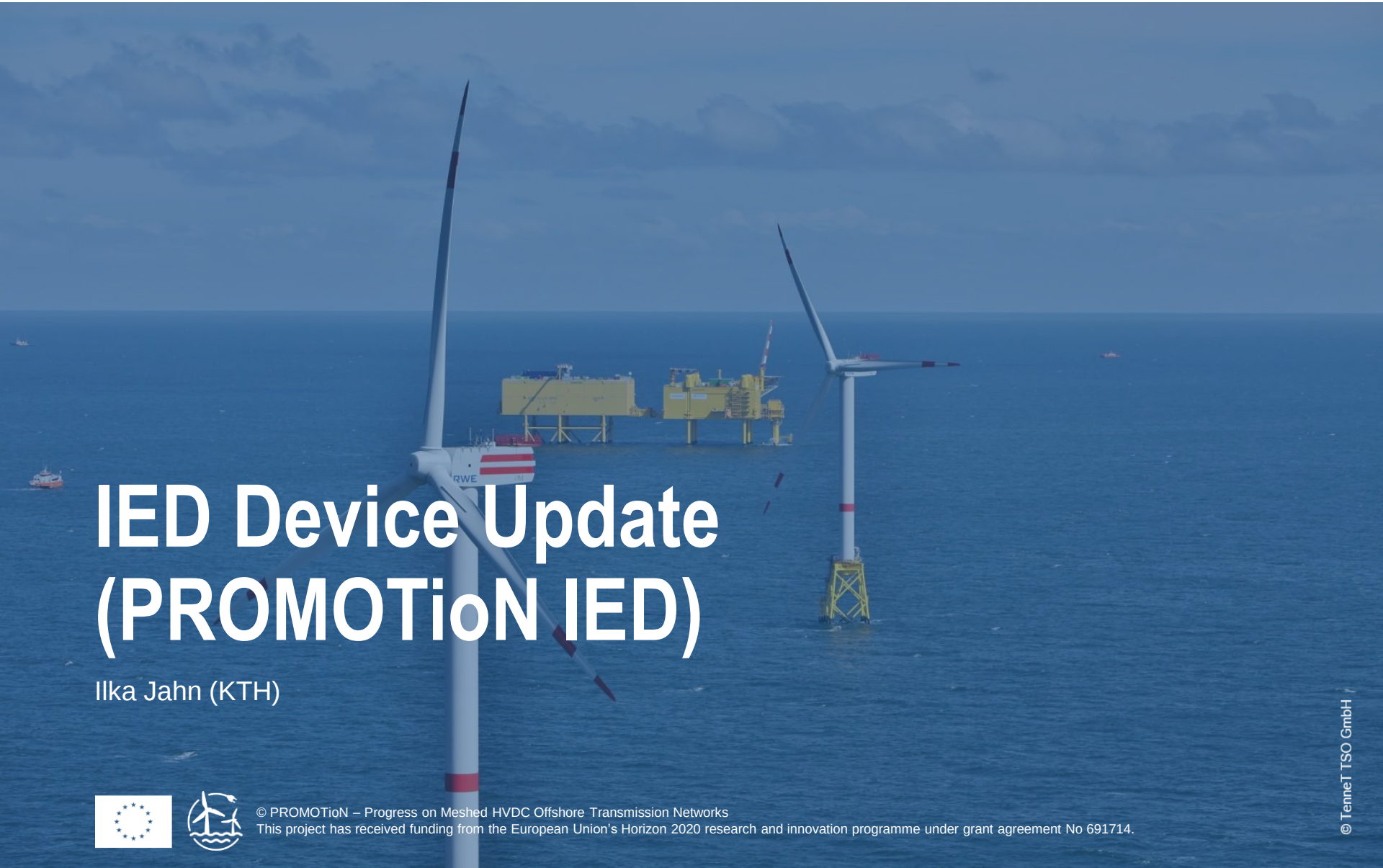
PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS



IED Device Update (PROMOTioN IED)

Ilka Jahn (KTH)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Agenda

This presentation is about the “PROMOTioN IED”.

- Overview deliverable 4.6 (“IED + documentation”)
- Design
- Test methods
- Results from pre-testing

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Overview of Deliverable D4.6

- Title: “Functional HVDC protection IED including documentation”
- Type: Demonstrator
- Due date: M36

+

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D4.6 (“IED”)

- Content (shortened):
  - Introduction
  - IED Hardware
    - Inputs
    - Outputs
  - IED Software
    - Programmable Logic
    - Processing System
    - Datalogging
    - Algorithms
  - Manual – How to operate the IED
    - Backpanel connectors
    - Start-Up
    - Troubleshooting
  - MATLAB GUI
  - IED Pre-testing
  - Component List

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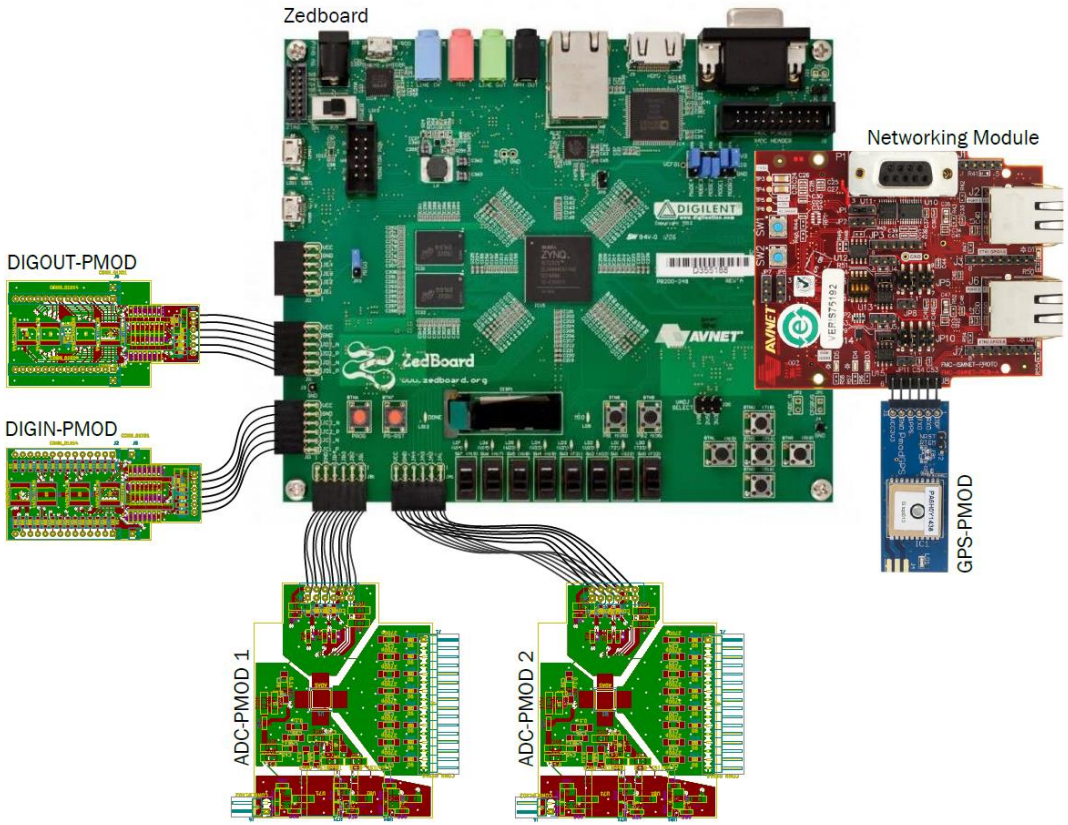
Modular approach!
Xilinx Zynq System-on-Chip



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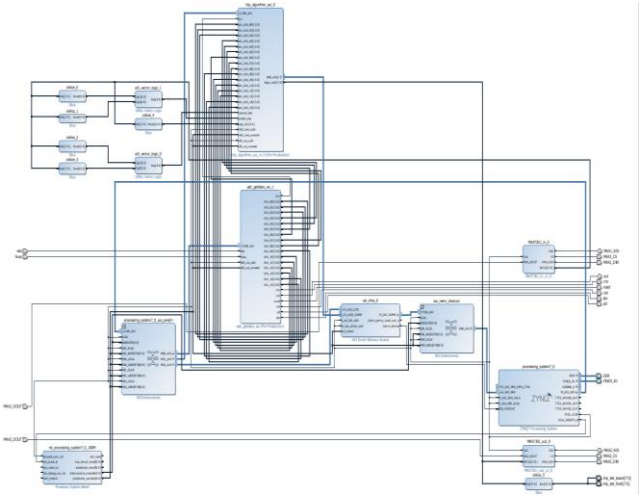

Modular approach!

Table 3-3: Summary of developed C-Code

C-File	Description
Alex_main.c	Implements the *main* function of the Alex SW – the first function called after a system reset. It handles the startup and initialization of the ARM_1 SW and the initialization of the PL-blocks.
Alex_bgstk.c/h	Implements a very basic background task that runs “forever”. It is responsible for toggling the PS LED. Users may add their own non-time-critical code in it.
Alex_xaxidma.c/h	Implements the Alex drivers for the Xilinx AXI DMA IP residing in the PL. The drivers are responsible for the initialization of the AXI DMA and also implement the interrupt routine called after a successful DMA transfer.
Alex_datlg.c/h	Implements the routines for datalogging. Since the datalogging uses the DMA engine in PS (DMSPS) it also implements the Alex drivers for it.
Alex_intc.c/h	Implements the Alex drivers for the interrupt controller. It is responsible for setting up the interrupt system at startup.
Alex_hstsk.c/h	Implements a function that is called once every AXI DMA transfer from PL has completed. Here, the trip algorithms are called.
Alex_matlab_uart.c/h	Implements UART communication between MATLAB and SDK. This is used to read out the IED datalog, configure algorithm thresholds and enable/disable algorithms.
Alex_tral1pos.c/h Alex_tral2pos.c/h Alex_tral3pos.c/h Alex_tral1neg.c/h Alex_tral2neg.c/h Alex_tral3neg.c/h	Implements signal filtering and protection algorithms. The data is available in u32int format and a second order IIR-lowpass filter with efficient implementation is used as described in [6].
Alex_param.h	This file contains defines of Alex “parameters” such as sampling frequency (now: 50 kHz) and datalog length.

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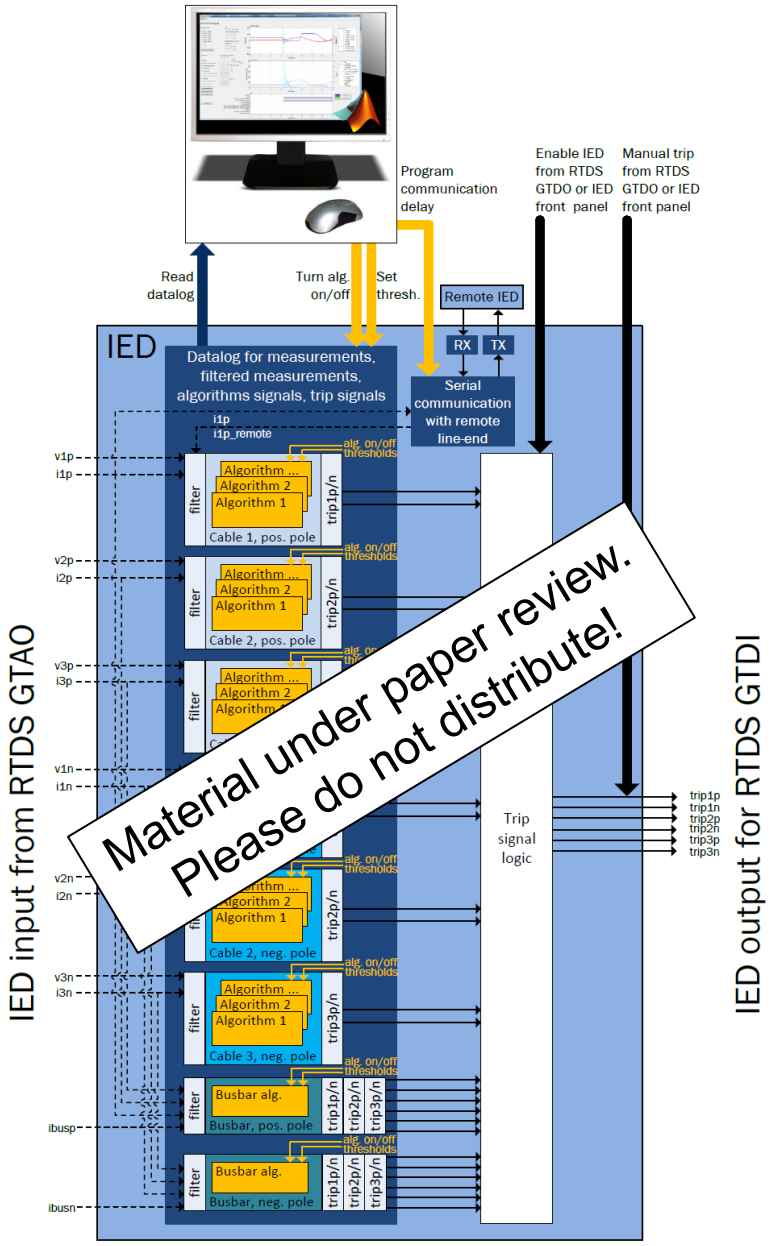

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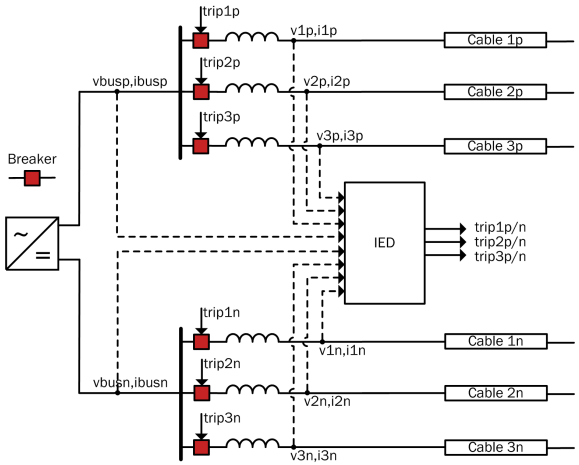

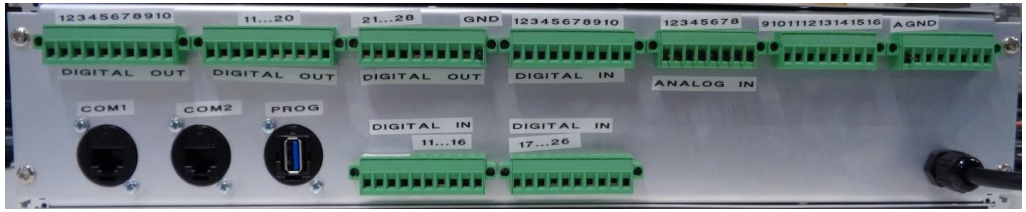

Table 4-1: Analog input signals

	Analog input connector	Signal	
Positive pole (ADC 1)	1	Pos. voltage 1	v1p
	2	Pos. current 1	i1p
	3	Pos. voltage 2	v2p
	4	Pos. current 2	i2p
	5	Pos. voltage 3	v3p
	6	Pos. current 3	i3p
	7	Pos. Busbar voltage	vbusp
	8	Pos. Busbar current	ibusp
Negative pole (ADC 2)	9	Neg. voltage 1	v1n
	10	Neg. current 1	i1n
	11	Neg. voltage 2	v2n
	12	Neg. current 2	i2n
	13	Neg. voltage 3	v3n
	14	Neg. current 3	i3n
	15	Neg. Busbar voltage	vbusn
	16	Neg. Busbar current	ibusn

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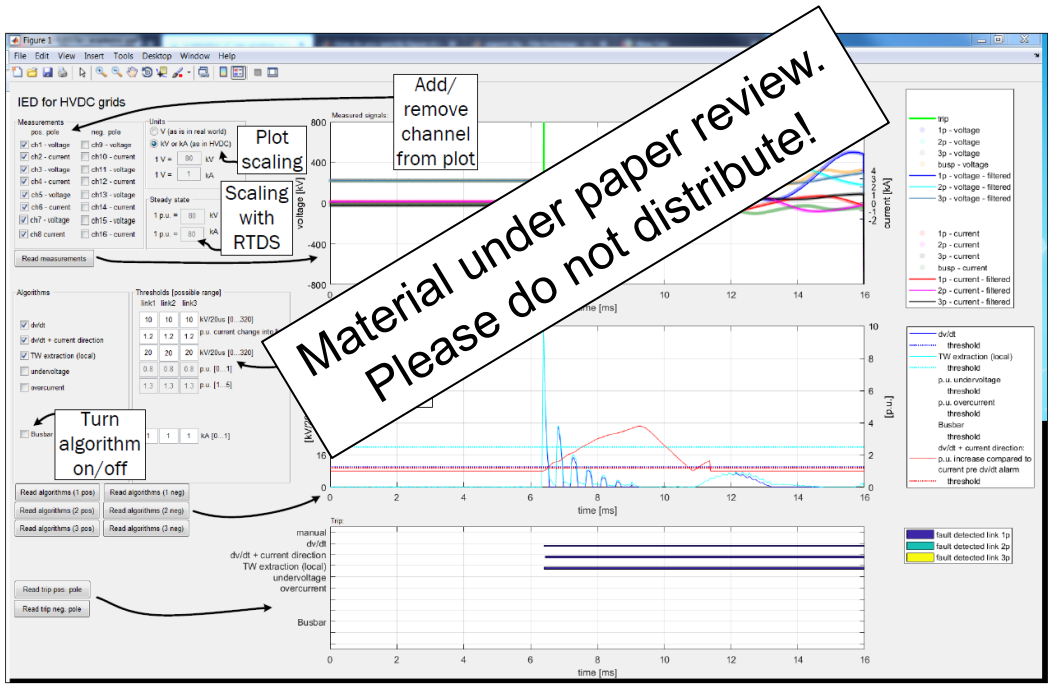

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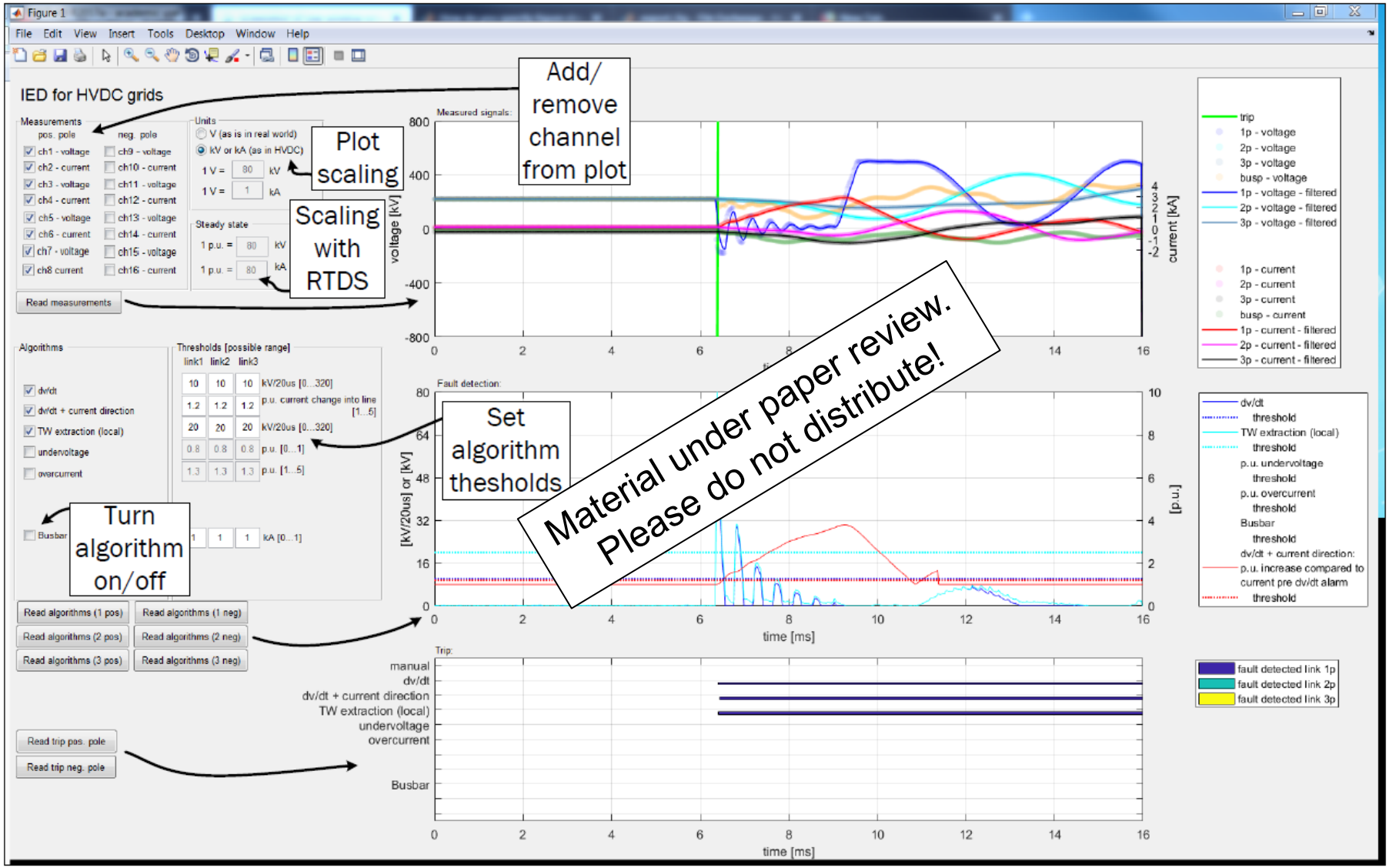

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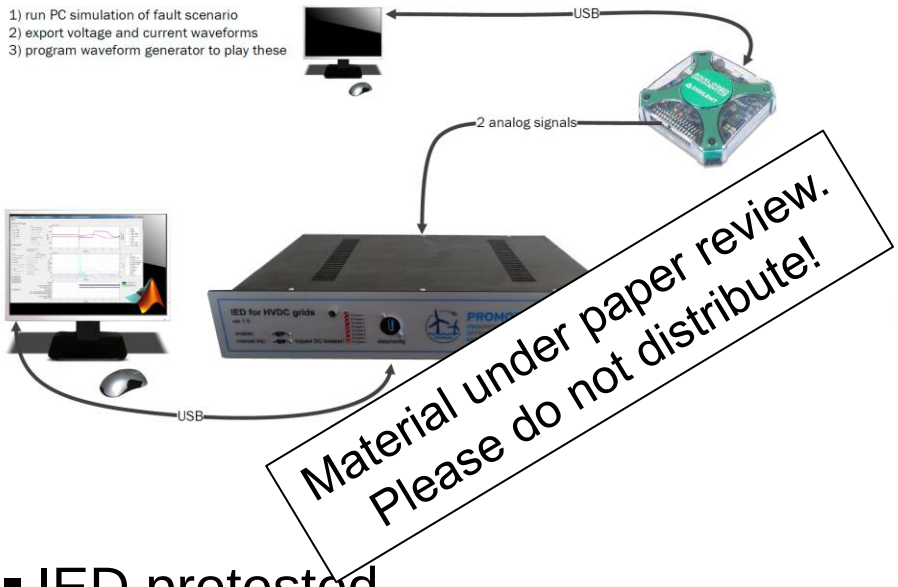
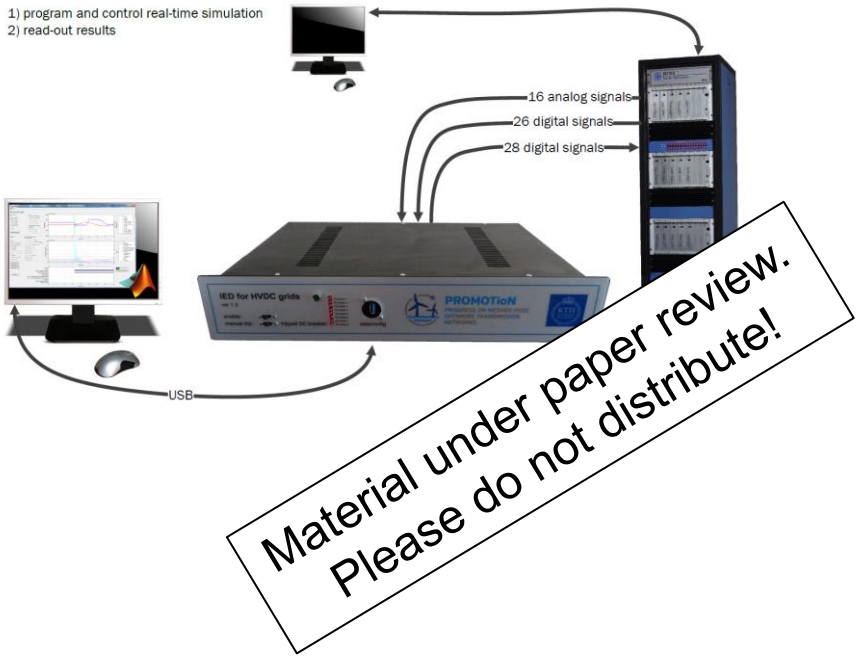
PROMOTioN IED Pre-Testing





Material under paper review.
Please do not distribute!

- IED pretested
  - KTH lab with signal generator
  - KUL/Energyville lab with RTDS, “unit test”
  - The National HVDC Centrel with RTDS, “system test”

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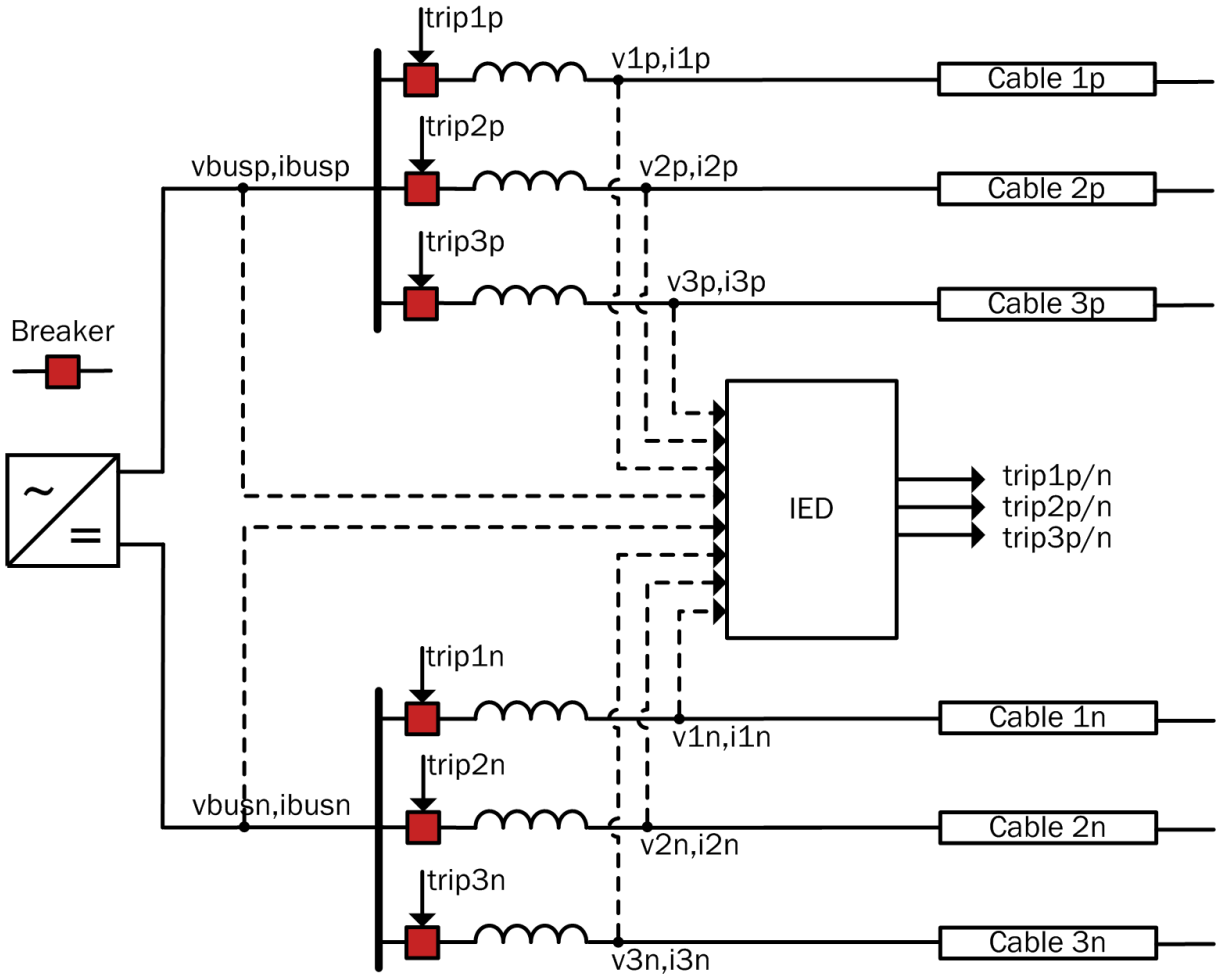
Example results with RTDS

RTDS test system



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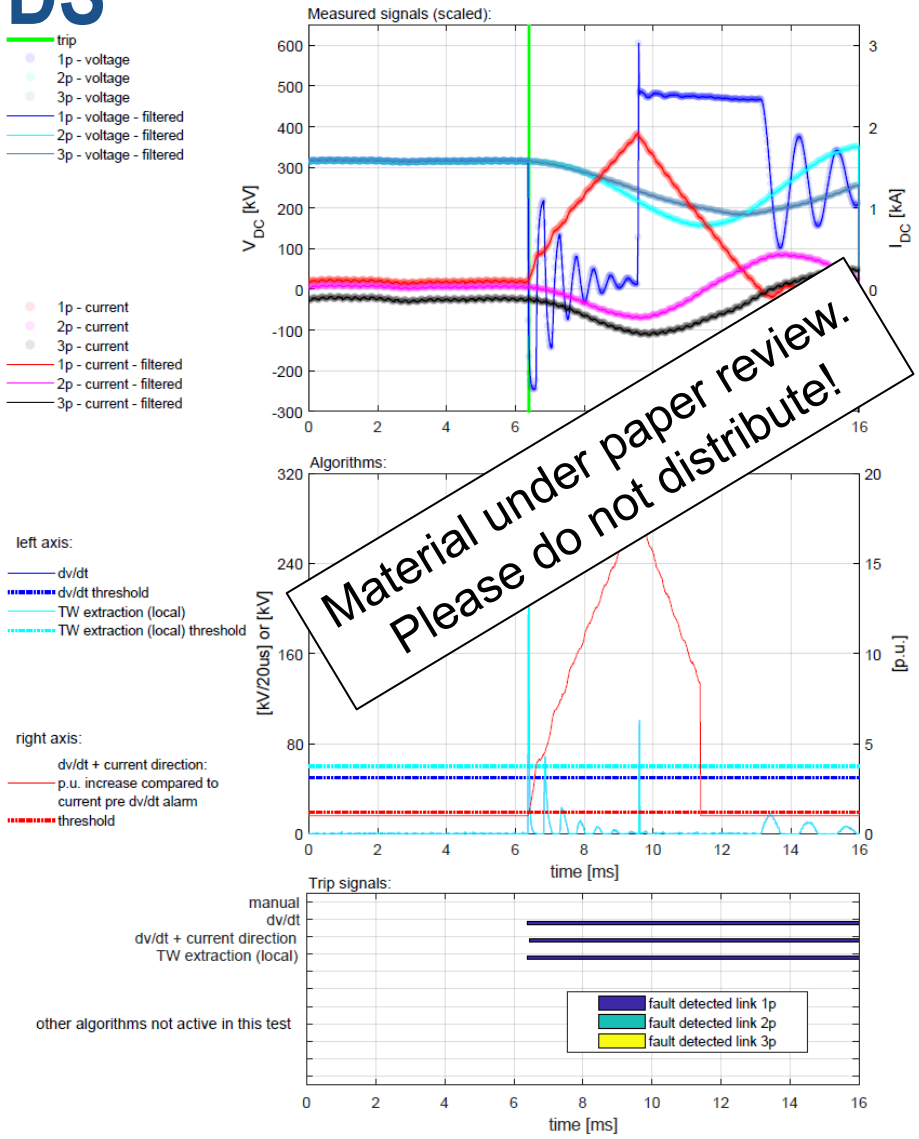
Example results with RTDS

- P-GND fault
- cable 1 positive pole
- distance: 20 km from terminal
- 100 mH line inductors
- 0 Ω fault resistance



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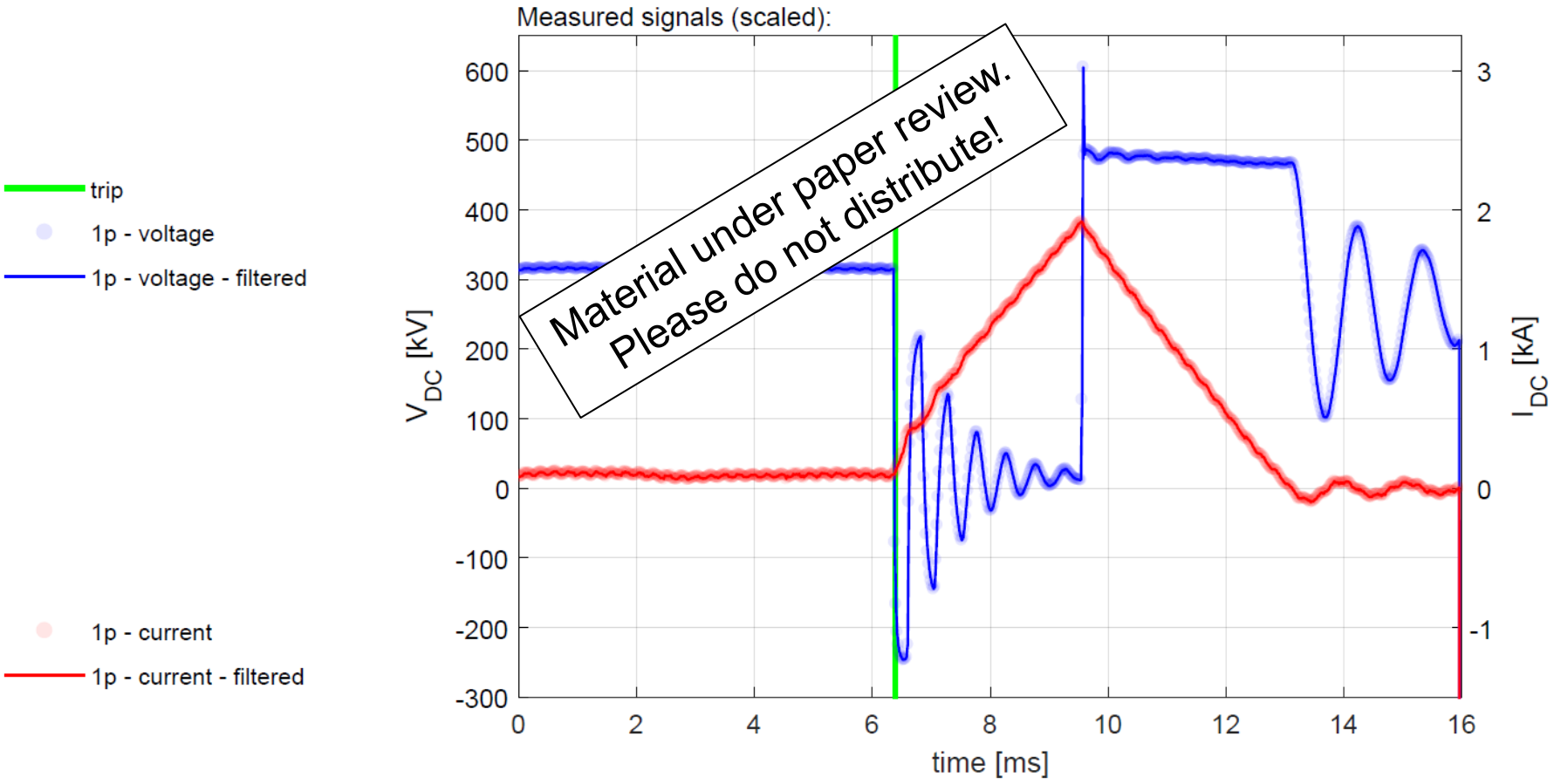
Example results with RTDS - Zoom



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