Maxim Integrated PIXI: How to make a highly functional Field Programmable Analog Array (FPAA)

Steve Taranovich - June 24, 2014

A brief history of the Field Programmable Analog Array (FPAA)

The Field Programmable Analog Array (FPAA) is a set of low level, basic analog computational elements in a reconfigurable interconnect. The choice of analog elements inside the IC tends to vary quite a bit, so FPAAAs come in many different varieties: some use discrete-time, virtual resistors (switched-capacitors), some are based on operational amplifiers and Gm-C circuits, some use translinear elements as the building blocks, and some a mix of all the above.

In 1999, in an EETimes article, Stephan Ohr said, “Where programmable analog will have an advantage is in rapid prototyping. It will sure beat a solder pencil or clip blocks for trying out amplifier circuits with leaded components. But, still, we're talking pocket change here-not nearly enough for success.”

Scott Elder at Linear Technology commented in a blog on Planet Analog in 2013 that “(FPAAAs) will remain always in the future for one simple reason: Analog is physical whereas digital is algorithmic. Unless someone can 3D-print an analog IC on your desk, FPAAAs will never come to pass”.

On the positive side, Mohammed F. Hassan says, “The main purpose of designing FPAAAs is the need of adaptive analog circuits in low power analog front-ends. Moreover, FPAAAs are needed for rapid-prototyping of analog circuitry to ensure the correct functionality of mixed signal system where simulations are not enough.” in VLSI Egypt in 2013

As for my experience in design---I have never had the occasion or the need to use FPAAAs, but I have
never seen it done any better, in my 42 years as an Analog Engineer, than the recent Maxim Integrated MAX11300 and MAX11301 Programmable Mixed Signal I/O (PIXI™) Devices.

The Maxim Integrated design team knew the FPAA history and wisely designed a solution that stayed away from all the other supplier designs that failed to live up to their potential. This design and marketing team chose to design with Data Converters that operated at 5 and 10 Volt levels, staying away from noise and dynamic range problems that plagued other FPAAAs. They also included temperature sensors and internal voltage references and as an added benefit, designers made two versions of this IC, one for SPI interface (MAX11300) and one for I²C interface (MAX11301).

All of the above functions behave extremely stable in a programmable environment unlike very highly accurate or very high speed components which were the downfall of prior FPAA developments trying to do what Maxim Integrated successfully achieved.

**Block diagram (Figure 1)**

![Figure 1: The Max11300 has 20 user programmable analog or digital I/O consisting of analog input (12bit ADC), analog output (12bit DAC) or analog switch, digital I/O. Each pin on the IC is uniquely programmable.](image)

**Applications**

Here is an area in which I have worked for about half of my career. I could have used one of these
PIXI ICs:

Wireless-Wired Infrastructure

- Power amplifier - biasing and monitoring circuit
- Tunable laser - biasing and monitoring circuit
- Backplane/rack (power) management (ATCA, MicroTCA)
- Telecom/networking signal path management

Pretty much anywhere PLDs or FPGAs are being used would be an application for these parts.

**On the input side**

**On the input side**

The PIXI Port can be set up as a Single-Ended ADC Input. See Figure 2.

![Figure 2: Any PIXI port can be used as analog input to the single ended ADC with flexible input range with internal or external reference voltage](image)

Two PIXI Ports can be set up as Differential ADC Inputs. See Figure 3.
Figure 3: Any pair of ports can form a differential ADC.

Any port of differential ADC can be biased internally to form a pseudo-differential ADC.

Multiple ADCs can share a common DC bias point.

On the output side

Any PIXI Port can be set up as a DAC Output. See Figure 4.
Figure 4: DAC output drivers can drive up to 25mA and current limited to 50mA.

DAC outputs can be read back using an internal ADC for correction and calibration purpose.

When this mode is used both DAC and ADC would use the same referenced voltage

Digital Inputs/Outputs

Now here’s what is neat about this FPAA, digital I/Os can also be programmable on the pins. See Figure 5.
Figure 5: Any PIXI pin can be used as GPI or GPO or as a pair.

Any two ports can be used as uni-directional logic level translator.

GPO output can be inverted with respect to GPI input.

Temperature sensors

The PIXI integrates one internal and two external (Transistor V_{BE} junctions that are connected as a diode) temperature sensors. Accuracy is typically +/- 1% without any calibration. The temperature can be read from the temperature data registers on chip.

Software

To make the IC easily programmable for us Analog “weenies”, designers have added Drag and Drop configuration software. See Figure 6.
Figure 6: Software, Quickstart and Video are available as a free download. Software is a register configuration file (.csv) to program PIXI.

Demo Board

PMOD format for use with Maxim Integrated USB2PMB, ZedBoard or any PMOD compatible board. Maxim Integrated is committed to support MAX11300 (PIXI) PMOD with ZedBoard firmware coming in 3Q2014.

Figure 7: The two demo boards are available now. (Reference 1 in Figure 7 is this link and...
Reference 2 is this link.

There is also a full MAX11300EVKIT See Figure 8.

Figure 8: The MAX11300EVKIT will interface to any system that uses Pmod-compatible expansion ports configurable for SPI communication.

A video demonstration

Video https://app.box.com/s/nwdzcihqc5124palw39t

References


3 Field Programmable Analog Array (FPAA) based Shunt Active Filter controller, Kumar, M.; Future Renewable Electr. Energy Delivery & Manage. (FREEDM) Syst. Center, North Carolina State Univ., Raleigh, NC, USA; Green, E.; De, A.; Roy, S., more authors, Energy Conversion Congress and Exposition (ECCE), 2012 IEEE