Application Note

AN000556

Proximity Detection

Optimizing Proximity Parameters

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Content Guide

1 Proximity Basics

ams proximity sensors function by pulsing an IR emitter (LED or VCSEL) and measuring the reflected energy returned from a target. The amount of reflected energy is inversely proportional to the target distance and proportional to the target size and reflectance. There are many system variables that will affect the amount of reflected energy returning to the proximity photodiode. These system variables include:

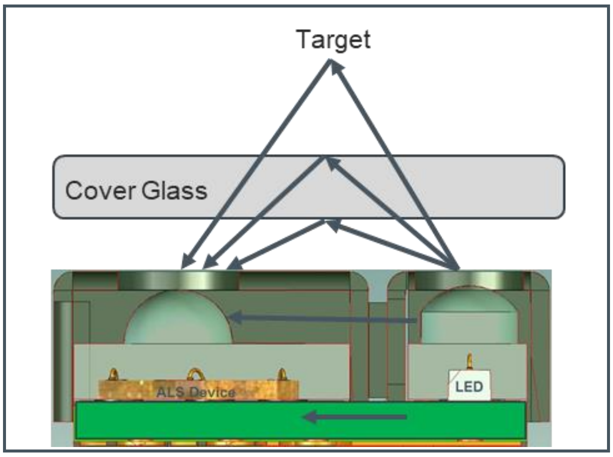
- the transmissivity of the cover glass at the IR wavelength,
- the surface quality of the IR ink application,
- the size and shape of the aperture(s) in the cover glass,
- the presence or absence of an optical barrier between the IR emitter and the photodiode,
- the presence or absence of a rubber boot,
- mechanical alignment of the proximity device relative to the apertures (x-offset, y-offset, tilt, etc.),
- the air gap between the sensor top surface and cover glass bottom surface,
- etc.

The key to a well performing proximity system is a well-designed optical stack that minimizes optical crosstalk. To assist with this, **ams** provides an Optical Design Guide (ODG) for most **ams** proximity sensor products. These ODGs are an excellent starting point for optical system design.

The purpose of this application note is to provide guidelines for selecting/optimizing proximity sensor parameters to achieve the desired proximity response. This document will assume the product being designed is a mobile phone where the proximity detector is used during an active phone call to disable the touch screen display when the phone is moved close to a person's head and re-enable it when the phone is moved away.

A basic illustration of proximity through a cover glass is shown in Figure 1.

Figure 1:
Proximity through Cover Glass



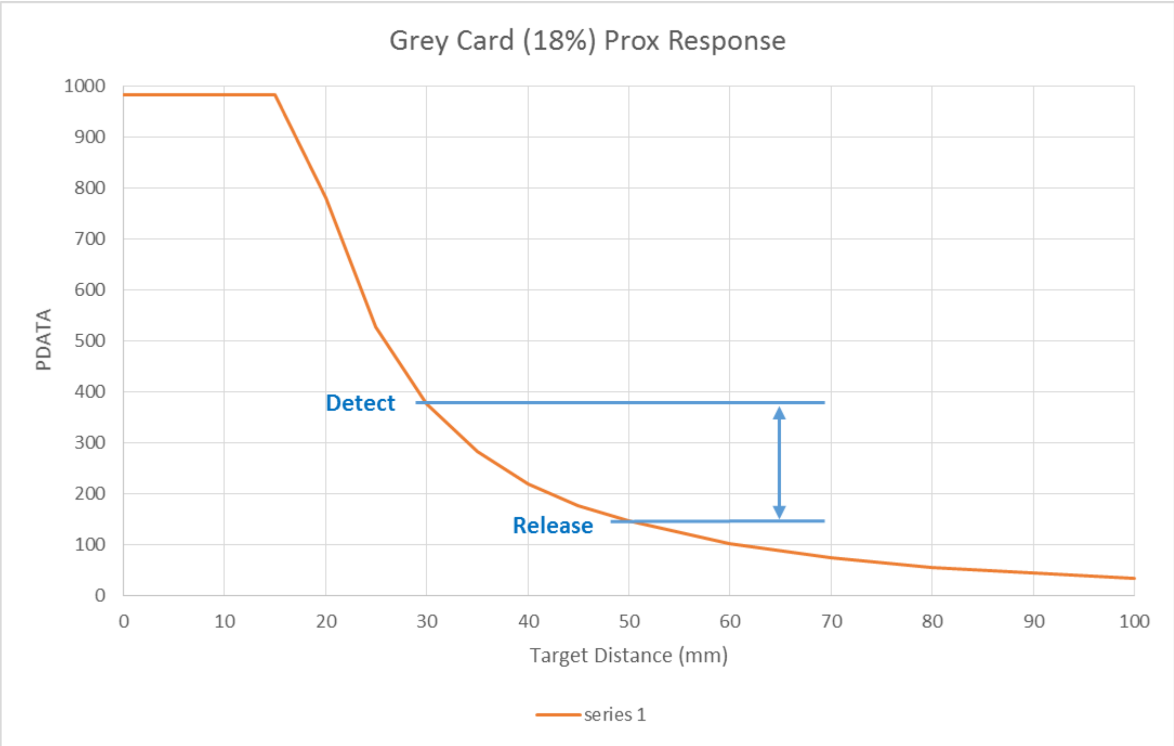
2 Detect and Release

The first step in selecting the proximity sensor parameters is to know the detect distance and release distance requirement. The detect point occurs when the phone is being moved toward the user's head and is defined as the distance between the phone and the head where the display should be disabled. The release point occurs when the phone is being moved away from the user's head and is defined as the distance between the phone and the head where the display should be turned back on. The detect point will have a higher proximity count value (more reflected energy from the user's head) and the release point will have a lower proximity count value (less reflected energy from the user's head).

The target materials used in the ams lab for determining proximity sensor parameters are 10cm x 10cm Kodak 18% gray card (which is an approximate representation of the reflectance of human skin) and Thorlabs BKF12 foil (which at ~4.6%, is an approximate representation of the reflectance of black hair).

Assuming a detect distance of 3cm and a release distance of 5cm, the goal when selecting the proximity sensor parameters will be to put these distances in the "sweet spot" of the proximity response curve. This is where the delta between detect and release distances results in an adequate number of counts to meet the system design requirements. See Figure 2.

Figure 2:
Proximity Detect/Release "Sweet Spot"



3 Proximity Test Fixture

In order to select proximity sensor parameters, it is important to be able to place the reflective target at accurate and repeatable distances above the proximity sensor. Some type of test fixture with a vertically moveable target is required. This can be a simple manually controlled device like the one shown in Figure 3. Or it could be a more sophisticated device with a motorized linear stage to move the target under computer control like the one shown in Figure 4. It is important that the device and target are parallel to each other and they are both secure and will not move or vibrate during data collection. If using cover glass over the device, the cover glass must also be parallel and secure.

Figure 3 :
Manual Proximity Test Tower

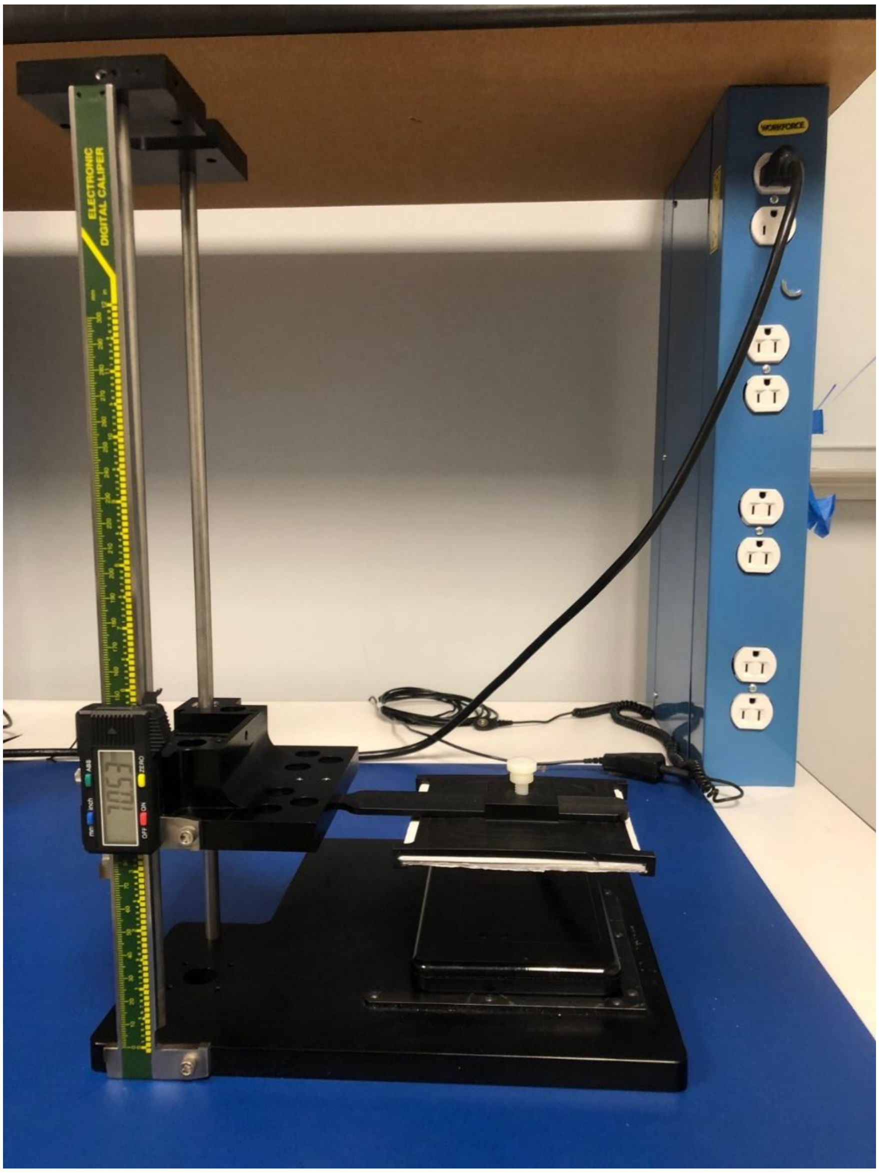
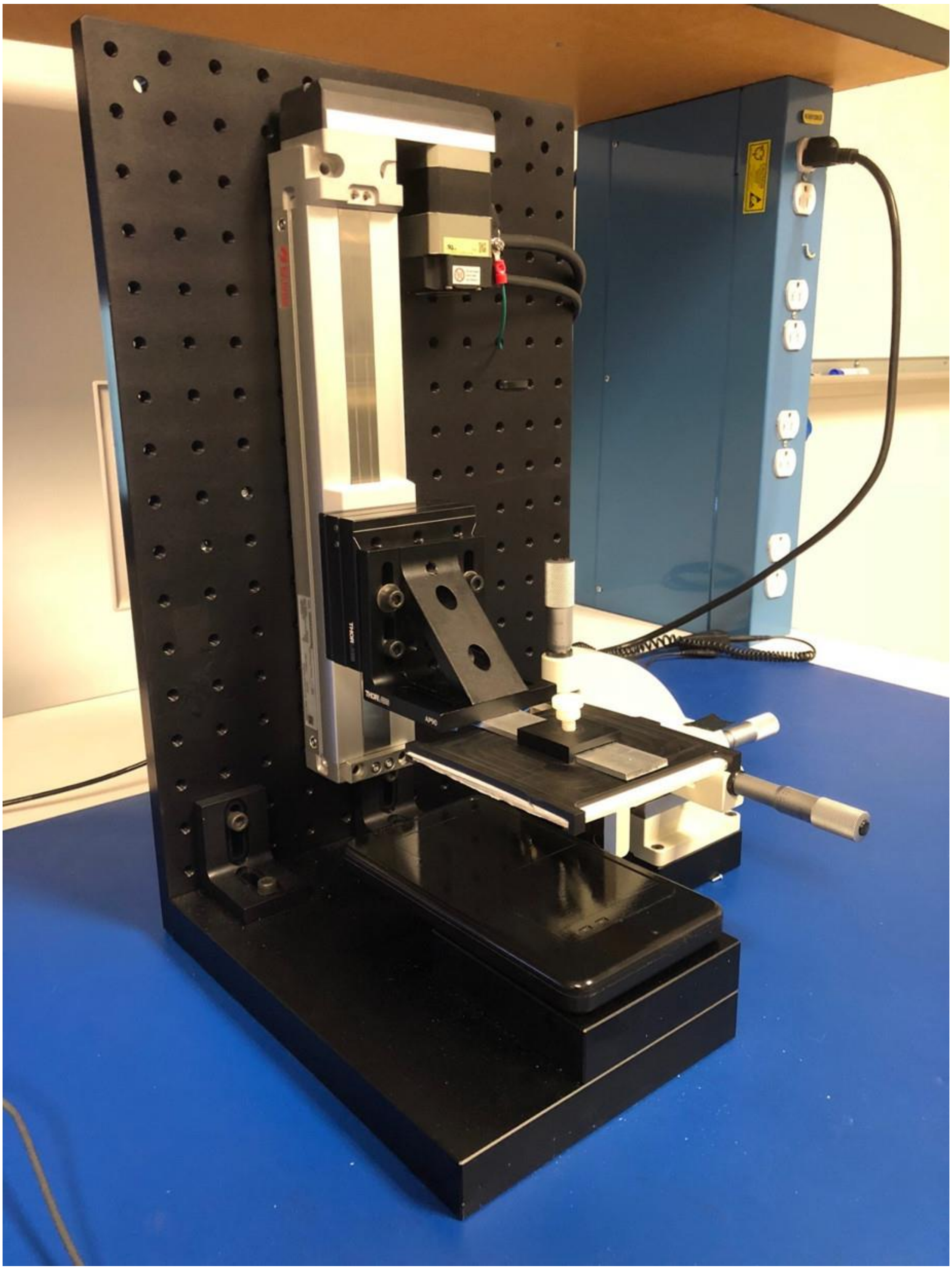


Figure 4 :
Automated Proximity Test Tower



4 Proximity Sensor Parameter Determination

ams proximity sensors have four main proximity parameters to adjust in order to optimize the proximity response: IR emitter drive current, number of IR pulses, length of each IR pulse, and the analog front-end gain. These are shown in the table below, along with several other proximity parameters that are typically available (device dependent).

Figure 5:
Proximity Parameters

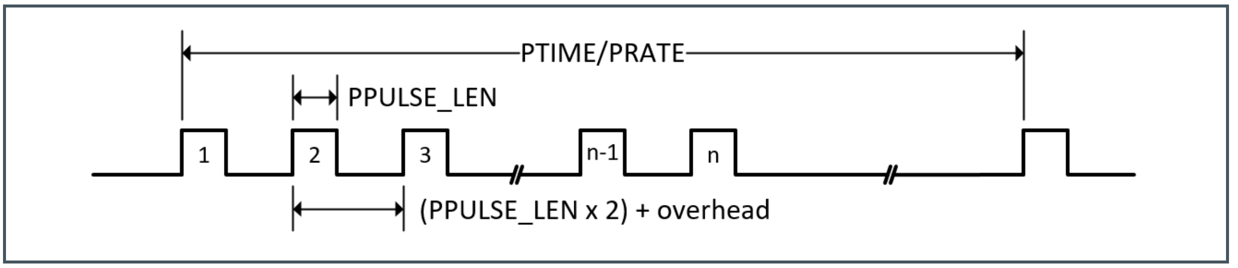
Parameter	Name	Function
Drive Current	PLDRIVE	The nominal drive current for the LED or VCSEL.
Number of Pulses	PPULSE	The number of times to pulse the LED or VCSEL during each proximity cycle time.
Pulse Length	PPULSE_LEN or PLEN	The duration of the active drive current for each pulse.
Gain	PGAIN	The analog gain of the proximity ADC
Offset	POFFSET	The offset applied to analog front-end to compensate for system (optical/electrical) cross-talk.
Proximity Time	PTIME or PRATE	The total time for one proximity measurement.(1)
Proximity Data	PDATA	The proximity data result from each proximity cycle.
Proximity Average	PROX_AVG	The hardware average of some number of proximity cycles. (device dependent) (2)

(1) 1. If PTIME/PRATE is programmed to a value that is less than the time required for the selected number of pulses, then it is ignored and the proximity cycle duration is extended to allow for the full number of pulses programmed.

(2) 2. PROX_AVG result may be a fixed or moving average, depending on the device. The number of PDATA samples that can be averaged is programmable and also device dependent. Refer to device datasheet for details.

Figure 6 shows an example of typical proximity pulse timing. The high time shown represents the proximity pulse length (4µs, 8µs, 16µs, or 32µs for most ams proximity devices), which is the time that the IR emitter is on. The period is two times the pulse length, plus a fixed (regardless of pulse length) overhead time that is needed internally to prepare for the next pulse. The PTIME/PRATE is the time between the start of a proximity cycle and the start of the next proximity cycle. Note that the cycle time can vary based on the programmed WTIME and/or ATIME, depending on the device architecture.

Figure 6:
Typical Proximity Pulse Timing



4.1 System Requirements

Before selecting proximity settings, the following system requirements should be determined.

- Detect and release distances.
- The margin needed between detect and release thresholds to account for the system variations/tolerances and noise. The amount of proximity data noise that can be tolerated is generally a function of the detect/release delta and must be determined by the system designer as part of the overall system design.
- Maximum power consumption.

4.2 Steps to Optimizing the Proximity Response

1. Start with low gain, mid-range current, mid-range pulse count, and mid-range pulse length.

2. With no target above the device, adjust POFFSET, or execute an offset calibration, so the no-target PDATA counts are greater than zero. (Note that the calibration must always be performed after the prox settings have been changed and before measuring the delta.)

3. Perform a quick test with a gray card to determine the delta between the targeted detect and release distances. (For example: delta = PDATA at 30mm – PDATA at 50mm).

4. Determine if this delta has enough margin to meet the system requirements.

5. If there is not enough margin, adjust the parameters following the guidelines below.

a. Increase the pulse length – noise stays the same; delta and power increase.
b. Increase the drive current – noise stays the same; delta and power increase.
c. Increase the number of pulses – delta, power and noise increase.
d. Increase the gain – power stays the same; delta and noise increase.
e. Increase averaging – delta stays the same; noise decreases but power may increase depending on the device.
f. To improve the signal to noise ratio, lower the gain and increase the pulse length or drive current proportionately. If the gain cannot be lowered, lower the number of pulses instead.

g. The impact of changing the proximity parameters on optical crosstalk can vary depending on the optical stack and proximity response range. Minimizing optical crosstalk is important for good proximity system operation. Careful attention to the optical stack design should be a priority in the overall system design.

6. After adjusting one or more parameters, repeat steps 2-5 until the system requirements are met.

4.3 Proximity Response Curves

Figure 7 shows the effect of changing the proximity pulse length when the other parameters are held constant. As shown in the response plots, increasing the pulse length may be used to increase the detect/release delta. The noise will typically stay the same but power consumption will increase due to increasing the IR emitter "on" time.

Figure 7 :
Proximity Response Curves for Various Pulse Lengths

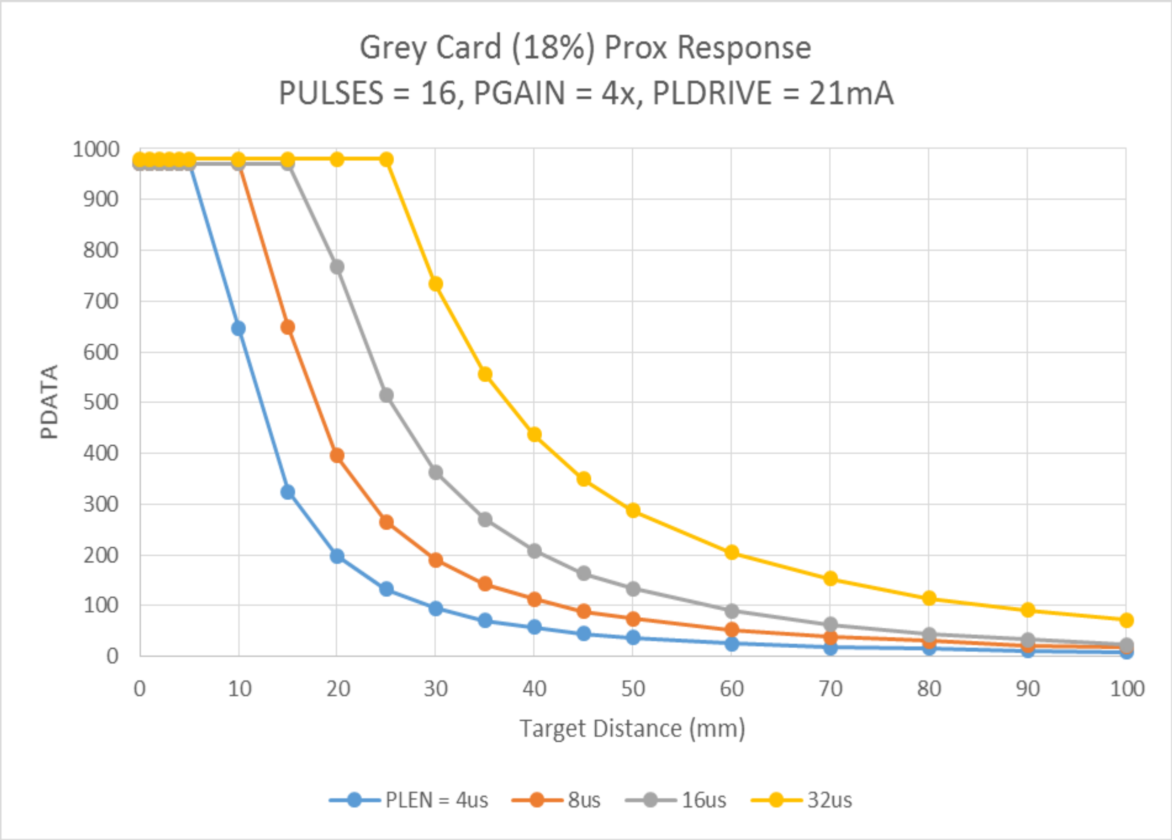


Figure 8 shows the effect of changing the proximity IR emitter drive current when the other parameters are held constant. As shown in the response plots, increasing the drive current may be used to increase the detect/release delta. The noise will typically stay the same but power consumption will increase as the current increases.

Figure 8 :
Proximity Response Curves for Various Drive Currents

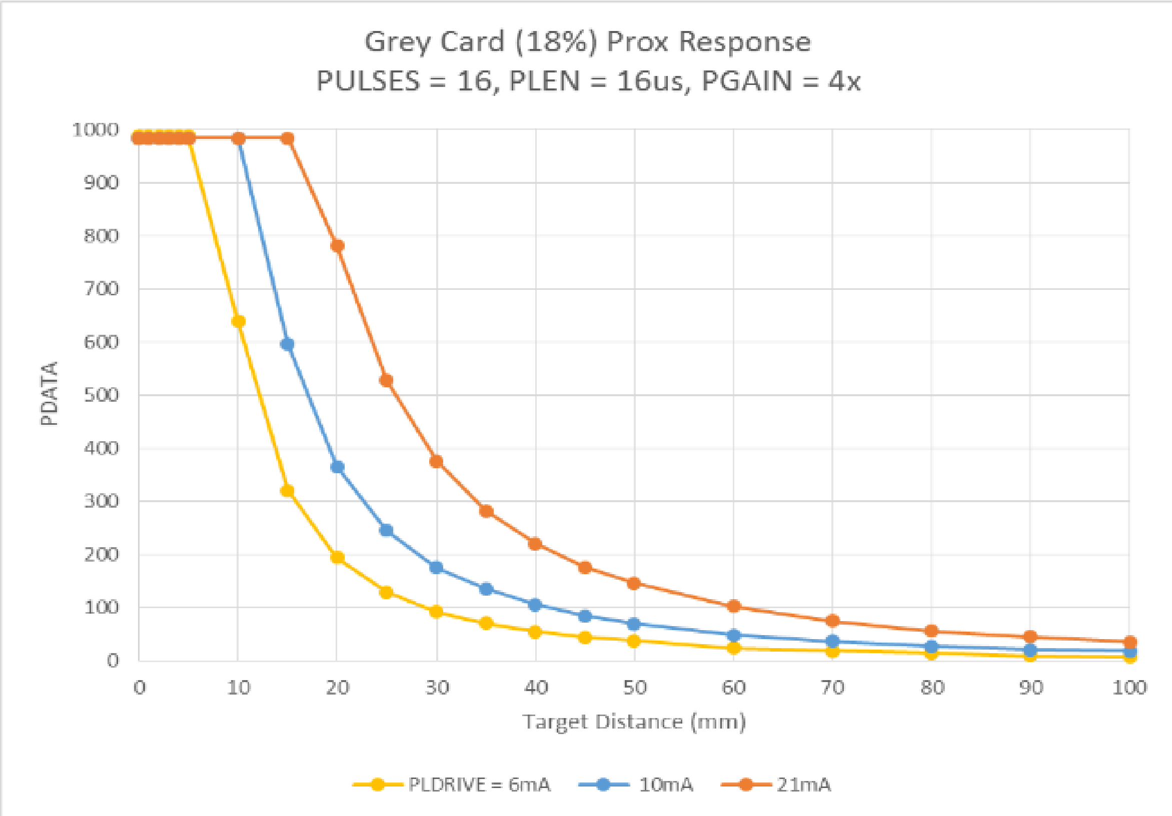


Figure 9 shows the effect of changing the number of proximity pulses when the other parameters are held constant. As shown in the response plots, increasing the number of proximity pulses may be used to increase the detect/release delta. In this case, both the noise and power consumption will increase as the number of pulses increase.

Figure 9 :
Proximity Response Curves for Various Numbers of Pulses

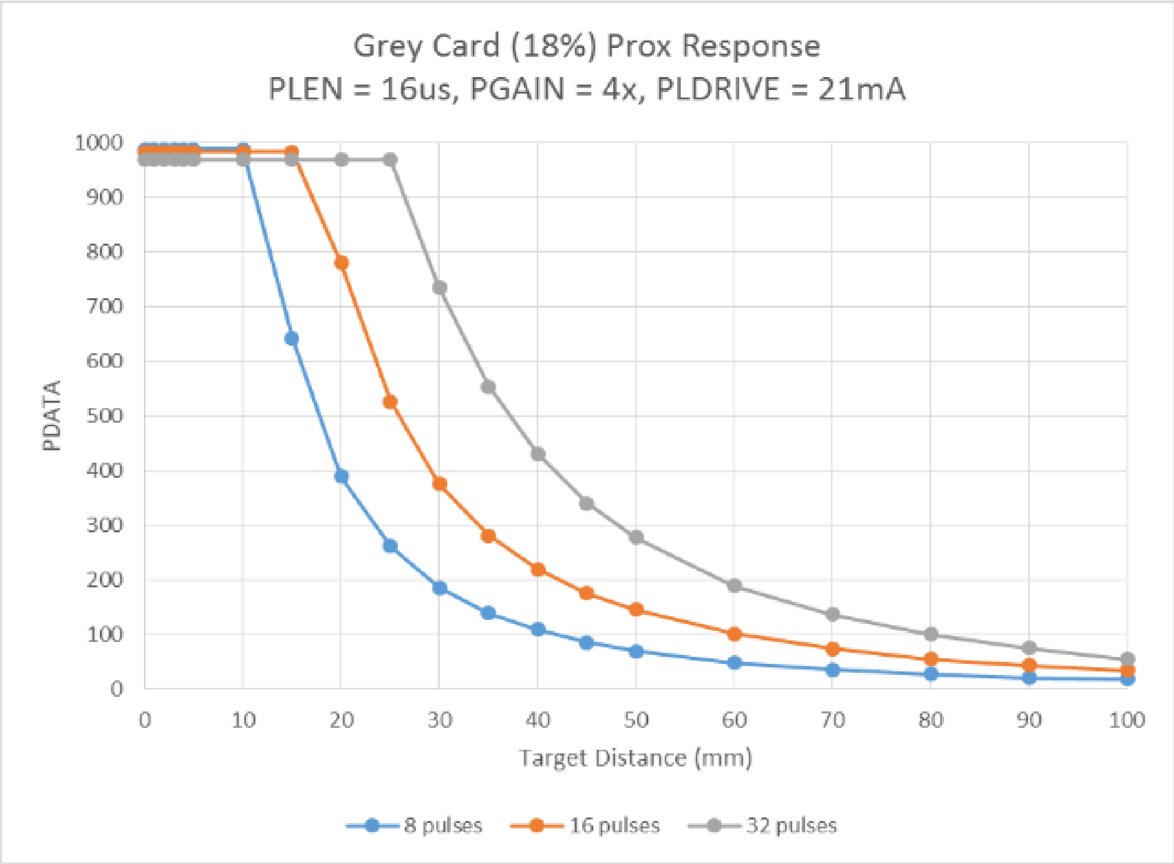


Figure 10 shows the effect of changing the proximity gain when the other parameters are held constant. As shown in the response plots, increasing the proximity gain may be used to increase the detect/release delta. In this case, the power consumption will stay the same, but the noise will increase as the gain increases.

Figure 10 :
Proximity Response Curves for Various PGAIN Settings

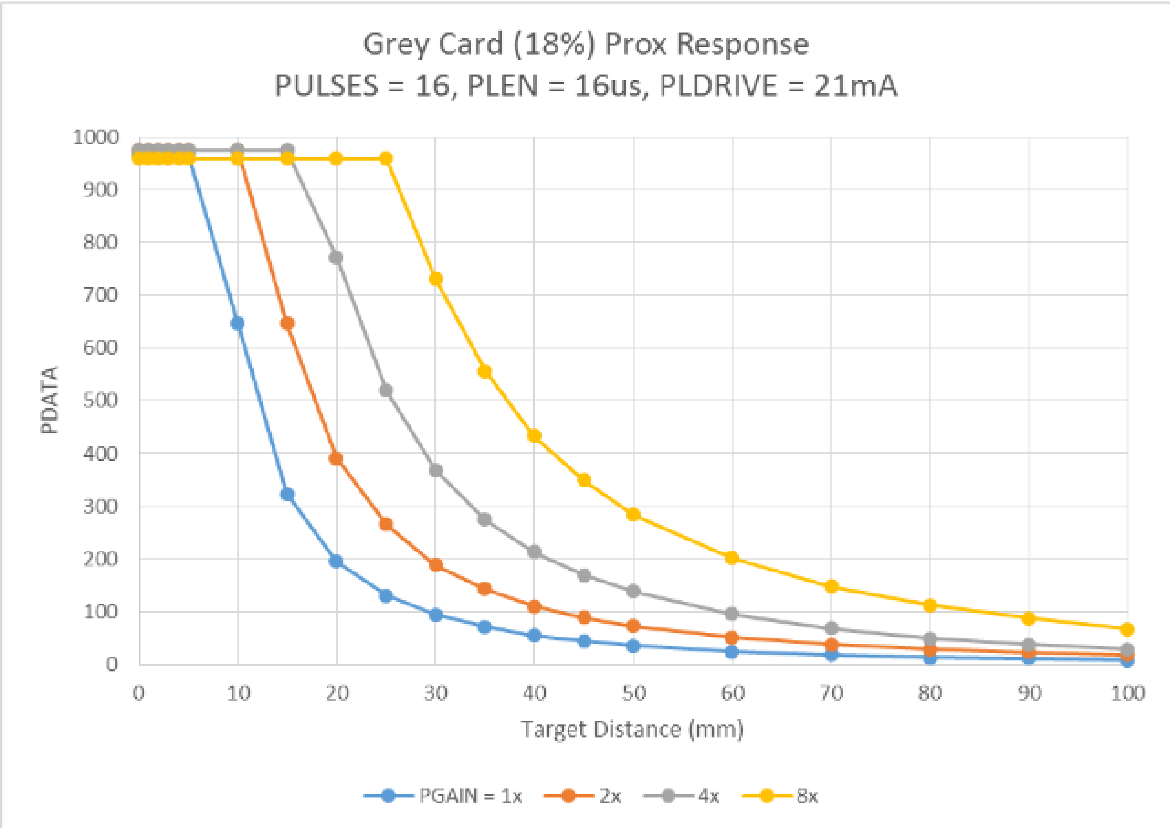
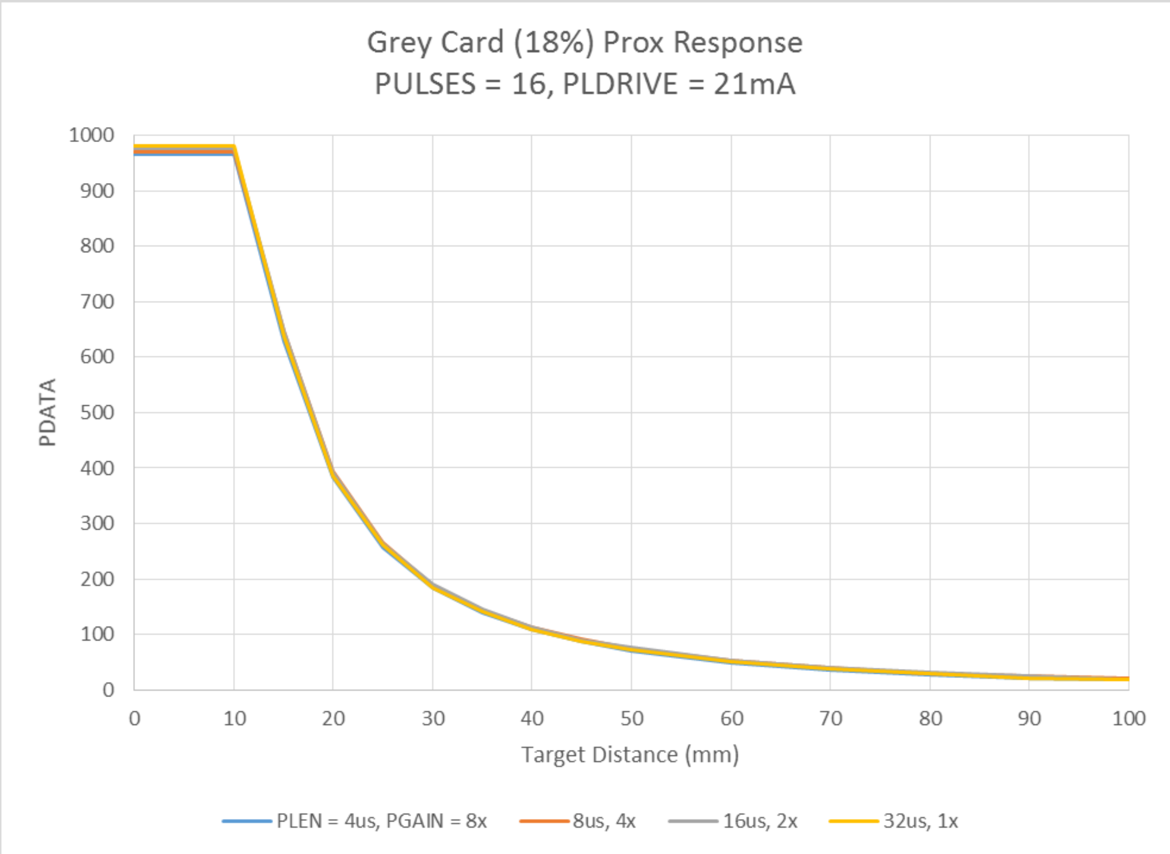


Figure 11 shows the effect of changing both the proximity gain and the proximity pulse length at the same time, when the other parameters are held constant. As shown in the response plots, doubling the pulse length and halving the gain, while holding the number of pulses and drive current constant, will result in identical response curves. Since the PDATA noise increases with the gain, it would typically be desirable to use the lowest gain possible that will provide the desired response curve.

Figure 11 :
Proximity Response Curves for Various PPULSE_LEN/PGAIN Settings



5 Summary

The process of optimizing proximity parameters involves determining acceptable detect and release thresholds while balancing the tradeoffs between power consumption, noise, and performance. This is an iterative process that can be achieved by following the guidelines in section 4.

6 References

For further information, please refer to the following documents:

- DN34: Proximity Detection IR LED and Optical Crosstalk
- DN37: Proximity Calibration and Test
- DN38: Proximity Detection and Link Budget
- DN58: Proximity Detection Behind Glass

7 Revision Information

Changes from previous version to current revision v3-00	Page
Initial version 1-00	
Revision 2-00: Remove confidential and make public	

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

8 Legal Information

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