SigmaXplore 3 Module User Guide

Contents

1 Introduction

SigmaXplore 3 is a complete learning platform built around a 3rd-order Delta-Sigma ADC and a differential Delta-Sigma DAC, designed to make the core principles of Delta-Sigma technology truly intuitive. The system can be configured as either a 1st-order or 3rd-order ADC, with cascading feedback paths that let you explore stability, noise shaping, and dynamic behavior firsthand. In the 3rd-order mode, optional feedforward paths can be enabled or disabled, allowing you to directly observe how they affect input range, loop stability, and integrator node behavior. On the digital side, you'll gain hands-on experience with essential signal-processing techniques, including CIC filters, FIR equalization, a Numerically Controlled Oscillator, and a simple UART interface for streaming data to your PC. All HDL blocks are fully accessible and customizable in Vivado, giving you complete freedom to experiment and modify the architecture. Python scripts are also included to help you process and visualize output data—and can be expanded as your skills grow. If you're looking to dive into mixed-signal and Delta-Sigma technologies, SigmaXplore 3 is an ideal starting point. All you need is a PMOD-compatible FPGA board and a PC. No additional test equipment is required, though an oscilloscope can be helpful for deeper exploration.

2 Features

ADC

- •1st/3rd configuration CIFB continuous time delta sigma ADC
- •Single bit or two-bit FIR feedback
- •Enable/disable feedforward cancelation
- •2.5MHz to 10MHz sampling rate
- •plugs directly into a FPGA PMOD connector
- •up to -92dB SNR OSR=128
- •3.3V Single Supply from PMOD

DAC

- •Single ended output
- •Single ended or differential FPGA interface
- •5th order equivalent analog filtering
- •configurable Nth order or MASH possible
- •Up to -95dB SFDR and -92dB SNR

APPLICATIONS

- •Delta Sigma practical learning for personal, professional, or an educational lab
- •Loop through signal analysis. DAC to ADC to PC
- •Numerically controlled signal generation
- •LAB grade signal generator 92dB SFDR
- •High fidelity audio digital signal processing or effects.

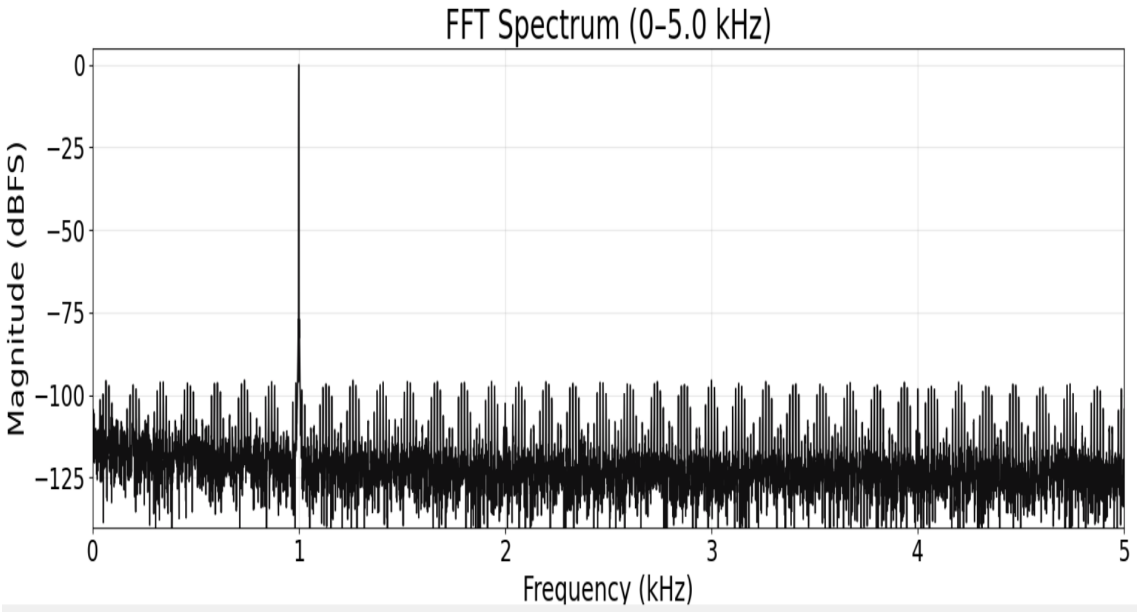
•Complete signal chain analog in/analog out.

3 Specifications

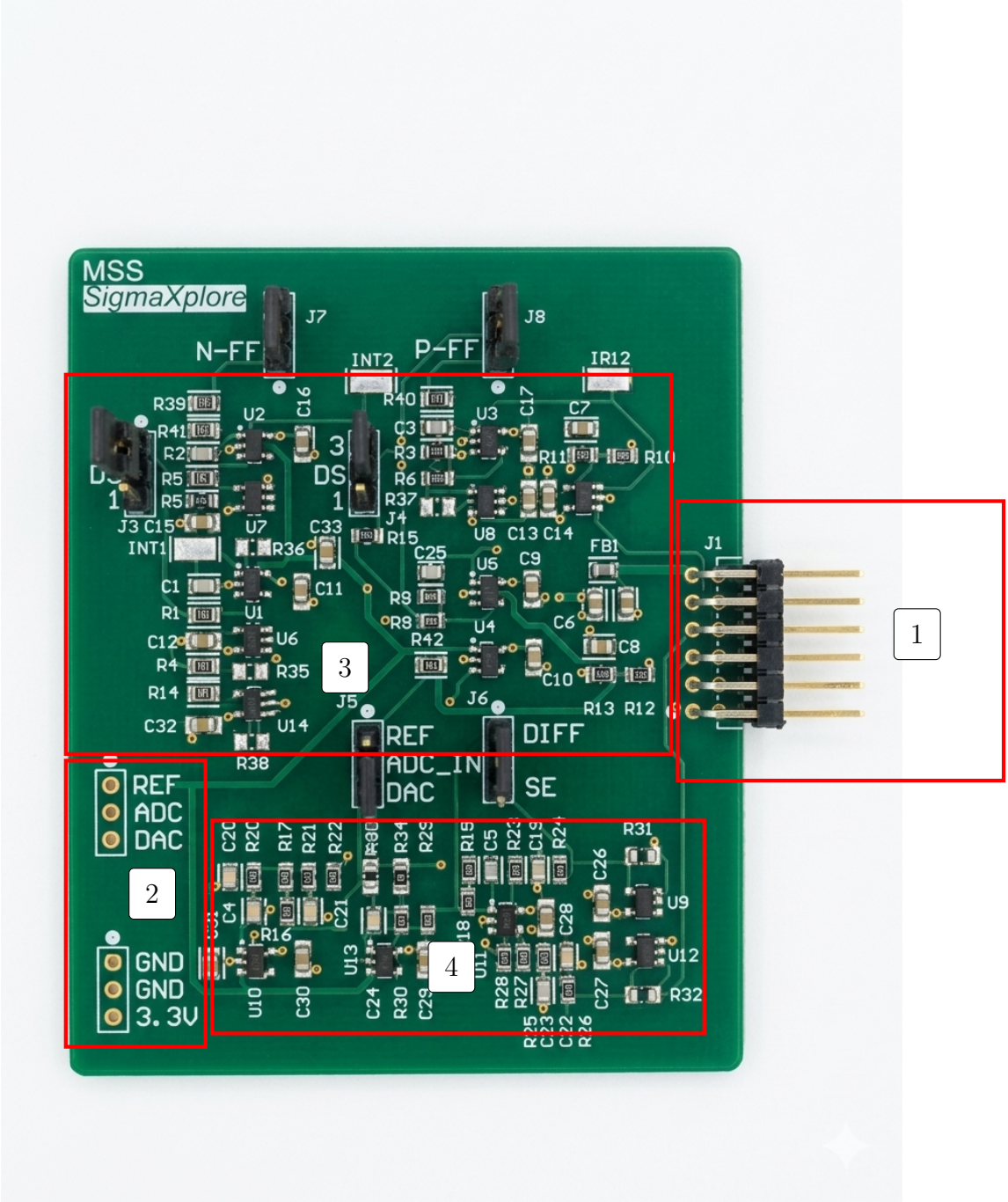
Parameter	Value	Unit
Supply Voltage	3.3	V
Supply Current	45	mA
SNR	-92	dB
Output Noise	13	uV RMS
Vout	3.25	Vpp

4 Performance

Below is the measured performance of the SigmaXplore 3 when the DAC directly drives the ADC in a loop through configuration. The ADC is configured for 16 bits with an OSR of 128. The 2nd order DAC is configured for 20 bits and is driven by a CORDIC NCO.



5 Board



Reference	Callout	Notes
1	Digital Interface	3.3V logic
2	External connection points	0-3.3V Maximum
3	3rd/1st Order DS ADC	
4	Delta Sigma DAC	3.25Vpp Output

6 Configuration

The SigmaXplore3 includes several configuration jumpers that control both the Delta-Sigma DAC and ADC signal paths.

1. DAC Output Mode The Delta-Sigma DAC can operate in either single-bit output mode or two-bit differential output mode from the FPGA. Select the desired mode by moving the three-pin jumper to the top or bottom position.

2. Third-Order Feed-Forward Paths The third-order Delta-Sigma modulator includes optional feed-forward (FF) paths. Moving the jumpers from the default open (top) position to the N-FF and P-FF positions enables these paths. Enabling feed-forward cancels the swing of the integrators, which allows the modulator to run at a wider range of clock frequencies and larger input without saturating the integrators. Keep in mind that the SigmaXplore 3 has input buffers that limit the input swing otherwise the feedforward cancaltion would allow for a larger input swing. The internal integrator nodes can be monitored at the INT1, INT2, and INT3 probe pads.

3. ADC Order Selection The Delta-Sigma ADC can be configured as either third-order or first-order. Move the two jumpers from the 3 position to the 1 position to select first-order operation. Important: The feed-forward paths must be disabled when operating in first-order mode.

4. Loop-Through Test Mode To place the DAC and ADC in a loop-through configuration, install the jumper that bridges ADC-IN to DAC. For normal operation, leave this jumper open and use the solder pads in Block2 to interface external input and output signals.

7 Software Support

The SigmaXplore DAC includes a compressed Vivado project that's already configured for the MOC FPGA boards, and it can be adapted to any PMOD-style FPGA board with only minor edits to the .xdc file. The design bundles a numerically controlled oscillator, a delta-sigma DAC configurable up to fourth order, and a linear DWA 16-bit differential output stage. Running the converter at 40MHz—rather than the 5MHz sweet spot of the simpler single-bit DACs—gives a substantial SFDR improvement across the band.

There's plenty of room to extend the core: adding a UART interface to set the NCO frequency, a high bit order MicroBlaze based NCO, fractional-scale NCO output, more advanced DWA or DEM calibration, or streaming WAV data from a PC over Python. You could also drop in an I^2S receiver to interface with external digital-audio sources.

8 Connecting the PMOD module

Connecting the SigmaXplore 3 is straightforward because the pins follow the PMOD standard: 0.9-inch spacing with a dual-row 12-pin, 0.1-inch header.

The module must only be inserted into a PMOD port in the correct orientation. A single-pin offset or an upside-down insertion can damage the module, since misalignment can place PMOD supply pins directly onto unprotected I/O pins. The MOC FPGA boards themselves are not at risk, but the modules can be permanently damaged if connected incorrectly. Always power down all boards when connecting or disconnecting modules.

Once aligned properly, the module can be used without concern for I/O configuration. The MOC FPGA boards follow the 200-ohm PMOD output-impedance guideline, which prevents damage from pins that might otherwise be driven incorrectly during development or testing.

The DAC output and ADC input have solder terminals to connect to external circuitry. The DAC output is not short circuit protected and a prolonged shorted output will result in damage to the output driver. The output can drive a 50 ohm load without problems. The ADC input can be driven within the 3.3V rails without problems. Driving more than 10mA above and below the rails will result in damage. Please double check all connections before powering up.