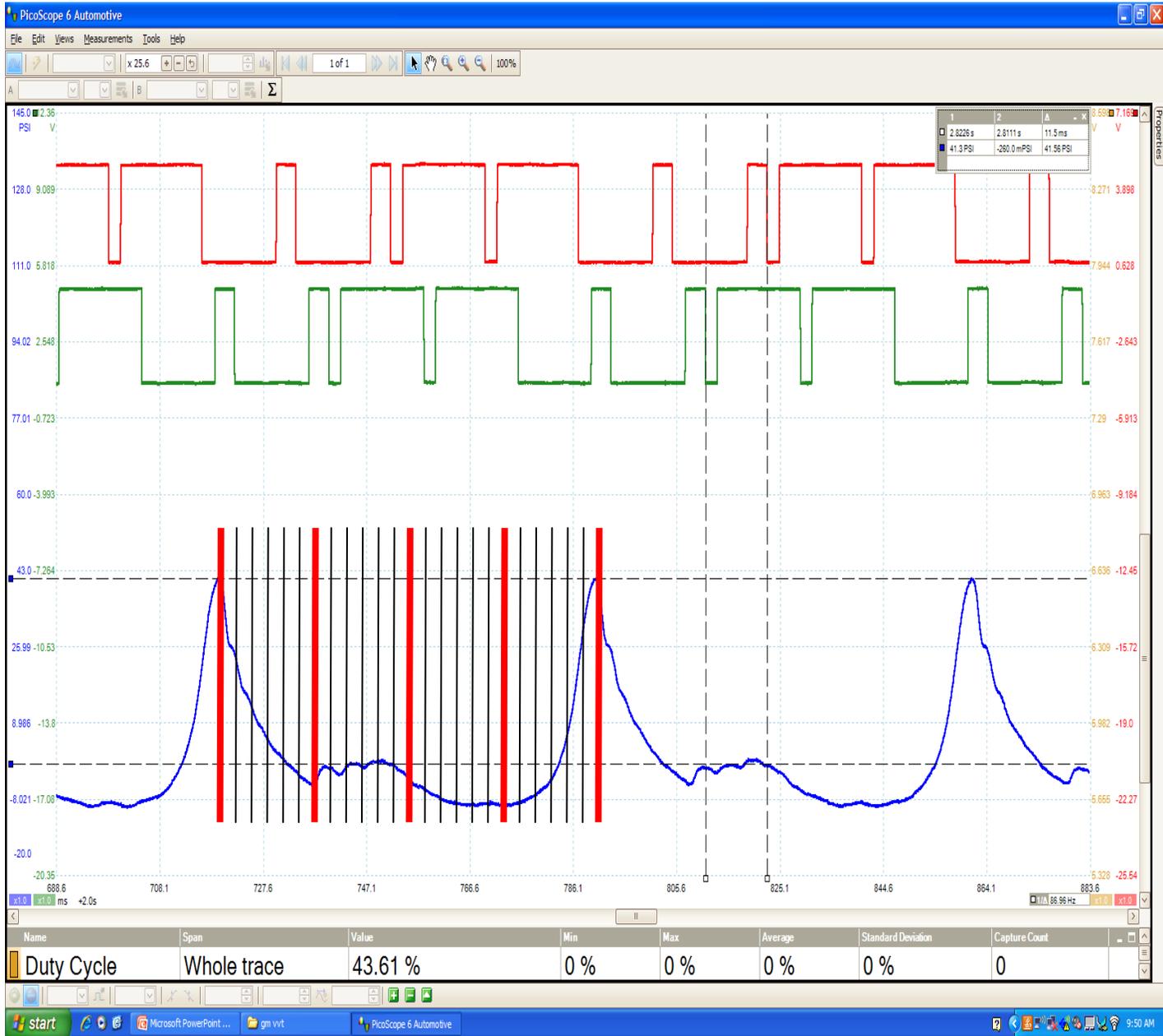
25 Degree intake



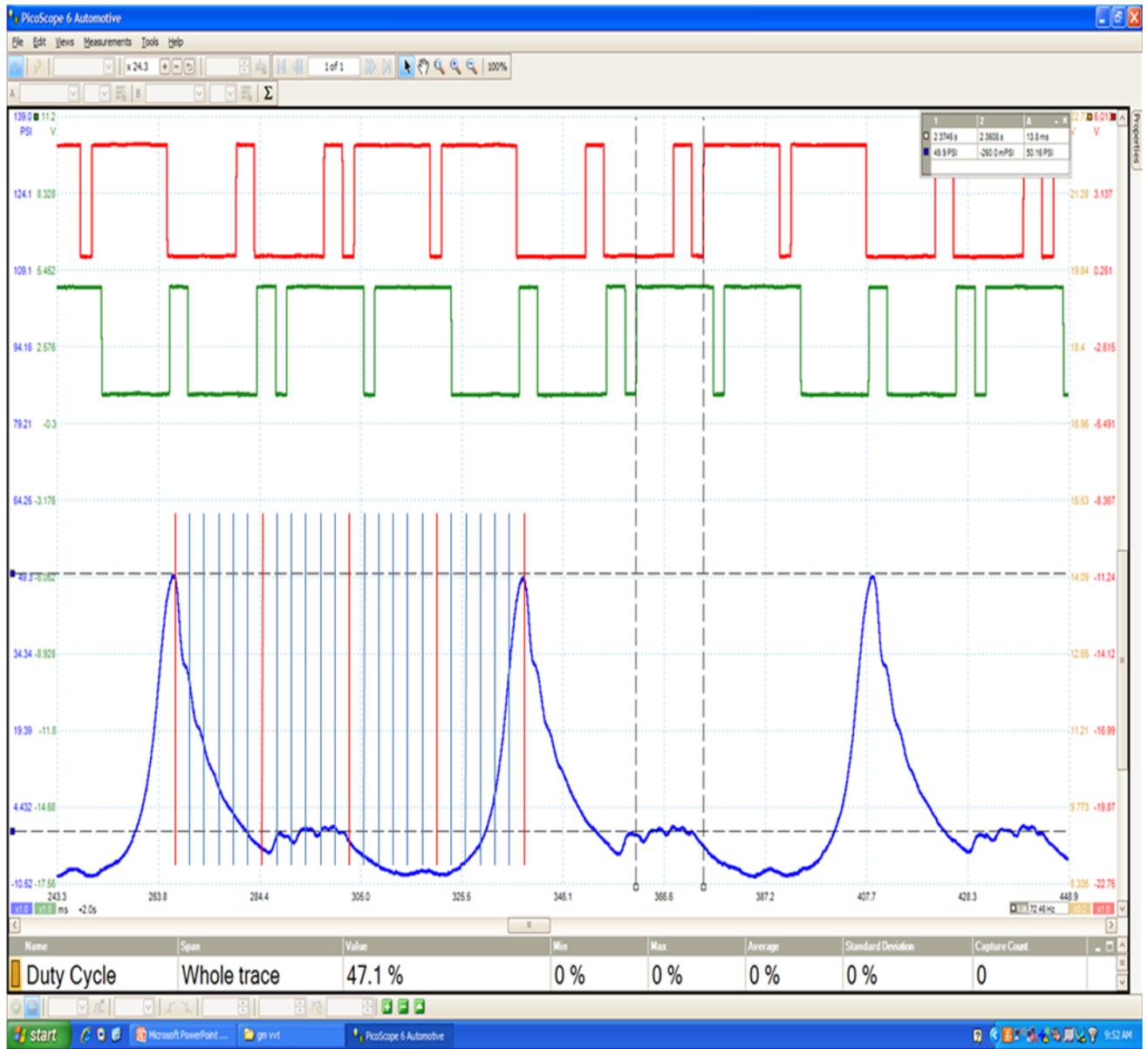
5 Degree Exhaust



15 Degree Exhaust



25 Degree Exhaust



References

Hatch, S. 2006. Computerized Engine Controls Seventh Edition

<https://mycourses.siu.edu/webct/urw/lc5116001.tp0/cobaltMainFrame.dowebct>

http://en.wikipedia.org/wiki/Variable_valve_timing

www.Alldatapro.com