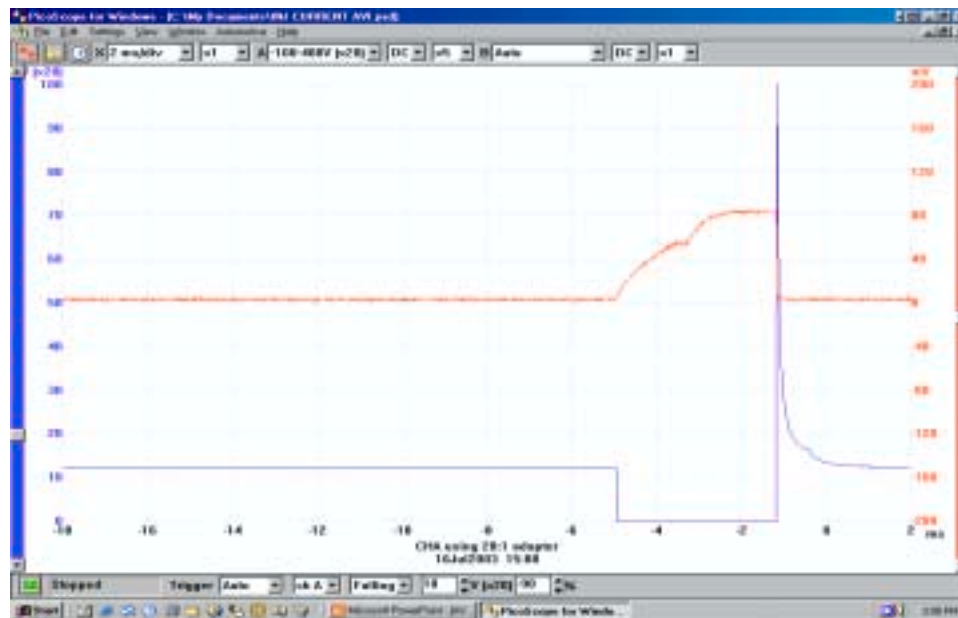


Tech Training

## Injector Waveform Analysis Part # 1



### Injector Waveform Analysis (Current over Voltage)

Fuel injector voltage (**shown in blue**) shows the applied battery voltage at 12 volts, the on signal (voltage drop to ground) and the off signal which shows 100 volts inductive kick. Also note the pintle closes at the off signal on the waveform.

#### Key Voltage points:

- **Supply voltage:** should be equal to battery voltage
- **On signal:** should be dropped to ground
- **On time:** measured in milliseconds (ms). Typically 1-2ms at idle.
- **Off signal:** inductive kick shown in example may be clipped in some circuits with a voltage limit.
- **Pintle close:** must be steady and consistent. Unsteady movement shows sticking or dirty injectors.

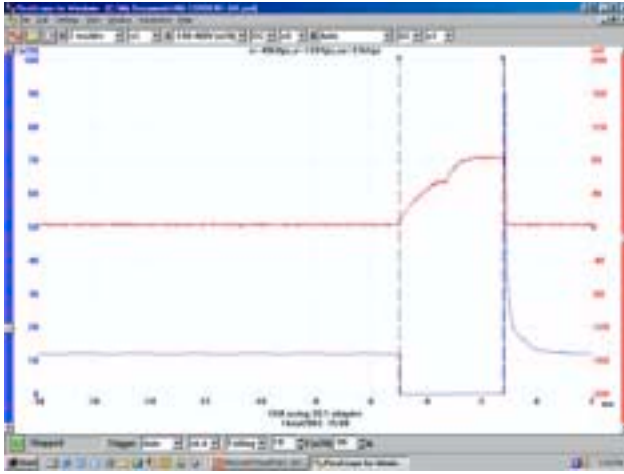
Fuel injector current (**shown in red**) shows a clean turn on or build up of current with a steady upward ramp (inductive current reaction of time). Pintle bump in current waveform shows point of pintle opening.

#### Key current points:

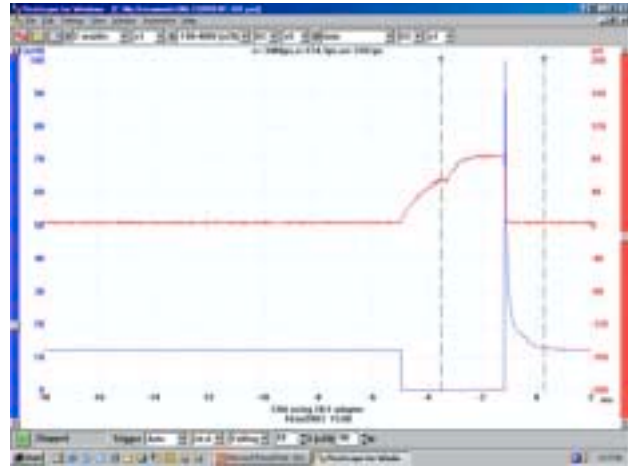
- **Current ramp:** smooth transition of current rise (ramps upward with no sharp changes)
- **Pintle bump:** opening point of fuel injector pintle shown on waveform with a bump or notch.
- **Clean off signal:** current flow stops with a clean cut off

## Tech Training.....continued from front page

### Injector Waveform Analysis Part #2



Fuel Injector Commanded on-time (3.7ms)



Fuel Injector actual spray time (3.7ms)

The injector waveform on the left shows actual ECM/PCM commanded on-time (measured in ms). The injector circuit is turned on and off and shows commanded on time of 3.7ms.

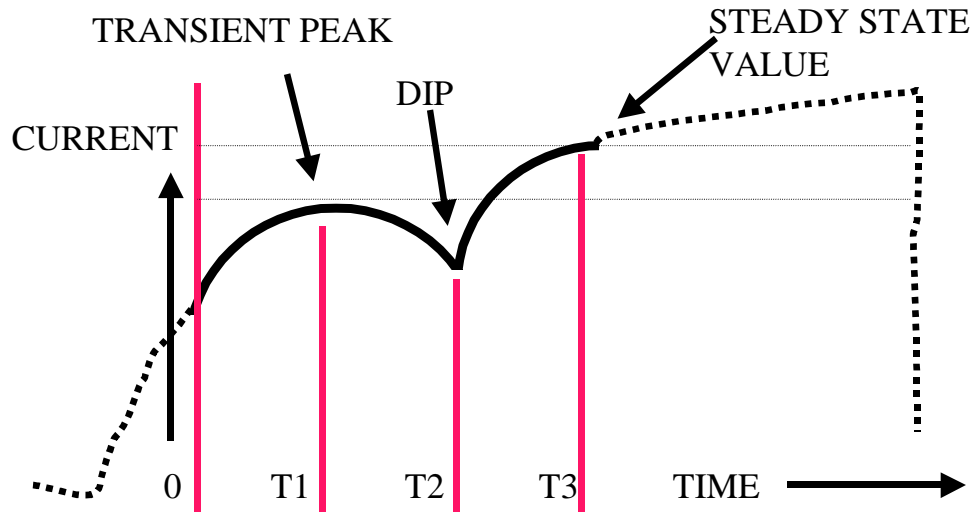
The waveform on right shows actual injector fuel spray time which is still 3.7ms. From this waveform, we can see that the current pattern can be divided into 2 easily defined areas.

**The first area** (prior to the pintle bump) is responsible for the electromagnetic force lifting the pintle. In the example this is approximately 0.6ms. At this point the current falls before rising again as the pintle is held open. With this in mind it can now be seen that the amount of time the injector is held open is not shown in time with the actual fuel spray. Therefore, it is reasonable to believe that commanded time (ms) would be the same as the time of actual fuel delivery or actual fuel spray.

**The second area** (after the pintle dip) is where the pintle is pulled all the way upward or open. The waveform will act like a normal resistive/inductive circuit. Current will continue to increase based on design.

Continued on page 3

*Learn more about this topic at the LTS Conference in September!*



**TIME 0-T1:** The solenoid is energized. The resistive/inductive circuit in the solenoid will take time to energize. At the end of T1, the current is close to transient peak. The injector pintle is NOT moving.

**TIME T1-T2:** The time depends on added mass. The solenoid has to attain sufficient force to pull the mass in. This force will cause acceleration in the pintle. Voltage will also decrease. A reduction in voltage causes the current to decrease. 0-T2 is the pull-in time. The injector pintle is fully open at this point.

**TIME T2-T3:** The pintle is completely pulled up or open. So, the solenoid will behave like a normal resistive/inductive circuit. Current will continue to increase based on design.

**Time after T3:** Steady state value of current: voltage / resistance



## LTS Conference 2003 Update

- Over 100 technicians are already registered to attend this year's conference! The theme of the conference is "Fuelish Thoughts" and the entire weekend will revolve around fuel-related topics such as:

Oxygen sensors	Catalyst monitors	Air/Fuel sensors
Fuel injectors	Fuel additives	Fuel trim

Seating is limited, so sign-up early. Deadline to register is August 31! Don't miss this exciting weekend! This year's conference will be held in a new location at a state-of-the-art training facility close to our shop on Gasoline Alley. As always, you can expect great speakers, lots of vendors, entertainment, door prizes and as plenty of food. Join us on September 12-14, 2003 for the LTS "Fuelish Thoughts" Conference. More information and registration forms are available online by going to our website at: [www.lindertech.com](http://www.lindertech.com). Hope to see you there!

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## **Technician of the Millennium Update!**

As promised, here is the update on the AC Delco Technician of the Millennium III Contest. We apologize that it took so long to post the results.

Five semi-final competitions were held across the US with 10 technician competing in each. Many of our present and former students along with several of our customers were among the distinguished list of semifinalists. The winners of the semifinal competitions are:

- Ricky Kelly of Bucks automotive in Tucson, Arizona
- Charles Murphy of Russels Automotive in Hampton, Georgia
- Scott Hager of Scotts Auto Service in Troy, Missouri
- Edward Robertson of Davis Auto Care in Northville, Michigan
- Curt Field of B&T Auto Repair in Butler, PA

These guys will compete with 3 winners from Canada for the title of ACDelco Technician of the Millennium III. The final competition will be held in Las Vegas this October. All of the finalists will receive many great prizes and the final winner of the competition will receive a new Chevy Silverado SS Truck.

Good luck to all the finalists!