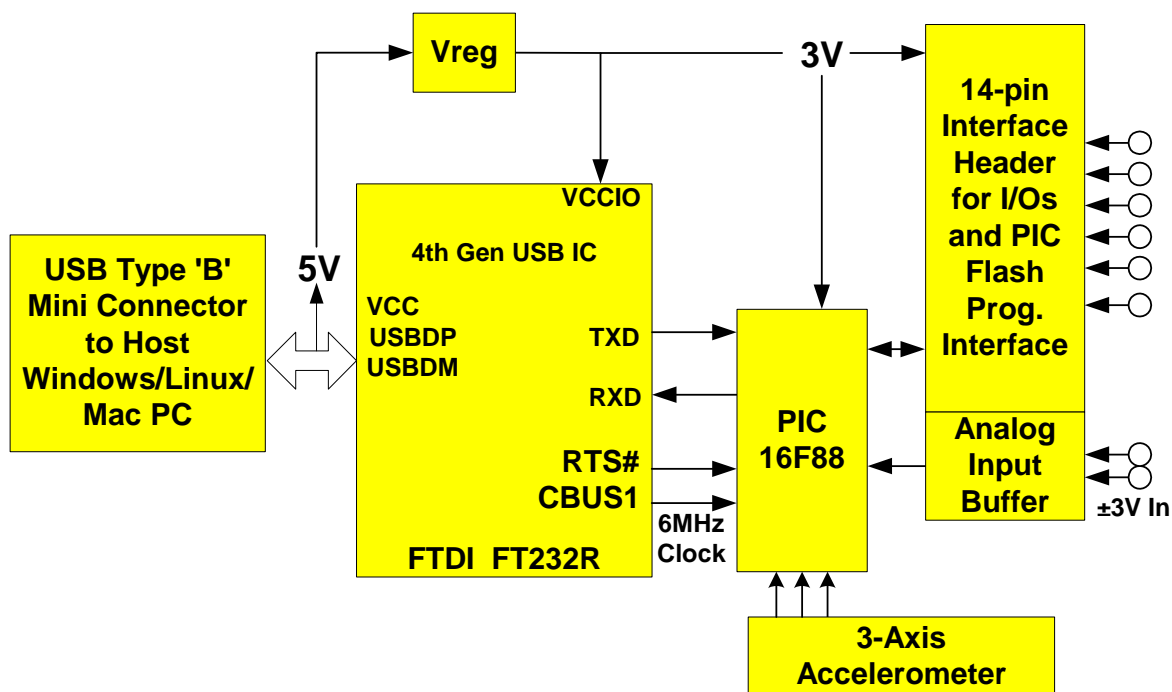


**DLP-TILT-G**  
LEAD FREE

## USB-BASED TILT SENSOR / ACCELEROMETER / VIBRATION ANALYSIS / AC SIGNAL ANALYSIS MODULE

### Features:

- Microcontroller Preprogrammed with Data-Acquisition Functions
- 3-Axis, 1.5g Accelerometer
- Single-Byte Access to All Firmware Features
- Continuously Streaming Analog Sample Rates from 100 to 6K Samples Per Second
- 4<sup>th</sup>-Generation USB Interface Silicon from FTDI (FT232R with internal ceramic resonator, internal setup EEPROM, and clock output for microcontroller)
- Virtual COM Port Drivers for Easy Programming Interface



### APPLICATIONS:

- 3-Axis Tilt Sensor
- Vibration Analysis (350Hz)
- Two-Button Mouse (Pointing Device Alternative)
- FFT-Based AC Analysis to 3KHz with Provided Software
- +/-3V Analog In (Dual Channel)
- Data Acquisition: 0-3V Analog In, Digital I/O
- Robotic/Motion Sensing and Control

## 1.0 INTRODUCTION

The DLP-TILT USB-to-accelerometer module has four primary applications: (1) vibration analysis, (2) tilt sensing, (3) AC signal analysis, and (4) two-button mouse pointing device alternative.

### 1.1 VIBRATION ANALYSIS

This module is designed to provide vibration analysis using an on-board, 2-axis, 1.5g accelerometer that is designed for analysis of frequencies up to 350 Hz. Two of the analog channels in the microcontroller are dedicated to the on-board accelerometer.

### 1.2 TILT SENSING

When used as a tilt sensor, the accelerometer can measure tilt up to approximately  $\pm 60$  degrees from center in both the X- and Y-axes. The position is reported as an 8-bit or 10-bit integer with the center position reporting the half-scale value of 128 (8-bit) from the A/D converter in the microcontroller. The A/D converter can also be run in 10-bit resolution mode with a resulting mid-scale value of 512. The Z-axis measurement data is also available as a simple voltage measurement.

### 1.3 AC SIGNAL ANALYSIS

Voltage data from the seven analog channels can be sampled at rates ranging from 100 samples per second to 6000 samples per second, thereby enabling AC analysis of audio frequencies up to 3KHz. One module input channel is dedicated to an analog input buffer that allows for voltages in the range of  $\pm 5$  volts to be acquired. The remaining channels allow voltages in the range of 0-5 volts to be acquired.

The microcontroller and preprogrammed firmware used in this design utilize single-byte commands to control all aspects of operation. Once the channel and sample rates have been selected, continuous streaming of A/D data can be enabled and disabled by sending a single-byte command. Data received by the host PC can be analyzed for frequency content using an FFT-based Windows application available as a free download from the DLP Design website upon purchase of the module.

### 1.4 POINTING DEVICE

The DLP-TILT's preprogrammed firmware includes the feature set of a standard two-button mouse with the motion of the cursor controlled by the tilt of the DLP-TILT's printed circuit board and accelerometer.

When the board is level, the cursor remains motionless. As the board is tilted from center, the cursor begins to move in the direction of the tilt. The further the board is tilted, the faster the cursor moves across the screen. Two of the digital I/O lines serve as inputs for the buttons. Shorting these lines to ground will cause the firmware to issue the "Button Down" signal to the host PC, thereby mimicking the operation of standard mouse buttons.

Shorting a pin to ground in the interface header before powering up the DLP-TILT activates the two-button mouse functionality. *Refer to Section 2.0 for the I/O lines associated with the Pointing Device mode of operation.*

## 2.0 ELECTRICAL INTERFACE DESCRIPTION

Refer to the electrical schematic at the end of this document for additional details.

| Pin | Description | Comments                                                                                     |
|-----|-------------|----------------------------------------------------------------------------------------------|
| 1   | MCLR        | Pulling this pin to ground will reset the microcontroller. See Note1.                        |
| 2   | Vin1        | Analog input for voltages in the range of $\pm 3V$ .                                         |
| 3   | B6/PGC      | Analog in (0-3V) or digital I/O. See Note1, Note2.                                           |
| 4   | Vin2        | Analog input for voltages in the range of $\pm 3V$ .                                         |
| 5   | SWVCC       | 3 Volt output; switched on once host enumeration is complete. See Note1.                     |
| 6   | B0          | Digital I/O; See Note2.                                                                      |
| 7   | Ground      | Note1.                                                                                       |
| 8   | Ground      |                                                                                              |
| 9   | B7          | Analog in (0-3V) or digital I/O. See Note1, Note2.                                           |
| 10  | B1          | Digital I/O. See Note2.                                                                      |
| 11  | B3          | Digital I/O. If held low at power up, Pointing Device functionality is activated. See Note2. |
| 12  | B4          | Digital I/O. See Note2.                                                                      |
| 13  | Ground      |                                                                                              |
| 14  | Ground      |                                                                                              |

Note1: These pins are used for reprogramming the Flash program memory area (a user-supplied device programmer is required).

Note2: Weak pull-ups in the microcontroller are enabled for Port B by default.

## 2.1 SOFTWARE INTERFACE DESCRIPTION

Royalty-free Virtual COM Port drivers are available for immediate download from [www.dlpdesign.com](http://www.dlpdesign.com). The VCP drivers are available for the following systems:

- Windows 2000 / XP / VISTA
- Windows CE
- MAC OS-8 and OS-9 (Mouser function not supported)
- MAC OS-X (Mouser function not supported)
- Linux 2.40 and greater

The DLP-TILT supports two standard baud rates: 38,400 (power-up default) and 128,000 baud. Communication with the DLP-TILT is accomplished by simply opening the COM Port at 38,400 baud and sending single-byte commands. The commands are outlined in Section 3.0.

## 2.2 QUICK START GUIDE FOR WINDOWS

- A. Download the modified Virtual COM Port (VCP) drivers from [www.dlpdesign.com](http://www.dlpdesign.com). Unzip these files into a new folder. The VCP drivers that are part of the Windows XP operating system will not work as the PID code has been changed to FBFA.
- B. Connect the DLP-TILT module to the host PC, then load the USB drivers obtained in Step A.
- C. Open Device Manager and look in "Ports (COM & LPT)" to determine the COM port number that Windows has assigned to the DLP-TILT module.

- D. Run Windows HyperTerminal by clicking the Start menu, selecting Programs, and navigating through Accessories to the HyperTerminal folder. Select the following parameters:

**Bits Per Second:** 38,400  
**Data Bits:** 8  
**Parity:** None  
**Stop Bits:** 1  
**Flow Control:** Hardware

- E. Press the letter 'P' on the keyboard. The letter 'Q' should appear in the HyperTerminal window. (Please note that all commands are case sensitive.)

At this point the DLP-TILT module is set up and ready for use with either one of the Windows applications provided by DLP Design or your own custom software.

### 3.0 COMMAND SET

To operate the DLP-TILT, the host application simply has to open the COM port assigned to the module, set the baud rate to 38,400, and send single-command bytes. A complete list of command bytes is presented here:

*Please note that the ASCII characters are case sensitive.*

| Command                                  | Hex  | ASCII Character (Case Sensitive) | Comments                                                               |
|------------------------------------------|------|----------------------------------|------------------------------------------------------------------------|
| <b>PING</b>                              | 0x50 | P                                | DLP-TILT will return "Q" (0x51) if module is present and port is open. |
| <b>SET BAUD RATE:</b>                    |      |                                  |                                                                        |
| 38,400 Baud                              | 0x69 | i                                | Default                                                                |
| 128,000 Baud                             | 0x39 | 9                                |                                                                        |
| <b>A/D OUTPUT RESOLUTION:</b>            |      |                                  |                                                                        |
| 8-Bit Data Returned                      | 0x51 | Q                                | Default                                                                |
| 10-Bit Data Returned                     | 0x52 | R                                |                                                                        |
| <b>A/D RETURN DATA TYPE:</b>             |      |                                  |                                                                        |
| Binary/Counts                            | 0x53 | S                                | Default                                                                |
| ASCII Text                               | 0x54 | T                                |                                                                        |
| <b>A/D SAMPLE RATE (TIMER INTERVAL):</b> |      |                                  |                                                                        |
| 100 Hz                                   | 0x41 | A                                |                                                                        |
| 200 Hz                                   | 0x42 | B                                |                                                                        |
| 300 Hz                                   | 0x43 | C                                |                                                                        |
| 500 Hz                                   | 0x44 | D                                |                                                                        |
| 1.0 KHz                                  | 0x45 | E                                |                                                                        |
| 1.5 KHz                                  | 0x46 | F                                |                                                                        |
| 1.8 KHz                                  | 0x47 | G                                | Default                                                                |
| 2.0 KHz                                  | 0x48 | H                                |                                                                        |

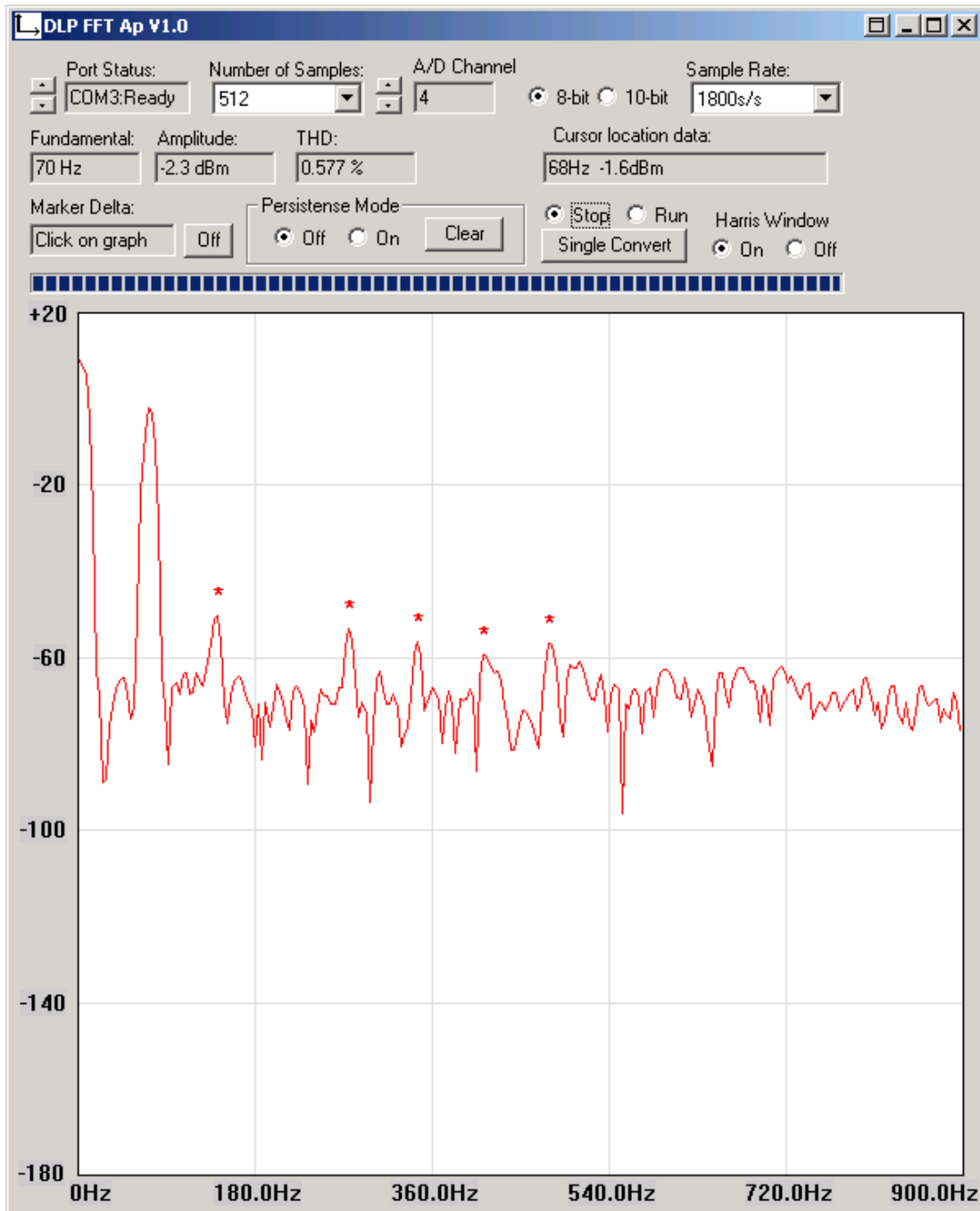
|                                                                           |      |   |                |
|---------------------------------------------------------------------------|------|---|----------------|
| 2.5 KHz                                                                   | 0x49 | I |                |
| 3.0 KHz                                                                   | 0x4A | J |                |
| 4.0 KHz                                                                   | 0x4B | K |                |
| 5.0 KHz                                                                   | 0x4C | L |                |
| 6.0 KHz                                                                   | 0x4D | M |                |
| <b>A/D CHANNEL SELECT:</b>                                                |      |   |                |
| Ch0 (AN0 / A0)                                                            | 0x30 | 0 | X axis         |
| Ch1 (AN1 / A1)                                                            | 0x31 | 1 | Y axis         |
| Ch2 (AN2 / A2)                                                            | 0x32 | 2 | Z axis         |
| Ch3 (AN3 / A3)                                                            | 0x33 | 3 | VIN2, J1 Pin 4 |
| Ch4 (AN4 / A4)                                                            | 0x34 | 4 | VIN1, J1 Pin 2 |
| Ch5 (AN5 / B6)                                                            | 0x35 | 5 | J1 Pin 3       |
| Ch6 (AN6 / B7)                                                            | 0x36 | 6 | J1 Pin 9       |
| <b>A/D CLOCK SELECTION:</b>                                               |      |   |                |
| A/D Off                                                                   | 0x61 | a |                |
| Internal                                                                  | 0x62 | b | Default        |
| Divide by 64                                                              | 0x63 | c |                |
| Divide by 32                                                              | 0x64 | d |                |
| Divide by 16                                                              | 0x65 | e |                |
| Divide by 8                                                               | 0x66 | f |                |
| Divide by 4                                                               | 0x67 | g |                |
| Divide by 2                                                               | 0x68 | h |                |
| <b>A/D CHANNEL ENABLE: (Channels 0, 1, 2, 3 and 4 are Analog In Only)</b> |      |   |                |
| Ch5 Enable                                                                | 0x6C | l |                |
| Ch6 Enable                                                                | 0x6D | m |                |
| <b>A/D CHANNEL DISABLE: (enable digital I/O)</b>                          |      |   |                |
| Ch5 Disable                                                               | 0x71 | q |                |
| Ch6 Disable                                                               | 0x72 | r |                |
| <b>MAKE DIGITAL OUTPUT AND CLEAR TO LOW :</b>                             |      |   |                |
| Port B4                                                                   | 0x75 | u |                |
| Port B0                                                                   | 0x76 | v |                |
| Port B1                                                                   | 0x77 | w |                |
| Port B3                                                                   | 0x78 | x |                |
| Port B6                                                                   | 0x2D | - |                |
| Port B7                                                                   | 0x3D | = |                |

| <b>MAKE DIGITAL OUTPUT AND SET HIGH:</b>                                                                                                      |      |   |                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------|------|---|--------------------------------|
| Port B4                                                                                                                                       | 0x56 | V |                                |
| Port B0                                                                                                                                       | 0x57 | W |                                |
| Port B1                                                                                                                                       | 0x58 | X |                                |
| Port B3                                                                                                                                       | 0x59 | Y |                                |
| Port B6                                                                                                                                       | 0x5B | [ |                                |
| Port B7                                                                                                                                       | 0x5D | ] |                                |
| <b>RETURN SINGLE A/D CONVERSION TO HOST USING CURRENT SETTINGS:</b>                                                                           |      |   |                                |
|                                                                                                                                               | 0x37 | 7 |                                |
| <b>BEGIN STREAMING A/D CONVERSION DATA TO HOST USING CURRENT SETTINGS:</b>                                                                    |      |   |                                |
|                                                                                                                                               | 0x38 | 8 | Halt on Any Character Received |
| <b>RETURN 8-BIT A/D CONVERSION DATA TO HOST FOR BOTH CHANNELS X AND Y OF THE ACCELEROMETER WITH OFFSET CORRECTION AND MOUSE BUTTON STATE:</b> |      |   |                                |
|                                                                                                                                               | 0x7A | z | 3 Bytes Returned               |
| <b>RETURN 8-BIT A/D CONVERSION DATA FOR ALL 7 CHANNELS</b>                                                                                    |      |   |                                |
|                                                                                                                                               | 0x73 | s | 7 bytes returned               |

## 4.0 DEMONSTRATION SOFTWARE

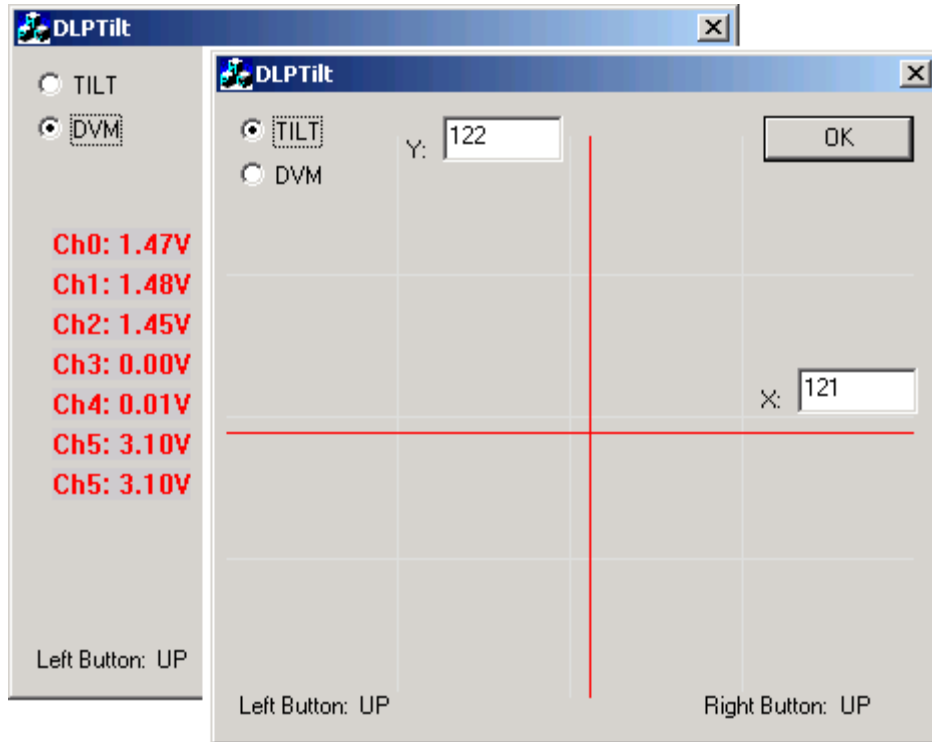
Three demonstration programs are available for the DLP-TILT module: AcqFFT.exe, DLPTilt.exe, and DLPVib.exe. All three programs are available for download from the DLP Design website upon purchase of the DLP-TILT module.

### 4.1 ACQFFT.EXE



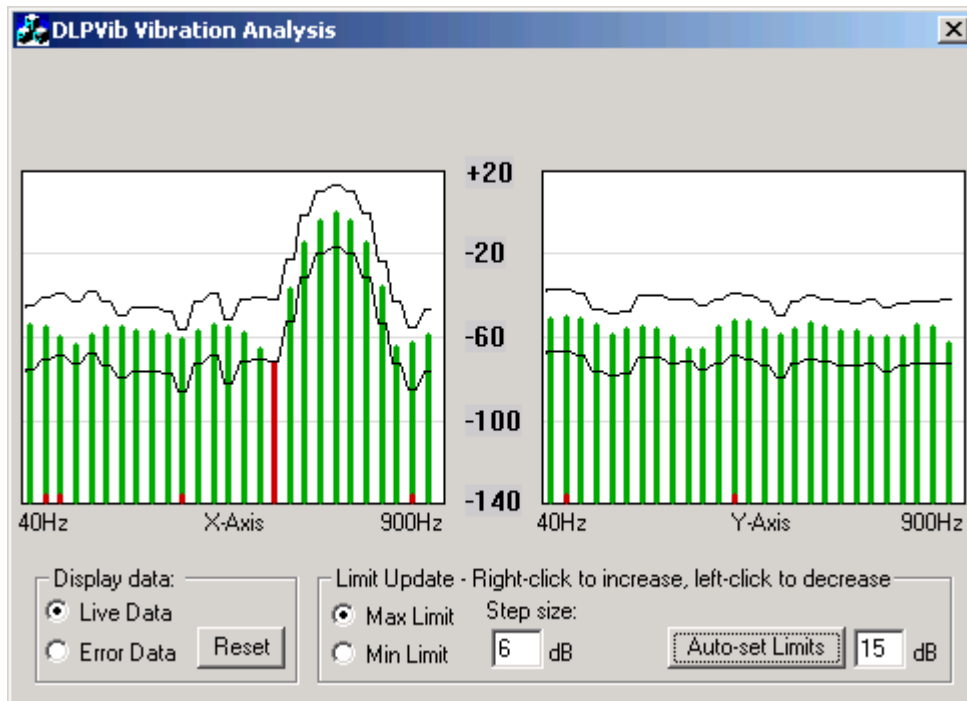
This program is designed to acquire AC signal data from any of the seven analog inputs on the DLP-TILT, then calculate and display the FFT of the signal and provide some basic analysis. Numerous program settings are possible including setting the COM port, A/D channel on the microcontroller, sample rate, number of samples, and a continuous run mode.

## 4.2 DLPTILT.EXE



This program is designed to both demonstrate the tilt feature of the accelerometer and present the acquired voltages from each of the seven analog inputs.

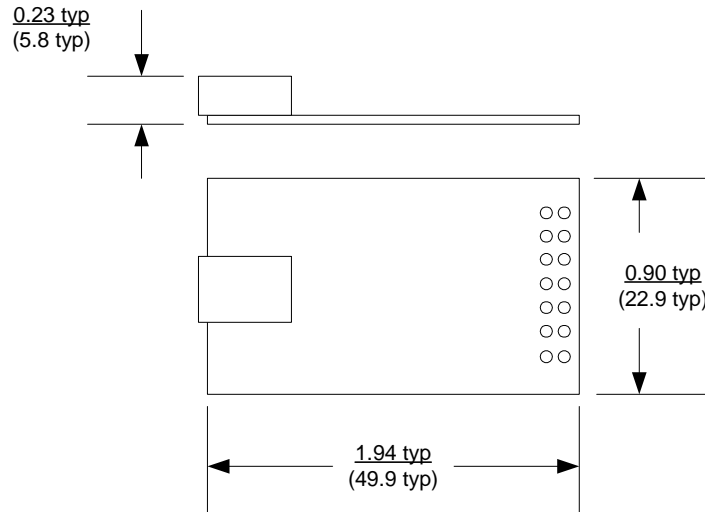
## 4.3 DLPVIB.EXE





This program is designed to monitor both channels of the accelerometer and graphically display frequency and amplitude data proportional to the vibration. Limits can be set such that an error indication is made when any frequency component rises or falls out of the limits.

## 5.0 MECHANICAL DIMENSIONS IN INCHES (MM) (PRELIMINARY)



## 6.0 DISCLAIMER

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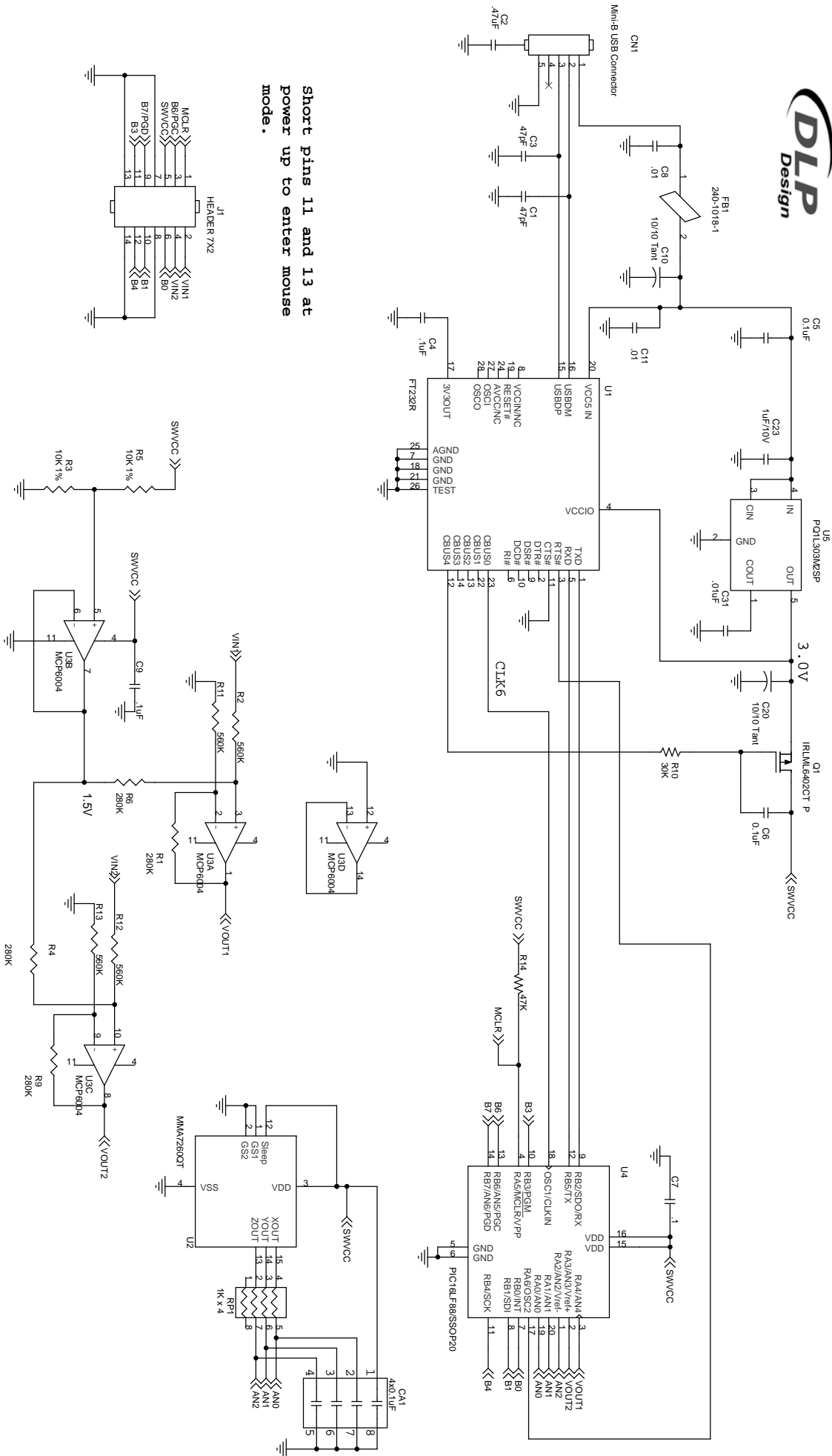
## 7.0 CONTACT INFORMATION

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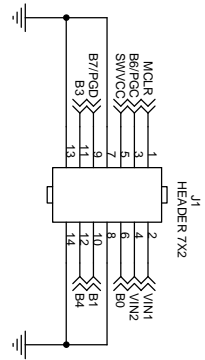
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# DLP-TILT-G



Short pins 11 and 13 at power up to enter mouse mode.



5 4 3 2 1