3V Accelerometer Featuring TLV2772 Application Brief

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Literature Number: SLVA050
November 1998

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Contents

List of Figures

List of Tables

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ABSTRACT

This application brief describes a 3-axis acceleration data collection system that uses a TLV2772 operational amplifier to amplify and filter sensor electrical signals. Use of the available evaluation modules from Texas Instruments allows for easy construction of the system for evaluation.

1 Introduction

Acceleration tests are most commonly used for aircraft and vehicle mounted equipment which experience motion-induced acceleration loads during use. The tests are also used to screen weak or marginal mounting points and to verify operation of moving parts under load.

This paper describes a 3-axis acceleration data collection system. Figure 1 shows the system diagram. The ACH04-08-05 shock sensor converts mechanical acceleration into electrical signals. The signal conditioning circuit uses a TLV2772 op amp to amplify and filter the electrical signal from the sensor. The TLV1544 ADC converts the analog signal from the signal conditioning circuit into digital data that is processed using the TMS320C50 DSP. The personal computer, or PC, is used for further manipulation and display of the data. Use of the available evaluation modules from Texas Instruments allows for easy construction of the system for evaluation.

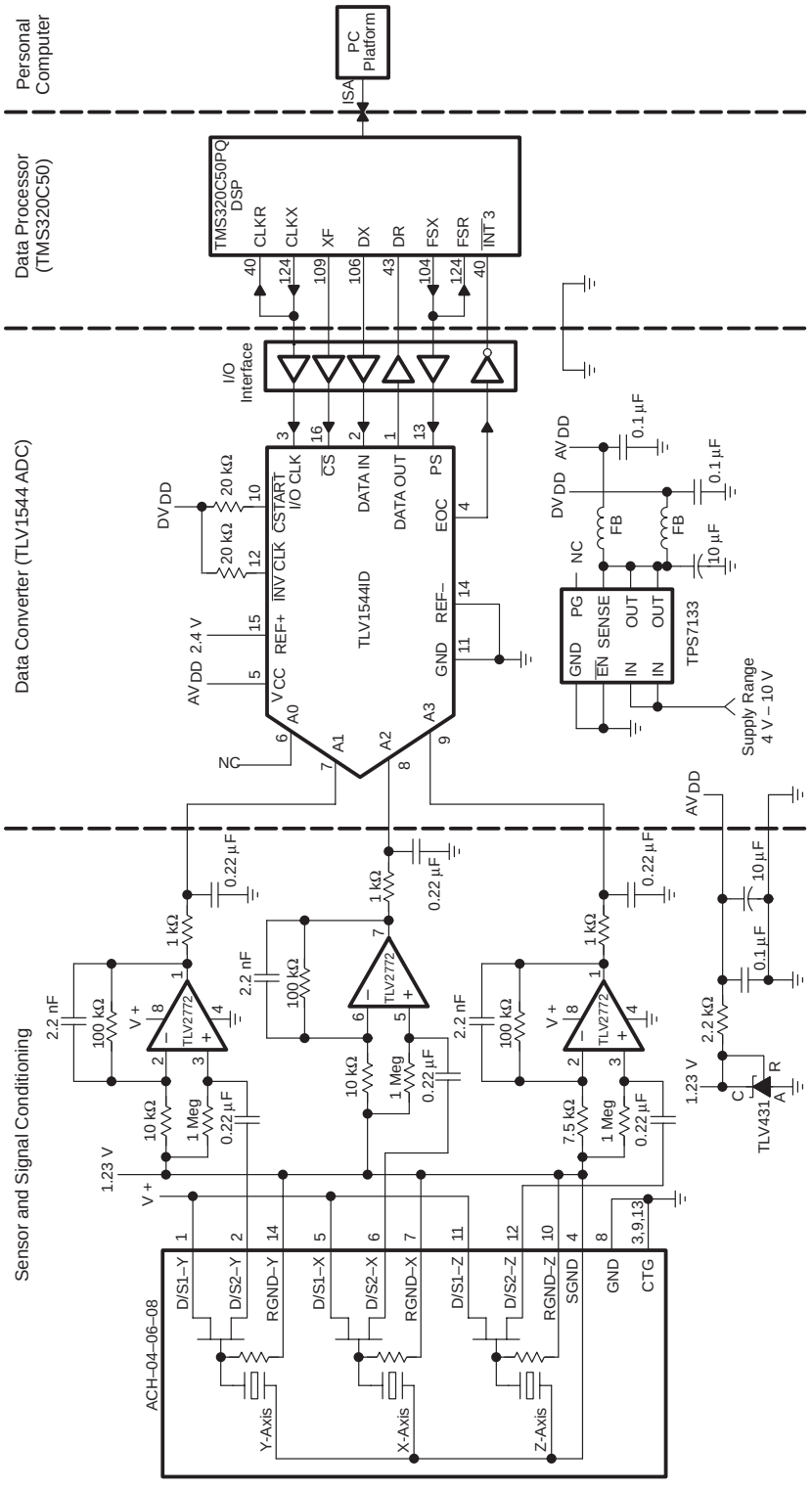

Figure 1. Accelerometer System Diagram

2 System Description

This section describes the system elements.

2.1 Sensor

The ACH04-08-05 shock sensor contains three piezoelectric sensing elements oriented to simultaneously measure acceleration in x-, y- and z-axis. The sensor responds from 0.5 Hz to above 5 kHz. The output is buffered with an internal JFET. Table 1 lists the voltage output sensitivity of the sensor for each axis.

Table 1. ACH04-08-05 Sensitivity

Axis Sensitivity	MIN	TYP	MAX	UNIT
X	1.35	1.80	2.25	mV/g
Y	1.35	1.80	2.25	mV/g
Z	1.00	1.37	1.70	mV/g

2.2 Signal Conditioning

The TLV2772 has an excellent combination of features: 10.5 V/μs slew rate, 5 MHz GBW, rail-to-rail output swing, high input impedance, 0.005% distortion driving 600 Ω, 17 nV/$\sqrt{\text{Hz}}$ input noise voltage, and 360 μV input offset voltage.

The output of the amplifier has a dc bias equal to 1.23 V. The ac response of the circuit is superimposed upon this dc level. In other words, Vadc = Vs H(s) + 1.23 V. Where Vadc is the voltage into the TLV1544 ADC, Vs is the ac signal from the ACH04-08-05 shock sensor, and H(s) is the ac transfer function of the signal conditioning circuit.

The ac transfer function of the signal conditioning circuit has a pass band gain of 21 dB for the x- or y-axis, and 23 dB for the z-axis. These gains provide for ±50g dynamic range, on all axis, in a 3V system.

The input RC, 1 MΩ and 0.22 μF, provides a high pass function which attenuates frequencies below 0.724 Hz at a rate of 20dB/decade. The RC, 100 kΩ and 2.2 nF, in the amplifier's feedback path, and output RC, 1kΩ and 0.22 μF, provide a low pass function which attenuates frequencies above 724 Hz at a rate of 40 db/decade rate to 7.24 kHz and 20 dB/decade thereafter. The filtering blocks unwanted dc variations from the sensor, and insures that high frequency signals do not cause aliasing errors in the data converter.

Figure 2 shows the Bode plot approximation of the ac transfer function of the signal conditioning circuit.

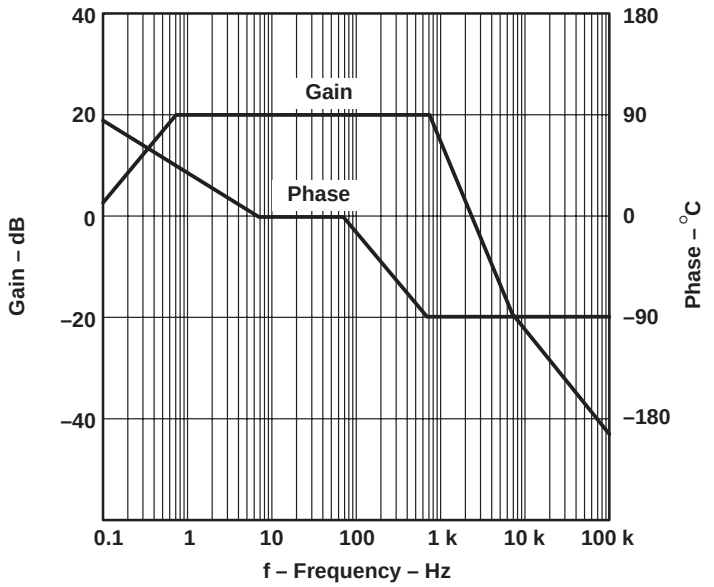

Figure 2. Bode Plot of Signal Conditioning Circuit

2.3 Data Converter

The TLV1544 ADC is a low-voltage (2.7 V to 5.5 V dc single supply), 10-bit analog-to-digital converter with serial control, 4 analog inputs, conversion time = 10 μs, and programmable 1 μA power down mode. The full-scale reference voltage is 2.4 V. The 10-bit resolution of the ADC provides resolution measurement of 0.1g. The converter is operated in fast conversion mode with consecutive conversions performed on 3 channels. This results in a sampling rate of 85 KSPS/3 channels = 28.3 KSPS for each channel.

2.4 Processor, Memory, and Display

The TMS320C50 DSP is used to control and collect data samples from the TLV1544 ADC.

The TMS320C5x EVM installs into a PC ISA slot. The PC is used for programming and control of the TMS320C5x EVM, and provides resources for file storage or other processing of the collected data.

3 System Test

With the shock sensor and signal conditioning circuit interfaced to the TLV1544 EVM and the TMS320C5X EVM, the system is operational.

The acceleration sensor and the signal conditioning circuitry were housed in a Bud CU–234 box, which was machined to mount on a fixture plate for calibrated testing. The calibrated acceleration source used was an Unholtz Dickie T-1000 vibration tester. The specifications for this machine are:

- 1 in maximum displacement
- 70 in/s maximum velocity
- 75g maximum sine acceleration
- ±10% operational tolerance

Signals from the signal conditioning circuitry were routed to the TLV1544 ADC via coaxial cables. Sine wave acceleration was used and data was collected on all 3 axis at various acceleration levels and frequencies. The data was analyzed and the average output vs input for each axis is plotted in Figure 3.

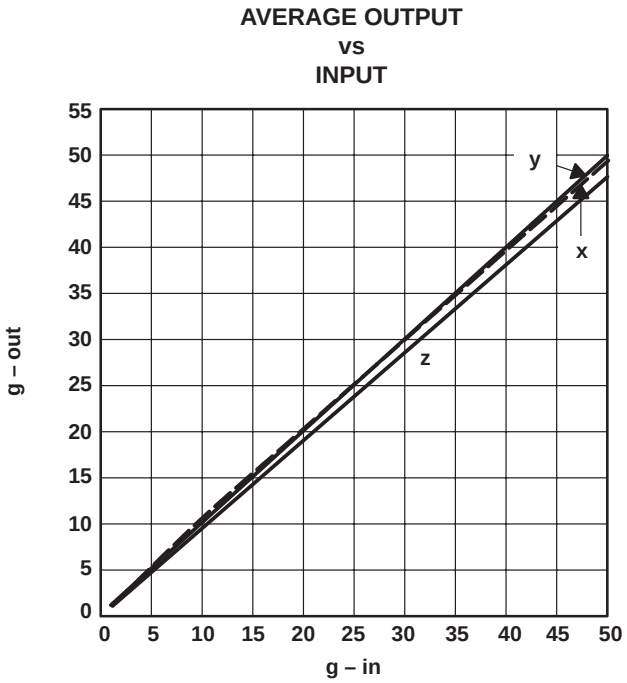

Figure 3. Average Output Vs Input Per Axis

4 References

1. *Application Report 3V Accelerometer Featuring TLV2272*, literature #SLVS050.
2. ACH04-08-05 Data sheet http://www.amp.com/sensors
3. TLV2772 data sheet, literature #SLOS209
4. *Universal Operational Amplifier EVM User's Manual*, literature #SLVU006
5. TLV1544 data sheet, literature #SLAS139B
6. *TLV1544 EVM User's Manual*, literature #SLAU014
7. *Interfacing the TLV1544 Analog-to-Digital Converter to the TMS320C50 DSP Applications Report*, literature # SLAA025
8. *TMS320C5X Evaluation Module Technical Reference* literature # SPRU087
9. *TMS320C5X C Source Debugger User's Guide* literature # SPRU055B
10. *TMS320C5x EVM Technical Reference*, literature #SPRU087