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INTELLIGENT OPTO SENSOR

Number 33.1 Appendix

DESIGNER'S NOTEBOOK

TAOS — TEXAS ADVANCED OPTOELECTRONIC SOLUTIONS®

Signal, Noise, Offset - TSL2771 Appendix

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Overview

TAOS proximity sensors are excellent devices for measuring "relative" distance to an object; however, the device capabilities must be properly understood to get the maximum performance from the device with minimum effort. The versatility of the device enables its use in many different applications, but requires more analysis to ensure the device settings are correct for the application.

This appendix to DN33: Signal, Noise, Crosstalk and TAOS Proximity Sensors will discuss how to get the maximum performance from the TSL2771. It is assumed that the reader is familiar with the TSL2771 data sheet and DN33.

Noise and the TSL2771

Recall from DN33 the formular for Signal + Noise:

Signal+Noise ~ Gain * (PPULSE * ((PDRIVE *(CC+ SR / (D * D) + BR) + NOISE * sqrt (PPULSE))

The first step in the process is the measure the noise from the TSL2771 in the final system implementation. This measurement is the standard deviation of the measure proximity counts. This can be done by collecting several hundred counts then using a spreadsheet such as Excel. A second way is to utilize the EVM software which supports direct measurement of the noise. In the EVM software, pull up the functional output screen which should look like Figure 1.

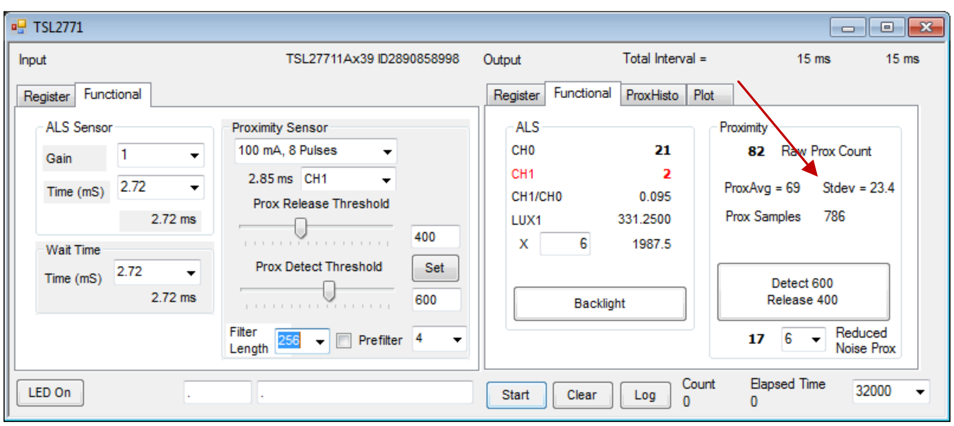
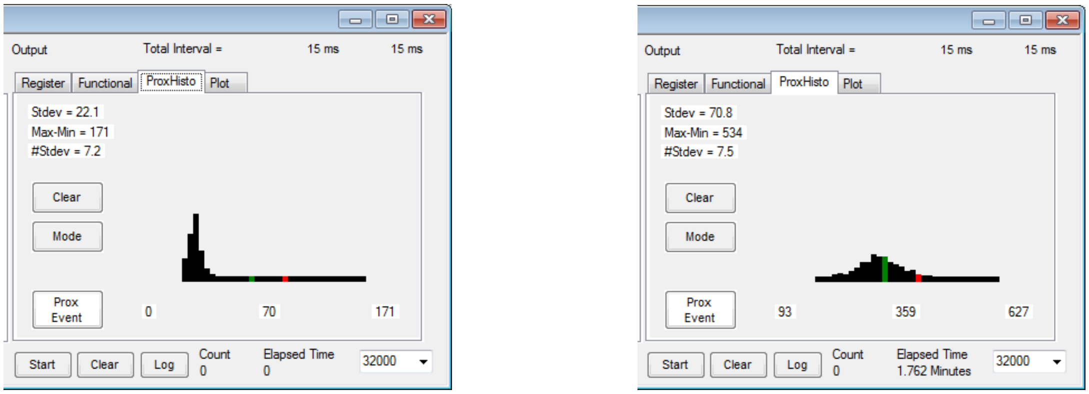


Figure 1 – EVM Software Showing Proximity Counts and Standard Deviation

To ensure a valid standard deviation, it also must be verified that all sample in the distribution are greater than zero (since a negative value would be reported as a zero). This can be easily seen using the ProxHisto tab of the EVM software, which displays a running histogram distribution of the sample prox values in 32 sample buckets.



8 Pulses 64 Pulses

Figure 2 – EVM Software Showing Proximity Count Histogram

Offset may be positive or negative. If there is a slight negative offset, a small target may be required to drive the signal such that there are no “zero” valued samples. Likewise with a target, the max value should be less than 1023. If any sample is at 1023, the results may be inaccurate. In other words, it is important to assure that the tails of the distributions (see Fig. 2) do not encroach on the lower limit at 0, or at the upper limit of 1023. For the TSL2771, the maximum number of effective pulses is 64 to 128.

Effective Resolution

Measurements for the TSL2771 standard deviations at different pulse settings then normalized pulse shows a standard deviation of 8 counts at one pulse. Recalling the formula for R68 from DN33:

$$R68 = 10 - \log_2 (2 * \text{Standard Deviation}) = 10 - \log_2 (16) = 10 - 4 = 6$$

Taking into account the number of pulses and averaging of samples:

$$R68 = 6 + \log_2 [\text{sqrt(Samples Averaged)}] - \log_2 [\text{sqrt(PPulse)}]$$

Distance and the TSL2771

To validate the assumption of the square relation between the count and the distance to the reflective surface, the TAOS proximity sensor was measured and compared to an ideal curve. The following graph show both measured and ideal transfer function demonstrating the inverse square laws.

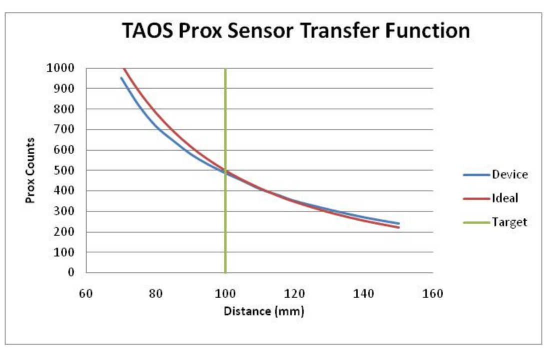


Figure 8 – Measured vs. Ideal Transfer Function for the TSL2771

Proximity Sampling Time

The following shows the state diagram for the TSL2771. The total time required to take a proximity measurement can be estimated from the diagram. For example with PPULSE = 8, PTIME = 2.72ms, WEN = 0 (no wait state) and ALS is set to the minimum ATIME = 2.72ms, the total time for a single prox reading can be calculated. Starting at the Start state, there is a 2.72ms of Prox Delay, then 8 * 16us or ~0.13ms (almost negligible) for the proximity detection time, then 2.72ms of prox conversion time, then 2.72ms of ALS delay, then 2.72ms of ALS conversion time. This is a total of 2.72 * 4 + 0.13 or 11.1ms of total time for the prox reading.

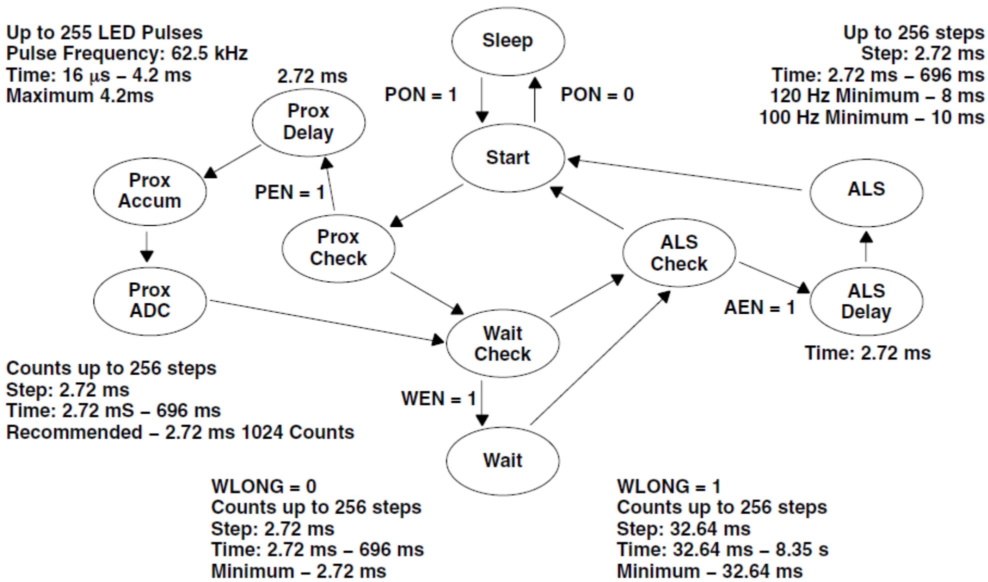


Figure 6 – TSL2771 State Diagram

Other Factors Impacting Proximity Detection

There are many other factors that impact the accuracy and sensitivity of the proximity detection. This paper has focused on the signal, noise and crosstalk factors. Variations in the proximity sensing device, the IR LED and the systems optical design must be taken into account.

One of the factors related to the device is the electrical noise which can be minimized by using good PCB layout techniques. Using the layout recommendation in DN32: Layout Recommendation for the TAOS Proximity Sensors (specifically the use of an RC filter in the Vdd) will reduce offset variations.

IR LED variation can also lead to variation in the output optical power and cause variation in the transfer function (by up to 3x). System calibration can eliminate this variation.

Other system optical design issues include transmissivity of the glass over the sensor, crosstalk caused by the glass, variations in the ink used to darken the glass, and variations in the distance between the top of the sensor and the glass.

Calibration is the most effective way to improve the overall system accuracy. Calibration in the final system will remove the systematic variations of the glass transmissivity and, IR LED variation as well as device to device variation.