1 INTRODUCTION

This technical note is a guide to operate the XDS220 I/O interface. The I/O interface supports the following features:

- USB power export
- Programmable Power export 1.2v-4.75v with 250mA limit.
- User USB UART.
- Two GPIO bits reserved for emulation functions.
- Three channels of current measurement. Two channels external one channel internal on the programmable power supply.

This product includes software developed by the LiveGraph project and its contributors. ([http://www.live-graph.org](http://www.live-graph.org))

2 I/O EXPANSION FRONT PANEL INTERFACE

All I/O signals are available through the XDS220 front panel via a 3x5 connector with 0.1 inch pin spacing and accept a standard 0.025 inch square post pin.

<table>
<thead>
<tr>
<th>PWR</th>
<th>COM</th>
<th>I/O</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAR-VCC(out)</td>
<td>RX(in)</td>
<td>BIO-1(io)</td>
<td>A-(in)</td>
<td>A-(in)</td>
</tr>
<tr>
<td>GND</td>
<td>GND</td>
<td>GND</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>+5V(out)</td>
<td>TX(out)</td>
<td>BIO-0(io)</td>
<td>A+(in)</td>
<td>A+(in)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAR-VCC</td>
<td>Programmable power output 1.2v-4.75v 250mA limit</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>+5V</td>
<td>USB VBUS (+5v) power passed through with 250mA resettable fuse.</td>
</tr>
<tr>
<td>RX</td>
<td>User UART receive, voltage tracks emulation TD pin 1.5v-4.1v.</td>
</tr>
</tbody>
</table>
**TX**
User UART transmit, voltage tracks emulation TD pin 1.5v-4.1v. Out is tri-state when TD falls below the emulation power detect threshold.

**BIO**
Emulation bit i/o. Voltage tracks emulation TD pin 1.5v-4.1v. Out is tri-state when TD falls below the emulation power detect threshold.

**A-/A+**
Current measurement input differential voltage of 15 volts. These signals do not have any dependency on emulation power.

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### 3 PROGRAMMABLE POWER OUTPUT SCHEMATIC

The following schematic shows the programmable power supply with its current measurement channel.

![Schematic Diagram](image)

### 4 CURRENT MEASUREMENT INPUT CHANNELS

The following schematic shows one of the three identical current measurement channels. Each channel includes the recommended input filter/current limit per the data sheet. The additional resistance adds minimal offset to the measurement. This offset along with the inherent offset of the INA219 can be compensated for in software.
5 TARGET INSTRUMENTATION

To support current measurement the target power supplies must be properly instrumented which generally consists of a small ohm, high power resistor and a pair of header pins as shown below.

When choosing a resistor the following has to be considered:

- How much voltage drop across the sense resistor is acceptable for my application?
- Will the expected current cause enough of a drop across the resistor for an accurate measurement?
- What power level does the sense resistor require?
- Can my power supply compensate for the drop across the sense resistor? Often power circuits support remote sensing so by placing the sense resistance before the remote sense point the target power will not be degraded.

See the INA219 data sheet for details on choosing the optimal sense resistor

6 HOOKING IT ALL UP

The connections between the target and XDS220 are straightforward. Connect the A+ signal to the input side of the sense resistor and the A- to the output side of the sense resistor. If you are not connected to your target via the emulation header then you should also connect a ground from the I/O header to the target. The two figures below show the direct connection to a test fixture and a wired connection.
In this setup the XDS220 I/O test jig is used to test the programmable power output driving two different current loads which are then measured with the xds2xx_currentmeasurement application.

The same test jig is connected similar to a target using 3 off the shelf jumper wires. The suggested wire length is less than 6 inches.
7 XDS2XX_CURRENTMEASURE APPLICATION

To collect current measurement data the XDS220 has a command line tool, xds2xx_currentmeasure which outputs data to a comma separated file. This file can then be manipulated in a spreadsheet or displayed with graphing tools like LiveGraph http://www.live-graph.org/. The free Live Graph tool supports both static and real-time data viewing and is included as part of the XDS220 demo package. Source code and a Microsoft Visual Studio 2008 project for the xds2xx_currentmeasure application are included in the source directory of the demo package.

Parameters for xds2xx_currentmeasure:
- **-p**: Port
- **-v**: Verbose <level>
- **-f**: CSV output file
- **-u**: Measurement application bin file
- **-d**: Delay in msec between samples
- **-n**: Number of samples to capture
- **-m**: Mask channels to capture
  - ch1-shunt 0x0001
  - ch1-bus 0x0002
  - ch2-shunt 0x0004
  - ch2-bus 0x0008
  - ch3-shunt 0x0010
  - ch3-bus 0x0020
  - ch1-current 0x0100
  - ch1-power 0x0200
  - ch2-current 0x0400
  - ch2-power 0x0800
  - ch3-current 0x1000
  - ch3-power 0x2000
- **-s**: Set output voltage in Mv
- **-c1**: DAC 1 config value, hex
- **-c2**: DAC 2 config value, hex
- **-c3**: DAC 3 config value, hex
- **-r1**: Channel 1 Resistance
- **-r2**: Channel 2 Resistance
- **-r3**: Channel 3 Resistance
The following example command line will capture all three channels and calculate the current and power for each channel. This example was run with connection to the XDS220 test jig with the programmable power level set to 3300mV (3.3V). You probably will not use the –s option for your target.

```bash
xds2xx_currentmeasure -p 0 -v 1 -f sample_win.csv -u
app_currentmeasure.bin -d 20 -n 1000 -m 0x3f3f -r1 0.02 -r2 0.02 -r3 0.02 -s 3300
```

The above command line generated the following output:

```
Time,Ch1-Shunt,Ch1-Bus,Ch1-Current,Ch1-Power,Ch2-Shunt,Ch2-Bus,Ch2-Current,Ch2-Power,Ch3-Shunt,Ch3-Bus,Ch3-Current,Ch3-Power,
2043.00,650.00,3304.00,32.5000,21.13,1200.00,3300.00,60.0000,72.00,1930.00,3304.00,96.5000,186.25
2074.00,650.00,3300.00,32.5000,21.13,1200.00,3296.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
2106.00,650.00,3300.00,32.5000,21.13,1190.00,3300.00,59.5000,70.81,1930.00,3300.00,96.5000,186.25
2137.00,650.00,3304.00,32.5000,21.13,1200.00,3300.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
2168.00,640.00,3304.00,32.0000,20.48,1200.00,3300.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
2199.00,650.00,3304.00,32.5000,21.13,1190.00,3300.00,59.5000,70.81,1930.00,3300.00,96.5000,186.25
2230.00,650.00,3304.00,32.5000,21.13,1200.00,3300.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
2262.00,650.00,3304.00,32.5000,21.13,1200.00,3300.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
2293.00,650.00,3304.00,32.5000,21.13,1190.00,3300.00,59.5000,70.81,1930.00,3300.00,96.5000,186.25
2324.00,650.00,3304.00,32.5000,21.13,1200.00,3300.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
2355.00,650.00,3304.00,32.5000,21.13,1190.00,3300.00,59.5000,70.81,1930.00,3300.00,96.5000,186.25
2386.00,650.00,3304.00,32.5000,21.13,1200.00,3300.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
2418.00,640.00,3304.00,20.48,1200.00,3300.00,60.0000,72.00,1930.00,3300.00,96.5000,186.25
```

The application captures the shunt and bus voltages from the INA219 and all other data are calculated by the application. If you wish to just capture the shunt values so that you can post process yourself then the following command line might be appropriate:

```bash
xds2xx_currentmeasure -p 0 -v 1 -f sample_shunt.csv -u
app_currentmeasure.bin -d 20 -n 1000 -m 0x0015
```

The INA219 configuration register can be controlled with the option –c(1,2,3) option. By default the application programs the configuration register with 0x019F. In general most +5V EVM class targets would not exceed the 40mV shunt voltage, or 16V range voltage.

<table>
<thead>
<tr>
<th>Configuration Register 00h (Read/Write)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT_NAME</td>
</tr>
</tbody>
</table>
|___________|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____
| POR_VALUE | 0   | 0   | 1   | 1   | 1   | 0   | 0   | 1   | 1   | 0   | 0   | 1   | 1   | 1   | 1   |

This selects:

- Range, 16V
- Gain 1, +/-40mV
- 12 bit samples
- Shunt/Bus continuous

8 DATA VISUALIZATION

If you wish to graphically display current measurement data then a free graphing tool from LiveGraph is a good choice as it supports both static and real-time display. The
LiveGraph tool is included as part of the XDS220 demo package. The data visualization is a two step process, 1\textsuperscript{st} capture the data, 2\textsuperscript{nd} display the data. If doing real-time display you must start the data capture first.

Follow the instructions from the XDS220 web site to download and install the demo package. Open a command line window in the demo package directory, typically “\textless ccs\_install\_dir\textgreater \textbackslash ccs\textbackslash ccs\_v5\textbackslash ccs\_base\textbackslash emulation\spec\textbackslash dig\textbackslash xds2xx\textless ”.

From the command line start the data capture using xds2xx\_currentmeasure. The following command line was used earlier to capture data on the XDS220 test jig. You may drop the –s 3300 if using your own target.

\texttt{xds2xx\_currentmeasure -p 0 -v 1 -f sample\_win.csv -u app\_currentmeasure.bin -d 20 -n 1000 -m 0x3f3f -r1 0.02 -r2 0.02 -r3 0.02 -s 3300}

**Start the LiveGraph application:**

**Adjusting LiveGraph:**
- Type X axis: Data Series
- Series X axis: Time (this will be default after opening the .csv file)

**Data file setting window:**
- Click on open button to open the .csv file.
- Select the Update frequency to 50 Hz by dragging the slider.

**Data series settings window:**
- Select the columns you wish to display

Following is a typical setup using the above instructions. To close all the Live Graph windows select X in the LiveGraph console window, upper right is the picture below.
9 CURRENT MEASUREMENT USAGE AND LIMITATIONS

- The XDS220 current measurement feature is a low end, low cost implementation comparable to some DVM products that might cost $19-$29 USD. The feature should not be used for making critical current measurements.
- The xds2xx_currentmeasure application does not calibrate the INA219 channels. Testing has shown that the INA219 shunt offset voltage plus the 10 ohm filter resistors plus error in the sense resistor(s) will typically induce a +10-15% error in the shunt reading. It is up to the user to calibrate each channel for their environment and then feed this back into the .csv file for compensation. The source code to the application is also provided so more sophisticated corrections can be made prior to csv output.
- While xds2xx_currentmeasure is running CCS/DSS cannot be running on the same USB port. There are two usage models:
  - Use DSS scripting to load and run your application, then disconnect and run the current measurement application. This supports a good model where you want to automate current measurement over a number of different application tests.
  - Use the USB port for current measurement and the ENET port for CCS/DSS or vise versa. In this model both communication channels are running performing independent tasks. When using the ENET port the –p port option is the IP address, for example –p 10.0.3.31.

10 USER UART

The user uart can be used to provide a communication link between the target and the host PC. Since this uart is meant for target communications its I/O levels and tri-state control are determined by the voltage level on the JTAG header PD signal pin 7. The expectation is that the JTAG cable is plugged into the target system to provide the necessary PD and ground connections.

Once the XDS220 in plugged into the USB port it should enumerate as 2 CDC serial ports. One port dedicated for emulation and one for user communications. The following screen shot shows how you can find the user serial port, COM4 in this example.