

Embedded Success

dSPACE

ACMC Motor Control Demo (Scalexio)

RELEASE 2020-A

Hardware

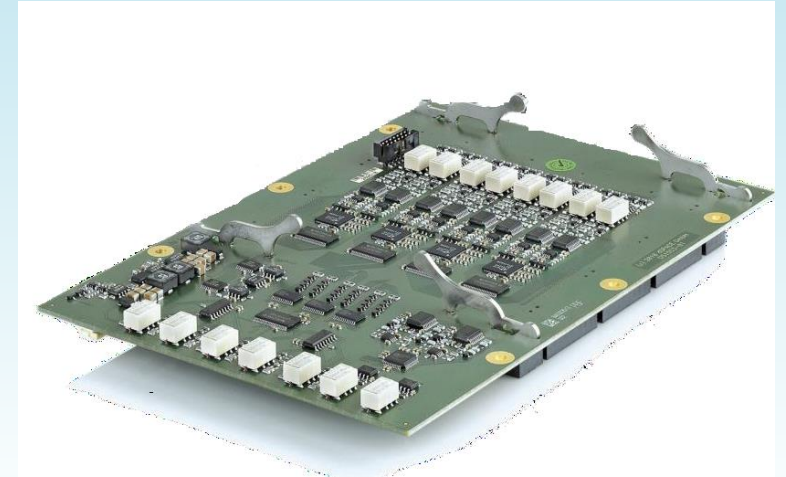
■ DS1403 Processor

■ DS1514 FPGA Board

- Xilinx® Kintex-7 FPGA which can be programmed by the user

■ DS1553 Piggyback Board

- 8 A/D channels with 10 MHz sample rate and adjustable voltage range
- 2 D/A channels with 10 MHz update rate and ± 20 V voltage range
- 8 digital single-ended or differential 5V input channels
- 24 digital single-ended 5 V output channels
- 4 RS485 digital differential bi-directional channels
- 1 resolver IC with 16 bit position resolution and 500 kHz update rate



ACMC Motor Control Demo (Scalexio)

Hardware

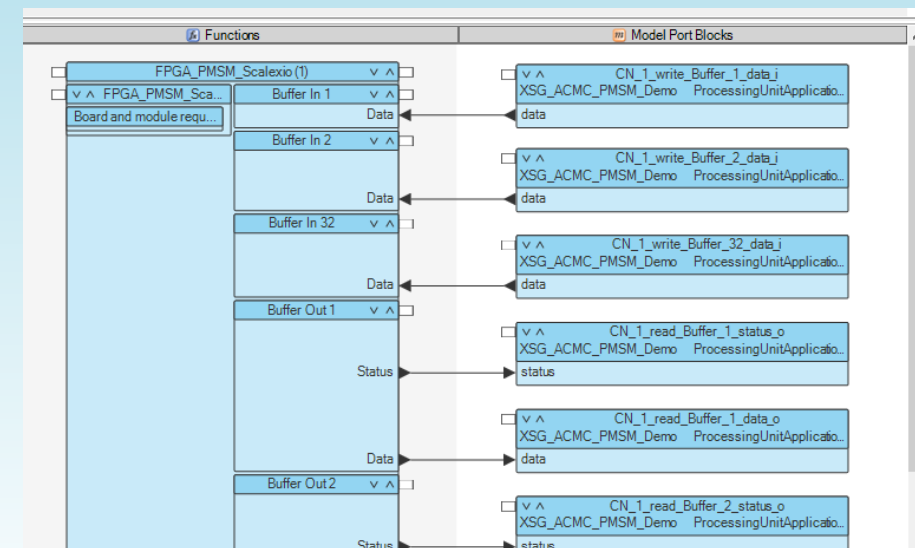
- RapidPro Power Unit
- Motor: 4 pole Permanent Magnet Machine
- Load: Electric Load
- DC Link Voltage up to 60V



ACMC Motor Control Demo (Scalexio)

Configuration Desk

- XSG based FPGA firmware for 1514 and piggyback board 1553
- Position Encoder (Input)
 - Hall Encoder
 - Incremental
- Analog to Digital Converters (Input)
 - 4X ADC with PT1 Filters (3x Current, 1x DC Link Voltage)
- FPGA and Processor based Current Controller
 - PM machine Vector Control (I_d , I_q)
- FPGA Based Space Vector Modulator and PWM Generation(Output)
- Extras
 - FPGA Scope
 - Overcurrent Protection (I_{2t} Protection)
 - Automatic Position Sensor Offset Calibration



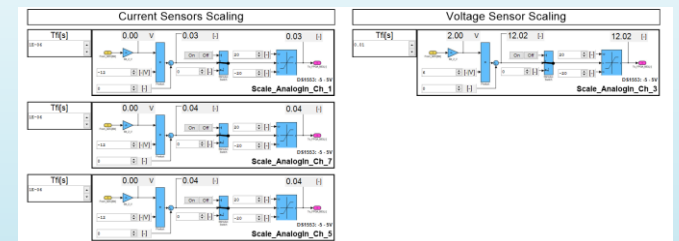
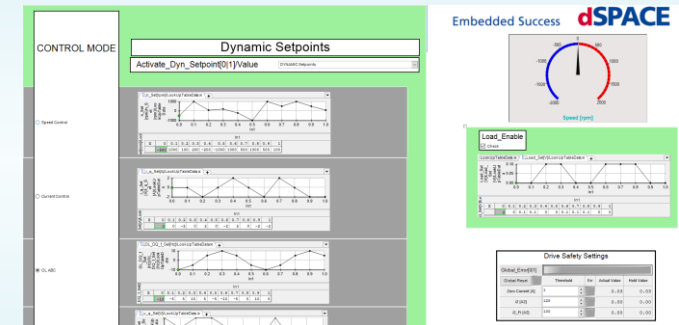
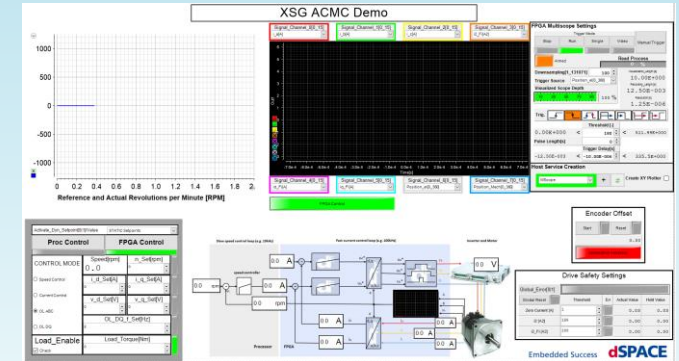
Communication (FPGA & Processor)

- Buffer Communication
 - Buffer 1(Base Task)
 - FPGA Scope, Version Information, Current Controller and Sensor Parameters
 - Buffer 2 (Controller task)
 - Setpoints from Speed Control or Processor based Current control
 - Buffer 32 (Scale IO)
 - Scaling Factors ADC and PT1 Filter time constant

ACMC Motor Control Demo (Scalexio)

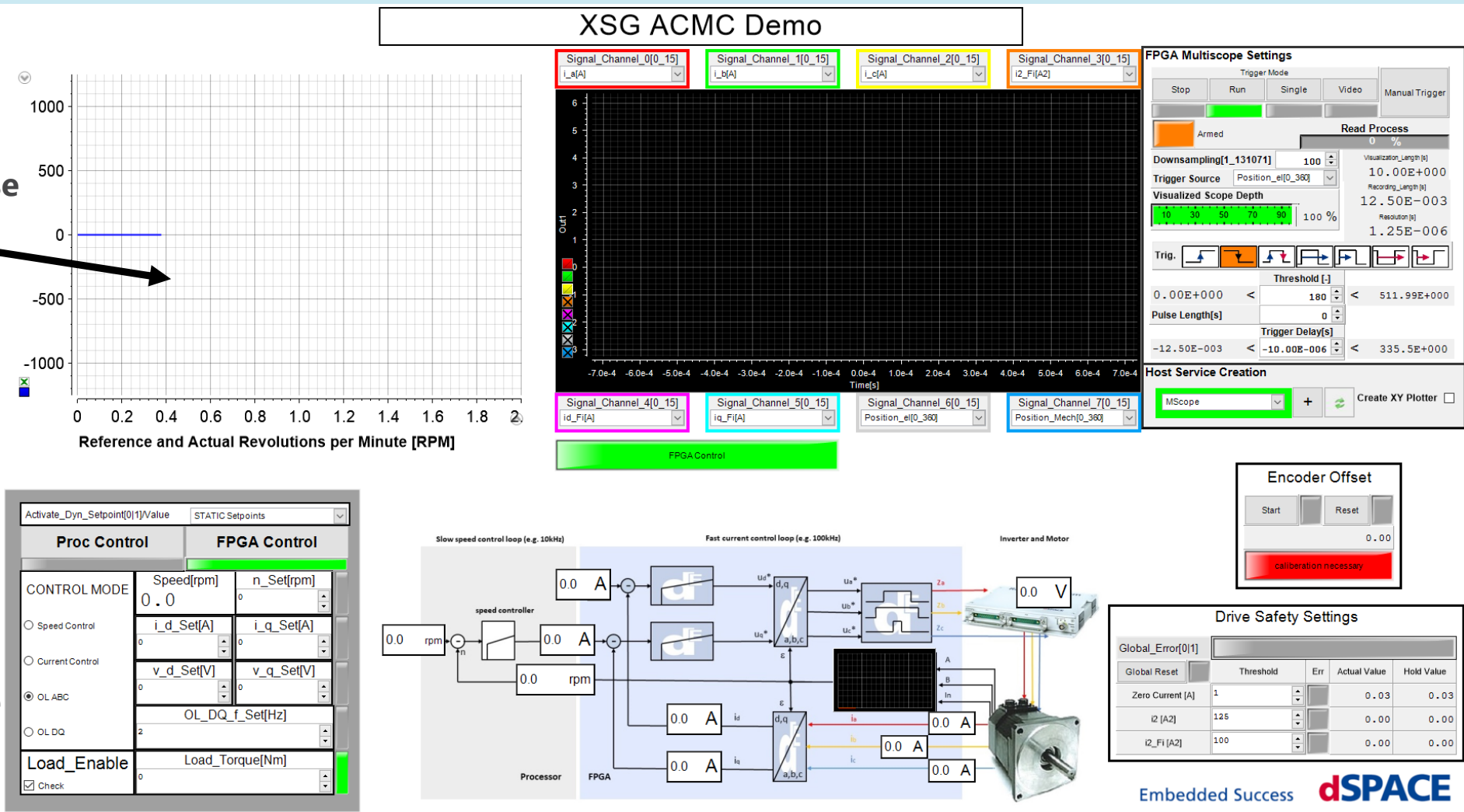
Control Desk

- Controller Layout
 - Speed Control (Processor Based)
 - Current Control (FPGA and Processor based)
 - Over Current Protection
 - Automatic Position Sensor Offset Calibration
- Dynamic Setpoint
 - Lookup table based Speed Current (Iq) Open loop Voltage and Frequency setpoints
- ADC
 - Scaling factor for ADC
 - Filter Time Constants
- System Information
 - Library Version number and Task turnaround time information



ACMC Motor Control Demo (Scalexio)

Speed Response
Plotter



FPGA Scope

Offset
Calibration

Over Current
Protection

ACMC Motor Control Demo (Scalexio)

RELEASE 2020-A

Folder Structure

■ Configuration

- XSG_ACMC_Demo.zip (Configuration Desk back up project)





■ Instrumentation







- XSG_ACMC_PMSM_Demo.zip (Control Desk back up project)

■ Simulation

- _ControlPMSM (Controller Parameter)
- IniFiles (IO Initialization Parameter)
- Model (Simulink Model)
- XSG_ACMC_PMSM_rtiFPGA (Firmware Files)
- go.m (Matlab Script)

■ Documentation

 Configuration	27.04.2020 15:10	File folder
 Documentation	27.04.2020 15:10	File folder
 Instrumentation	27.04.2020 15:10	File folder
 Simulation	27.04.2020 15:10	File folder

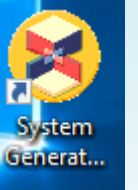
Data (D:) > XSG_ACMC_PMSM_Demo_Scalexio > Simulation				
Name	^	Date modified	Type	Size
 _ControlPMSM		27.04.2020 15:10	File folder	
 IniFiles		27.04.2020 15:10	File folder	
 Model		27.04.2020 15:10	File folder	
 XSG_ACMC_PMSM_rtifpga		27.04.2020 15:10	File folder	
 go.m		01.04.2020 19:41	MATLAB Code	5 KB
 SimulationInit.m		08.08.2019 10:23	MATLAB Code	31 KB

ACMC Motor Control Demo (Workflow to Edit Demo Model)

Simulink Demo

■ Step 1

- The Xilinx system generator should be opened and thereafter Demo folder /Simulation should be selected.
- go.m should be executed and corresponding Simulink File is opened by the script.

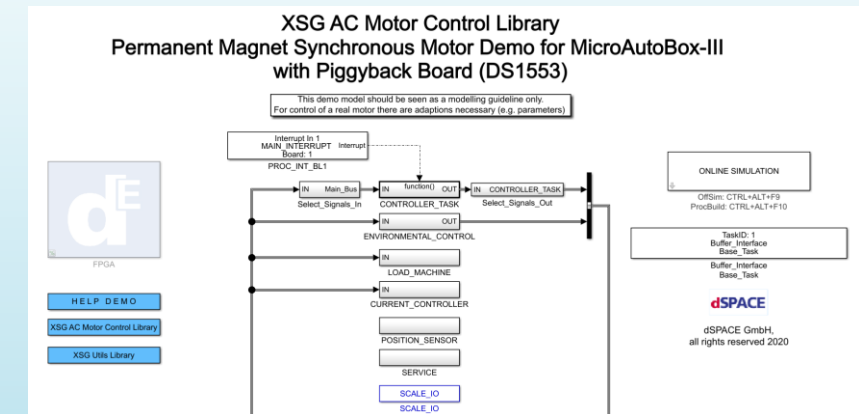


■ Step 2

- Configuration Desk –Implementation version should be opened
- XSG_ACMC_Demo.zip Configuration Desk Back up project should be opened.
- Platform, if need, must be registered.
- Add Simulink Model to Configuration Desk and Analyze Model

■ Step 3

- Any conflicts that may appear in Configuration Desk must be resolved
- A test build needs to be performed.
- The test build should generate a SDF file successfully.



ACMC Motor Control Demo (WorkFlow)

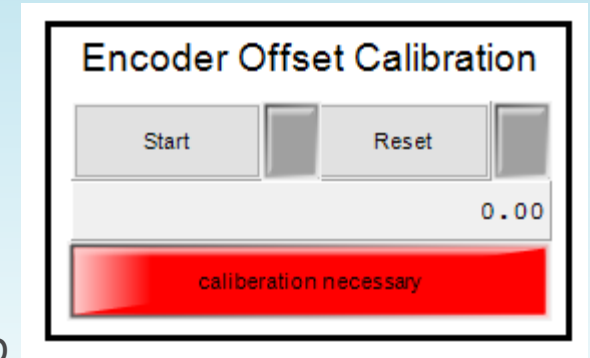
Control Desk Before Start

■ Step 4

- XSG_ACMC_PMSM_Demo.zip Control Desk Back up Project must be loaded.
- The Platform connection is checked SDF file provided with the control Desk backup experiment is loaded.
- Note SDF file generated in Step 3 can be loaded if needed by navigating to Configuration desk project build Folder.

■ Step 5

- Check the encoder offset calibration instrument if it shows drive ready
- If not then press **Start** on the Instrument.
- Check if the Drive safety status is OK (Global Error LED is NOT Red)



Drive Safety Settings					
Global_Error[0 1]					
Global Reset		Threshold	Err	Actual Value	Hold Value
Zero Current [A]		1		0.01	0.01
i2 [A2]		125		0.00	0.00
i2_Fi [A2]		100		0.00	0.00

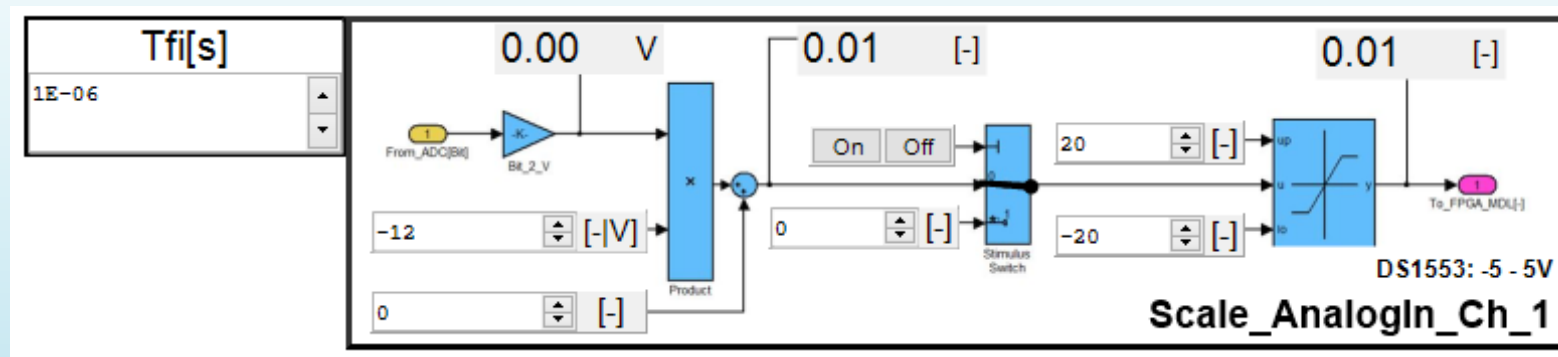
NOTE: During Encoder Calibration make sure Processor Control is active.
See Slide No 6

ACMC Motor Control Demo (WorkFlow)

Control Desk Before Start Contd..

■ Step 6

- The Scaling Factors of ADC from the ADC Layout must be checked
- Scaling Factor for Current sensors RapidPro Setup is usually -12
- Scaling Factor for DC link Voltage is usually 6. (Note that the scaling factor is not same for all ADC)
- Sensor PT1 Filter values, if necessary, should be adjusted



ACMC Motor Control Demo (WorkFlow)

Control Desk Static Setpoints

■ Step 7

- Demo is ready for operation.
- Different Control Modes and set points from the Controller layout can be set.
- FPGA based Current Control or Processor based Current Control can be selected.
- Dynamic setpoints can be set using Dynamic setpoint layout

The screenshot displays the 'Control Desk Static Setpoints' interface. At the top, there is a dropdown menu labeled 'Activate_Dyn_Setpoint[0]1)Value' with 'STATIC Setpoints' selected. Below this, there are two main tabs: 'Proc Control' (highlighted in green) and 'FPGA Control'. Under 'Proc Control', there is a 'CONTROL MODE' section with four radio buttons: 'Speed Control', 'Current Control', 'OL ABC' (selected), and 'OL DQ'. To the right of these are several input fields with numerical values and up/down arrows: 'Speed[rpm]' (0.0), 'n_Set[rpm]' (500), 'i_d_Set[A]' (0), 'i_q_Set[A]' (0.9), 'v_d_Set[V]' (0), 'v_q_Set[V]' (0), and 'OL_DQ_f_Set[Hz]' (2). At the bottom, there is a 'Load_Enable' section with a checked 'Check' box and a 'Load_Torque[Nm]' input field (0). The 'FPGA Control' tab is currently inactive.

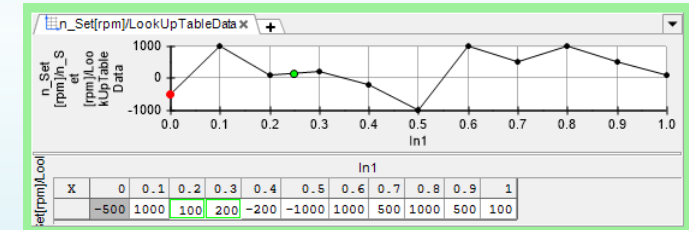
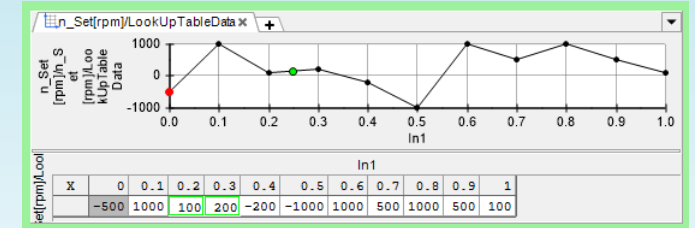
Proc Control		FPGA Control	
CONTROL MODE	Speed[rpm]	n_Set[rpm]	
	0.0	500	
	i_d_Set[A]	i_q_Set[A]	
	0	0.9	
	v_d_Set[V]	v_q_Set[V]	
	0	0	
	OL_DQ_f_Set[Hz]		
2			
Load_Enable	Load_Torque[Nm]		
<input checked="" type="checkbox"/> Check	0		

ACMC Motor Control Demo (WorkFlow)

Control Desk Dynamic Setpoints

■ Step 7

- Different Control Modes can be selected in the Dynamic setpoints layout.
- Setpoint tables have Values that can be edited using the table editor tool
- Default time period of the entire cycle is 20 Seconds and can be changed in Real time from Control Desk



ACMC Motor Control Demo (Extras)

Control Desk Extra – FPGA Scope

- **FPGA Scope can show signals directly from FPGA**
 - FPGA Scope measures various signals within the FPGA and displays them on control Desk at FPGA clock. For Example: 12.5 nS in case of MABX.
 - The measurement can be triggered using signals mapped on the scope or from the Processor.
 - For more details on the scope refer to XSG_Utils Documentation
- **NOTE: LED underneath the scope shows which control mode is currently on FPGA or Processor.**



ACMC Motor Control Demo (Extras)

Control Desk Extra Drive Safety

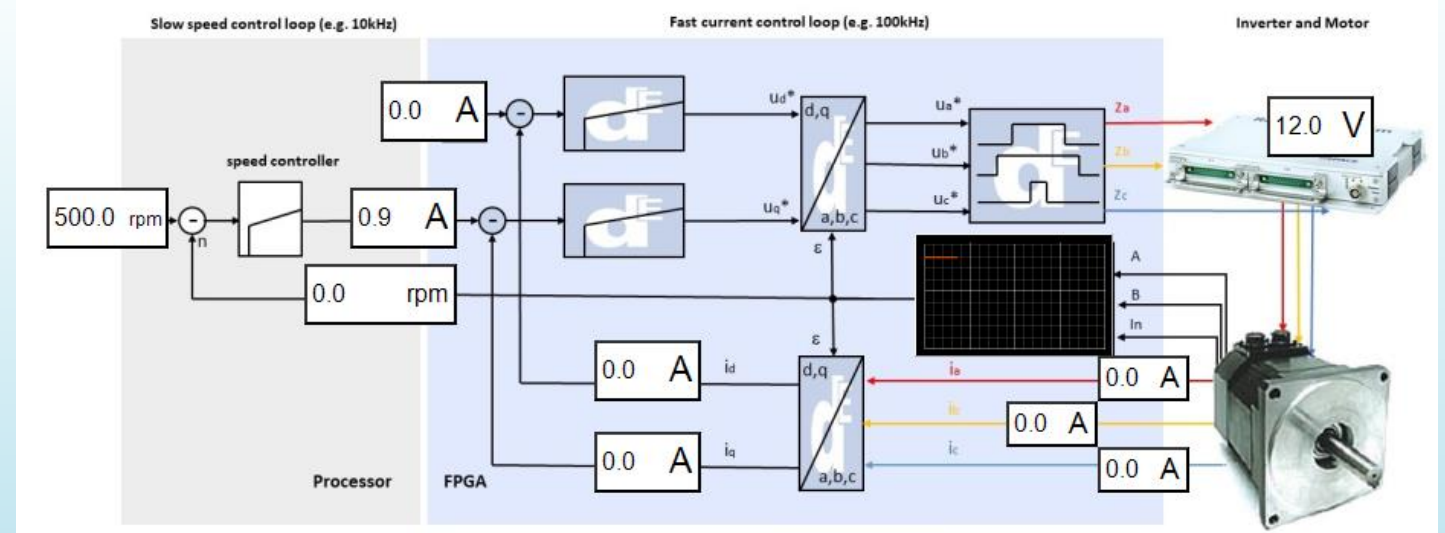
- Drive Safety Instrument can Protect the motor against
 - Zero Current Error (If one or more ADCs are faulty)
 - i2 protection (Protects against exceeding maximum rated motor current)
 - i2_Fi (Protects against high current applied to motor for a long period of time)
- Actual Value on the instrument Shows the real time values
- Hold Values show values when error occurs.

Drive Safety Settings				
Global_Error[0 1]				
Global Reset		Threshold	Err	Actual Value
Zero Current [A]	1			0.01
i2 [A2]	125			0.00
i2_Fi [A2]	100			0.00

ACMC Motor Control Demo (WorkFlow)

Control Desk Extra Overview Diagram

- Overview diagram shows the current state of the motor inverter setup i.e. 3 phase currents DC link voltage. D and q currents and various set points
- Speed Control of the motor is always in Processor. However the current control loop can be Processor based or FPGA based.



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