GO PYNQ!

Get introduced to Xilinx FPGAs and Fun

Why PYNQ?

Ease of use of Python with Programmable technologies

Introducing to:

- PYNQ and ZYNQ
- PYNQ Framework
- PYNQ-Z2 Board
- Jupyter Notebook Interface
- PYNQ Overlay
- PYNQ Packages
- Benefits of PYNQ
- Join the Community!

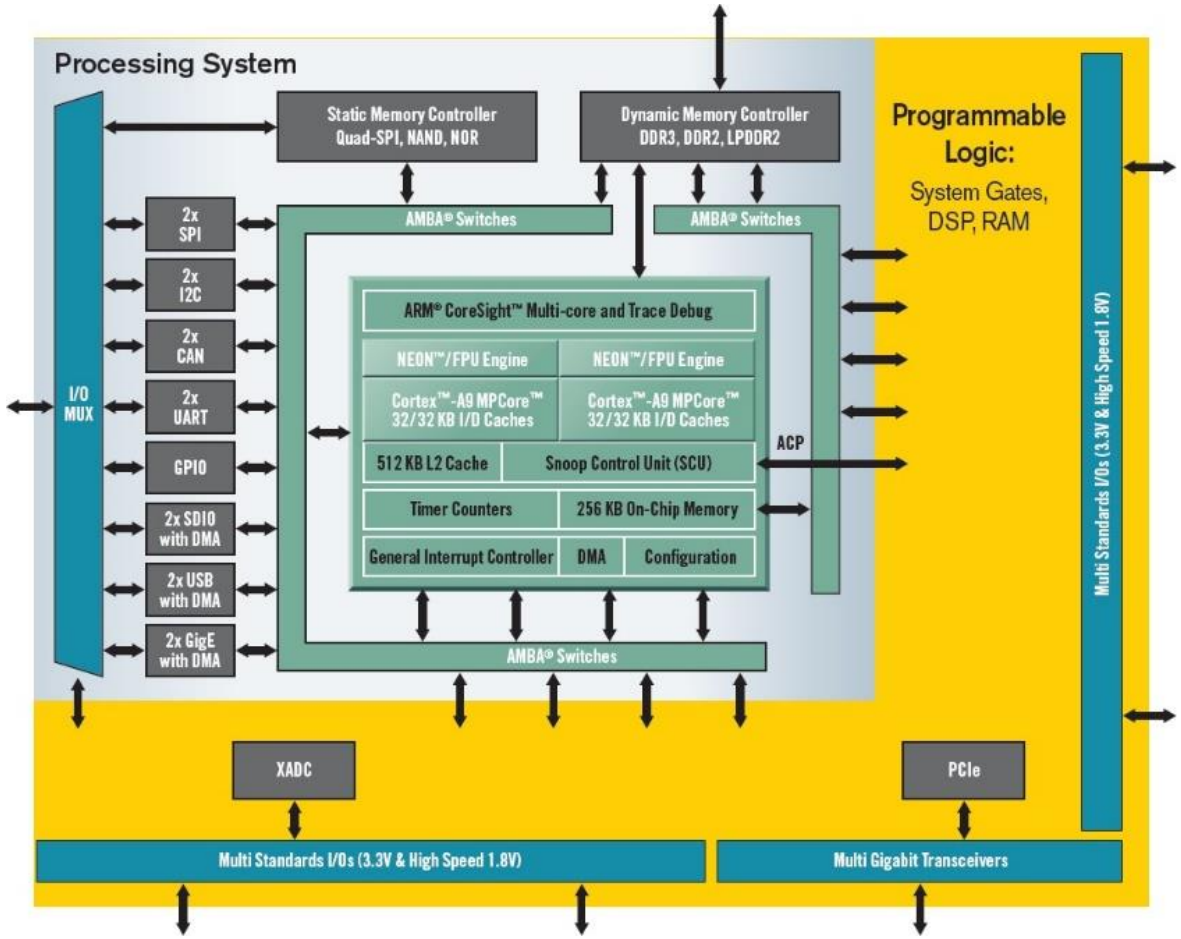
Python Productivity for Zynq

XILINX

ZYNQ

Best-in-class, All Programmable SoCs

ZYNQ 7000



- The device is based on a dual-core ARM® Cortex®-A9 processor (referred to as the *Processing System* or **PS**), integrated with FPGA fabric (referred to as *Programmable Logic* or **PL**).

- The *PS* subsystem includes a number of dedicated peripherals (memory controllers, USB, Uart, IIC, SPI etc) and can be extended with additional hardware IP in a *PL* Overlay.

Zynq applications

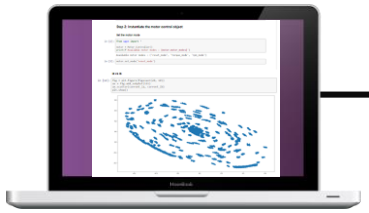
FPGAs and tightly-integrated CPUs enable entirely new opportunities

PYNQ framework

Python Productivity for Zynq

Jupyter notebooks,
browser-based interface

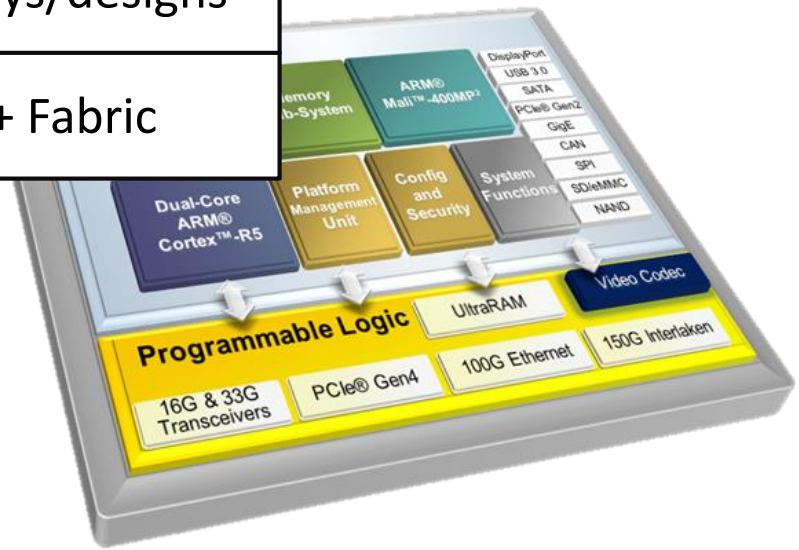
Most competitive, open
and advanced GUI



PYNQ enables JupyterLab
on Zynq and ZU+

Jupyter web server	
IPython kernel	
Ubuntu-based Linux	Overlays/designs
ARM A9 / A53	ZU+ Fabric

Hardware C-drivers wrapped in Python packages



Ubuntu-based Linux versus embedded Linux

Ubuntu-based Linux

Optimized for developer productivity

- All the Linux libraries and drivers you expect
- Pre-built SD card image
- Ubuntu/Debian ecosystem & community
  - >>145,000,000 Google hits

3 orders of magnitude difference

Embedded Linux

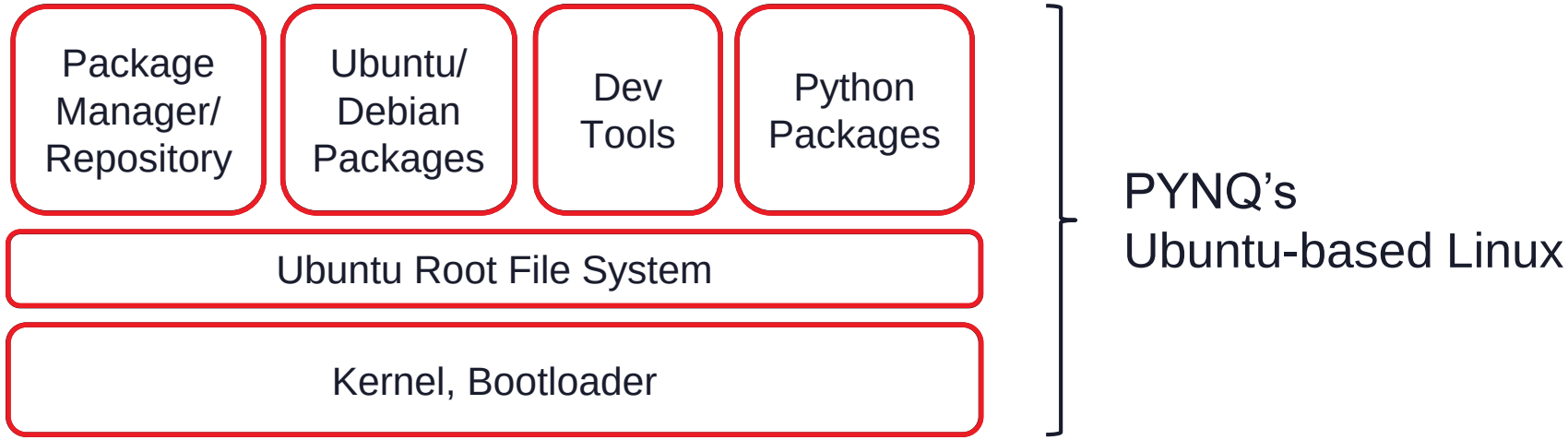
Optimized for deployment efficiency

- Selective Linux libraries and drivers
- Commonly delivered in flash memory on board
- PetaLinux ecosystem:
  - >> 143,000 Google hits

PYNQ's Ubuntu-based Linux

PYNQ uses Ubuntu's:
- Root file system (RFS)
- Package manager (*apt-get*)
- Repositories

PYNQ bundles :
- Development tools
  - Cross-compilers
- Latest Python packages

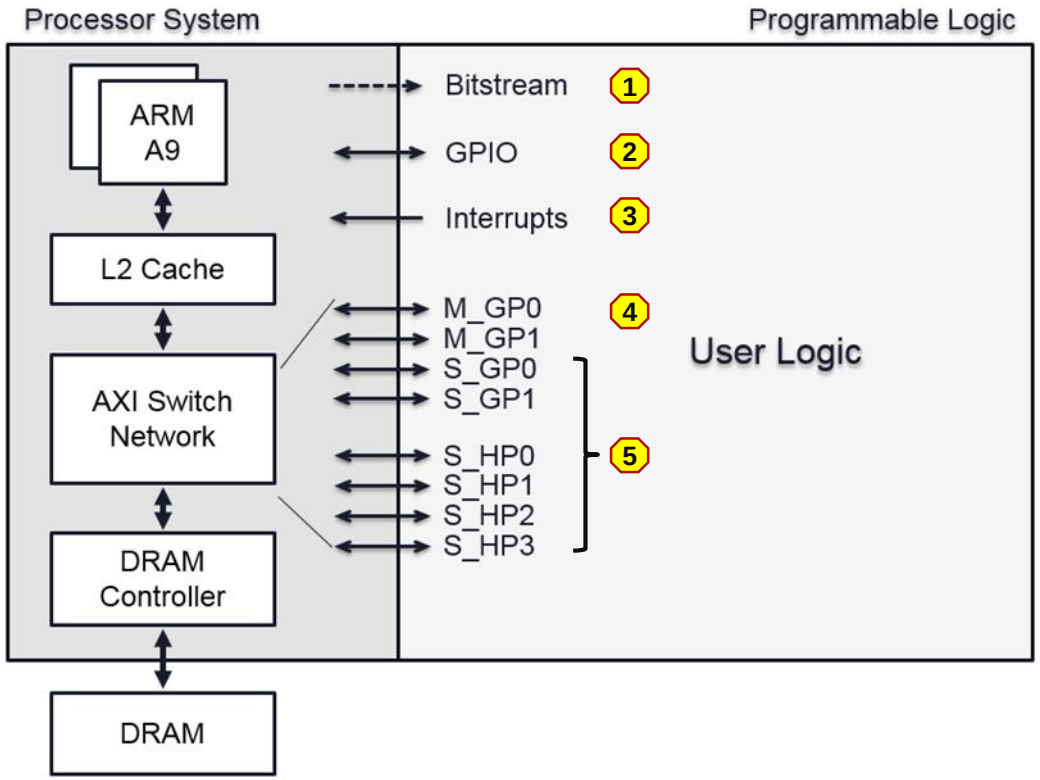


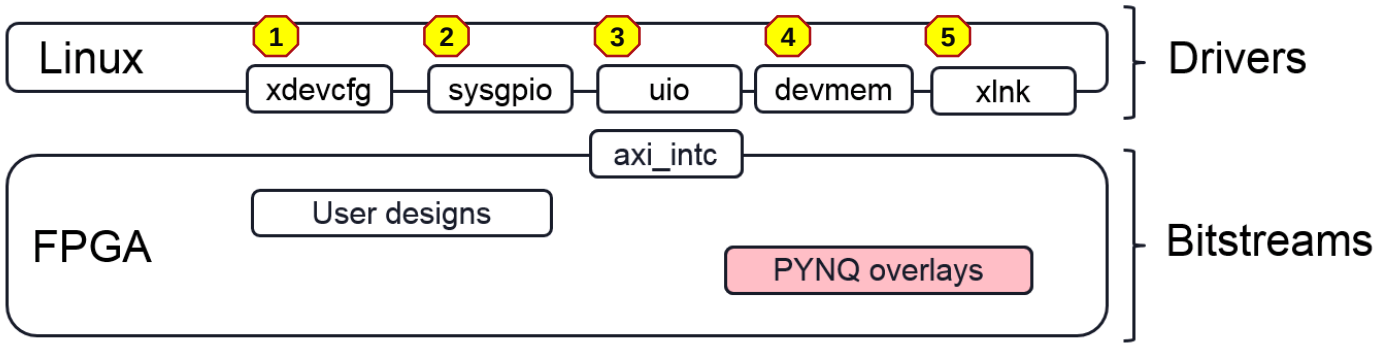
PYNQ uses the PetaLinux build flow and board support package:
- Access to all Xilinx kernel patches
- Works with any Xilinx supported board
- Configured with additional drivers for PS-PL interfaces

PYNQ provides Linux Drivers for PS-PL Interfaces …

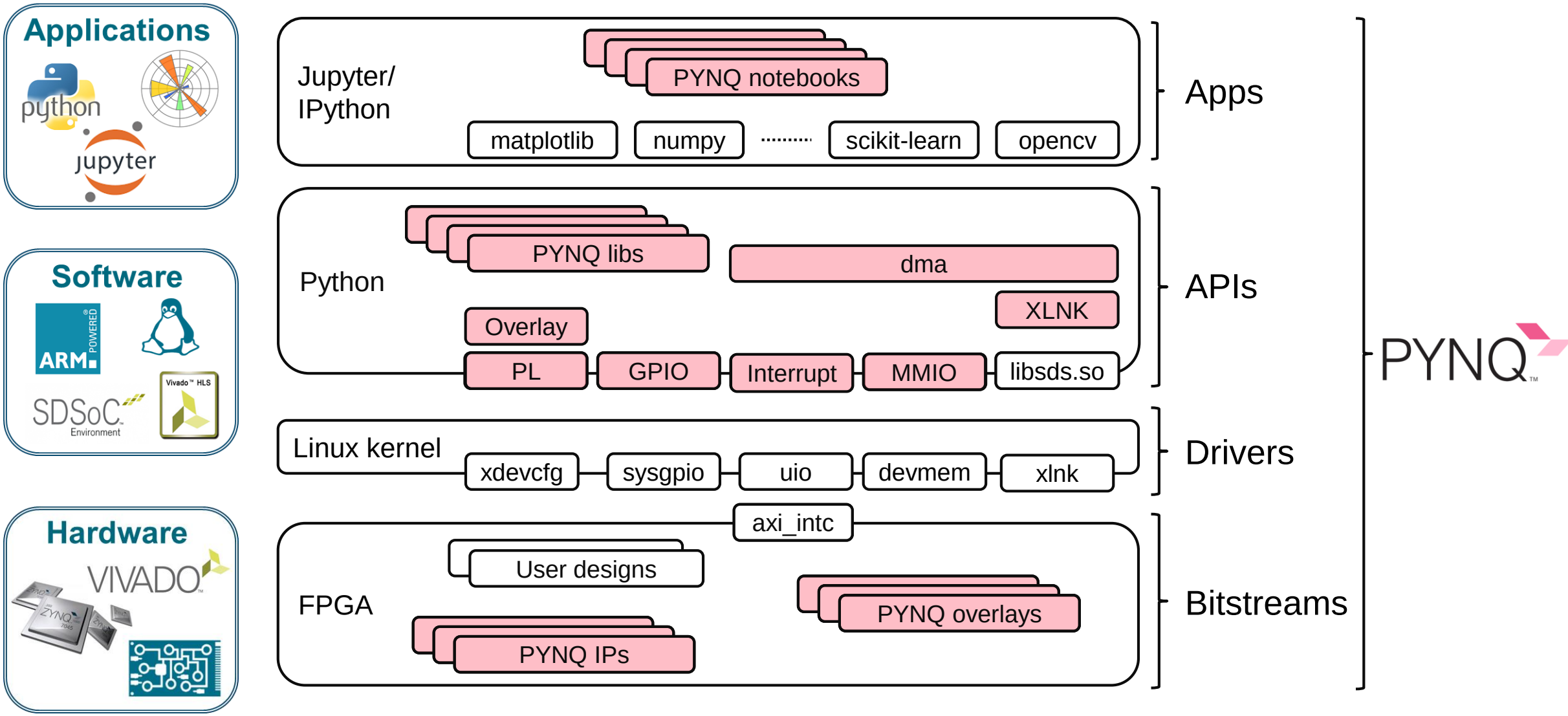
wrapped in Python Libraries

Zynq





PYNQ is a Framework

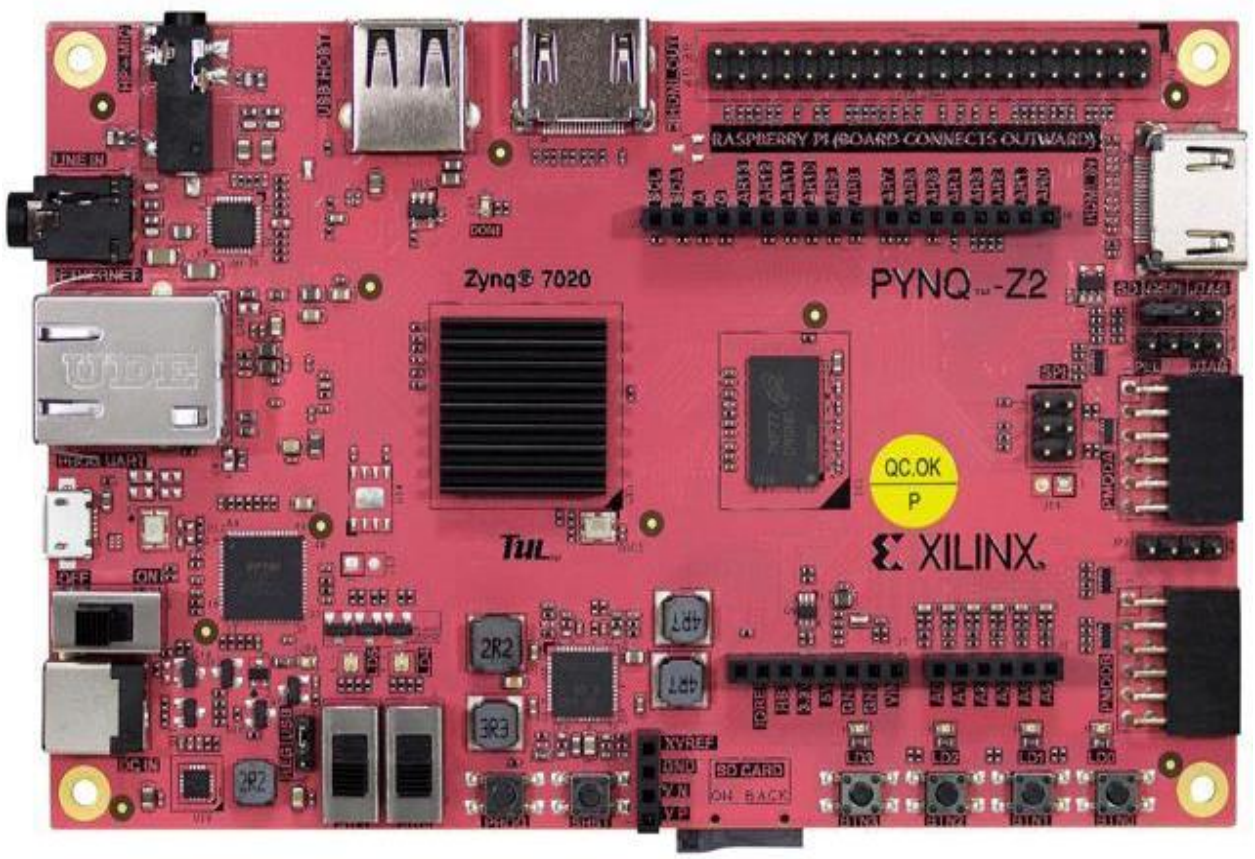


PYNQ™

PYNQ-Z2 Board

XILINX

PYNQ-Z2 Board



	PYNQ-Z2
Device	Zynq Z7020
Memory	512MB DDR3
Storage	MicroSD
Video	HDMI In & Out
Audio	ADAU1761 codec with HP + Mic, Line in
Network	10/100/1000 Ethernet
Expansion	USB host (PS)
GPIO	1x Arduino Header
	2x Pmod*
	1x RaspberryPi header*
Other I/O	6x user LEDs
	4x Pushbuttons
	2x Dip switches
Dimensions	3.44” x 5.51” (87mm x 140mm)
Webpage	**TUL PYNQ-Z2 webpage**

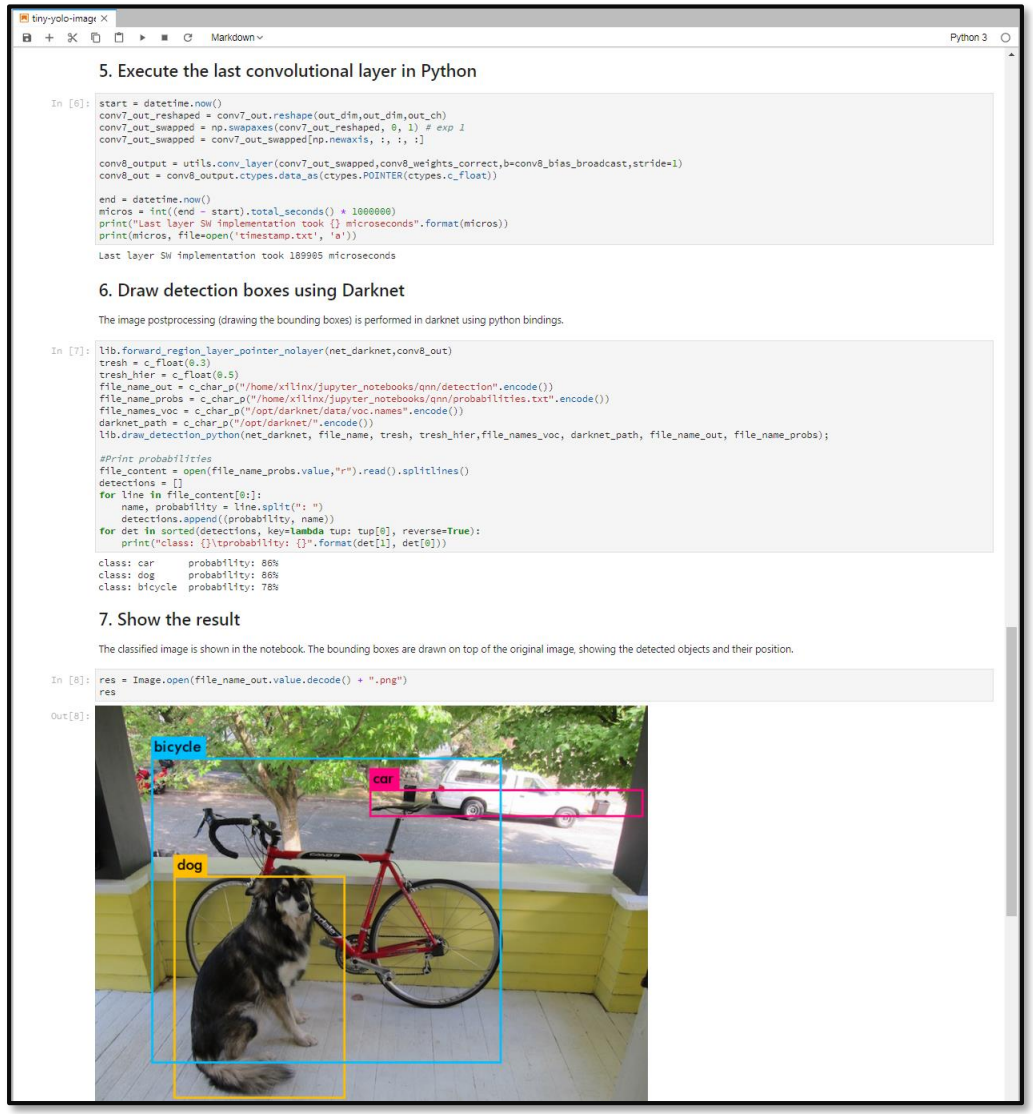
*PYNQ-Z2 RaspberryPi header shares 8 pins with 1 Pmod

PYNQ™

Jupyter Notebook Interface

XILINX

Jupyter Notebooks … the engine of data science



jupyter

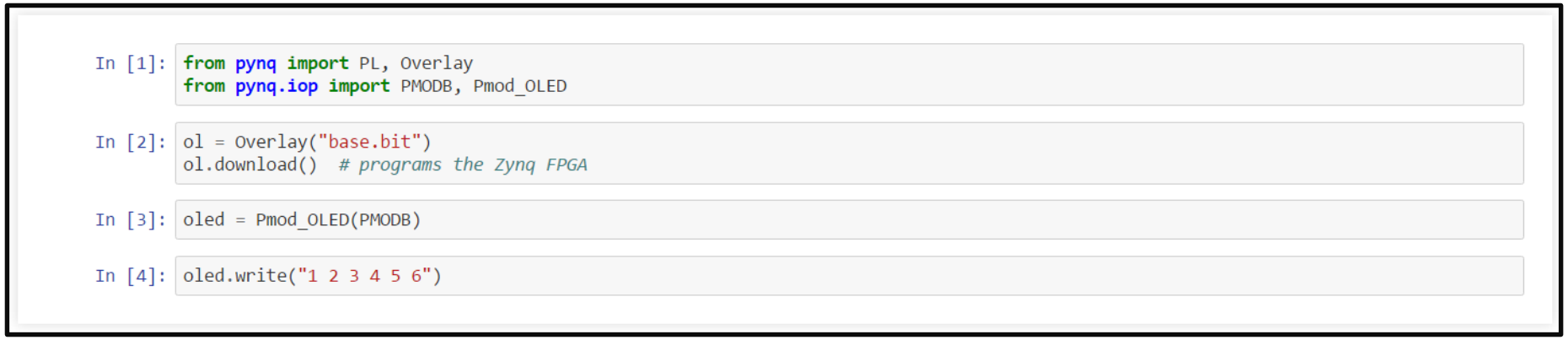
Open source browser-based, executable documents

Live code, text, multimedia, graphics, equations, widgets …

1.7 million notebooks on GitHub

Taught to 1,000+ Berkeley data science students

Jupyter Notebook



```
In [1]: from pynq import PL, Overlay
        from pynq.iop import PMODB, Pmod_OLED

In [2]: ol = Overlay("base.bit")
        ol.download()  # programs the Zynq FPGA

In [3]: oled = Pmod_OLED(PMODB)

In [4]: oled.write("1 2 3 4 5 6")
```

6 lines of user code … thanks to Python, FPGA overlays, abstraction & re-use

PYNQ Overlays

FPGA overlays – hardware libraries (kernels)

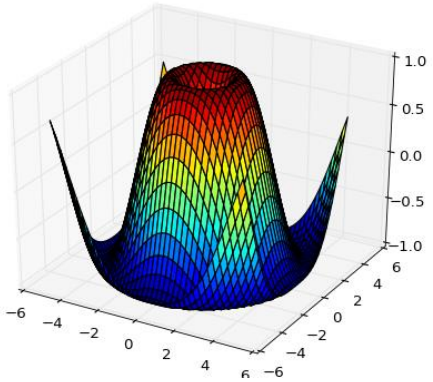
> **Overlays are generic FPGA designs that target multiple users with new design abstractions and tools**

- Post-bitstream programmable via software APIs
- Typically optimized for given domains
- Encourages the use of open source tools & fast compilation
- Enables productivity from re-using pre-optimized designs
- Exposes benefits of FPGAs to new users

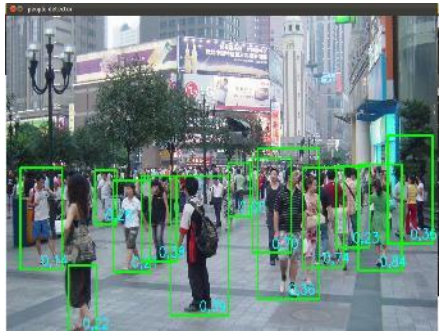
> **Active research area with many papers**

PYNQ Packages

Python packages for data analysis and visualisation



Matplotlib



OpenCV

- **Take advantage of Python for data analysis and processing**
  - NumPy
    - Scientific computing package for Python
  - Matplotlib
    - Python 2D plotting library
  - Pandas
    - Data analysis tools for Python
  - OpenCV
    - Computer Vision and machine learning software

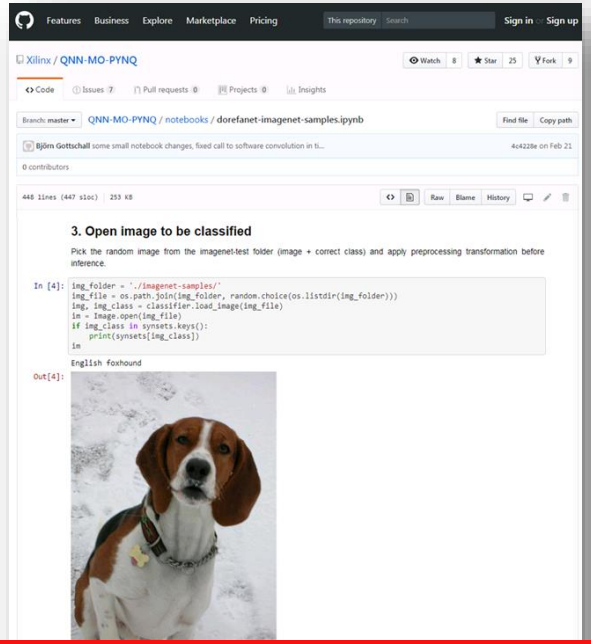
Optimized open-source software libraries ✓

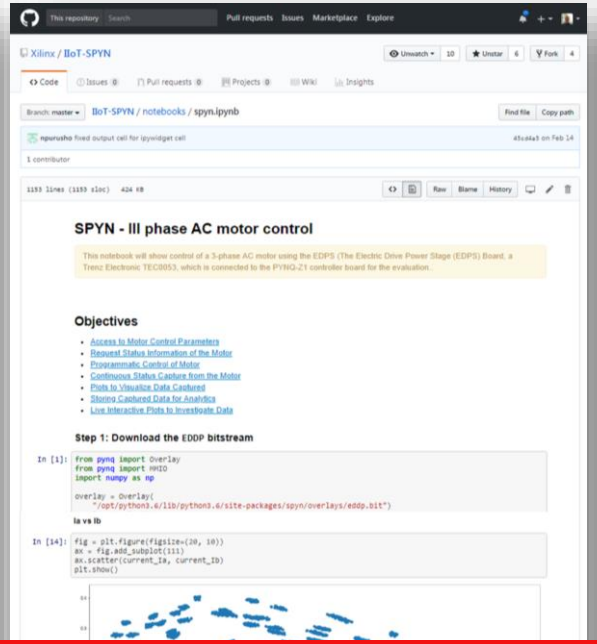
Hybrid Packages

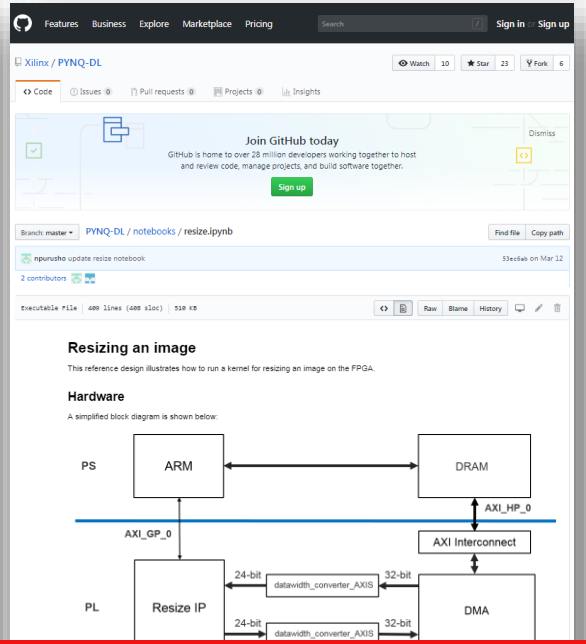
- **New *hybrid packages* are created by extending Python packages with additional files:**
  - Design Bitstream
  - Design metadata file
  - C drivers
  - Jupyter notebooks
- **Hybrid packages enable software-style packaging and distribution of designs**
- **Use the Python package installer, `PIP` to install a hybrid package just like any regular Python (software only) package**
  - Delivers package's files to target board
- **Uses Python standard `setup.py` script for installation**

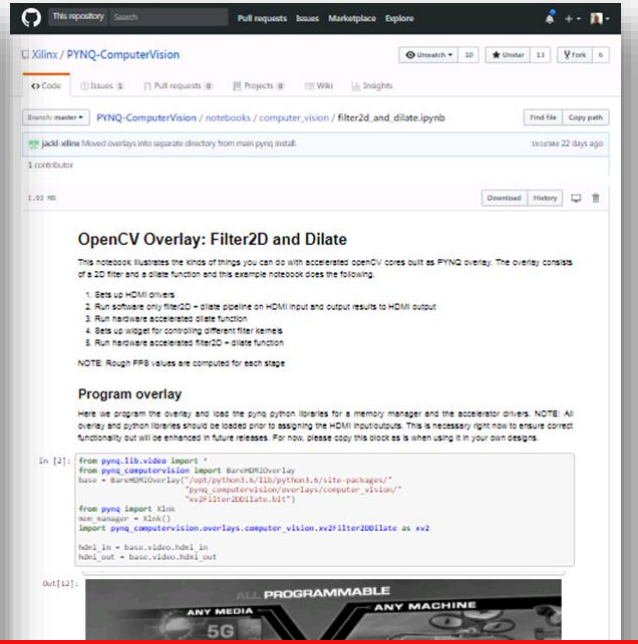
Software-style Packaging & Distribution of Designs

Enabled by new *hybrid packages*







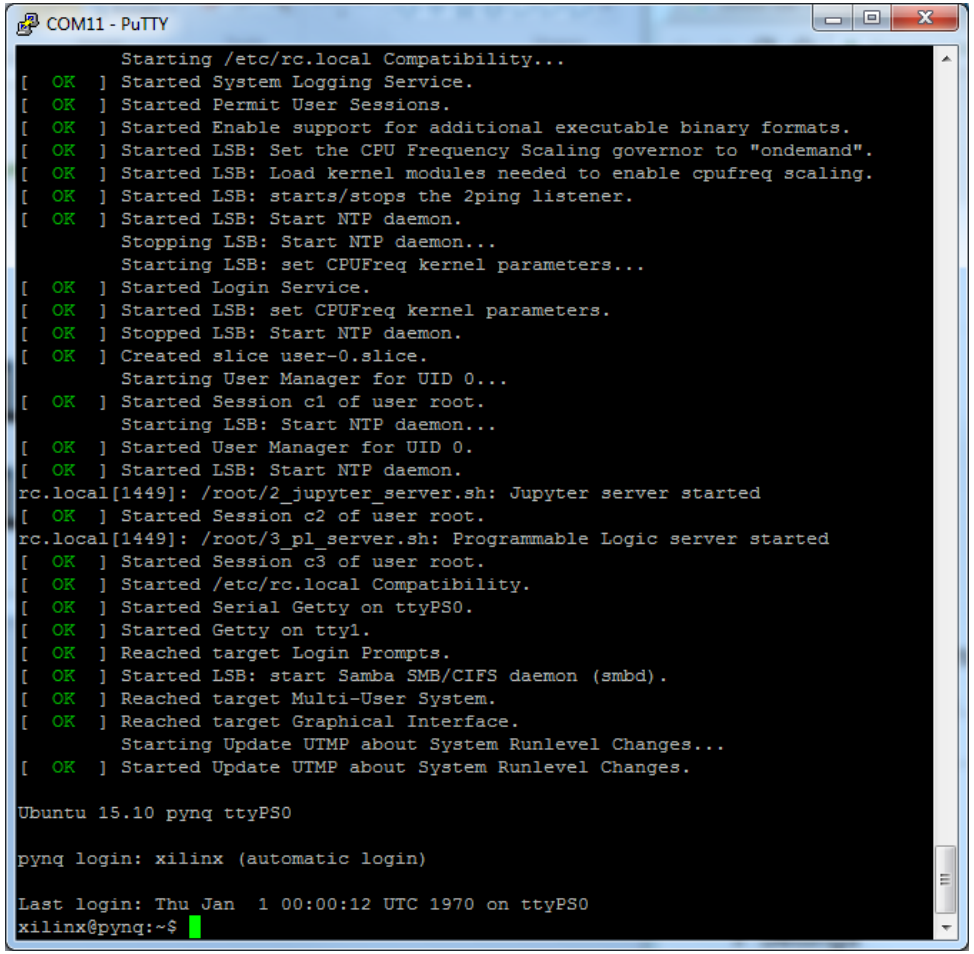



```
Download a design from GitHub with a single Python command:

pip3.6 install git+https://github.com/Xilinx/PYNQ-DL.git
```

Benefits of PYNQ

Start using PYNQ out-of-the-box

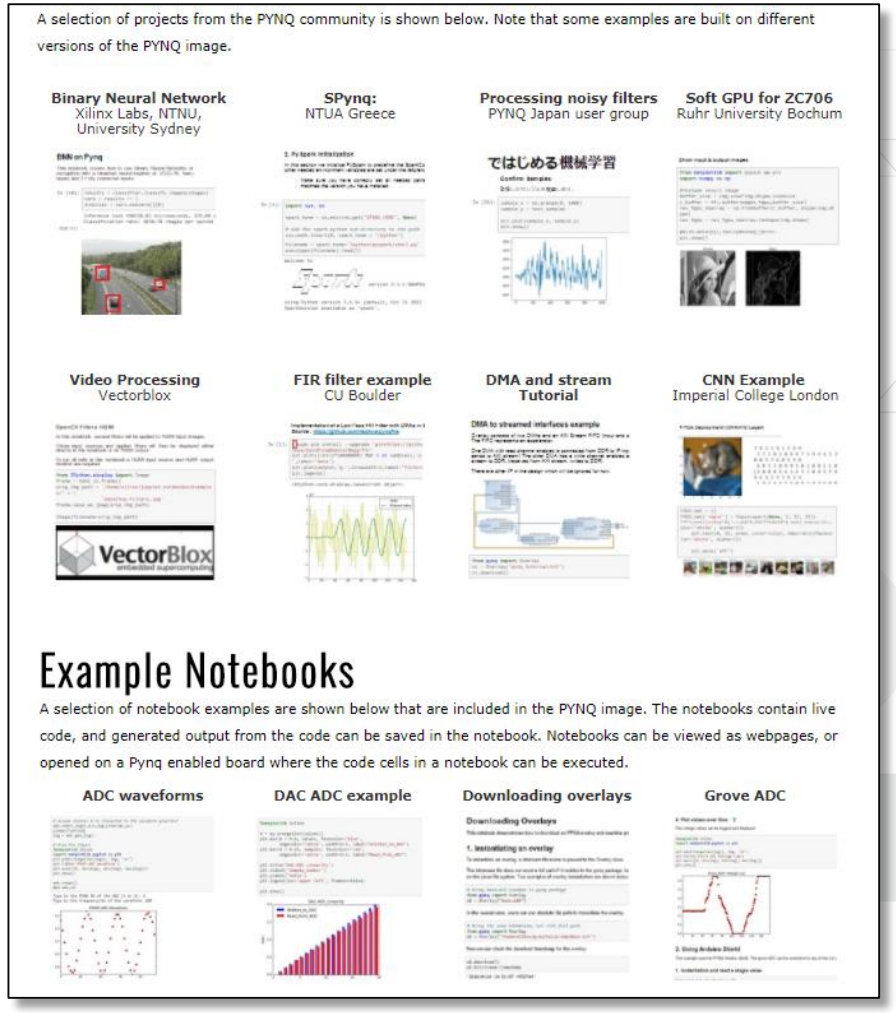


- **PYNQ delivered as downloadable SD card image**
  - Linux preconfigured
- **Additional packages and drivers pre-installed**
  - USB peripheral drivers: webcams, wifi modules …
- **PYNQ is for Zynq**
  - PYNQ image is portable to other Zynq boards

Start using Zynq out of the box ✓

Desktop Linux

- **Network/Internet access**
  - “apt-get” to install packages from Ubuntu universe
  - Samba(Network drive)
  - Web services
- **Git directly on board**
- **Compilers and other development tools**
  - Gcc,, MicroBlaze, RISC-V ….
- **Python packages**
  - “pip install”
  - PYNQ Community examples



Simplify downloading bitstreams to PL

- **PYNQ ‘Overlay’ class**
  - Simplifies downloading bitstream
  - two lines of code
  - No Xilinx tools required
- **Maintain many bitstreams on the SD card**
  - E.g. multiple different demos
- **Can execute Python in browser, or from command line**

```
from pynq import Overlay

ol = Overlay('gray.bit')
```

Simply and fast way to configure Programmable Logic ✓

Join the Community!

Home Get Started PYNQ-Z1 Bo

Community Projects

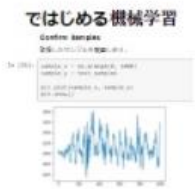
Selection of projects and notebooks

A selection of projects from the PYNQ community is shown below. Note that some examples are built on different versions of the PYNQ image.

Binary Neural Network
Xilinx Labs, NTNU, University Sydney

SPynq:
NTUA Greece

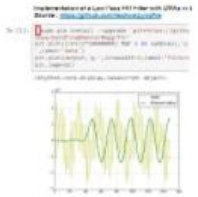
Processing noisy filters
PYNQ Japan user group



Soft GPU for ZC706
Ruhr University Bochum

Video Processing
Vectorblox

FIR filter example
CU Boulder



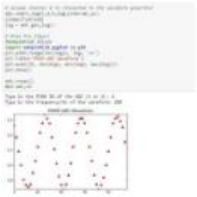
DMA and stream Tutorial

CNN Example
Imperial College London

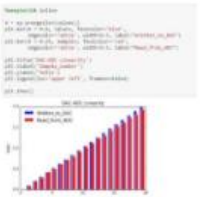
Example Notebooks

A selection of notebook examples are shown below that are included in the PYNQ image. The notebooks contain live code, and generated output from the code can be saved in the notebook. Notebooks can be viewed as webpages, or opened on a Pynq enabled board where the code cells in a notebook can be executed.

ADC waveforms

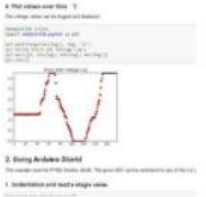


DAC ADC example



Downloading overlays

Grove ADC

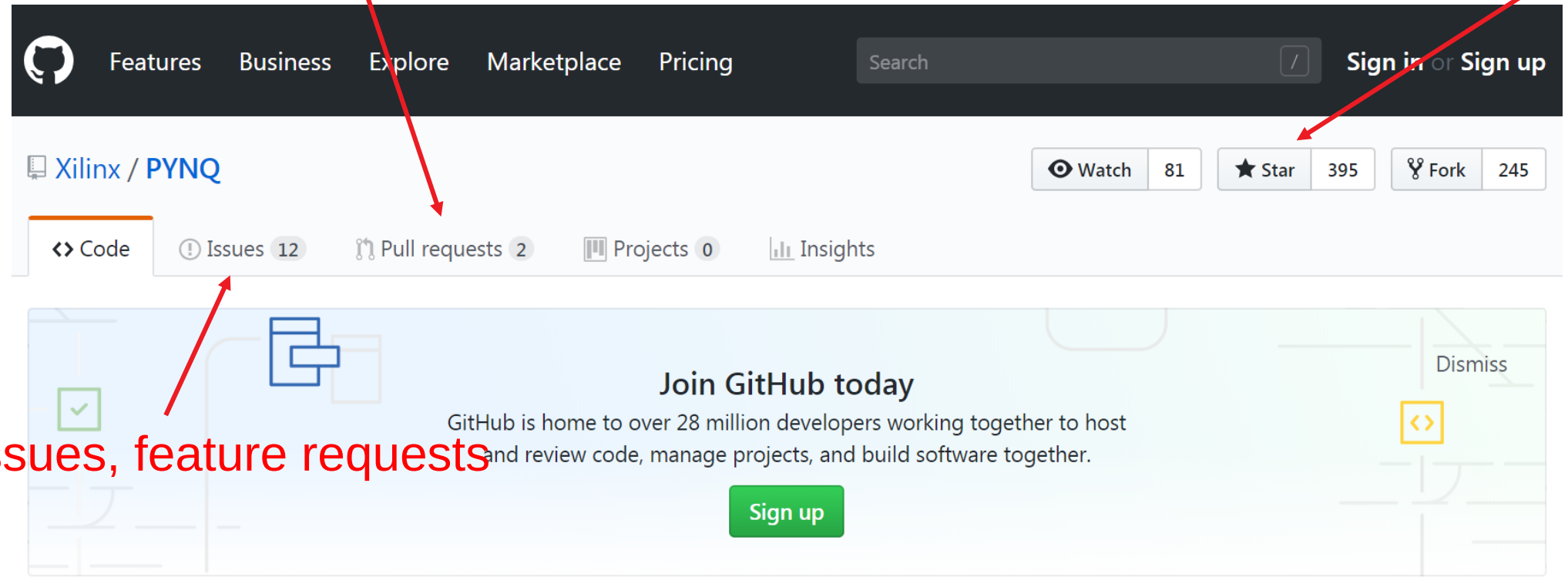


All Feedback helps

Contribute

If you like it, star it!

Issues, feature requests



Python Productivity for ZYNQ http://www.pynq.io/

pynq

Summary

PYNQ™

- PYNQ is Python productivity for Zynq
- Everything runs on Zynq, access via a browser
- Support for Zynq Ultrascale+
- Overlays are hardware libraries and enable software developers to use Zynq
- Provides a rapid prototyping framework for hardware developers

pynq.io

pynq.readthedocs.org

github.com/Xilinx/PYNQ

tul.com.tw/ProductsPYNQ-Z2.html

pynq.io/support

Adaptable.
Intelligent.

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