

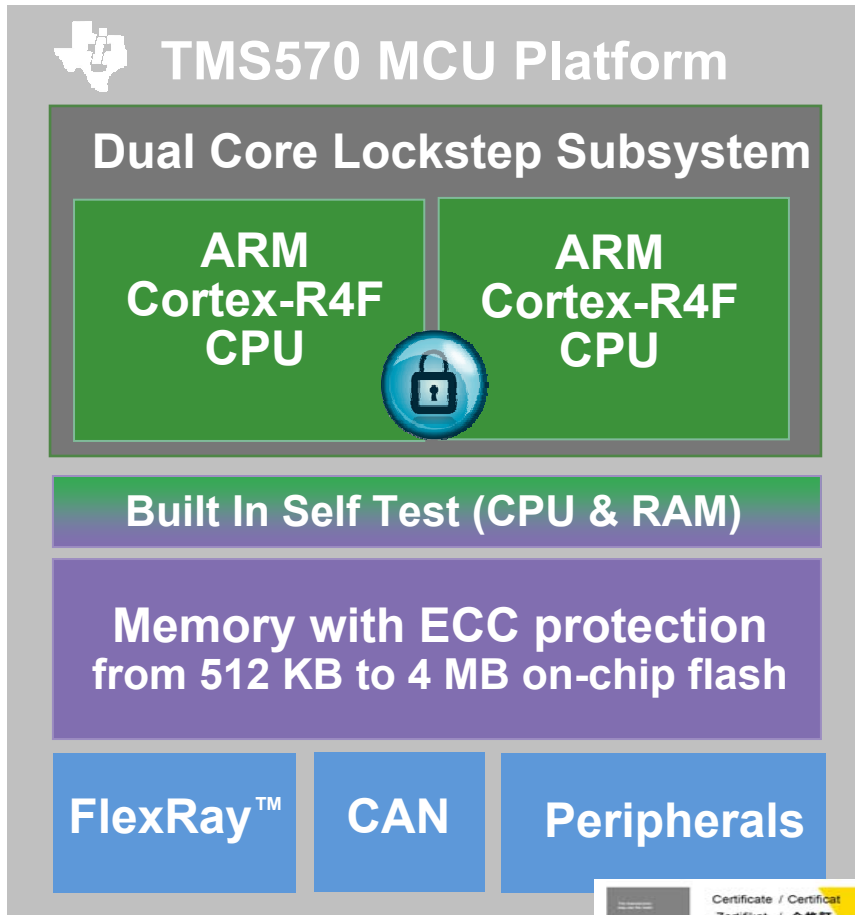


**TI Innovation Day France 2010**

# **TMS570 for safety critical motor control application**

**Marie-Claire DESJARDINS**

# TMS570 Developed Specifically to Simplify SIL3 / ASIL D Safety System Implementations

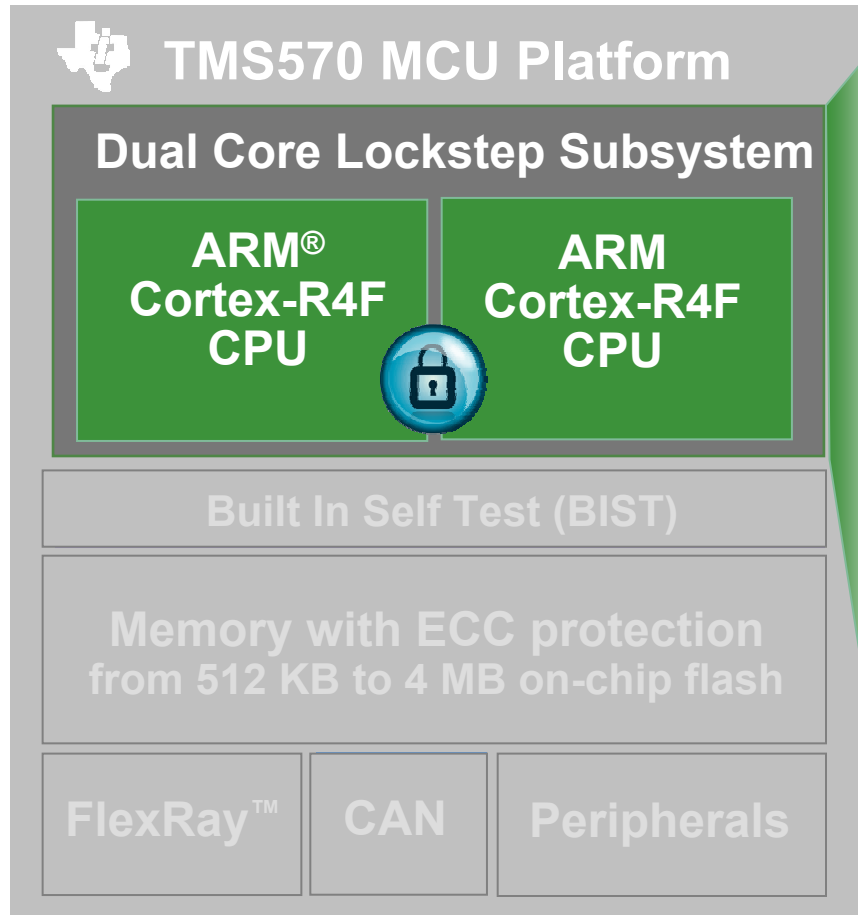


...The SafeTI Controller

- TMS570 developed with a functional safety management plan and has been assessed by *Exida* for use in SIL3 safety systems
- ARM Cortex-R4F floating-point CPU available today up to 160MHz going to 200+MHz
- Dual core lockstep, ECC on Flash/RAM, Built-In-Self-Test provides high diagnostic coverage and simplifies safety development
- Scalable family of embedded Flash MCU's going from 512KB up to 4MB
- Flexible Automotive peripheral set designed to offload CPU load
- Samples, Software Development Tools, AutoSAR drivers available Today!!



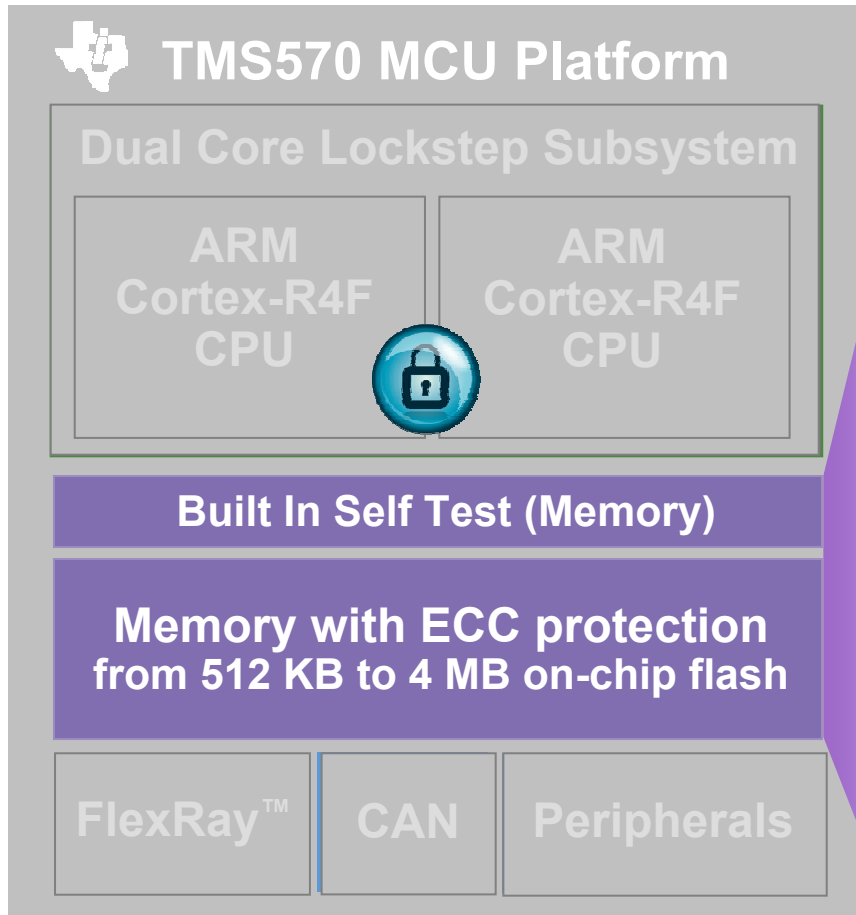
# TMS570 Floating Point Unit Helps Simplify Complex Control Algorithms



## Protected Dual-Core Floating-Point TMS570 MCU

- First ARM Cortex-R4F floating-point MCU available
- Single precision / double precision IEEE 754 floating-point math
- Fast Multiply, Divide, and SQRT enables physical model based control and simplifies algorithm implementation
- Floating point and integer instructions can operate in parallel for higher performance at lower frequency
- Dual Core Lockstep simplifies software development with high diagnostic coverage for safety critical system implementations

# TMS570 Developed Specifically to Simplify SIL3 / ASIL D Safety System Implementations



## Protected memory

- Enhanced ECC logic integrated in Cortex-R4F protects both memories and busses
- Address protection of busses and memory decoders
- All memories can be tested using HW BIST for high diagnostic coverage
- Background 64b hardware CRC using DMA provides additional coverage for static data in memories
- Integrated Memory Protection Unit protects against deterministic errors in application software (8 regions)

# TMS570LS20216

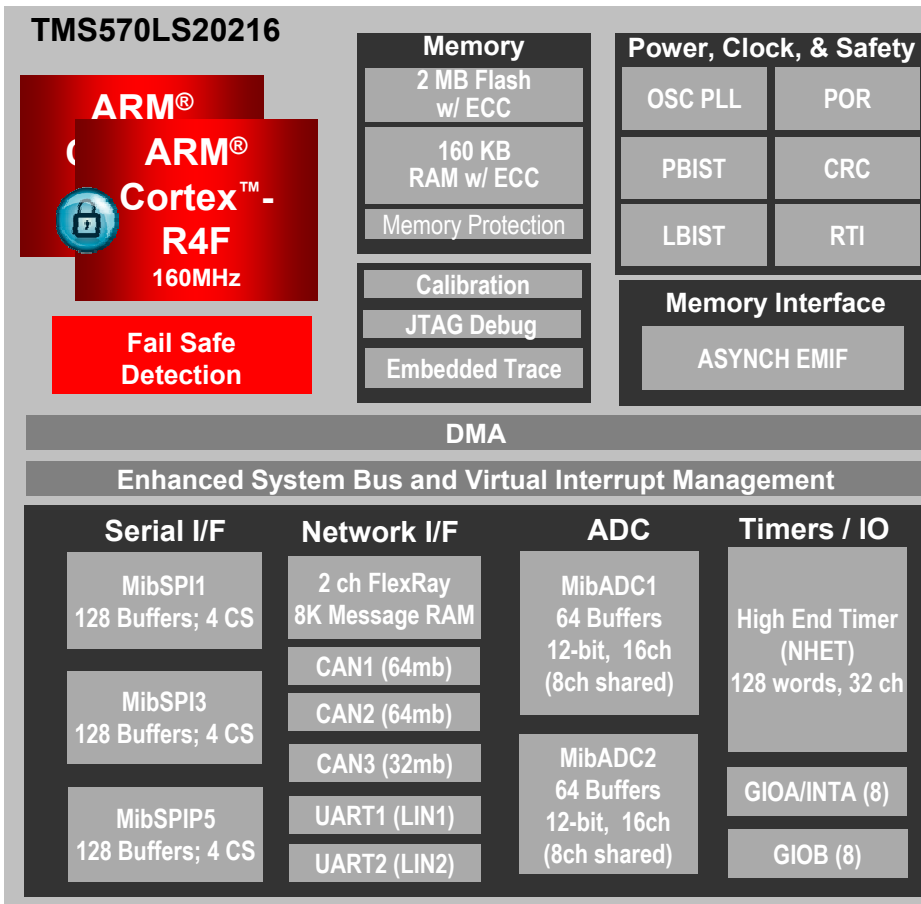
## Features

- 160 MHz ARM Cortex-R4F w/ Floating Point
- 2MB Flash and 160KB Data SRAM
- 16 Channel DMA
- **Safety**
  - Dual CPU's in Lockstep
  - CPU Logic Built in Self Test (LBIST)
  - Flash & RAM w/ ECC (w/ bus protection)
  - Memory Built-in Self Test (PBIST)
  - Cyclic redundancy checker module (CRC)
  - Peripheral RAMs protected by Parity
- **Reliability**
  - Low PPM Production Flow Support
  - Extended Temp and AEC-Q100 Qualification
- **Communication Networks**
  - FlexRay with 8KB RAM and dedicated DMA
  - 3 CAN Interfaces (2x64 messages, 1x32 messages)
  - 3 Multi-Buffered SPI (128 buffers/4CS each)
  - 2 UART – both with LIN 2.1 master support
- **Enhanced I/O Control**
  - High End Timer Coprocessor (NHET)
    - 32 channels and 128 instruction RAM
    - All pins can be used as Hi-Res PWM or Input Capture
    - Dedicated DMA for HET
  - 2 x12-bit Multi-Buffered ADC
    - 24 total input channels (8 shared)
    - Continuous Conversion Mode
    - Calibration and Self Test
  - 16 Dedicated GIO pins
    - 8 External Interrupt Capable

## Targeted Automotive Applications

- Integrated Chassis Control and ESC (Stability Control)
- Hybrid and Electric Vehicle Control
- Driver Assistance (Radar)

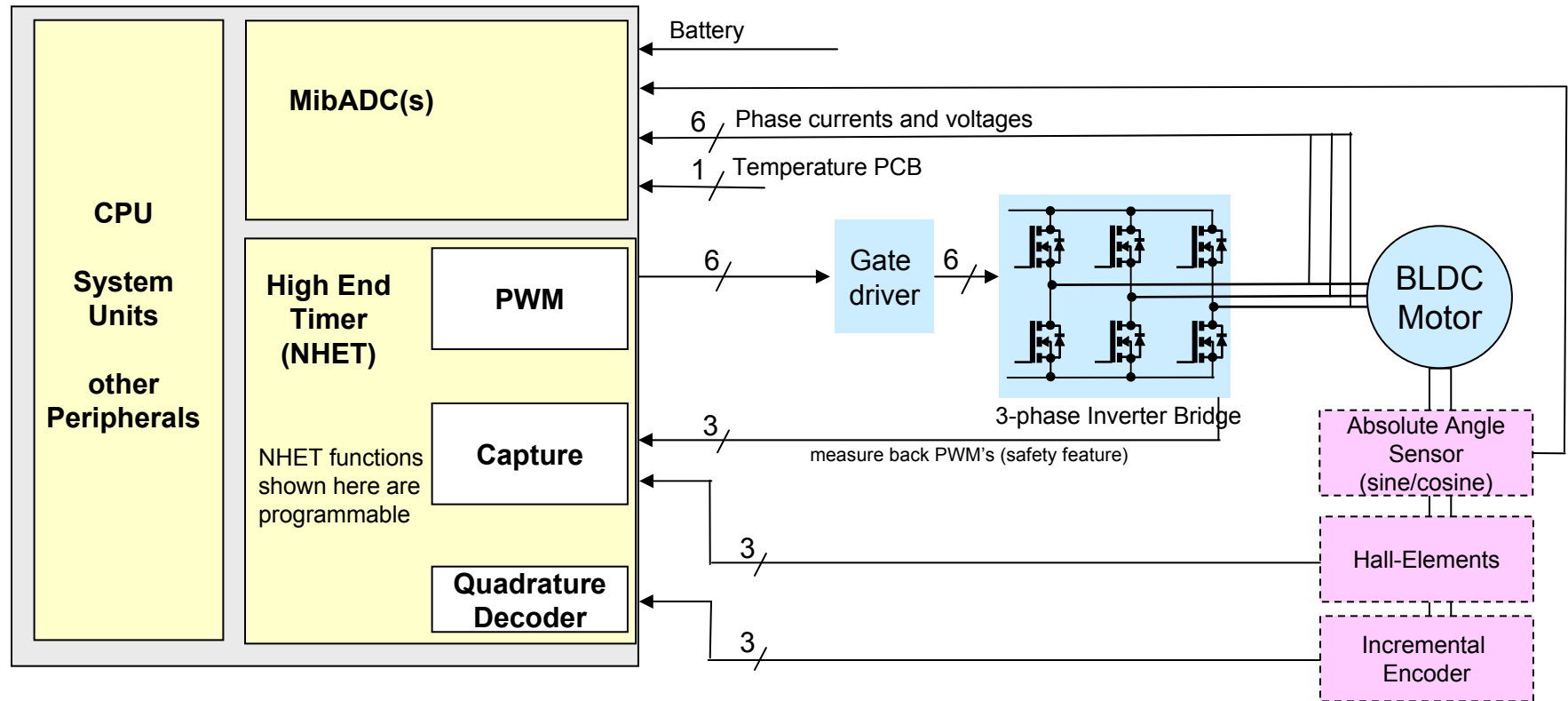
**Samples Today!**  
**Production Dec10**



Packages: LQFP: 144pin -20x20; nFBGA: 337 pin-16x16, 0.8mm  
-40 to 125 C Temperature Range

# BLDC Motor Control Example with TMS570

## TMS570 Microcontroller



Position / Speed measurement.  
(Usually just one of the 3 shown sensor types used)

# nHET: High End Timer Co-Processor

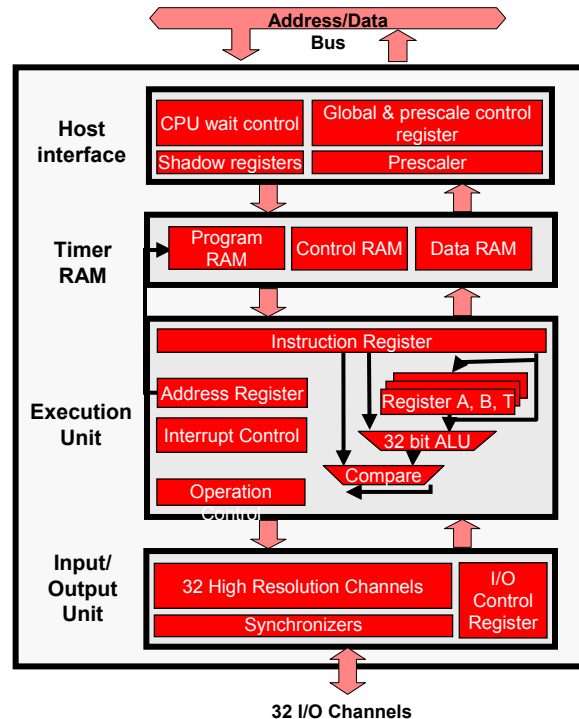
User Programmable  
128 word instruction  
RAM with Parity

Dedicated DMA (HTU)  
from NHET to Data Ram

32 I/O pins for complex  
or typical timing  
functions - capture,  
compare, PWM, GPIO

Conditional program  
execution based on pin  
conditions and  
compares

Multiple 25-bit virtual  
counters for timers,  
event counters, and  
angle counters



- Frees CPU MHz
- Supports typical/complex functions
- Simplified development environment

## Pulse Width Modulation

- Single, multi channel PWMs
- PWM with duty cycle update
- PWM with sync/async update
- Phase shift PWM's
- Symmetrical & asymmetrical PWM with deadband

## Timer/Counter Functions

- Frequency Modulated Output
- Pulse width count
- Time stamp
- Event counter
- Pulse accumulator
- Multi-resolution scheme

## Freq / Pulse Measurements

- Pulse and period measurement (same channel)
- Quadrature Decoding

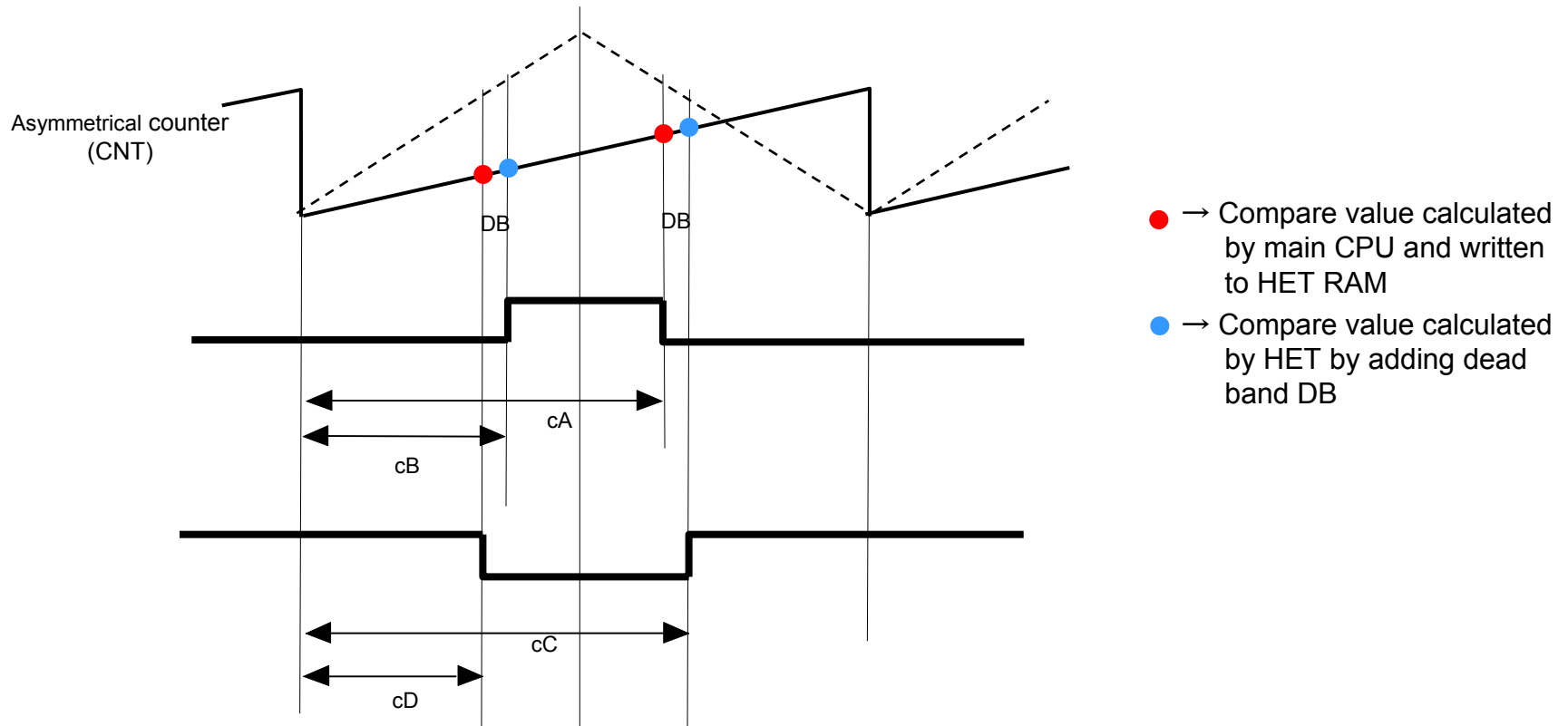
## Special Functions

- SPI Emulation
- TFT Display Timing

# PWM Made Simple with NHET

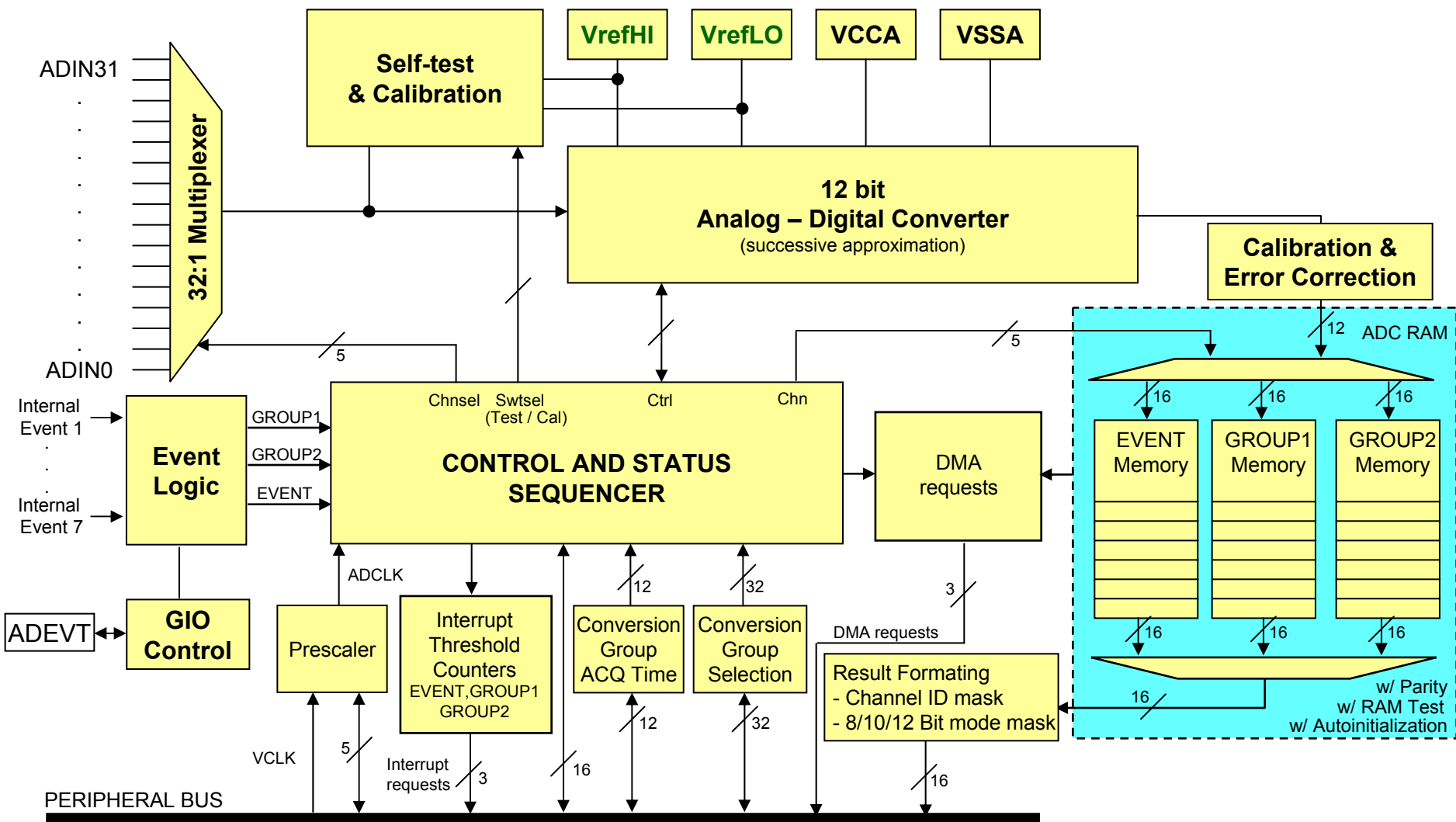
## Symmetric, Asymmetric, Deadband

- NHET supports any number of counters and compares – limited only by instruction RAM
- With NHET simply specify all four toggle points per pin pair – Or specify a subset and let NHET compute the rest of the points.
- Multiple pins may share the same counter if desired





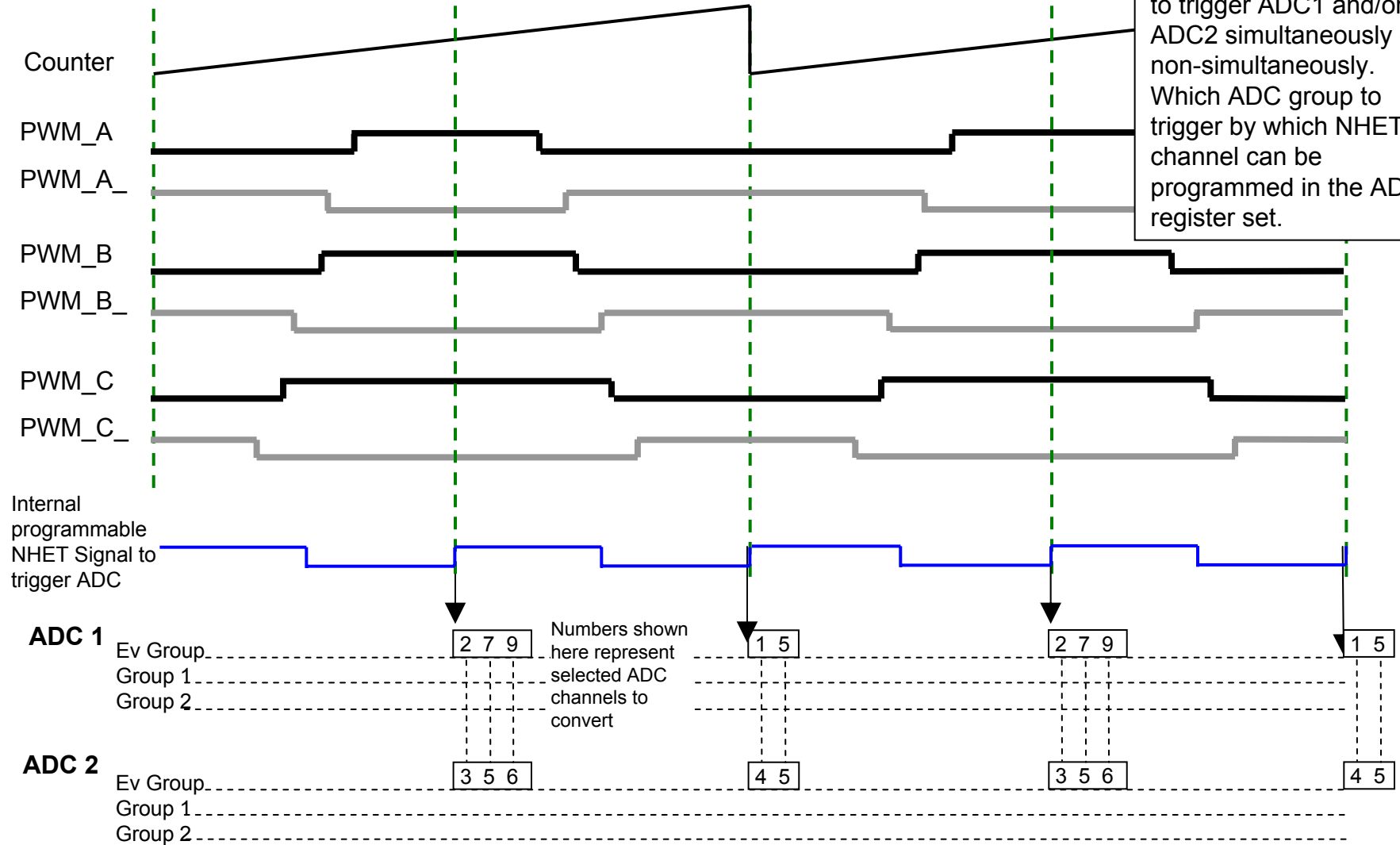
# 12 Bit MibADC Module



# NHET ADC Triggering -

## Example for symmetrical PWMs

On TMS570LS20216 there are 4 NHET channels which can be programmed to trigger ADC1 and/or ADC2 simultaneously or non-simultaneously. Which ADC group to trigger by which NHET channel can be programmed in the ADC register set.

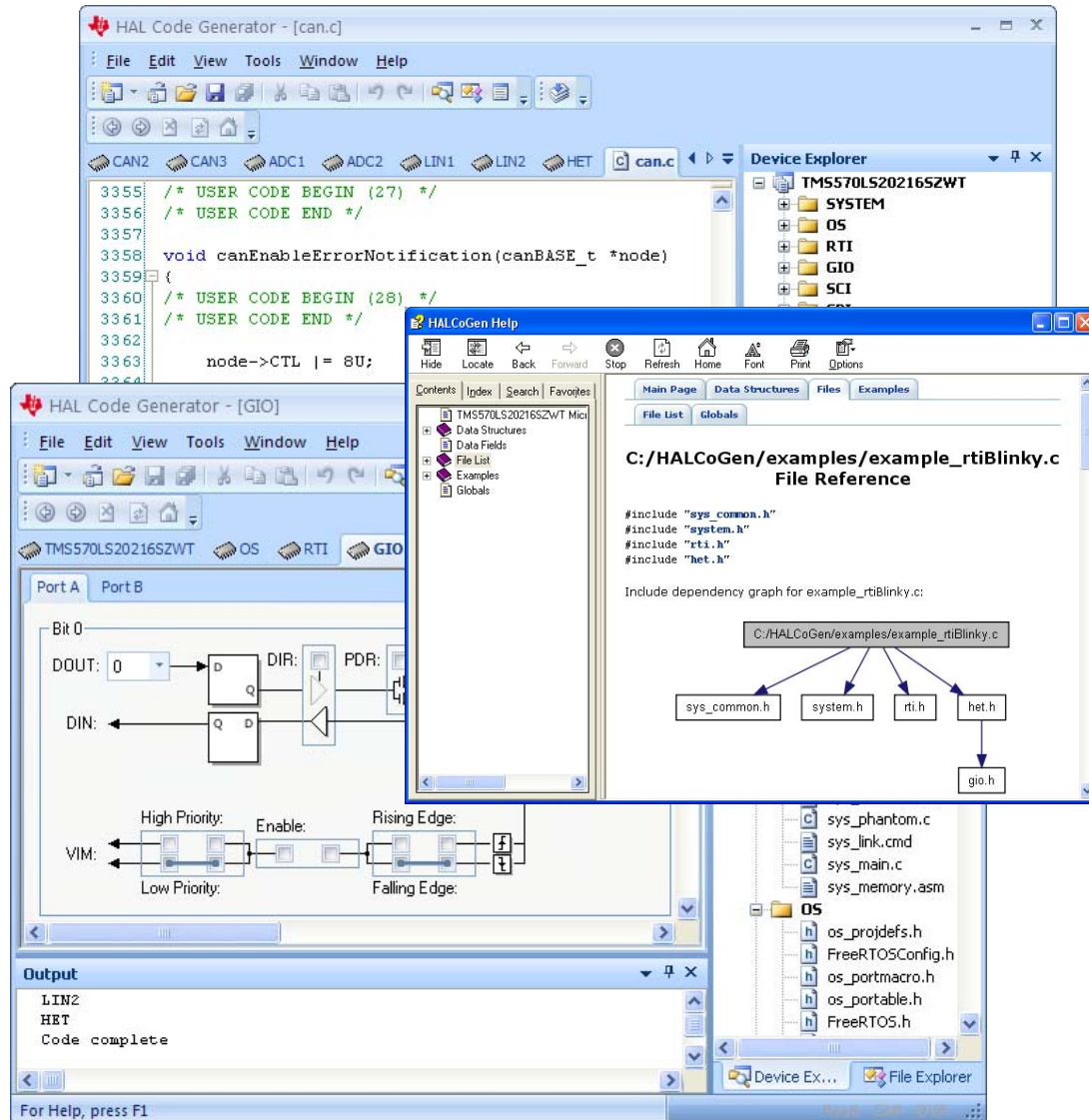


# NHET/ADC Feature Examples for 3 Phase Electric Motor Control

- Effective support of many different motor control concepts and application concepts due to NHET programmability
  - Single or multiple shunt systems
  - Deadband generation required or not
  - Number of input and output channels freely programmable
- Symmetrical and Asymmetrical PWM with deadband
- High flexibility to synchronize PWM duty cycle updates
- Quadrature Decoding
- Implementation of state machines (e.g. for block commutation)
- NHET can trigger the ADC(s) with many configuration possibilities
- NHET and ADC can trigger DMA (or optionally local transfer units) to transfer values without CPU intervention

# HALCoGen

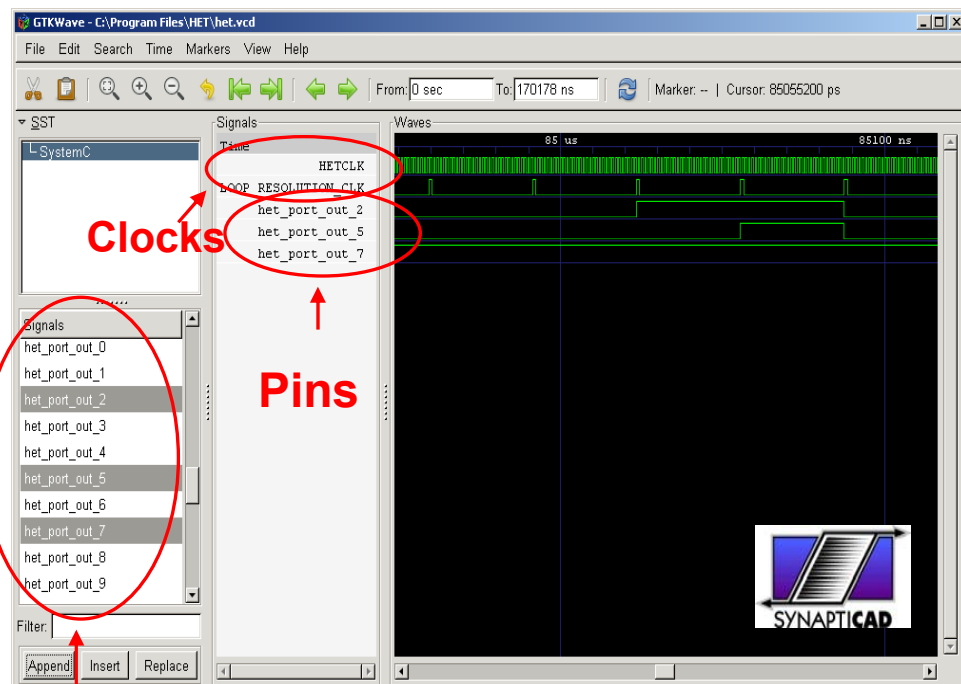
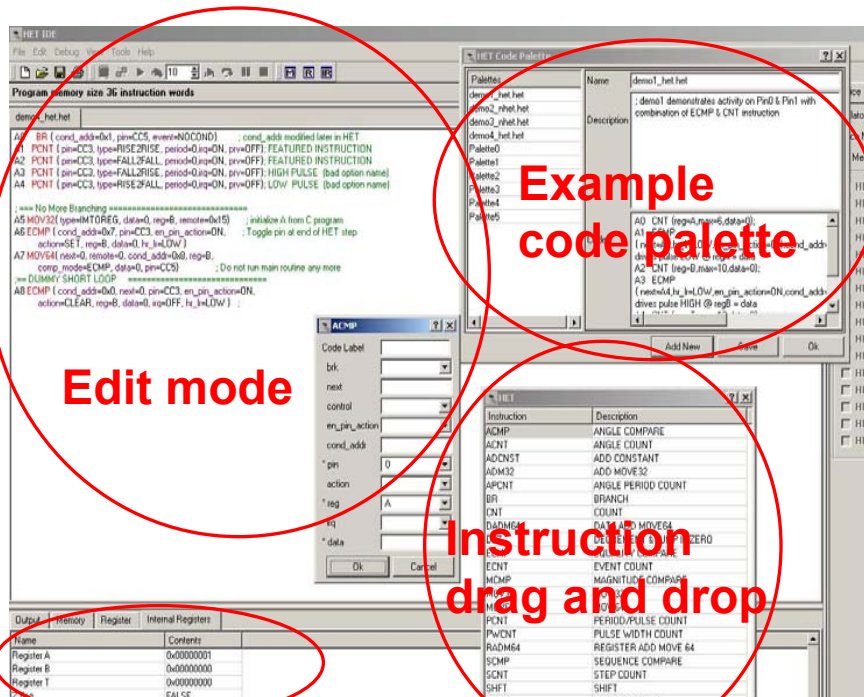
## Hardware Abstraction Layer Code Generator



## Features

- **User Input on High Abstraction Level**
  - Graphical-based code generation
  - Easy configuration
  - Quick start for new projects
- **Generates C Source Code**
  - ANSI Conforming
  - Clear, structured, coding style
  - Customizable code for user maintenance
- **Supported Peripherals**
  - System Module
  - RTI
  - GIO
  - SCI/LIN
  - CAN
  - SPI
  - ADC
  - Timer Co-processor (nHET)
- **Interactive Help System**
  - Describes tool features and functions
  - Provides detailed dependency graphs
  - Provides useful example code
  - Tool tip help available
- **Hierarchical project code viewing**

# Timer Co-Processor Development Tools



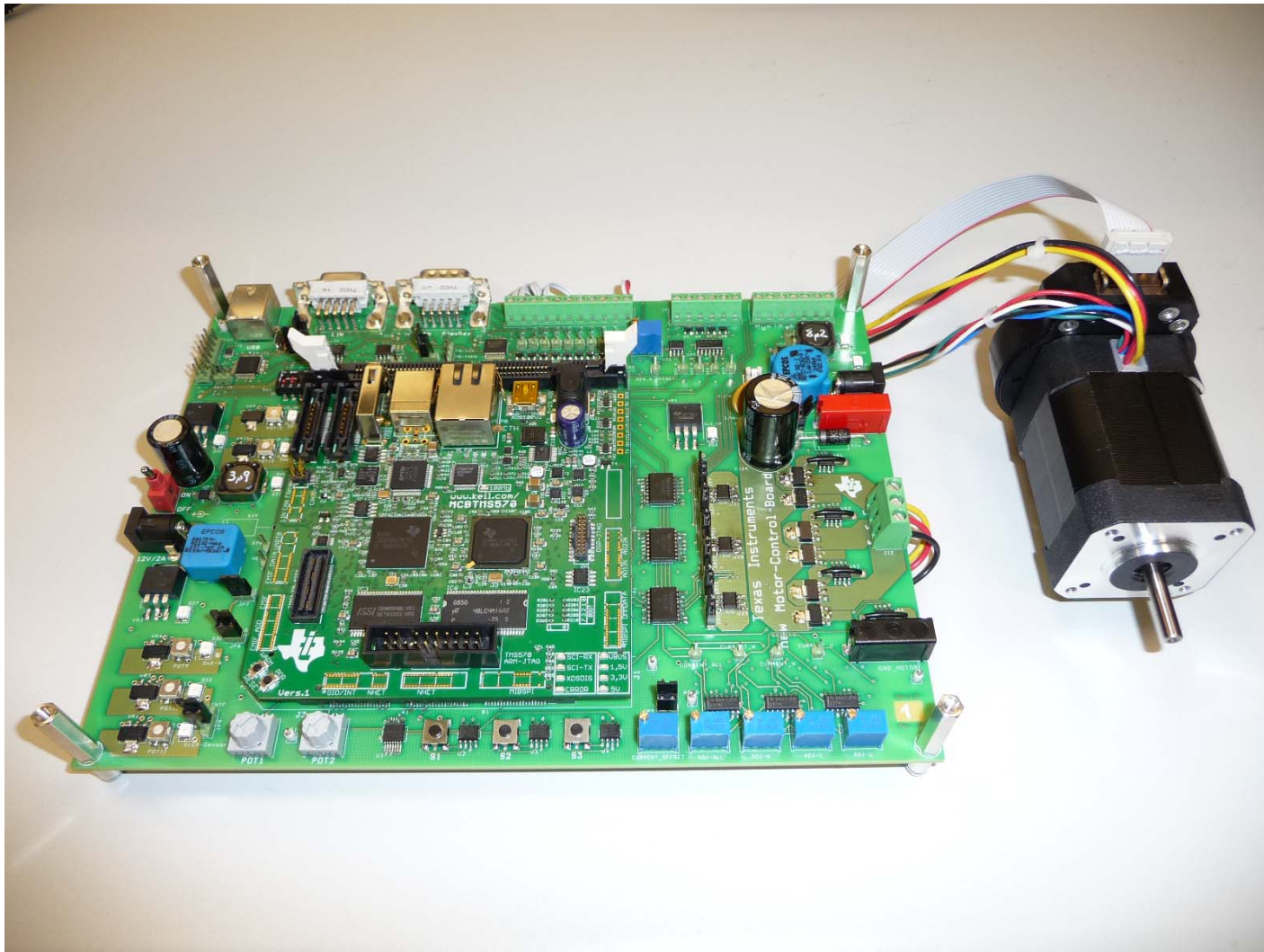
## Internal Registers & Memory

- Graphical Programming Environment
- Output Simulation Tool
- Generates CCS-ready software modules
- Includes functional examples from TI

## Select pins for waveform

- Graphical Waveform Viewer
- Input Generation Tool
- Seamless interface to coding tool
- Upgradable to Full SynaptiCAD

# Motor Control Demo System



# Motor Control Demo System: Field Oriented Control (FOC)

