Python Productivity on ZYNQ & SPYN

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June 2019, Japan

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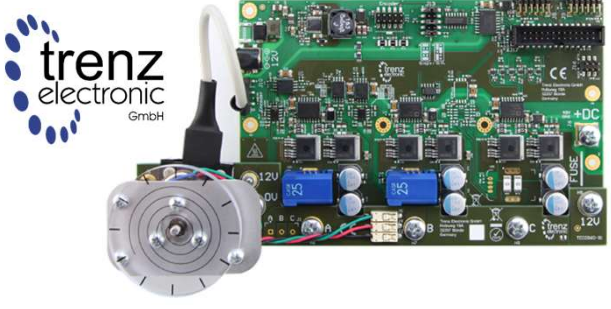
Recap: Electric Drives Demonstration Platform

- Design Methodology Predicated on Open Source & Ease of Use
- EDDP takes complete advantages of **Xilinx Zynq SoCs**
- Platform offers two different flows to build motor control solutions
  - Xilinx SDSoC Design Flow
  - Xilinx Vivado HLS Design Flow

EDDP KIT



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Three simple steps to get started!
EDDP Demo Video

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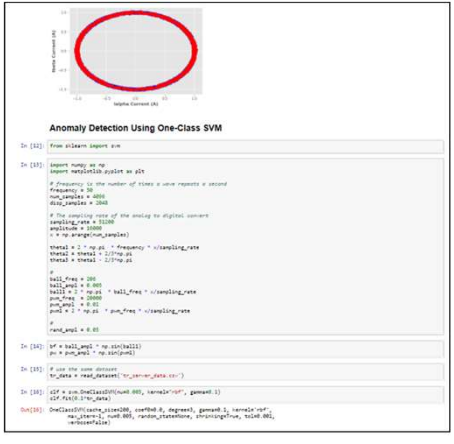
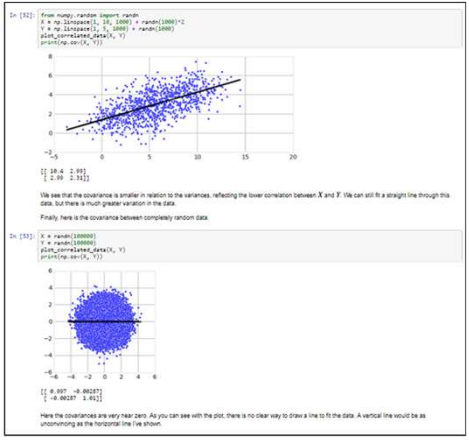
Recap: Intelligent Motor Control

PYNQ™ Framework

- **Python productivity for Extreme Edge Analytics – Cloud Compute at the Edge**
  - Anomaly Detection for Predictive Maintenance via Numpy and Scikit-learn, many other capabilities





- **PYNQ**
  - Visit pynq.io for more information on the PYNQ Framework and the SPYN Motor Control Design

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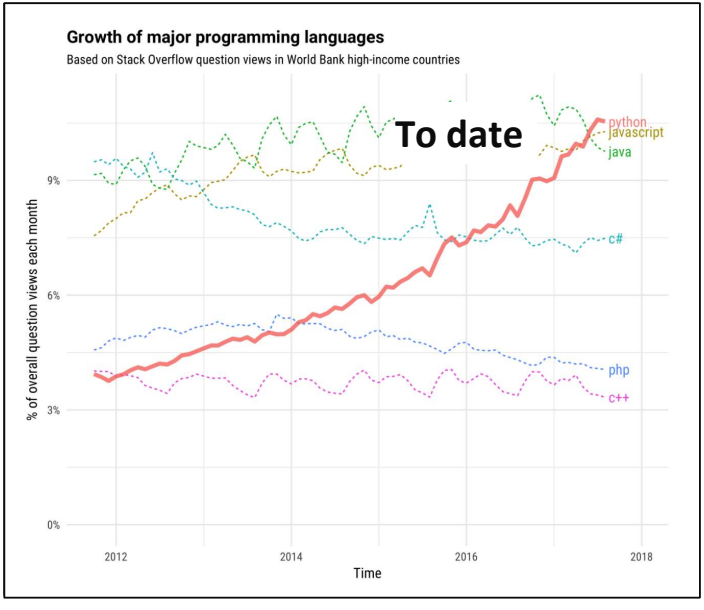
Python is increasingly the Language of Choice

Top Programming Languages,
IEEE Spectrum, July'18

Language Rank	Types	Spectrum Ranking
1. Python		100.0
2. C++		98.4
3. C		98.2
4. Java		97.5
5. C#		89.8
6. PHP		85.4
7. R		83.3
8. JavaScript		82.8
9. Go		76.7
10. Assembly		74.5

Python is listed as an embedded language for the first time

https://spectrum.ieee.org/at-work/innovation/the-2018-top-programming-languages



https://stackoverflow.blog/2017/09/06/incredible-growth-python/

Python is the fastest growing language: driven by data science, AI, ML and academia

PYNQ: Python Productivity for Zynq

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PYNQ Python Productivity on Zynq

Domain Experts
Software Engineers

Embedded software
Engineers

Hardware
Engineers

New users are not always hardware designers, or embedded systems designers

PYNQ

Enables more people to program Xilinx processing platforms, more productively

AND

Offers more rapid development for h/w designers and embedded s/w engineers

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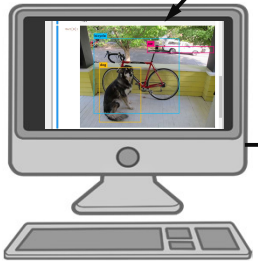
Python productivity for Zynq

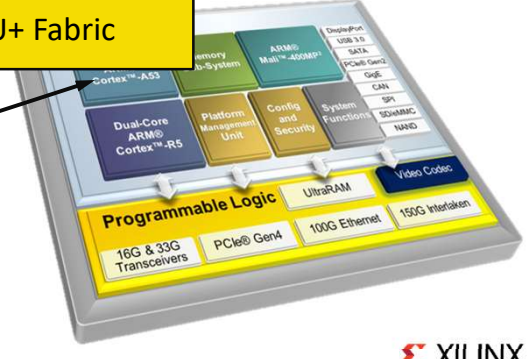
Jupyter notebooks,
browser-based interface



PYNQ enables JupyterLab
on Zynq and ZU+

Jupyter web server	
IPython kernel	
Ubuntu-based Linux	Overlays/designs
ARM A53s	ZU+ Fabric

Hardware C-drivers wrapped in Python packages



PYNQ runs natively on
ARM processors

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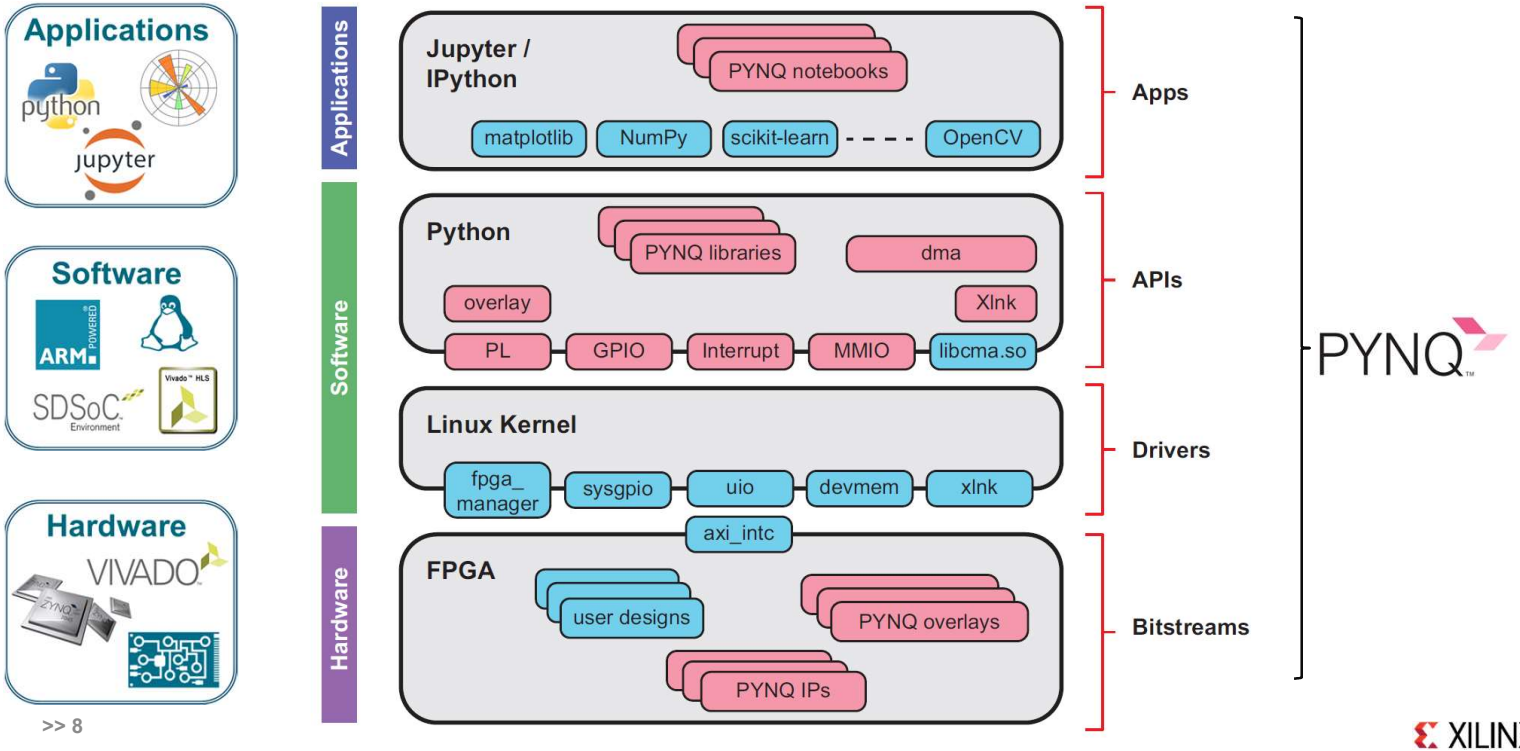
PYNQ is an open source Framework



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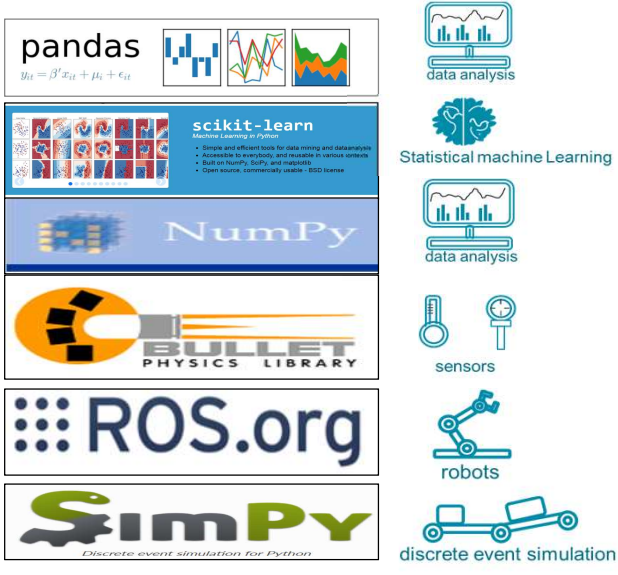
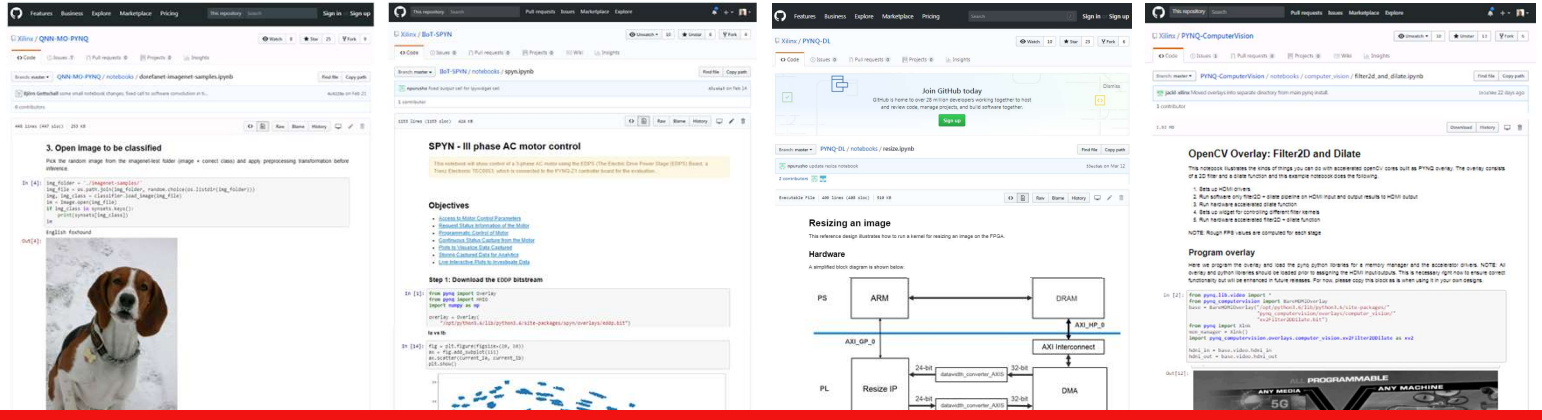
Python Powered: Machine Learning & Analytics Libraries



- SPYN enabled by PYNQ can support all of these libraries
- Many of the libraries are extensively used in:
  - Data manipulation
  - Machine Learning
  - Analytics
- Many more libraries available!!

Software-style packaging & distribution of designs

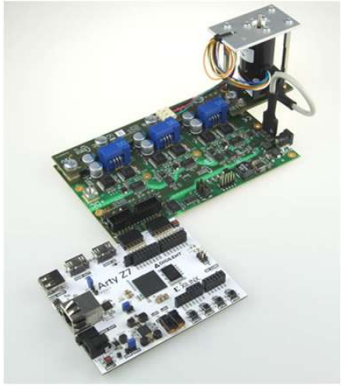
Enabled by new *hybrid packages*



Download a design from GitHub with a single Python command:

```
pip install git+https://github.com/Xilinx/pynq-helloworld.git
```

SPYN: Bridging two worlds for an Intelligent Drive



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PYNQ™ python powered

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EDDP
Electric Drives Demo Platform

PYNQ
Python Productivity for Zynq

SPYN
Extreme Edge Analytics for Motor Control

- **SPYN takes advantage of both EDDP Kit & PYNQ framework**
- **EDDP kit can also be used to test, modify & build SPYN project at no additional charge**
- **The solution enables python powered machine learning & edge analytics for motor control**
- **Python libraries are leveraged to provide UI for control, data manipulation, analytics & visualization**

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PYNQ harnesses the power of Programmable Logic

Two most common use models for PYNQ—SPYN Showcases Both

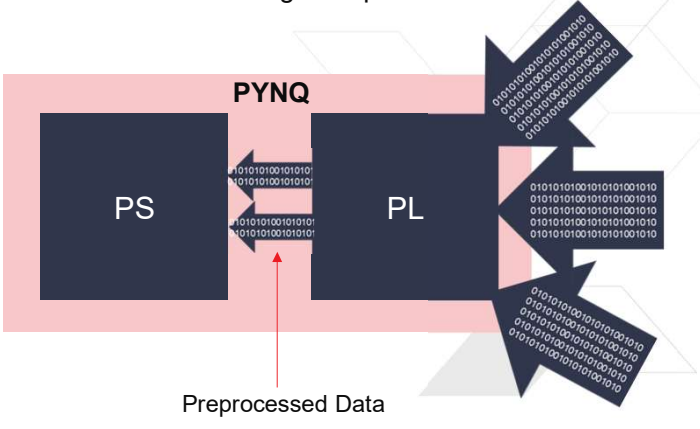
> Control & Query Programmable Logic IP

Steering wheel, pedals, gauges: **PYNQ Framework**

High Performance Engine: **Programmable Logic**

> Division of labor between PS & PL

- PL to rapidly preprocess raw, streaming IO data from sensors and passes to PS
- Processor leverages extensive libraries to execute wide range of operations on data



Python Powered: IIoT-SPYN Design Enhanced Capabilities (1 of 3)

```
motor_status = [(motor._read_controlreg(i + ANGLE.offset)) for i in
                range(0, 16, 4)]
high_sp, low_sp = bytesplit(motor_status[1])
high_id, low_id = bytesplit(motor_status[2])
high_iq, low_iq = bytesplit(motor_status[3])

print(f'Angle in degrees : {motor_status[0] * 0.36}')
print(f'Angle in steps per thousand: {(motor_status[0])}')
print(f'Id : {np.int16(low_id) * 0.00039} Amp')
print(f'Iq : {np.int16(low_iq) * 0.00039} Amp')
print(f'Speed in RPM : {-(np.int16(low_sp))}')
```

```
Angle in degrees : 104.39999999999999
Angle in steps per thousand: 290
Id : -0.062009999999999996 Amp
Iq : 0.31785 Amp
Speed in RPM : 983
```

Monitoring

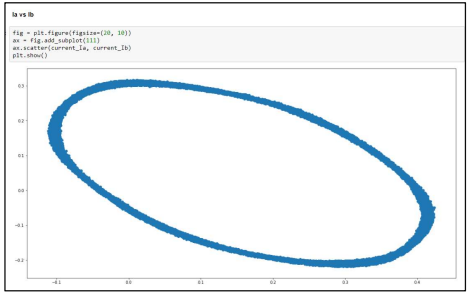
Monitor the status parameters of the motor remotely anytime

```
import time
motor.set_mode('rpm_mode')
for i in range(2):
        motor.set_rpm(1000)
        time.sleep(1)
        motor.set_rpm(0)
        time.sleep(2)
        motor.set_rpm(-50)
        time.sleep(2)
        motor.set_rpm(0)
        time.sleep(2)
motor.stop()
```

Control:

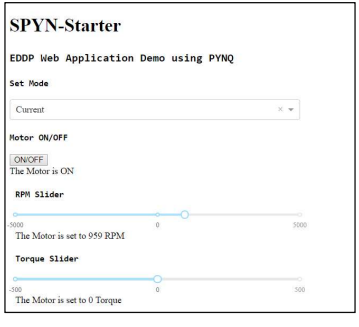
Simple python code routine to control motor

Python Powered: IIoT-SPYN Design Enhanced Capabilities (2 of 3)



Visualization:

Leverage matplotlib library to draw plots to visualize motor data



Custom Interactive UI:

Custom UI to control motor & generate plots using dash by plotly

Python Powered: IIoT-SPYN Design Enhanced Capabilities (2 of 3)

```
import pandas as pd

data = {'Ia' : current_Ia,
        'Ib' : current_Ib,
        'angle':cap_list[3],
        'rpm':  cap_list[2]}

df = pd.DataFrame(data, columns = ['Ia', 'Ib', 'angle', 'rpm'])
df
```

	Ia	Ib	angle	rpm
0	0.09204	0.09009	846	3541
1	0.09048	0.08853	845	3541
2	0.08619	0.09126	845	3527
3	0.08424	0.09321	845	3527
4	0.08307	0.09945	844	3527
5	0.08502	0.09789	844	3527
6	0.08697	0.09711	843	3527
7	0.09126	0.09594	843	3527
8	0.09360	0.09204	843	3527
9	0.08892	0.09282	842	3527
10	0.08463	0.09204	842	3527

Analytics & ML Ready Data Format:

Acquired Motor Data is stored as pandas data frames providing training data for ML & Analytics

Installable & Upgradable packaging :

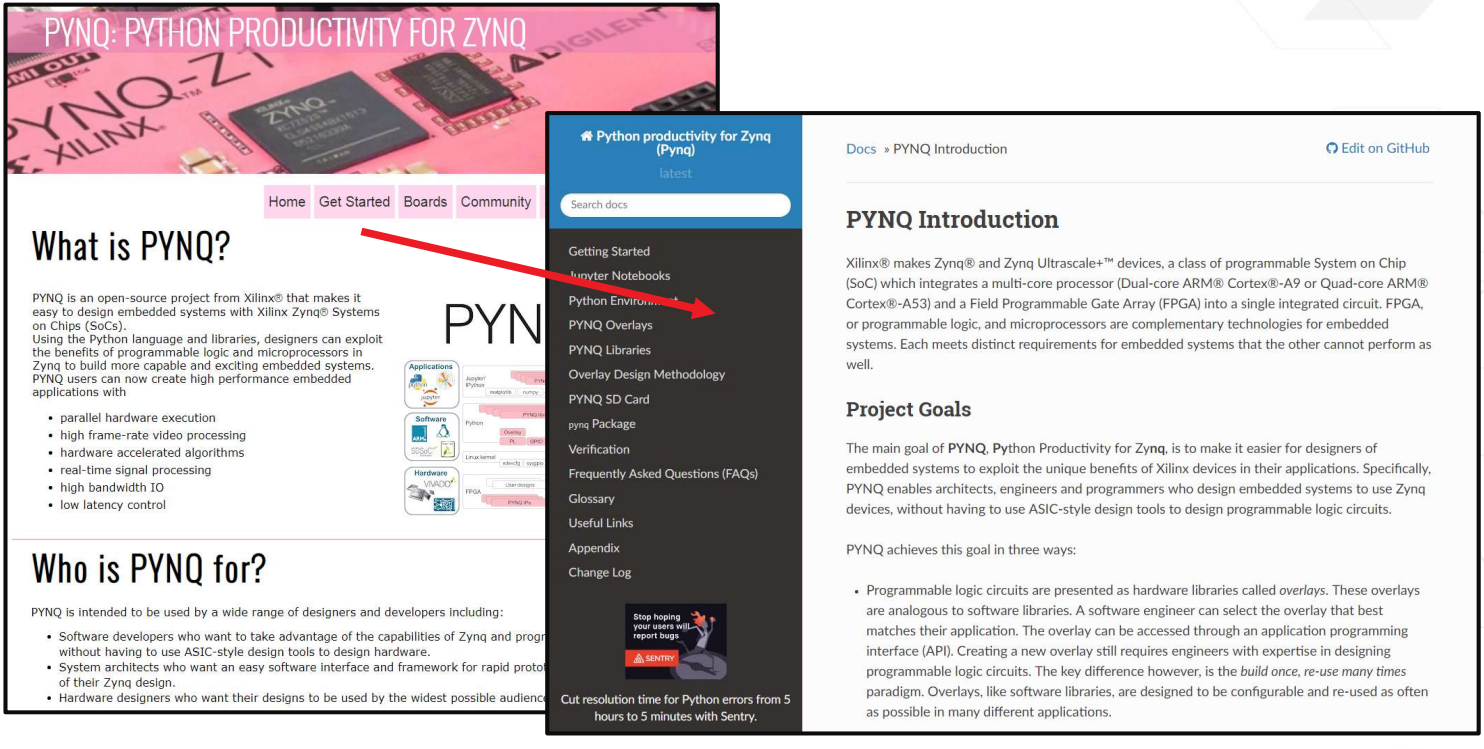
```
root@kv_pynq:/home/xilinx# sudo pip3.6 install --upgrade git+https://github.com/Xilinx/IIoT-SPYN.git
Collecting git+https://github.com/Xilinx/IIoT-SPYN.git
  Cloning https://github.com/Xilinx/IIoT-SPYN.git to /tmp/pip-ge20fs95-build
Installing collected packages: spyn
  Found existing installation: spyn 1.0
    Uninstalling spyn-1.0:
      Successfully uninstalled spyn-1.0
  Running setup.py install for spyn ... done
Successfully installed spyn-1.0
root@kv_pynq:/home/xilinx#
```

IIoT-SPYN is made into a installable package & enables remote upgradability

Next Steps

Getting started with PYNQ

Find out more at www.pynq.io



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PYNQ Community

www.pynq.io/community.html

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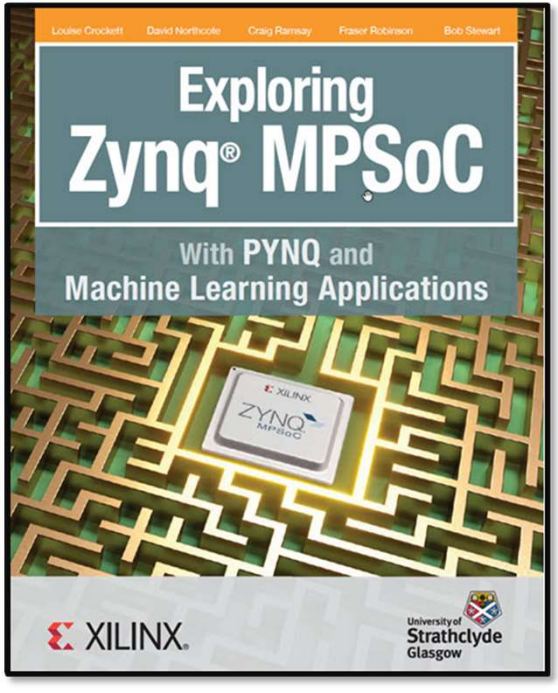
Exploring Zynq MPSoC with PYNQ & ML Applications



PDF version available free of charge

https://www.zynq-mpsoc-book.com/

SPYN GitHub

IIoT-SPYN

IIoT-EDDP: Industrial IoT Electric Drive Demonstration Platform is an open-source project that provides all necessary software and hardware components for development and evaluation of motor control applications.

PYNQ: Python on Zynq is an open-source project from Xilinx that makes it easy to design embedded systems with Zynq All Programmable Systems on Chips (APSoCs). Using the Python language and libraries, designers can exploit the benefits of programmable logic and microprocessors in Zynq to build more capable and exciting embedded systems.

IIoT-SPYN: Industrial IoT SPYN is an open source project that leverages IIoT-EDDP and PYNQ. Using IIoT-SPYN users can control, monitor, capture data, visualize and analyze Industrial grade motors.

IIoT-SPYN is intended to work with the EDDP kit. Here is the link to purchase the kit: EDDP Kit

Quick Start for Arty-Z7-10

Step 1: Download the Arty-Z7-10 PYNQ image

Step 2: Write the image file to a SD card

Step 3: Use the following command in a terminal to install IIoT-SPYN

```
$ sudo pip3 install --upgrade git+https://github.com/Xilinx/IIoT-SPYN.git
$ sudo reboot now
```

After the setup, new Jupyter notebooks will be added under the spyn folder, ready to try out, no additional steps are needed.

Quick Start for Pynq-Z1 / Arty-Z7-20

Step 1: Download the PYNQ image

Step 2: Write the image file to a SD card

Step 3: Use the following command in a terminal to install IIoT-SPYN

```
$ sudo pip3 install --upgrade git+https://github.com/Xilinx/IIoT-SPYN.git
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https://github.com/Xilinx/IIoT-SPYN

Adaptable.
Intelligent.

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