

Adiabatic Compensation for Digiquartz® Intelligent Transmitters



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“The standard by which other standards are measured”

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1. Introduction

Paroscientific recently introduced the ability to compensate for adiabatic effects in its line of Intelligent Transmitter products. Products that support the feature include the 1000 and 9000 Series Intelligent Pressure Transmitters and 8000 Series Intelligent Depth Sensors built with 4000 Series pressure transducers. The feature is available in firmware version R5.12 and later.

The adiabatic compensation feature was designed to address a specific application involving a consistent, repeatable positive-going pressure event. It is not possible to compensate for negative-going, inconsistent, or non-repeatable pressure events at the present time.

2. Concept

Adiabatic compensation involves characterizing the adiabatic effect, setting a group of serial configuration parameters accordingly, and verifying that the adiabatic compensation has been properly configured.

The serial configuration parameters are as follows:

Command	Description
AA	Read/write the adiabatic excursion amplitude in current pressure units.
AC	Read/write the adiabatic compensation time constant in seconds.
AH	Read/write the adiabatic compensation trip threshold in current pressure units.
AM	Read/write the adiabatic compensation mode enable.
AR	Read/write the adiabatic compensation re-arm threshold in current pressure units.

3. Characterizing the Adiabatic Effect

The adiabatic effect is characterized by acquiring pressure data during the pressure event, graphing it vs. elapsed time, and analyzing the pressure data per Figure 1. When values A through H have been determined, set the AA, AC, AH, and AR parameters accordingly. Set the AM parameter to 1 to enable adiabatic compensation. Once again, acquire pressure data during the pressure event, graph it vs. elapsed time, and verify adiabatic compensation. It may be necessary to tune one or more parameters for optimum performance.

Complete documentation for the serial commands used to configure adiabatic compensation can be found below.

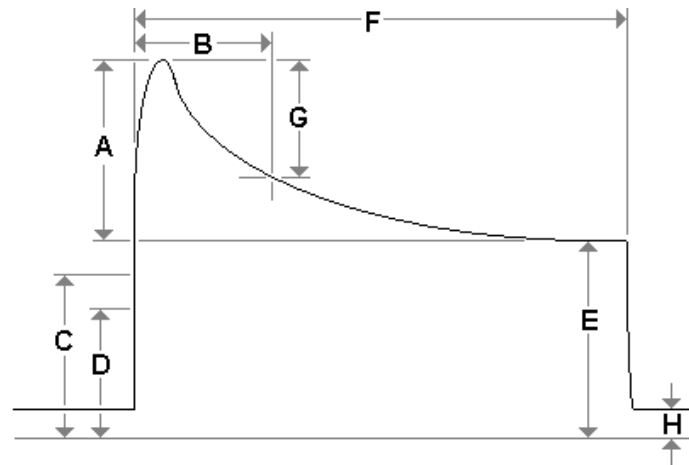


Figure 1: Pressure Pulse Showing Adiabatic Effects (not to scale)

- A** – Adiabatic pressure overshoot amplitude from the steady state level [E]. This value is entered into the AA serial command (see below) in the current pressure units.
- B** – Adiabatic pressure pulse time constant that is entered into the AC serial command (see below) in seconds.
- C** – Pressure pulse trip threshold turns ON the active adiabatic compensation and is entered into the AH serial command (see below) in the current pressure units and establishes the start time.
- D** – Pressure pulse re-arm threshold turns OFF the active adiabatic compensation and resets the algorithm. This value is entered into the AR serial command (see below) in the current pressure units.
- E** – Pressure pulse steady state level that would be generally found greater than five time constants [B] after the start of the pulse.
- F** – Pressure pulse duration before returning below the re-arm threshold [D].
- G** – Adiabatic pressure overshoot level after one time constant [B], which is down approximately 37% from the peak overshoot amplitude ($A * e^{-1}$).
- H** – Quiescent pressure level prior to and after the pressure pulse.

AH : Read/write the adiabatic compensation trip threshold in current pressure units.
ACTION: Reads or writes (EW command required) of the adiabatic compensation trip threshold is a floating point number in current pressure units. This value is used in the calculation of the adiabatic pressure error by determining the start time (T_{START} , see above calculation) of the pressure pulse and adiabatic over-shoot (see [C] of figure 1). Also, this value is always greater than or equal to the re-arm threshold of the AR serial command. If the value entered is less than the current AR value, AR will be made equal to the new AH value otherwise, it is left unaltered.

Command format:

*UUHHAHrl Read current trip threshold value.
*UUHHEW{rl}*UUHHAH=ccccccrl Write new trip threshold value.

Response format:

*HHUUAH=ccccccrl Report current trip threshold value.

Where:

cccccc = Trip threshold (floating point ASCII decimal value.)

AM : Read/write the enable state of the adiabatic compensation mode enable.
ACTION: Enabling/Disabling the adiabatic compensation mode is done by writing (EW required) an ASCII 0 or 1 in accordance to the following chart:

Argument	Description
0	Adiabatic compensation is disabled
1	Adiabatic compensation is enabled

Command format:

*UUHHAMrl Read adiabatic compensation enable state.
*UUHHEW{rl}*UUHHAM=drl Write argument (see above).

Response format:

*HHUUAAM=drl Returns the current adiabatic compensation enable state.

Where:

d = Boolean value (ASCII 0 or 1)

AR : Read/write the adiabatic compensation re-arm threshold in current pressure units.
ACTION: Reads or writes (EW command required) of the adiabatic compensation re-arm threshold is a floating point number in current pressure units. This value is used to determine when the active adiabatic compensation is disabled (sampled pressure is less than the AR value) and also to reset the algorithm for the next pressure pulse event that exceeds the trip threshold of the AH command (see also [D] of figure 1). This value cannot be set greater than the trip threshold of the AH command. Thus, as a value of AR is set larger than the current AH value, AH will be made equal to the new AR value. An AR value set less than the current AH value will leave the AH value unchanged.

Command format:

*UUHHARrl Read current re-arm threshold value.
*UUHHEW{rl}*UUHHAR=ccccccrl Write new re-arm threshold value.

Response format:

*HHUUAR=ccccccrl Report current re-arm threshold value.

Where:

cccccc = Re-arm threshold (floating point ASCII decimal value.)

5. Formulas

Adiabatic Pressure Error Calculation:

$$P_e = A * e^{\left(\frac{-(T_{CAPTURE} - T_{START})}{T_{TC}}\right)}$$

Adiabatic Pressure Compensation:

$$P_{CORRECTED} = P_{RAW} - P_e$$

where:

P_e = adiabatic pressure error in current pressure units.

$P_{CORRECTED}$ = pressure corrected for adiabatic effects.

P_{RAW} = temperature compensated pressure value containing adiabatic pressure effects.

A = adiabatic excursion amplitude in current pressure units (see AA, [A] from Figure 1).

$T_{CAPTURE}$ = time captured at pressure acquisition(s) after trip threshold event in seconds.

T_{START} = start time captured at pressure acquisition of the trip threshold event in seconds. (see AH)

T_{TC} = adiabatic time constant in seconds (see AC, also [B] of figure 1).