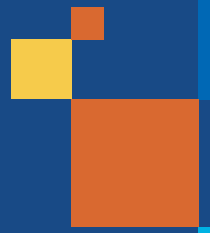
Intel FPGA System Solutions Engineering, project proposal

Advanced power converter

Ben Jeppesen, Manager, Embedded Control and Functional Safety



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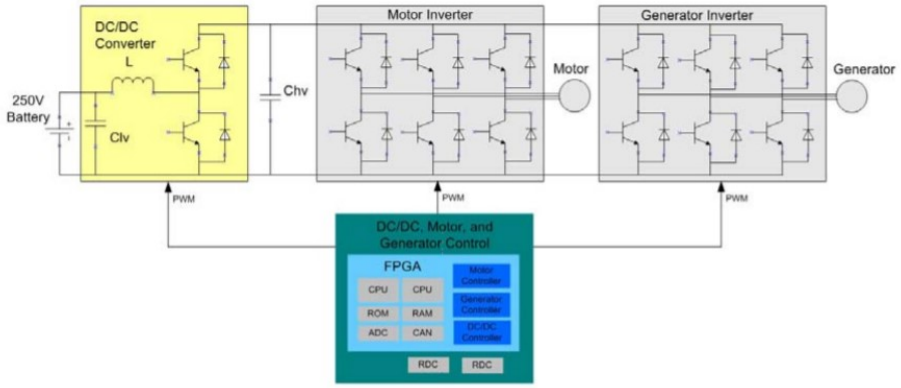
Advanced power converter

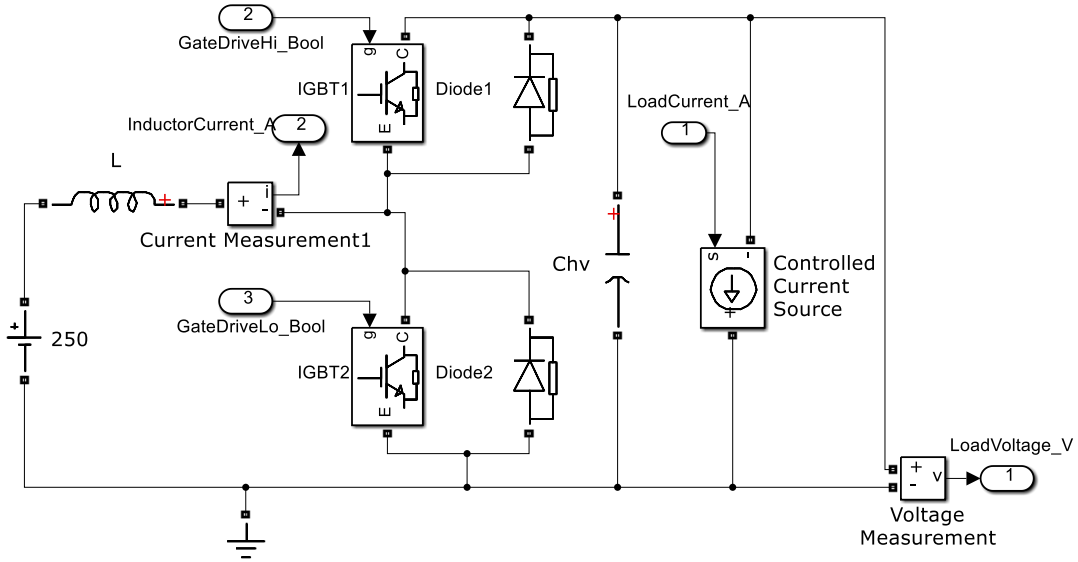
- Project proposal
  - Attention is switching to the efficiency and cost of power converters.
  - FPGAs enable digital control at high frequencies:
    - Reducing the size and cost of passive components required to stabilize voltage
    - Enabling alternatives to PWM switching waveforms to reduce switching losses.
  - **Aim: create a high performance power converter design example**
    - Intel has practical designs to start from, so work can focus on optimization

- Ben Jeppesen
  - leads the Embedded Control and Functional Safety team in Intel FPGA
  - supports customers and strategic marketing of FPGAs in control applications

Existing work on bi-directional DC-DC

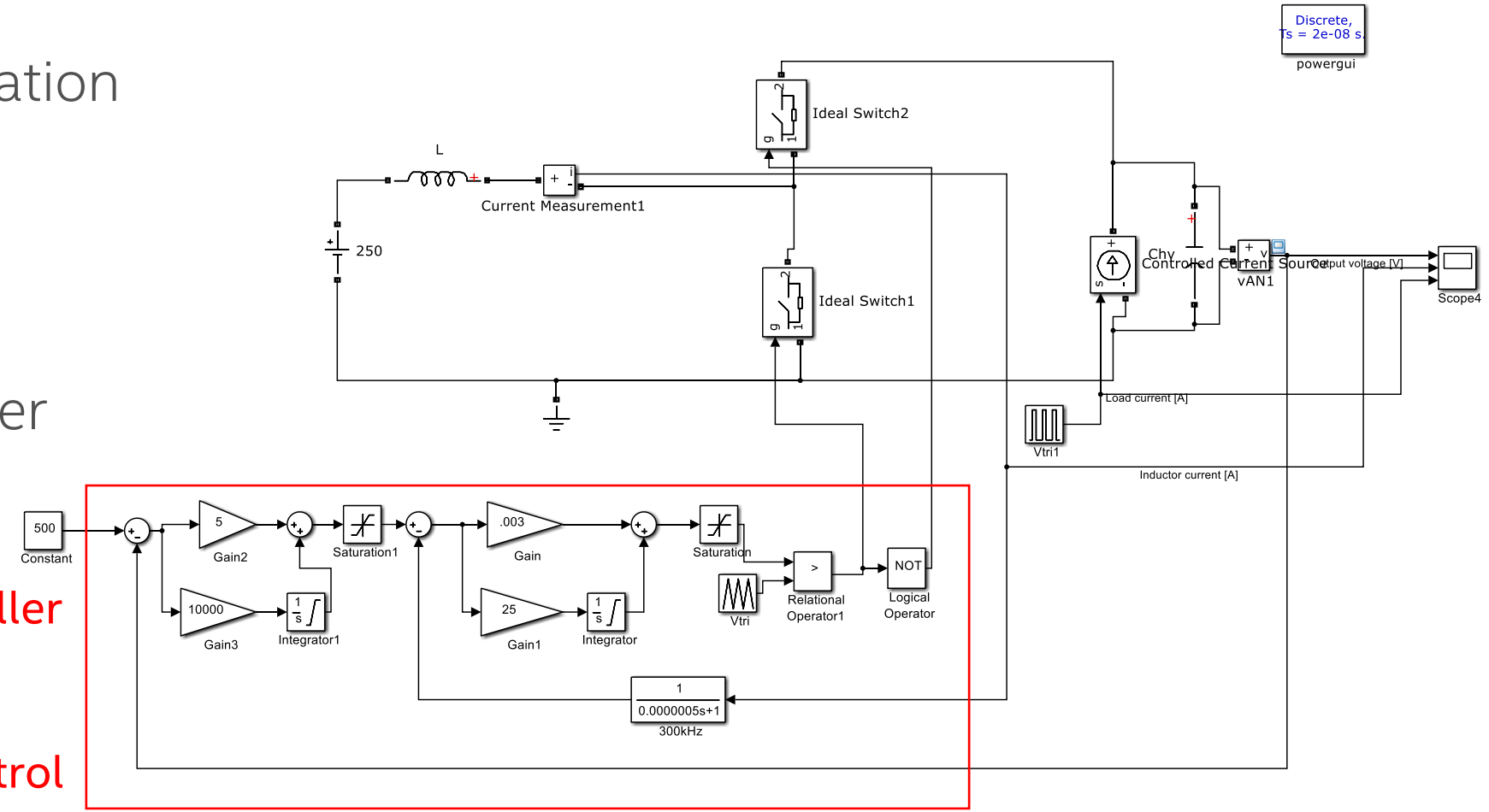
- Public paper: wp-01210-electric-vehicles.pdf
  - IGBT, 250 V ↔ 500 V, 50kW
- Simulation at 20 MHz in MATLAB/SimPower
  - Circuit
    - Energy losses in IGBT and diode models
    - Two versions from L, C sizes for PWM:
      - “10kHz”, “50kHz”
  - Control
    - Sensing delays simulated
    - Voltage PI control demands L current
    - L current control is PI+PWM or Hysteresis
- PCIM conference paper by Intel





Develop algorithm in MATLAB/Simulink

- Fixed step 2e-8s to simulate 50MHz FPGA clock
- Electronic simulation
- Voltage controller



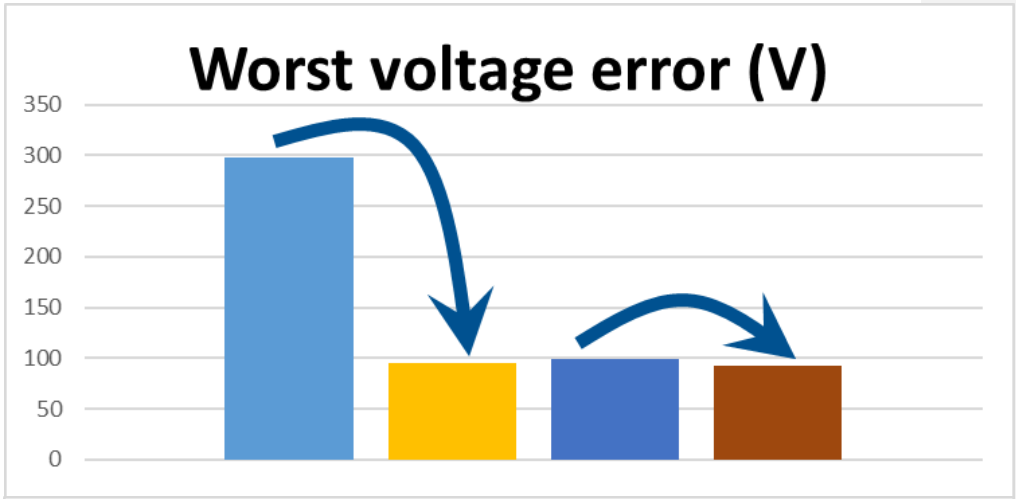
Replace PI+PWM controller with alternatives, e.g.:

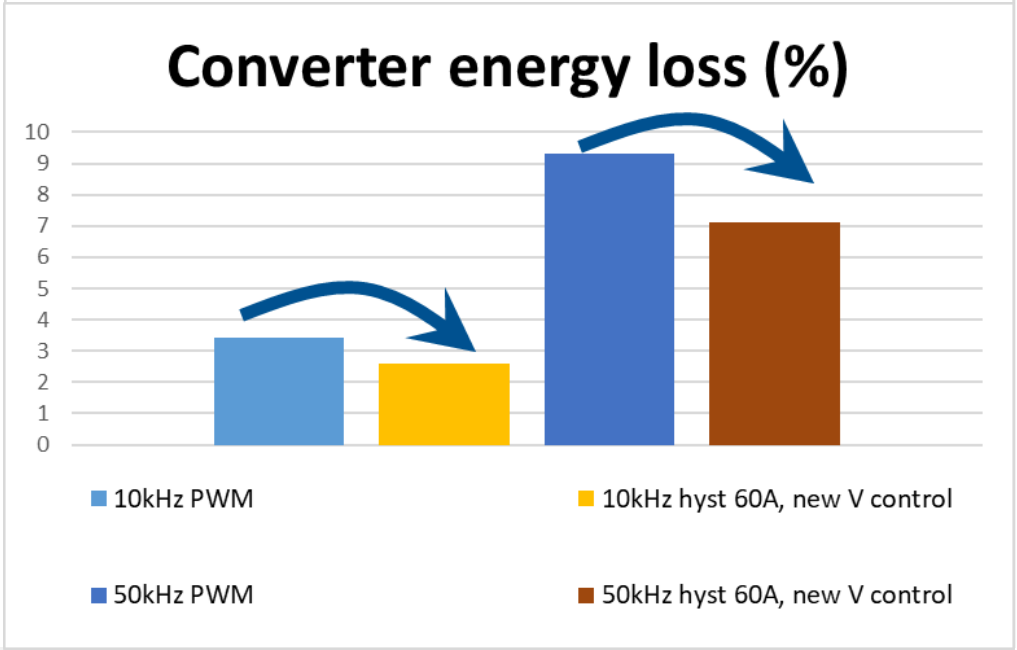
- Hysteresis controller
- Model predictive control
- Neural Net

Performance metrics

- Example results from conference paper:
  - Worst voltage error
    - Voltage deviation from command with changing voltage command and changing load current
  - Converter energy losses (%)
    - Over the duration of a simulation with changing load current
- Optimization on FPGA
  - Minimize resource usage on FPGA
    - logic elements, DSP blocks, memory blocks
  - Maximize clock frequency on FPGA
    - Better control of transistor pair in half-bridge and faster reaction to disturbances

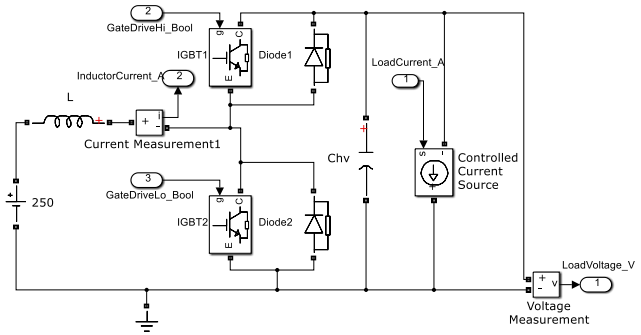
- Can we do better with a new controller?

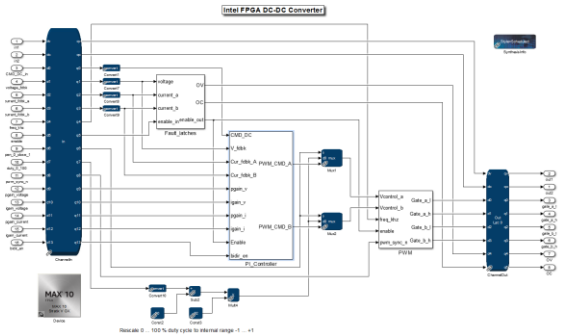




Aim to test on FPGA and publish…

- Research control algorithms
- Control development
  - MATLAB Simulink, Simscape
- Code development
  - HDL Coder, DSP Builder, hand coding
- HDL verification by simulation
  - ModelSim, VCS
- HDL verification on FPGA
  - Quartus, SignalTap, SystemConsole
- Validation on FPGA with real power electronics
  - Quartus, Terasic Tandem Motion-Power 48 V kit
- Publish as conf paper or new Design Example





Support from Intel

- An Intel engineer will be available for weekly meetings
  - Give technical guidance
  - Use a tool like Trello for project management
  - Advise on team roles
- Intel DSP Builder licenses for FPGA code generation in MATLAB/Simulink
- FPGA development kits when required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