Application Report
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Optimizing Performance of the PGA450-Q1

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ABSTRACT

The PGA450-Q1 device must be optimized and fine-tuned for each particular application. All supporting materials provided by TI for the PGA450-Q1 have been optimized for Texas Instruments' lab-bench setup. The PGA450-Q1 device is not ensured to perform identically in an end-user's test environment because of varying environmental factors. These factors include temperature, humidity, air pressure, size and clearance of room, size and material of the targeted object, unaccounted for reflective surfaces, and external noise within the transducer range of operation that interferes with the bursting and return echoes. To account for these factors, the majority of PGA450-Q1 device changes must be applied through the software. Hardware changes are reserved for tuning of the transformer when using different transducers or minimizing the decay time.

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1 Parameters for Short and Long Distance Optimization

TI's experiments define two general modes of operation: short-distance mode and long-distance mode. When referring to short distance detection, the object is typically no more than 1.5 m from the transducer, while a long distance detection is between 1.5 m to 6 m. Depending on the range of how far the targeted object can be from the transducer, four registers must be adjusted to optimize this detectable range for a custom mode as defined by the user. These registers are PULSE_CNTA, FIFO_CTRL, BLANKING_TIMER, and FIFO_CTRL. Refer to *PGA450_isrs.c* in the firmware sample project to see the example short and long distance configurations.

1.1 PULSE_CNTA

A greater number of pulses improves the signal strength, but increases the decay time as well. The increased decay time makes shorter distances more difficult to detect because the signal can be masked by the initial transducer excitation signal. Figure 1 shows this tradeoff. In the sample firmware, 1 burst is used for short distance measurements and 18 bursts are used for long distance measurements.

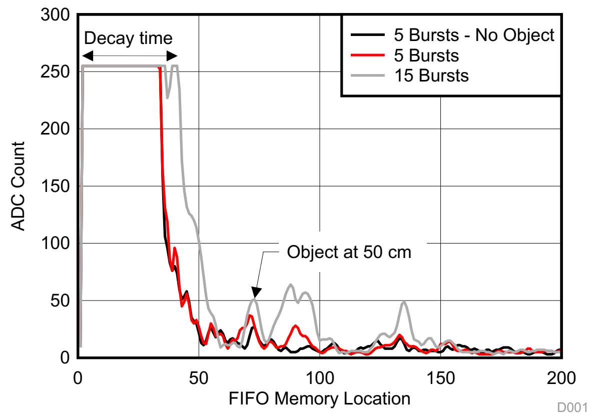

Figure 1. Burst Count Comparison for Object at 50 cm

1.2 FIFO_CTRL

The digital datapath is a total of 12-bits, but there are four possible modes for how to store this data into the FIFO RAM. Typically, either the lower 8-bits or the mid-8 bits are stored. Using the 8 LSBs allows for the maximum resolution, which is important when targeting low return signal strengths. The trade-off is that saturation occurs sooner for larger signals, which can result in a loss of information, especially when trying to detect very short distances. Figure 2 shows the difference between FMODEx bit configurations. Notice that the noise is higher in the 8 LSB mode; however, the SNR improves for low amplitude signals. For high amplitude signals, the mid [10:3]-bits mode is helpful for minimizing saturation when optimizing short distance detection.

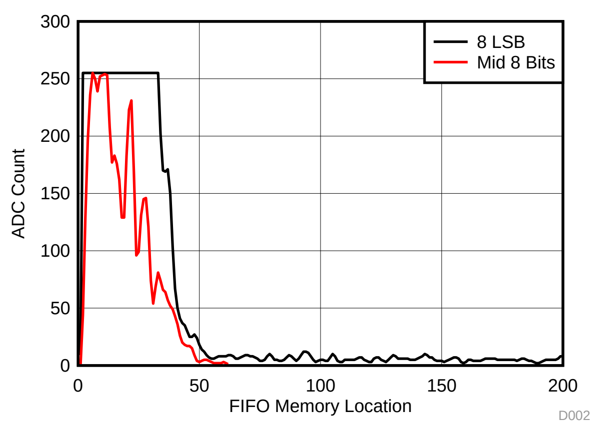

Figure 2. FIFO_CTRL Comparison for No Object

1.3 BLANKING_TIMER

The data stored immediately after the transducer is excited is not usable because any echo signal will be masked by the saturated decay signal. The BLANKING_TIMER can be set to delay in increments of 16 µs the time when the FIFO begins storing data. For the data shown in this document, the BLANKING_TIMER was set to 0 so that all of the echo signal could be analyzed.

1.4 DOWNSAMPLE

The downsampling rate affects the time interval between each sample stored in the FIFO RAM. Consider that the FIFO RAM can only store 768 bytes. As the downsample rate decreases, the maximum distance that can be measured decreases, but greater resolution is made available for short distances. A downsampling rate of 40 was used during these tests; however, this could be reduced if only short distances are targeted.

2 Transducer Resonant Frequency Detection

To measure the resonant frequency of the transducer, a diagnostic test can be run by storing the ADC output data directly to the FIFO RAM. To ensure the FIFO is loaded with the ADC output, set FIFO_ADC (bit-2) of the DP_SCI_CTRL register to 1.

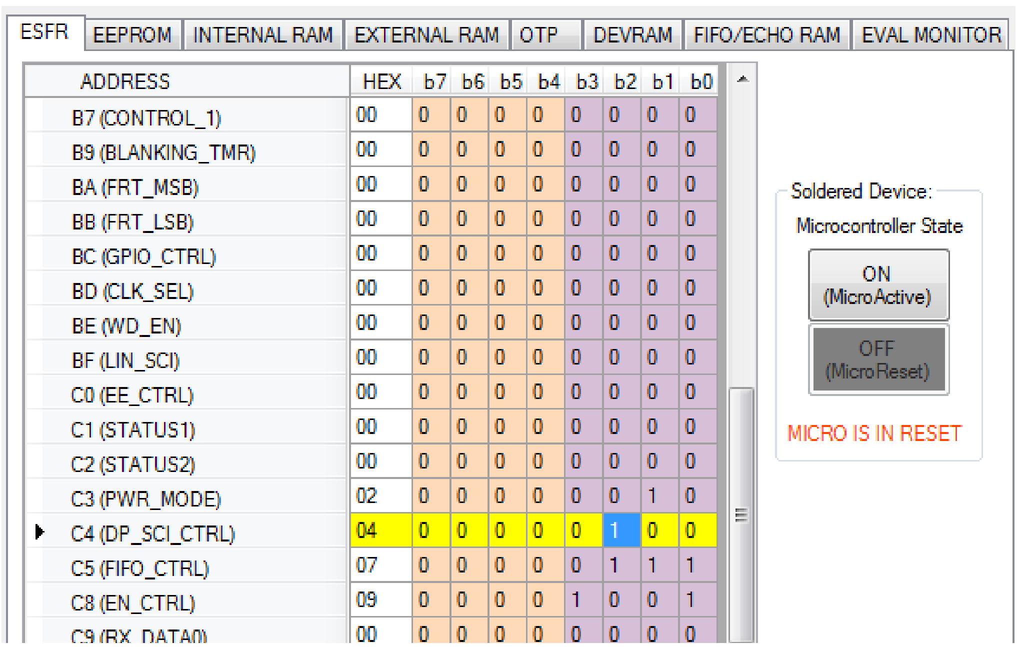

Figure 3. DP_SCI_CTRL Register Change in PGA450Q1EVM GUI

To demonstrate this procedure using the EVAL MONITOR of the PGA450Q1EVM GUI, the evaluation (EVAL) tab must be set with the following values:

- Transducer frequency: 58 kHz
- BPF coefficient:
  - B1 = 032D
  - A2 = EC3D
  - A3 = F9A5
- LPF coefficient:
  - B1 = 2D68
  - A2 = 253
- VREG voltage: 8 V
- LNA gain: 64 dB

- XFMR configuration: Push-pull
- Clock select: Internal clock
- Number of bursts = 18
- Downsample = 40
- Blanking timer = 64
- FIFO mode: 8 MSB

When the device is configured with the necessary register settings, click *START* in the EVAL tab. The measurements should appear similarly to what is shown in Figure 4.

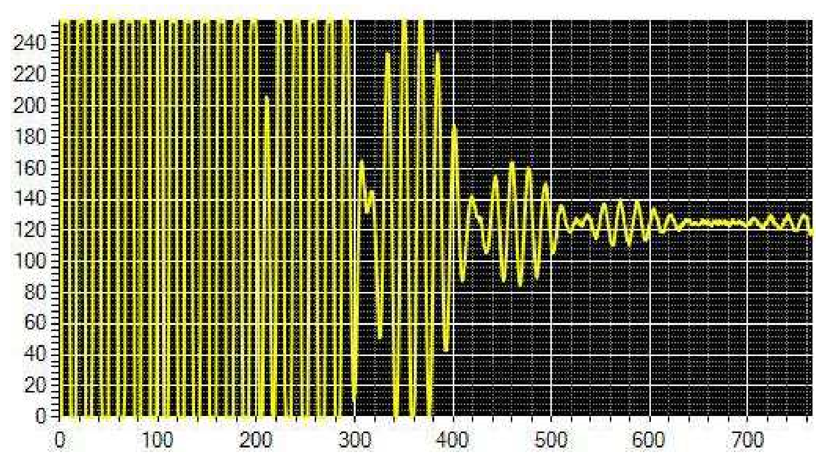

Figure 4. ADC Output to FIFO Data Representation

Stop the measurements and export the FIFO data to Excel® using the *Read and Save FIFO data to File* process. The resonant frequency can be measured by counting the number FIFO bytes logged between zero-crossings while the transducer is ringing (after the 18 count burst-excitation has been applied). Every data point plotted in Figure 5 represents a time interval of 1 µs because the downsample rate is irrelevant when the digital data path is bypassed.

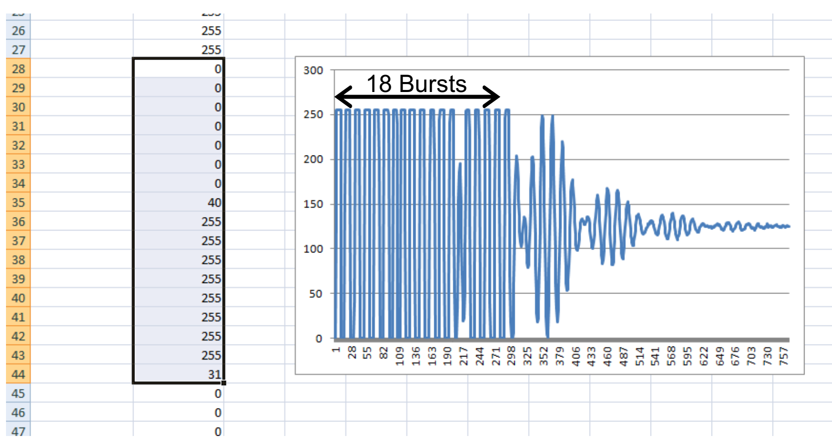

Figure 5. FIFO Data Exported to Excel for Zero-Crossing Analysis

From the plot in Figure 5, 17 data-points (sample numbers 28 through 44) are measured from the time the signal was equal to 0 to the time that the signal is equal to 0 again. The nominal resonant frequency of the transducer is specified as 58 kHz, while the calculated equivalent yields the value shown in Equation 1.

$$f_{TRANSDUCER\_RESONANT} = 1 / (17 \times 1\ \mu s) = 58.8\ kHz \quad (1)$$

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