TEXAS INSTRUMENTS

Automotive Ultrasonic Sensor Interface for Park Assist or Blind Spot Detection Systems - Test Data

This document shares the tests results of the PGA450-Q1with a Murata sensor (MA58MF14-0N).

The data is structured into two main categories:

1. Test set up
2. Test strategy
3. Power Considerations
4. Test data

Equipment used to create this data:

1. PGA450-Q1 EVM + TI communication (TIger) board
2. PC with the PGA450-Q1 EVM GUI installed
3. 5V power supply

Section 1: Test set up

Before the system is powered up, please make sure all hardware is configured properly. Check that all jumpers and headers are connected appropriately. For a detailed description of configurations, see EVM user's guide.

To power the board:

1. Only one main power supply is needed. Apply 7 VDC to 18 VDC to the PGA450-Q1EVM that supplies power to the entire board, except for the USB communications board and LIN which are powered by the USB communication PCB (TIger board).
2. Connect a power supply to the banana jacks, P1 "VPWR_IN" and P3 "GND" or use the screw terminal P2.
3. As stated prior, the TI communication board (TIger) supplies 5V to portions of the hardware and also connects the EVM to the PC. For the TIger board to supply 5V, make sure the "Jumper 5V" is connected (default settings). This board could be replaced by an MSP430 launchpad that connects to PC through USB.

To test functionality of board:

1. Connect the PGA450-Q1 EVM to the interface board. Connect the interface board to a PC. Install the PGA450-Q1 GUI.
2. A Murata transducer is included with the EVM. Solder the transducer connector to the through-holes at P6. Alternatively, use the screw terminal to connect the transducer.
3. To program OTP bits, program registers, then take data, see PGA450-Q1 EVM user's guide.

Section 2: Test strategy

The PGA450 parameters can be optimized for either short distance measurements or long distance measurements. Automotive grade waterproof transducers must be driven with large voltages to generate a sound wave with enough SPL (Sound Pressure Level) to survive the attenuation due to air, and the scattering and absorption that occurs when the sound wave reflects off of an object, to still be strong enough to excite the transducer upon its return.

To detect at a maximum distance, it is necessary to create the highest SPL possible, and to have a high degree of granularity after the signal processing stage of the PGA450 IC. For short distances, it is imperative Below is an overview of the settings on the PGA450 and how to optimize them for short and long distance measurements.

- Number of bursts (PULSE_CNTA, PULSE_CNTB)
  - This setting controls the number of times that the low side drivers switch on and off.
  - Short distance optimization: Reduce this to the minimum number of bursts, 1. This still excites the transducer enough to generate a good sound wave, and it minimizes the time needed for the drive energy resonating in the transducer to decay.
  - Long distance optimization: When attempting to measure longer distances, the decay time of the drive signal is not as important, so increase the number of bursts to create a stronger and longer duration signal with a higher SPL. The setting used for testing was 18 pulses.
- Blanking timer (BLANKING_TMR)
  - The blanking timer waits a specified amount of time before starting data collection into the FIFO RAM. Increasing the blanking timer will increase the maximum possible distance that can be measured (since there is a finite amount of memory in the FIFO). It also helps mask the section of the data where the returned signal is saturated since that does not give any useful data.
  - Short distance optimization:
  - Long distance optimization:
- Bits to store in the FIFO (FIFO_CTRL)
  - The digital datapath has 12 bits of resolution, but storing all 12 bits would fill up the 768 bytes of RAM allocated for capturing the echo signal quickly. There are four options for which bits to save to the FIFO: all 12 bits, the 8 most-significant bits, the 8 least-significant bits, and the 8 middle bits.
  - Short distance optimization: The echo signal is stronger at short distances, well above the noise floor. To achieve the minimum distance, it's more important to reduce the length of time that the data is saturated, which makes using the 8 most-significant bits the optimum choice.

- Long distance optimization: The farther away an object is, the weaker the returned echo signal. This means that the extra resolution is important when attempting to distinguish the signal from the noise floor. Using the 8 least-significant bits is the optimum choice for long distance

measurements.

The test object for the data shown below is a 1m tall, 76mm diameter PVC pipe. The transducer was placed 40cm above the ground and testing was completed outside on concrete.
The transducer used is the MA58MF14-0N.

Section 3: Power Considerations

This particular application is only on and consequently consuming power, when the car is on. In applications where the PGA450-Q1 is always on, even when the car is turned off, careful measures must be taken to consider power consumption.

There are three general modes of operation that the PGA450 will cycle between during operation, quiet mode, active mode, and VREG charging mode. The data below is from the PGA450Q1 datasheet and is at VPWR = 18V.

		Max Current
Quiet	LNA, ADC, data path, OUTA/B are off, MCU and LIN are still active	7.5mA
Active	Everything is active	15mA
VREG Charging	The VREG capacitor is charging	Quiet or Active current + 110mA

The length of time that the VREG capacitor needs to charge will depend on how much it was depleted during the bursting (which will depend on the transducer/transformer components used and the number of bursts). With the components on the TI EVM, recovering from 18 bursts (long distance mode) takes about 5ms to charge, and 1 burst (short distance mode) takes about 1ms to charge.

The time of flight for an ultrasonic signal to reach an object 6m away and return takes about 35ms in air at room temperature (TOF = distance/v = 12m/(343m/s)). The length of time between measurements is dependent on the application. For this example, assume that another 35ms is spent in quiet mode between measurements and that the long distance mode is being used. This is a worst case measurement since maximum current values are being used instead of typical.

$$P_{avg} = 18 * \frac{15mA * 35ms + 7.5mA * 35ms + 110mA * 5ms}{70ms}$$

$$P_{avg} = 146.6mW$$

Section 4: Test Data

Figure X1 shows data from six separate runs with a 1m tall, 76mm wide PVC pipe placed various distances away from the PGA450. The amplitude refers to the signal strength of the echo signal after it goes through the signal processing steps on the PGA450 (LNA, ADC, BPF, peak extractor, and downsampling). When the echo signal exceeds the programmable threshold, the PGA450 recognizes that an object was detected and records a time of flight. This time of flight can be converted to a distance by knowing the speed of sound. The division by two is because the sound wave must travel to the object and then back again.

$$distance = (v_{sound} * TOF)/2$$

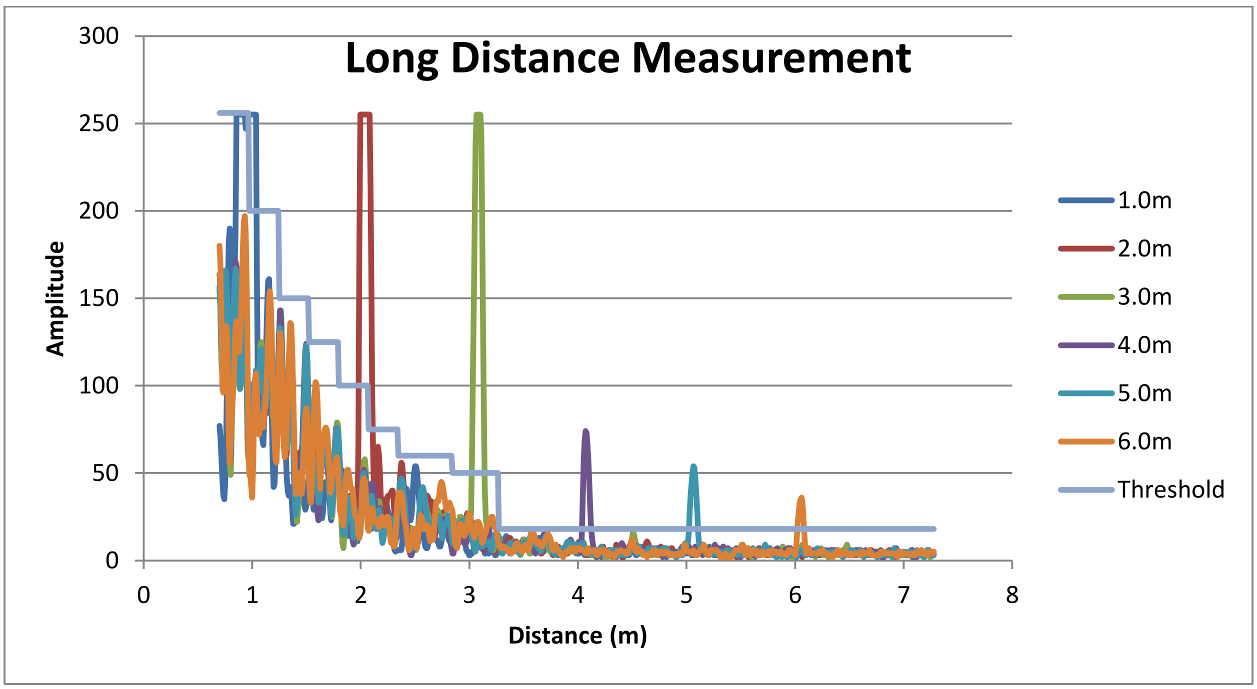

Figure X1 – Test data for long distance measurements

Figure X2 shows data taken in the short distance mode from three separate runs.

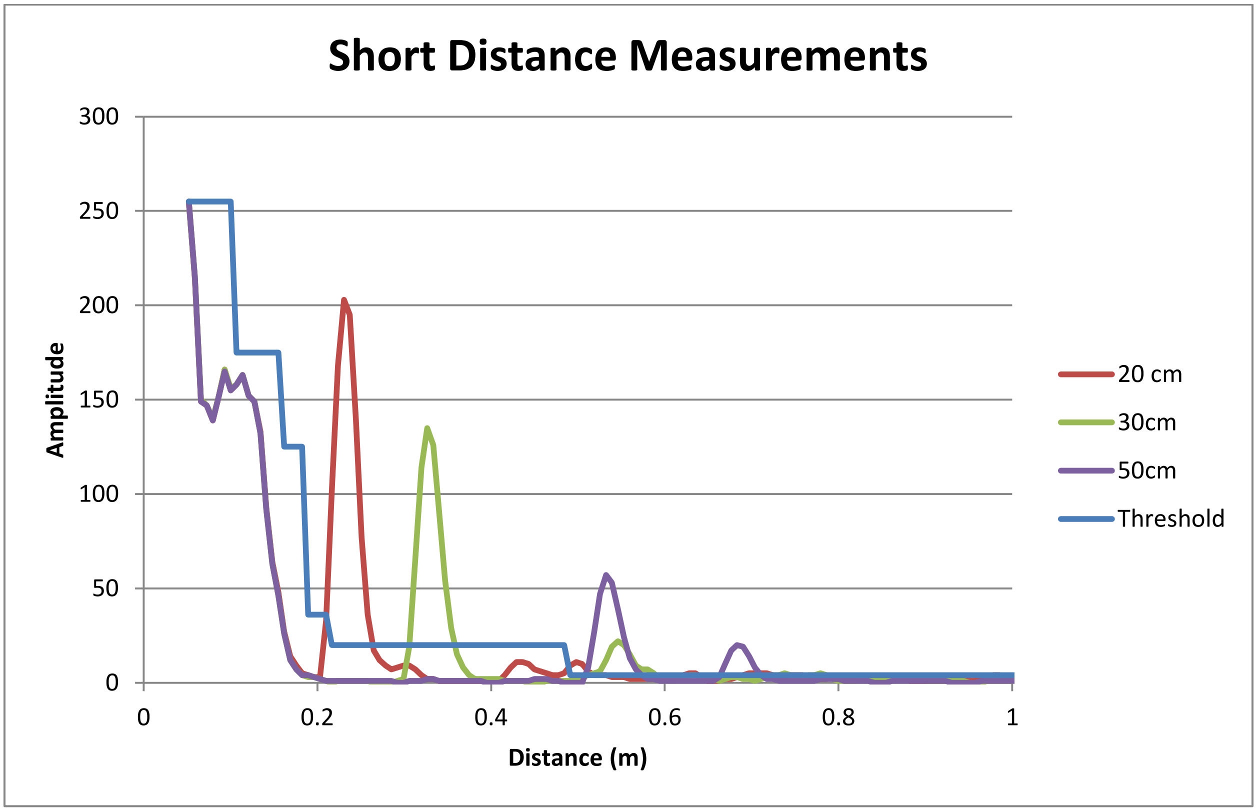

Figure X2 – Test data for short distance measurements

See the referenced example code to see how to program the PGA450 8051 microcontroller to process the FIFO RAM to extract distance information.