

Application Report
Clamp On Water Meter for PVC Pipes



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MSP430 System Applications

ABSTRACT

This document describes nonintrusive clamp on ultrasonic metering solutions for PVC pipes. The solutions described here use the [MSP430FR6047 Ultrasonic Sensing Evaluation Module](#).

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1 Introduction

In this example, the MSP430FR6047 Ultrasonic Sensing Evaluation Module ([EVM430-FR6047](#)) is used with a pair of Jiakang 1-MHz transducers. These transducers use a 50° angle intended for use with clamp on meters. A 3D printed fixture is used to attach and clamp the transducers to the PVC pipe. All tests are performed with 0.75-inch PVC pipe.

Different transducer configurations can be used to obtain ultrasonic time-of-flight measurements. The testing described in this document uses a direct face-to-face configuration as shown in the first option in [Figure 1-1](#).

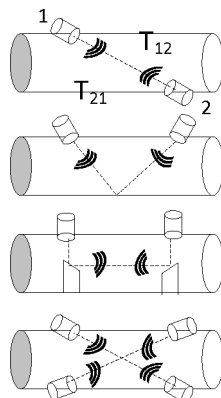


Figure 1-1. Different Possible Configurations for Ultrasonic TOF-Based Measurement



Figure 1-2. Jiakang 1-MHz Transducer

1.1 Transducer Placement and Couplant

To obtain proper signal levels, the transducers must be aligned and couplant such as ultrasound gel or industrial grease must be placed between the transducers and pipe. For zero-flow tests, the pipe must be filled with water with as little space for air as possible.

The transducers are aligned using the 3D printed fixture in [Figure 1-3](#). The fixture is two separate pieces clamped together with metal hose clamps.



Figure 1-3. 3D Printed Fixture Attached the PVC Pipe

Testing showed that typical ultrasound gel dries out quickly, and industrial grease provides similar performance without drying out. Magnalube-G (<https://www.magnalube.com/>) is readily available and was used for these tests.

1.2 EVM430-FR6047 Configuration

The EVM430-FR6047 evaluation module was used in the standard water meter configuration with transducers connected to J8. The Design Center GUI is used to configure the MSP430FR6047 and capture data.

The following figures show the Design Center configuration that was used for testing. Only the internal PGA (programmable gain amplifier) was used with no external amplification required. A good signal level was acquired with 22.8-dB gain. The internal PGA of the MSP430FR6047 allows for up to 30.8 dB.

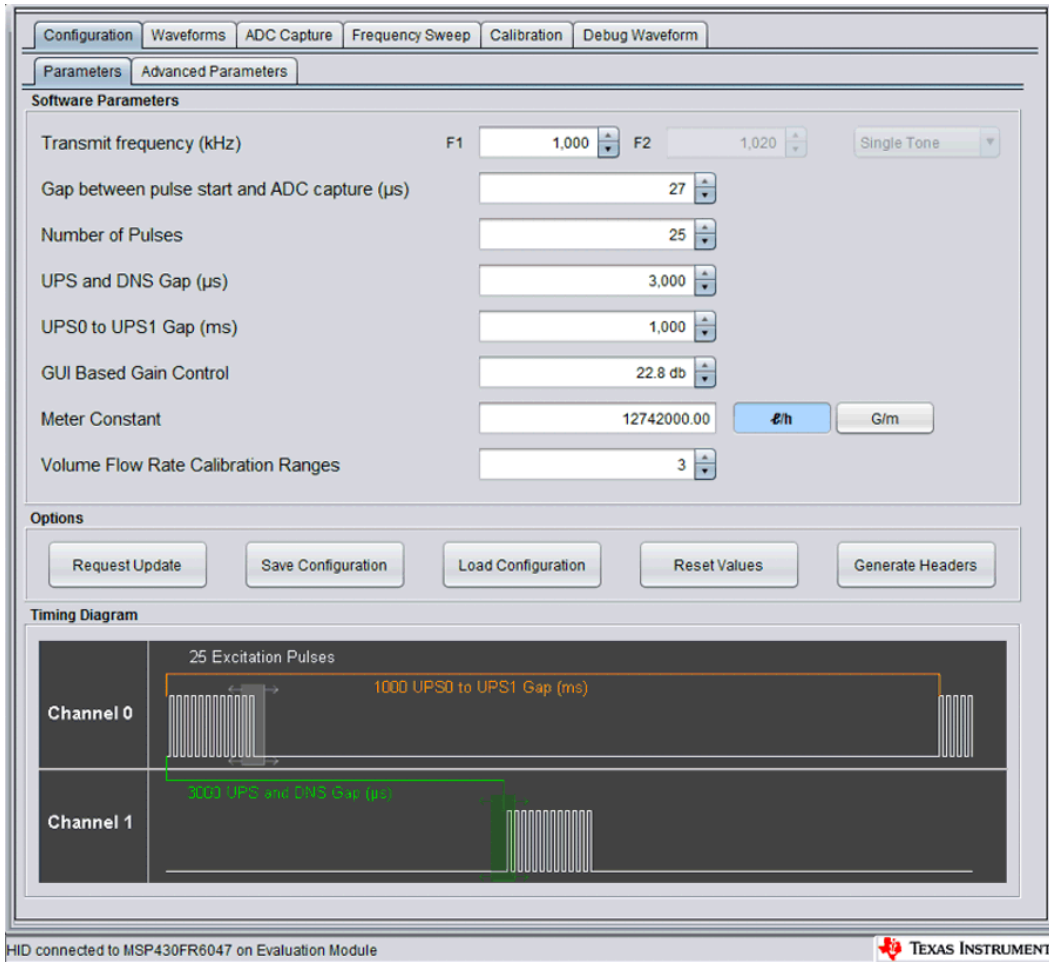


Figure 1-4. Design Center Configuration

The screenshot displays the 'Advanced Software Parameters' section of a configuration tool. It includes various input fields and dropdown menus for parameters such as USSXT (kHz), ADC Sampling Frequency (kHz), Signal Sampling Frequency (kHz), and Algorithm Option. Below the parameters is an 'Options' section with buttons for 'Request Update', 'Save Configuration', 'Load Configuration', 'Reset Values', and 'Generate Headers'. At the bottom, a 'Timing Diagram' shows two channels: Channel 0 with 25 excitation pulses and a 1000 µs gap, and Channel 1 with a 3000 µs gap and a subsequent pulse train.

Advanced Software Parameters

USSXT (kHz)	8000	Algorithm Option	Lobe
ADC Sampling Frequency (kHz)	200	ULP Bias Delay	3
Signal Sampling Frequency (kHz)	4000.0	Start PPG Count (ns)	10,000
ADC Over Sampling Rate	20	Turn on ADC Count (ns)	5,000
Delta TOF Offset (ps)	0	Start PGA and IN Bias Count (ns)	0
Abs TOF Additional Delay (ns)	0	User Param #6	0
Capture Duration (µs)	50	USS XTAL Settling Count (µs)	120
Interpolation Correction Table Size	256	Envelope Crossing Threshold	15
		Search Range	3
		User Param #10	0

Options

Request Update Save Configuration Load Configuration Reset Values Generate Headers

Timing Diagram

Channel 0: 25 Excitation Pulses, 1000 µs Gap (ms)

Channel 1: 3000 µs Gap (µs)

HID connected to MSP430FR6047 on Evaluation Module

Figure 1-5. Design Center Configuration (continued)

2 Test Results

Figure 2-1 shows the captured ADC waveform at zero-flow and measured-flow rates. These tests were performed at room temperature.

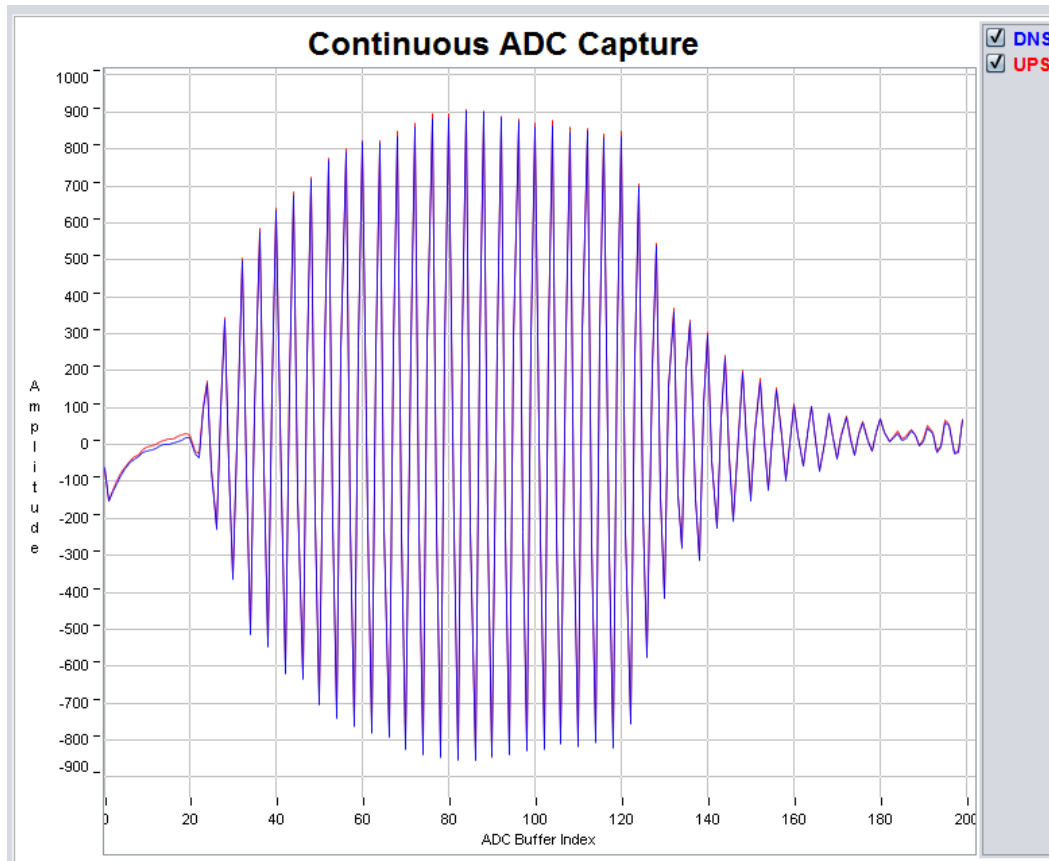


Figure 2-1. ADC Capture

Flow measurements were acquired by clamping the transducers to the PVC of an existing flow meter test setup (see Figure 2-2), which includes a reference meter in series and a pump to vary the flow rate.

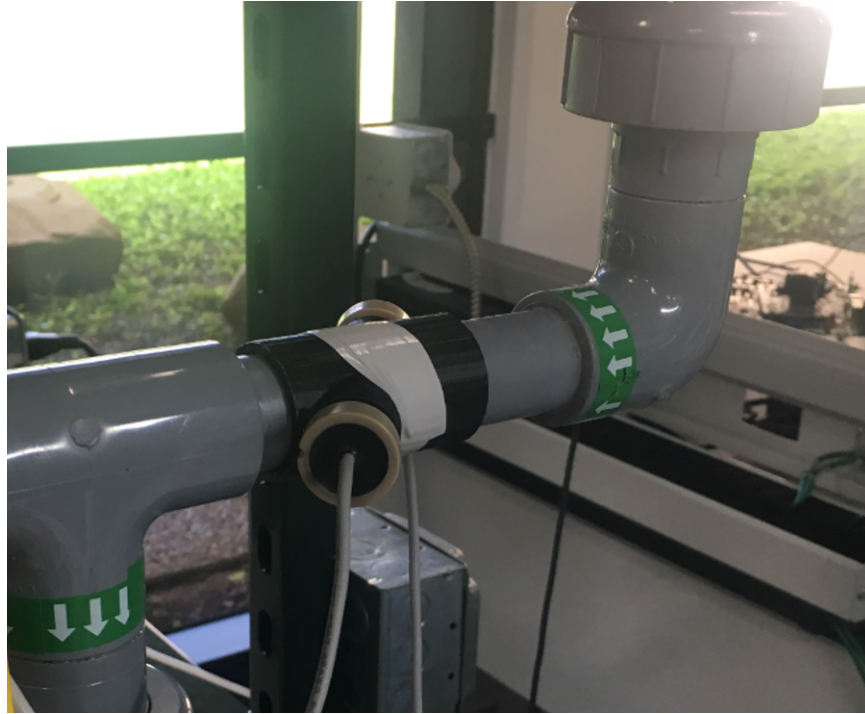


Figure 2-2. Flow Meter Test Setup

Figure 2-3 shows a linear relationship between the reference flow rate and MSP430FR6047 measured flow rate.

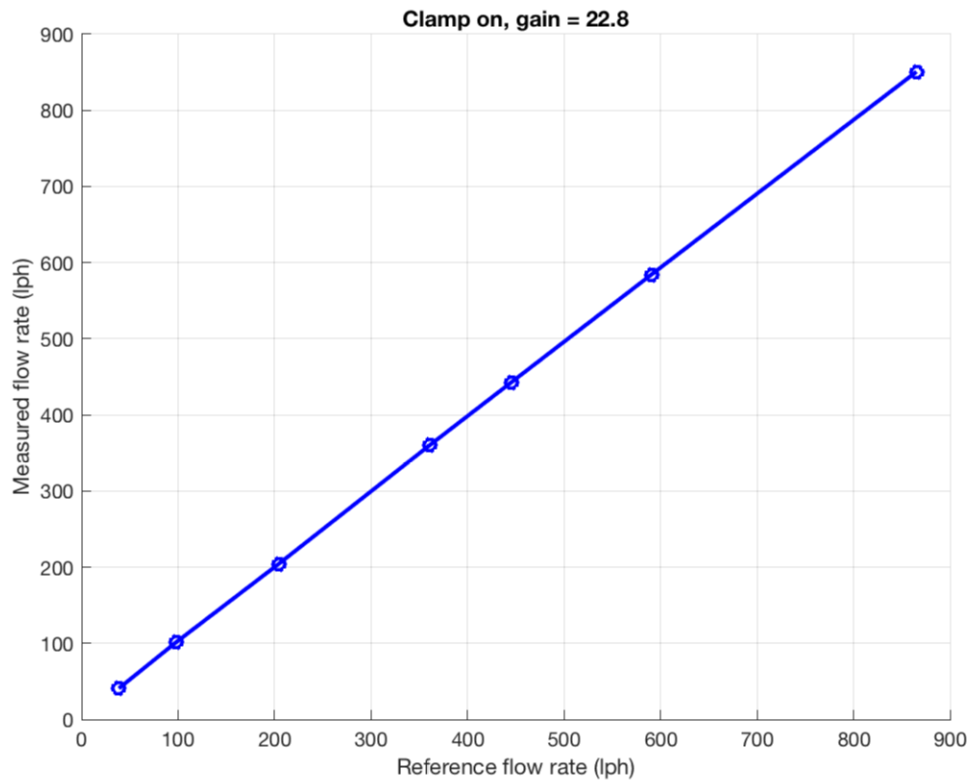


Figure 2-3. Flow Measurement Results

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