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# Multi-Purpose Compact Zynq-Based System-on-Module for Data Acquisition Systems

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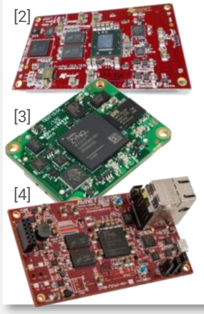
VIDEO
CAMERA

## Introduction

FPGAs and programmable logic are essential in many applications such as medical imaging and high energy physics experiments. Recent system-on-chip (SoC) [1] devices combine the advantages of FPGA logic with the ease of use of embedded processors. They however require extensive electronics to support their operating conditions. System cost and complexity can be significantly reduced by reusing the same densely-packed system-on-module (SoM), integrating all basic components. Carrier boards can then use a reduced number of layers and larger feature size to reduce printed circuit board costs at the system level.

## Rationale

Commercially-available SoM provide an interesting avenue for prototyping and firmware development, but they lack in many features required by highly integrated mixed-signal systems due to their low-cost and design choices :


[2] [3] [4]

- *Limited to entry-level processors.*
- *Limited number of I/Os.*
- *Poor electromagnetic interference (EMI) and electromagnetic compatibility (EMC) performance.*
- *Poor signal integrity (impedance control, crosstalk, no matched length routing).*
- *Low reliability (low cost components).*
- *Sparse availability.*

## Objective

**Design a Zynq-Based SoM for low noise and high-performance applications with :**

- High number of I/Os
- Low EMI
- High EMC
- High signal integrity
- Matched-length routing
- Simple integration
- Integrated power supply and sequencing

## Features

TOP

BOTTOM

**Xilinx ZYNQ-7030 SoC [1]**
Kintex 7 Fabric – ARM Cortex A9 Processor.

**1 GB DDR3L-1066 RAM**
32 bit bus width.

**All I/Os Available on Connectors**
40 single-ended PS I/O (processor only).
76 diff. pairs / 157 single-ended PL I/O (logic).
4 RX / 4 TX – 10 Gbit/s Transceivers (GTX)
50 ohms SE/ 100 ohms diff. impedance control

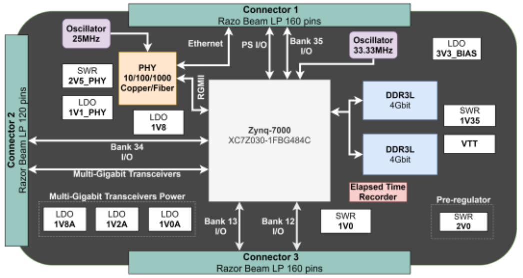
**Matched-Length Routing**
Compensated for package delay.

**Gigabit Ethernet PHY (1000Base-T/X)**
Supports copper and optical.

**18-Layer Printed Circuit Board**
60 x 70 mm² - 2 mm thickness.
All signal layers separated by ground layer.
Low crosstalk (high signal-to-signal isolation).

**Elapsed Time Recorder**
Records on-time and number of boot-up.
Preventive maintenance planning.

BLOCK DIAGRAM

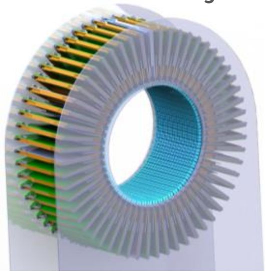



**Onboard Power Supply and Sequencing**
Single power supply (5V) operation.
Low emissions (EN55022 Class B) shielded switching regulators.
Heavy power supply filtering and bypassing.
1.8 V @ 1.5 A and 2.5 V @ 1.5 A supply for external peripherals.
Adjustable I/O bank supplies.
Fully managed sequencing (including external supplies).

## Ultra-High Resolution (UHR) Brain PET Scanner

### Scanner Characteristics

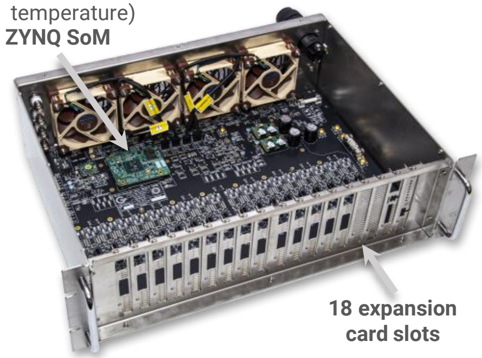
**1.3 mm spatial resolution [5]**
**390 mm diameter**
**235 mm axial length**



**129 024 pixels**
**1008 detector modules**
**56 radial boards**
**4 distribution units**

### Back-End Distribution Unit

- Power distribution and control
- Clock and synchronization distribution
- Circuit protection (ESD, surge)
- Ancillary systems (power monitoring, temperature)




### Gating Unit

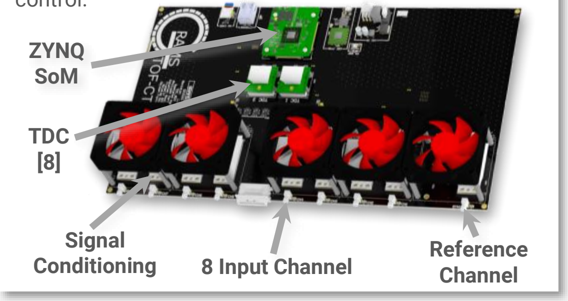
Measure cardiac or respiratory gating synchronized with system.

### SoM Test Board

All Zynq SoM are fully tested using a custom test board to simplify debugging and integration.

## TCSPC and ToF-CT

Due to its high signal integrity, the ZYNQ SoM can be used in ultra-precise time measurement applications such as time-correlated single photon counting (TCSPC) and time-of-flight (ToF) measurement. It is used in our ToF computed tomography (ToF-CT) and TCSPC system [6,7]. It is also the perfect candidate for FPGA-based time-to-digital converter (TDC) due to its extremely precise length matching and impedance control.




## Conclusion

The new Zynq SoM is a versatile, compact and cost-effective solution to integrate a powerful processor and FPGA fabric on a larger and lower technology PCB. The module can be assembled and fully tested separately using a custom test board, leading to simplified prototyping and integration. Its high number of I/O, low EMI emissions, high signal integrity and high reliability are significant advantages over commercially available SoM.

[1] Xilinx, Zynq 7000 Overview, 2018, [Online].
[2] Avnet, PicoZed, 2017, [Online].
[3] Trenz Electronics, TE0720, 2017, [Online].
[4] Avnet, MicroZed, 2017, [Online].
[5] Gaudin et al., IEEE TRPMS, vol.3, no. 3, 2019.
[6] Rossignol et al., in IEEE Real Time, 2018.
[7] Gaudreault et al., in IEEE NSS-MIC, 2019.
[8] Nolet et al., in Electronic Letters, Vol 56, No 9.

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