UNDERSTANDING INPUT SIGNAL VARIATION in Sensor ICs with SolidSpeed Digital Architecture

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Modern Allegro MicroSystems speed sensors use SolidSpeed Digital Architecture technology that moves most signal processing into the digital domain. With the advancement of this technology, the restriction of input signal variation has also changed. For many previous ICs, there was a restriction on the total input magnetic magnitude change that could occur during a given power-on instance. ICs with this updated specification are capable of continuously tracking a signal where the magnetic magnitude varies throughout the full operational range of the IC. There is a restriction on the rate of change of the magnetic magnitude from one input period to the next to maintain uninterrupted output.

The datasheet representation of this limitation has changed and may not be immediately obvious how it is to be interpreted. This application note is to be used to aid the understanding of these datasheet line items. This specification change can be seen in the A19302 and A19571 datasheets and will continue to be used in many parts that use this technology moving forward.

Background

With the invention of SolidSpeed Digital Architecture parts, a signal can be tracked throughout its entire dynamic range using a fixed gain. This fixed gain removes the need for automatic gain control. Instead of comparing the current signal's magnitude to the maximum and minimum since power-on, parts compare the current signal magnitude to a previously stored tracked magnitude.

This creates a requirement that the current period's peak-to-peak value must be within a certain amount to the previous or several previous peak-to-peak values. This is represented in datasheets using the Allowable Signal Variation line items and is shown in the Typical Datasheet Representation section of this document.

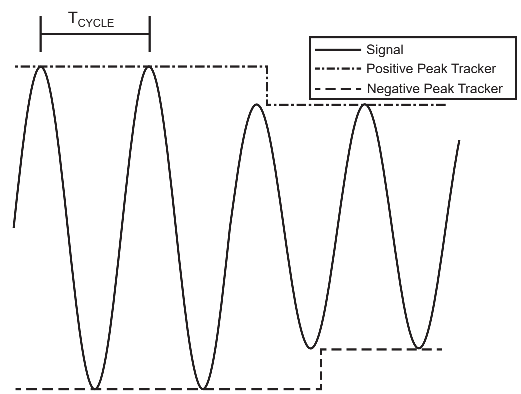

Figure 1: Peak Tracking Example

These line items are typically accompanied by two figures showing the common cases of signal variation. A signal period-to-period variation where the peak-to-peak value changes over a single period and a repeated period-to-period variation where the peak-to-peak value changes continuously over multiple periods. One can see that these are similar cases that are further enforced by both using the same accompanied equation and limitations.

How to Interpret

This section will discuss how to interpret these datasheet line items and how to know what cases are within datasheet limits. Looking at the line items separately, it can be understood what each means.

Operating Magnetic Input Signal Window is a rolling window that sets the limit for how many periods the IC has "memory" of in the past. Or if looking at a waveform, it is how many periods in the future that must be compared to the current signal magnitude.

Operating Magnetic Input Signal Variation is the symmetrical limit that the signal can increase or decrease in peak-to-peak amplitude without the inclusion of offset within this specified window. This value is represented in terms of a ratio of the current peak-to-peak to any of the previous period's peak-to-peak within the specified windows.

Using the equation shown in Figure 2 and Figure 3:

Equation 1:

$$\Delta B_{DIFF(pk-pk)} = \frac{B_{n+m}}{B_n}, m = 1,2,\ldots,T_{WINDOW}$$

starting from period n and using a window size of T_{WINDOW}. The signal peak-to-peak variation, $\Delta B_{DIFF(pk\text{-}pk)}$, of period $n+m$ with respect to period n must be within datasheet limits of Δmin and Δmax.

How the magnitude changes within this window does not matter so long as $\Delta B_{DIFF(pk\text{-}pk)}$ remains in specification. That is to say that the signal can have a single period-to-period variation of Δmin or Δmax and no other changes within this window; or the signal can have a repeated period-to-period variation such that B_{n+m} has a ratio of Δmin or Δmax; or there can be a mixture of the two such that $\Delta B_{DIFF(pk\text{-}pk)}$ is not violated within any window of size T_{WINDOW}.

Typical Datasheet Representation

Characteristic	Symbol	Notes	Min.	Typ.	Max.	Unit
Operating Magnetic Input Signal Variation	$\Delta B_{DIFF(pk\text{-}pk)}$	Bounded amplitude ratio within T_{WINDOW} [1]. No missed output transitions or flat line condition. ossible incorrect direction information. See Figure 2 and Figure 3.	Δmin	–	Δmax	–
Operating Magnetic Input Signal Window	T_{WINDOW}	Rolling window in which $\Delta B_{DIFF(pk\text{-}pk)}$ cannot exceed bounded ratio. See Figure 2 and Figure 3.	W_{min}	–	–	T_{CYCLE}

[1] Symmetrical signal variation is defined as the largest amplitude ratio from B_n to B_n + T_{WINDOW}. Signal variation may occur continuously while B_{DIFF} remains in the operating magnetic range.

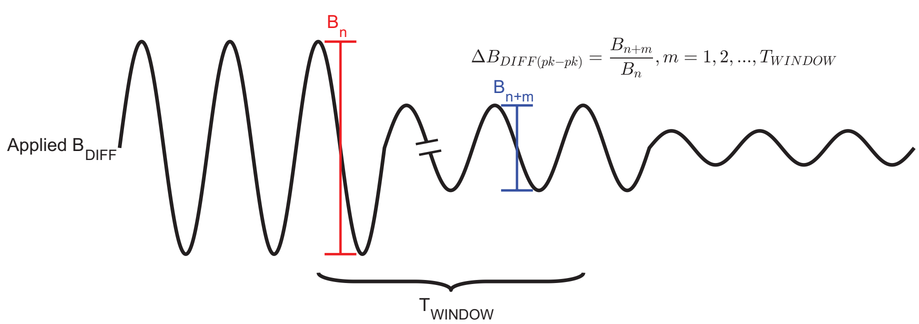

Figure 2: Single period-to-period variation

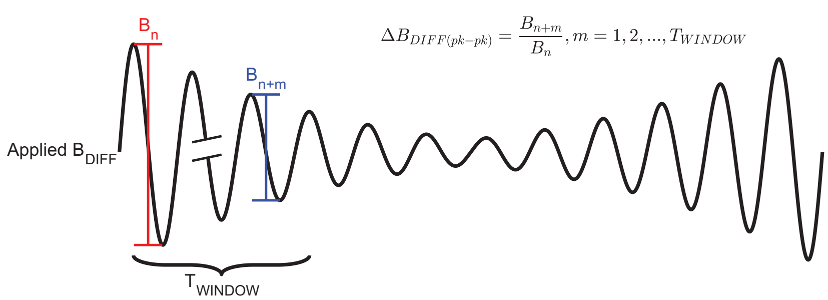

Figure 3: Repeated period-to-period variation

Examples

It may be useful to further understand this datasheet specification by looking at several hypothetical scenarios for a hypothetical part. For the following examples, a part with a Δmin of 0.4, no Δmax requirement, and a W_{min} of 3 T_{CYCLE} is used, and a second part with the same Δmin and Δmax as the previous part but a W_{min} of 4 will be considered.

Case 1

This case will look at a simple single period-to-period variation. There are two events that change the peak-to-peak by 50% relative to the previous peak. Periods [1,2,3] have a peak-to-peak value of 200 units, [4,5,6] have 100 units, and [7,8,9] have 50 units.

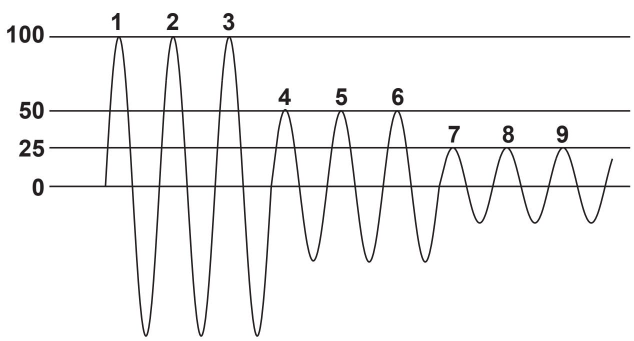

Figure 4

Using equation 1, it can be determined if this signal remains within datasheet specifications. Starting with n equal to 1 and m equal to 1, the following is obtained:

Equation 2:

$$\frac{B_2}{B_1} = \frac{200}{200} = 1$$

This gives a ratio of 1, which is greater than Δmin. This process can be repeated for m equal to 2 and 3, which give a ratio of 1 and 0.5 respectively. These are both greater than Δmin. The process is then repeated for n equal to 2 and m equal to 1, 2, and 3, which give ratios of 1, 0.5, and 0.5—still within datasheet specifications. In fact, this waveform will continue to remain in specification for all cases.

Changing W_{min} to 4, the steps can be followed again. For n equal to 1 and m equal to 1, 2, 3, and 4, the ratios are 1, 1, 0.5, 0.5 respectively. Following these steps, one can see with n equal to 3 and m equal to 1, 2, 3, and 4, the ratios are 0.5, 0.5, 0.5, and 0.25. Since 0.25 is less than Δmin, then this waveform would be out of datasheet specifications.

Case 2

This case will look at a simple repeated period-to-period variation. This case the peak-to-peak of a signal will reduce by 25% for each peak-to-peak with respect to the previous peak-to-peak. Starting with period 1 to period 9, the peak-to-peak values are [200, 150, 112, 84, 63, 47, 36, 27, 20] respectively.

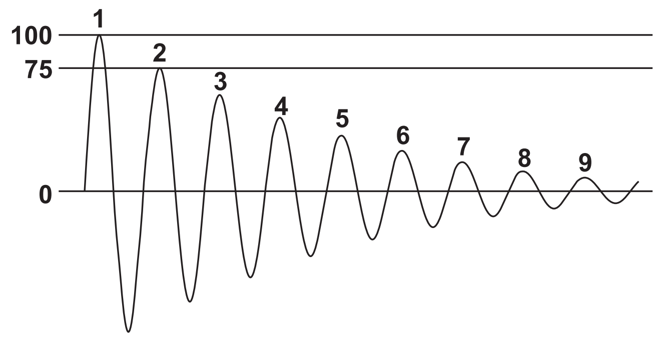

Figure 5

The same process presented in case 1 will be used for the first sensor, with a W_{min} of 3. Starting with n equal to 1 and m equal to 1, 2, and 3, it can be seen that the largest ratio change will be for m equal to 3, where B_1 is equal to 100 and B_4 is equal to 42. This will result in a ratio change of 0.42, which remains within datasheet specifications. Repeating this math on B_2 and B_5, the resultant reduction is 0.42 again. In fact, with a constant 25% reduction for all cases, this signal will remain in datasheet specification.

For the second sensor, with W_{min} of 4, the same process can be taken for B_1 and B_5, and it can be seen that a reduction ratio of 0.32 occurs. This input signal would be outside of datasheet specification.

Revision History

Number	Date	Description	Responsibility
–	June 7, 2021	Initial release	S. Veilleux