PLX Critical Response Wideband Technology

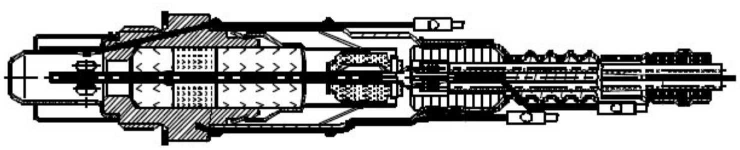
(V1.0) Sept 12, 2005

Summary

Not all wideband controllers are alike. The proper design and implementation of a wideband controller core is absolutely essential for guaranteeing proper air/fuel ratio measurements from an oxygen sensor. "PLX Critical Response Technology" employs the latest digital, analog, and feedback controller techniques designed to fully take advantage of the oxygen sensor's response characteristics. **This technical article explains the advantages of using "PLX Critical Response Technology" and addresses key performance parameters which are vital for guaranteeing good system performance.**

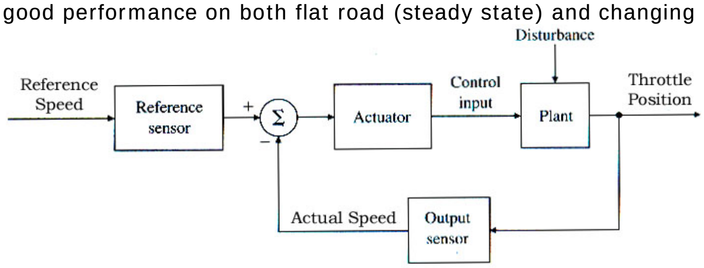
The Wideband Oxygen Sensor

The primary difference between a wideband and a narrowband oxygen sensor is that a wideband oxygen sensor can not function by itself. A sophisticated electronic circuit (a.k.a wideband controller) is required to properly interpret the oxygen concentration of the measured exhaust gases. Unlike a narrowband sensor, where the 0-1V output can be used directly from the sensor, the wideband sensor must be controlled by a variety of reference voltages (Vs, Vs/Ip) and drive current (Ip). Based on the feedback voltage Vs/Ip, the wideband controller regulates the amount of current Ip through the sensor's pump cell. Proper control and regulation of this current Ip is the key to obtaining accurate lambda (air/fuel ratio) readings under steady state and transient conditions.



What is a Wideband Controller?

The wideband controller is a feedback control system. One example of a feedback control system is your vehicle's cruise control. The driver sets a "reference" vehicle speed and the cruise control system maintains the vehicle's speed by varying the throttle position based on "feedback" from the vehicle speed sensor. If there is a change in road condition, for example the road ahead becomes steeper; the cruise control system senses the decrease in vehicle speed and increases the throttle position. A properly designed cruise control system must have good performance on both flat road (steady state) and changing road (transient) conditions.



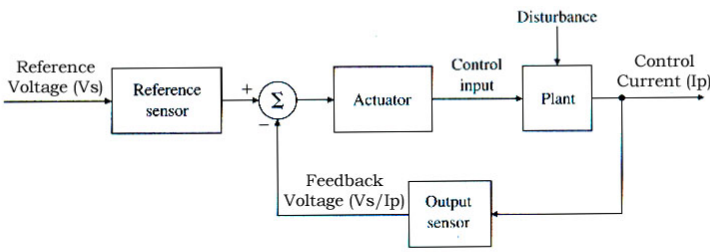
1) Steady State - On flat road the vehicle must maintain its speed as close as possible to the reference speed set by the driver. If the vehicle's reference speed is set to 100 mph, the vehicle should be traveling at 100 mph. However, in real world conditions, an error is always present. If the vehicle travels at 102 mph, there is a 2% error in the system. This error is called steady state error.

2) Transient - If the vehicle approaches a series of hills, the cruise control system must dynamically adjust to the changing conditions to maintain a constant speed. If the vehicle is traveling at 100 mph on a flat road and approaches a 30 degree incline, the vehicle will require additional throttle. A properly designed cruise control system will "respond" properly to the decrease in vehicle speed and apply additional throttle. If the system applies too much throttle correction, the vehicle will over compensate and result in the vehicle traveling faster than 100 mph, then slower than 100, then faster again until it

stabilizes to 100 mph. If the system applies too little throttle correction, it will take a long time to for the vehicle to accelerate back to up 100 mph.

The concept of a wideband controller is identical to that of a cruise control system. The wideband controller relies on a voltage (Vs/Ip) "feedback" and compares it with a reference value (Vs) from the oxygen sensor to determine how much current (Ip) is to be applied.

	Cruise Control System	Wideband Control System
Reference	Set Vehicle Speed	Set Reference Voltage (Vs)
Feedback	Vehicle Speed Sensor	Voltage from O2 Sensor (Vs/Ip)
Output	Throttle Position	O2 Sensor Current (Ip)



1) Steady State – If the actual air/fuel ratio of the sampled exhaust gasses remains unchanged at 14.7 AFR for a long period of time, the wideband controller must read 14.7 AFR with an error no greater than +-0.1 AFR.

2) Transient – If the exhaust gasses suddenly changes from, 14.7 to 13.0, the wideband controller system is responsible for detecting a change in the reference voltage Vs/Ip and adjusts the control current Ip accordingly. Over compensating current Ip will result in a reading less than 13.0, then over 13.0, and then under again until it stabilizes at 13.0. If the system under compensates current Ip, it will take a long time for the system to stabilize at 13.0, making the oxygen sensor appear to be slow and unresponsive.

Wideband Controller Design

"PLX Critical Response Wideband Technology" employs a finely tuned PID (proportional, integral, differential) feedback controller designed to give excellent steady state accuracy and transient response from a wideband oxygen sensor. Using a PID controller is extremely effective in error reduction and simultaneously provides excellent stability and damping.

PID Controller Transfer Function:

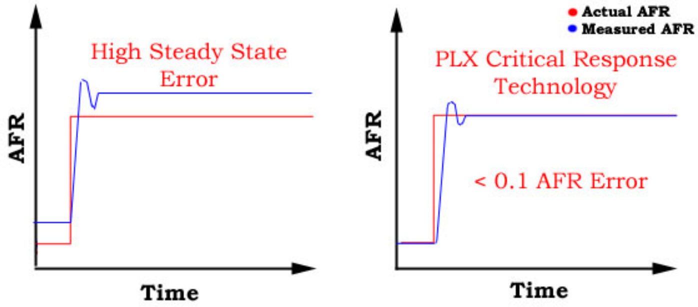
$D(s) = K(1 + 1/Ti*s + Td *s)$

The key to proper PID feedback controller design is to properly adjust constants K, Ti, and Td to achieve maximum sensor performance. Through years of Research and Development PLX Devices wideband products implement a finely tuned PID controller core called the "PLX Critical Response Wideband Technology."

Advantages of PLX Critical Response Technology

Low Steady State Error:

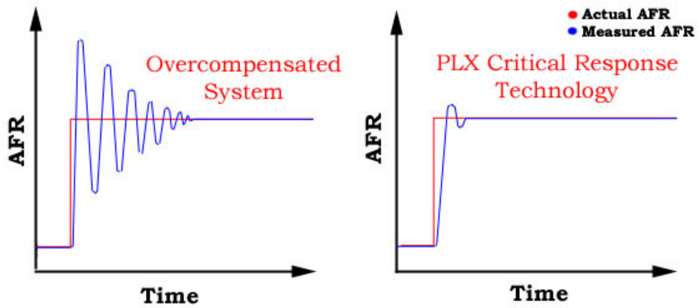
All PLX Devices wideband products go through an extensive quality control checklist to ensure that all references voltages and electronics fall within specified parameters. Wideband controllers are extremely sensitive and as little as 50 mV can skew the measured accuracy by more than 0.1 AFR. PLX Devices uses only high quality electronic components with 1% tolerances to guarantee less than 0.1AFR steady state error.



Excellent Transient Response:

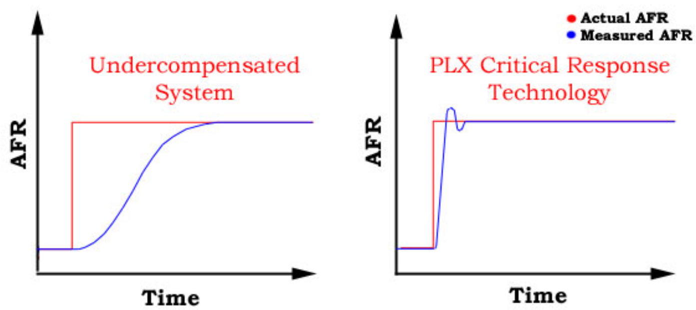
Below is an example of an improperly designed wideband controller. This system is known as an overcompensated or under damped system. During the time that the system is adjusting to the change, incorrect and erroneous values are being measured. Notice that the PLX wideband controller overshoot is minimized and quickly settles to the correct reading.

A good real world example of an under damped system is a vehicle's shock absorber set to soft. When a vehicle hits a bump on the road, the vehicles bounces up and down drastically and takes a long time to settle.



Below is another example of an improperly designed wideband controller. This system is known as an under compensated or over damped system. During the time that the system is adjusting to the change, incorrect values are being measured. The sensor's response characteristics are not being fully utilized and the entire system will seem sluggish. Again notice that the PLX wideband controller overshoot is minimized and quickly settles to the correct reading.

A good real world example of an over damped system is a vehicle's shock absorber set to hard. When a vehicle hits a bump on the road, the shock absorber hardly moves.



No Sensor Calibration Required:

Using a PLX wideband controller is extremely simple and hassle free. Simply install the oxygen sensor in the vehicles' down pipe and power up the product. You're ready to start measuring your precise air/fuel ratio immediately. Unlike other products on the market, frequent free air sensor calibration is unnecessary with "PLX Critical Response Technology."

Manual free air sensor calibration is often required in other wideband products primarily to account for reference voltage deviations in its internal electronics. As mentioned earlier, the wideband sensor is extremely sensitive to reference voltages as little as 50 mV and Ip current as little as 1 mA can influence the measurement accuracy significantly. In order to save on manufacturing and quality control costs, these other wideband controllers pass the burdon of fine tuning their electronics to the end user. All PLX wideband products go through an extensive quality control procedure before they are shipped. Electrical tolerances and internal reference voltages are kept extremely tight to ensure excellent performance and accuracy. Products which do not pass quality control are sent back to manufacturing for engineering analysis and the procedure is repeated.

In addition, some wideband controllers which require calibration to free air may introduce unwanted errors. A calibration procedure requires a known oxygen concentration to reference the wideband controller. “Ideal free air” is an oxygen concentration at sea level (0 elevation), and 25 Deg C. If a wideband controller is calibrated to free air outside of “ideal free air” conditions, the controller will improperly reference the oxygen concentration. The oxygen concentration of air at high elevation is less than the oxygen concentration at sea level. To obtain accurate readings, the user must expose the oxygen sensor to free air at 0 elevation and an ambient temperature of 25 Deg C. This proves to be an impractical procedure and greatly complicates the usability of the product. PLX Devices wideband products do not require sensor calibration and come pre calibrated to “ideal free air” from a controlled laboratory environment.

High Operating Temperature:

Other wideband controller products on the market may require a heat sink to be installed on the oxygen sensor if the EGT (Exhaust Gas Temp) rises above ~550 Deg C. PLX Devices wideband products DO NOT require a heat sink to be installed and will function up to 850 Deg C. 850 Deg C is the maximum temperature the Bosch LSU sensor is design to operate. “PLX Critical Response Technology” has proven to be extremely reliable in high boost and high exhaust gas temperature applications.

Conclusion

Through years of research and development, PLX Devices offers unsurpassed wideband controller technology and performance. Each wideband controller product is carefully tested and verified to the highest standard before it is shipped. With a PLX wideband controller, steady state error is meticulously controlled to 0.1 AFR and transient response of the sensor is maximized, making “PLX Critical Response Wideband Technology” the most trusted wideband technology on the market.

Revision History

Version 1.0 (9/12/05)	Initial release