# System-on-Chip-based magnet control in a MicroTCA system

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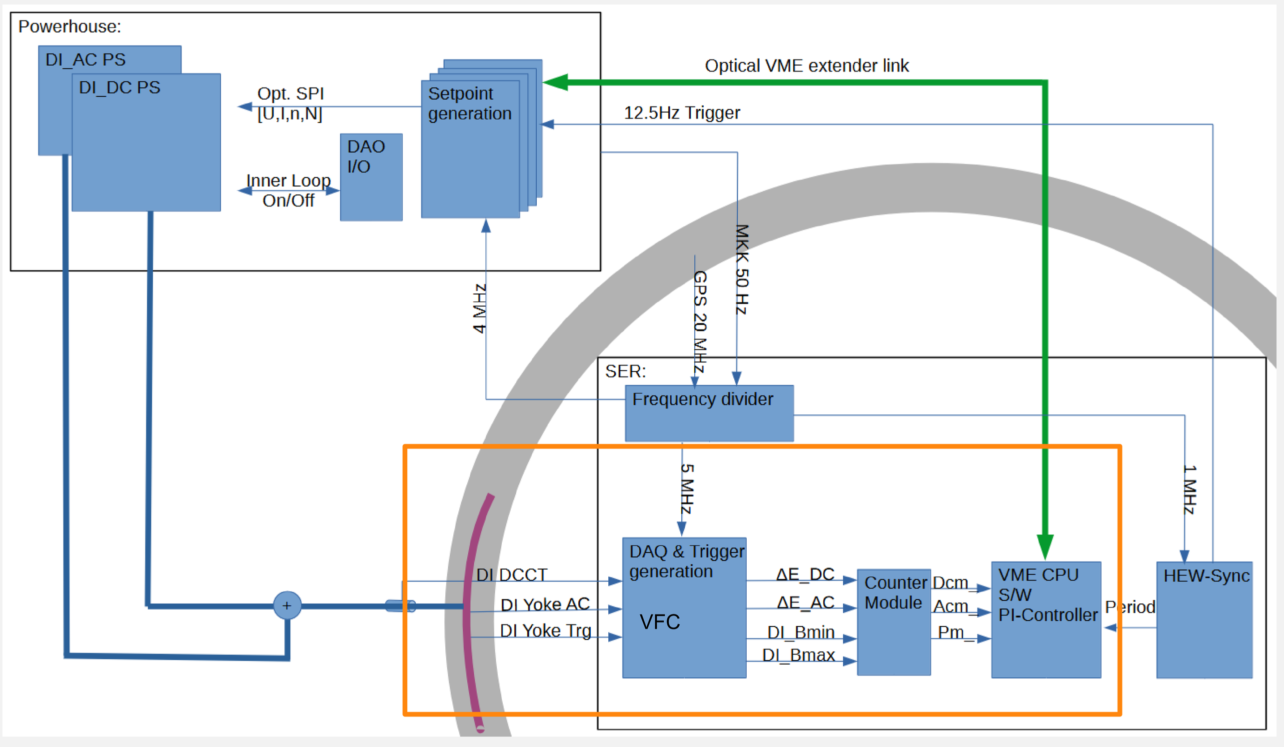
## DESY II magnet control

- Pre-accelerator of PETRA III
- DESY II magnet control is currently implemented on VMEbus standard
- Renewal as part of the PETRA IV project
  → Migration of DESY II magnet control to MicroTCA standard
- Six magnet circuits in the DESY II accelerator (dipole DC and AC, quadrupole/sextupole focusing and defocusing)
- Current measurement at the magnets → acquisition of actual values for control
- Digitization of measured signals with voltage to frequency converters (VFC)
  → frequency of generated pulse signals is proportional to measured voltage



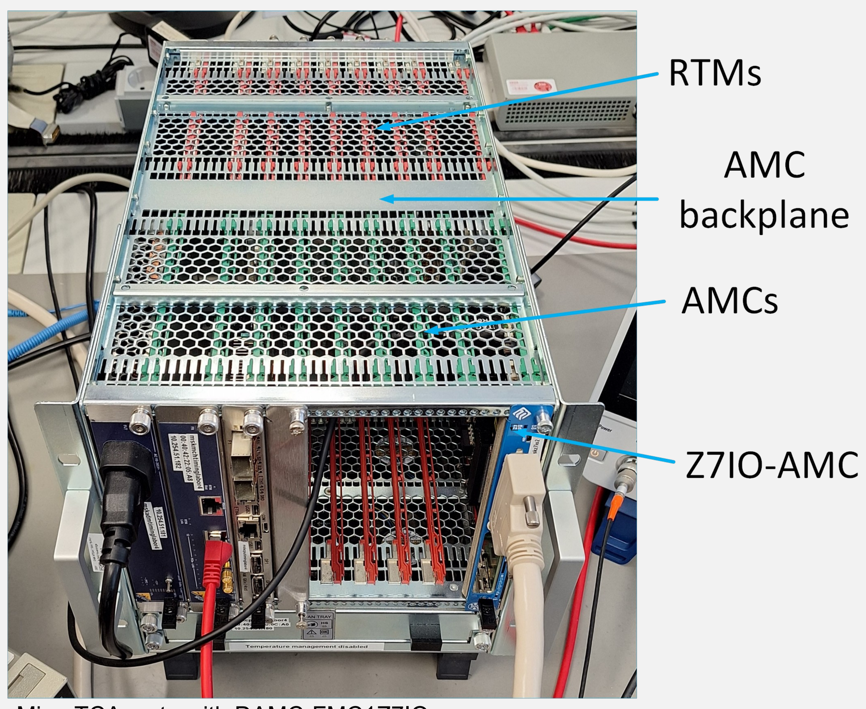
Schematic overview of the DESY II magnet control for the dipole circuit

- Trigger signals Bmin and Bmax are created from the measured signals → minimum and maximum magnetic field energy
- The pulse signals from the VFCs are counted by counter modules, that are implemented on FPGAs on VME modules → the generated counter values are proportional to the current measurement
- The PI controller is implemented on the CPU module of the VME crate
- Calculation of new setpoint values for the internal control of the magnet power supplies
- There is also a control system server installed on the CPU → new setpoints for the control loop can be transferred via the server
- The real-time operating system VxWorks runs on the CPU
  → real-time requirement of 80 ms

## Thesis - Migration of DESY II magnet control from VMEbus to MicroTCA

### MicroTCA

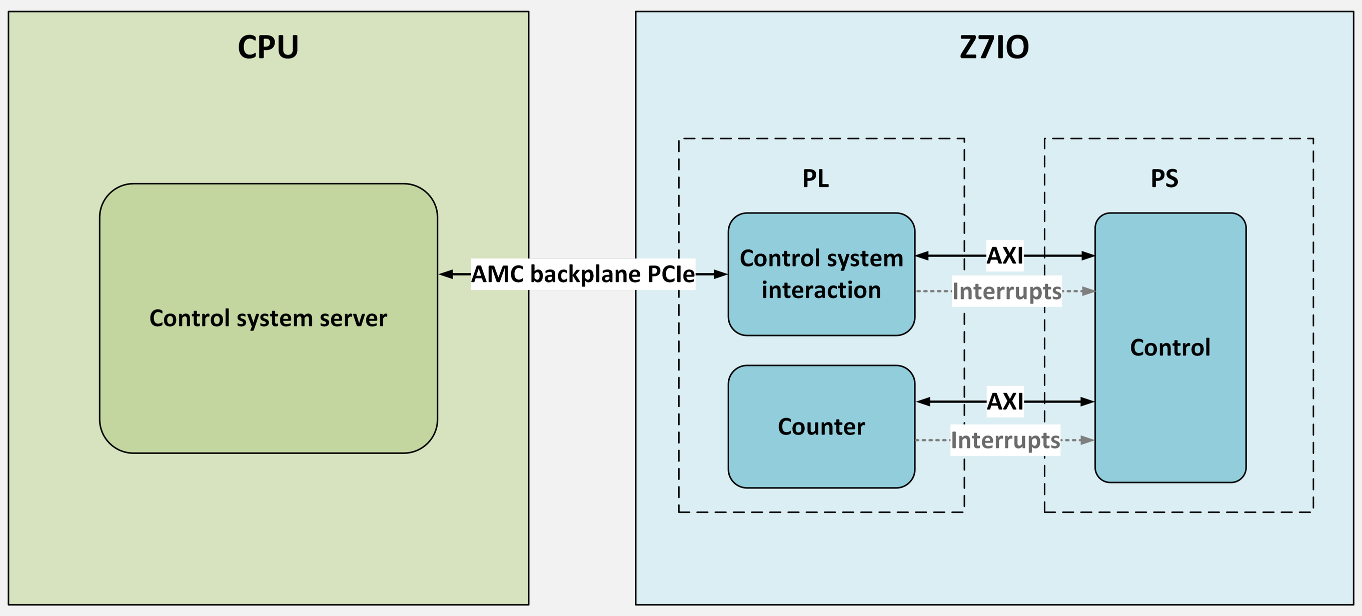
- Micro Telecommunications Computing Architecture
- Modular, open standard to build computer systems
- Advanced Mezzanine Cards (AMC) are inserted into the AMC backplane of a crate
  → can be interconnected via the backplane
- MTCA.4 sub-specification offers an extension of the crate for Rear Transition Modules (RTM)
- An AMC and RTM module can be connected to each other via the Zone 3 connector



MicroTCA crate with DAMC-FMC1Z7IO

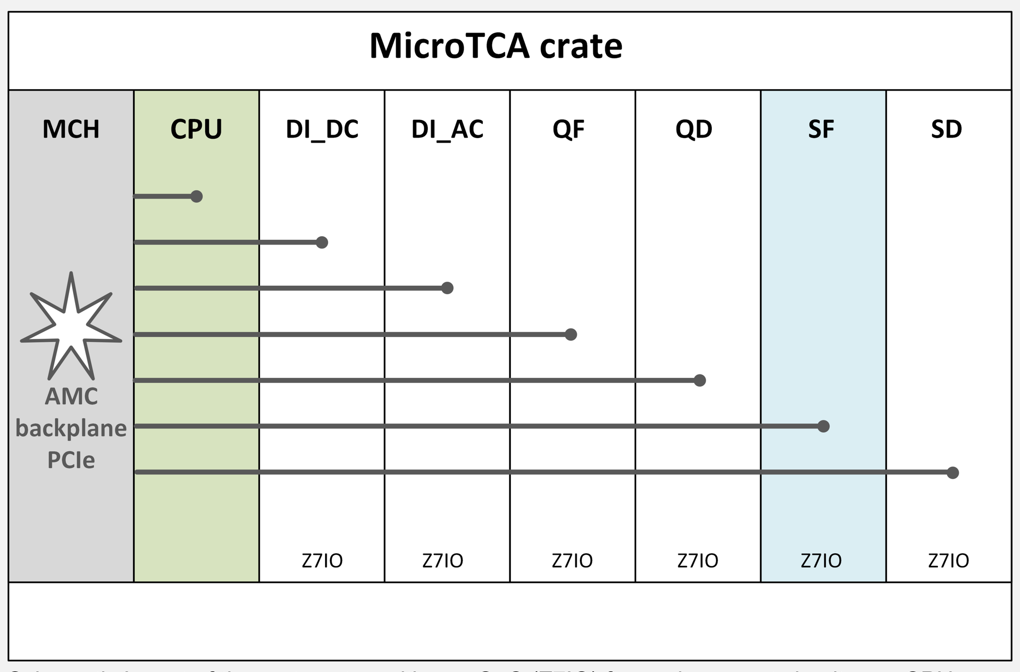
### System-on-Chip approach

- In the VME system, control and calculations for all magnet circuits are performed on the same CPU → high computing load
- In this thesis the DAMC-FMC1Z7IO, which was developed at DESY, is used
  → AMC module with ZYNQ7000 SoC
- In the MicroTCA system one Z7IO is used for each of the six magnet circuits
- The calculations for each magnet circuit are offloaded to the corresponding Z7IO of the respective circuit



Conceptual block diagram of the SoC approach, CPU module of the MicroTCA crate (left) and one Z7IO with SoC (right)

- The control for each magnet circuit is implemented on the ARM processor of the SoC of the respective Z7IO
- Trigger signals start and stop the counters in the FPGA and generate interrupts
- The processor reads the counter values from the FPGA via the AXI bus
- The control system server is installed on the CPU of the MicroTCA crate
- The communication between this server on the CPU and the Z7IO AMC modules is carried out via the AMC backplane (PCIe)



Schematic layout of the crate setup with one SoC (Z7IO) for each magnet circuit, one CPU module and the PCIe switch in the MCH (Management Carrier Hub) of the crate

### Results

- By reducing the computational load on a single processor, the real-time requirement of 80 ms is met without the use of VxWorks
- The time from receiving the trigger, trough the AXI interface and control processing, to the availability of the fully calculated control results is approximately 10 µs
- Bidirectional data communication between the control system server and the Z7IO was successfully established via the AMC backplane
- The components required for the DESY II magnet control were successfully implemented using the MicroTCA architecture

## Next steps

### Testing

- Testing and further development of the developed concept under real-world conditions
- Integration into the actual DESY II magnet control system
- Recording and archiving of counter and control values using the implemented data communication with the control system server
- Migration of the setpoint generator to MicroTCA → enables testing of the closed control loop

### RTM development

Development of a new RTM for actual value acquisition:

- The board is planned to include VFCs, trigger generation an other components like filters, level converters and more
- This brings the entire preprocessing, which previously took place outside the VME crate in the VME system, into the MicroTCA crate
- AMC backplane and Zone-3 connectors will be used for internal signal distribution

→ Reduction of cabling
→ Improvement of maintainability

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