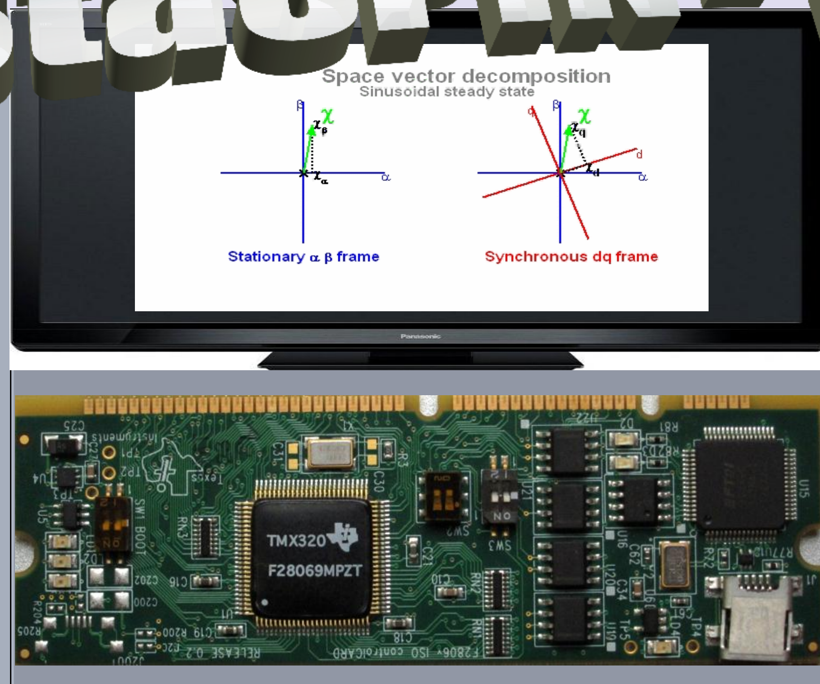
2014 Texas Instruments Motor Control Training Series

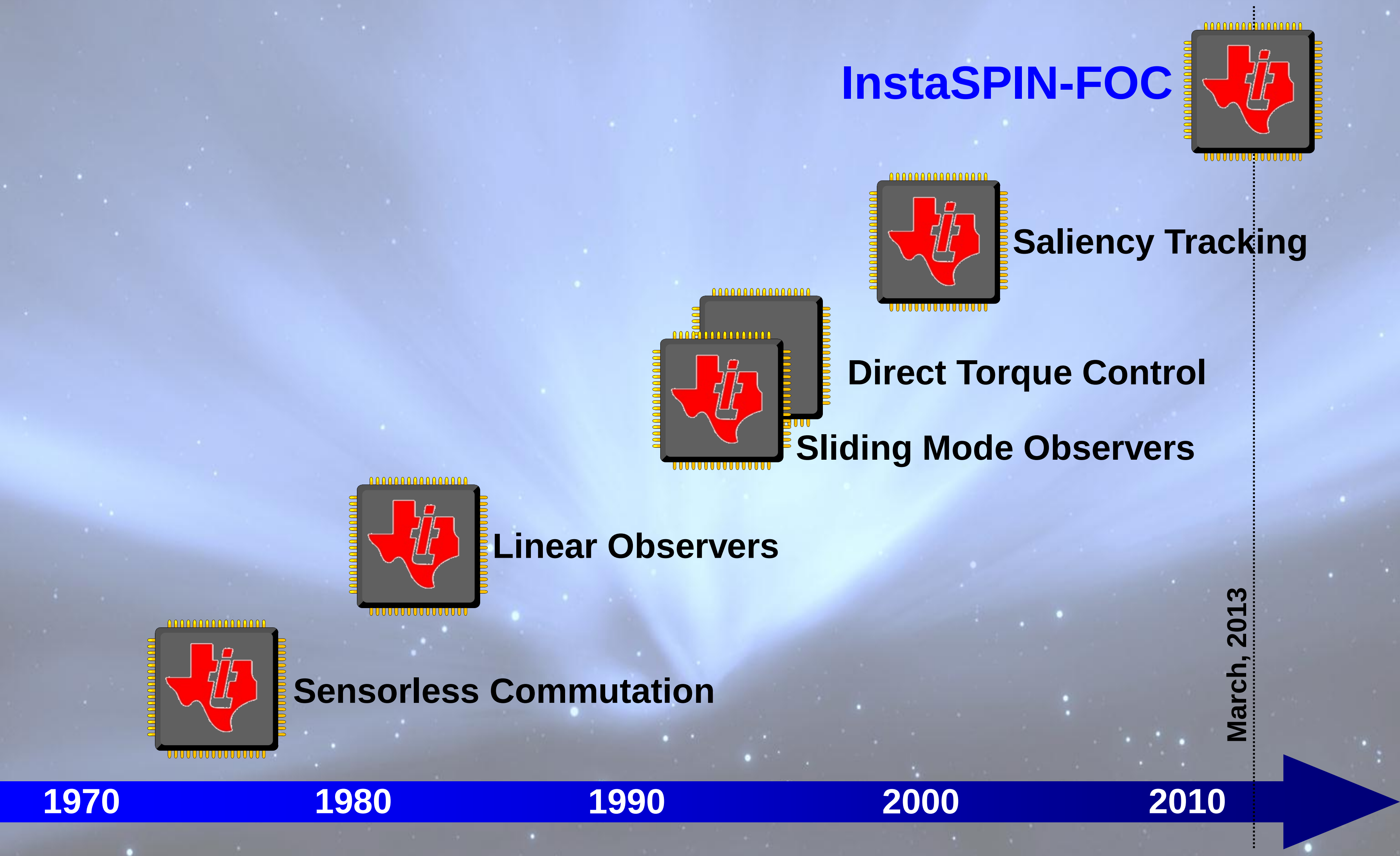
Intro to InstaSPIN-FOC



Dave Wilson

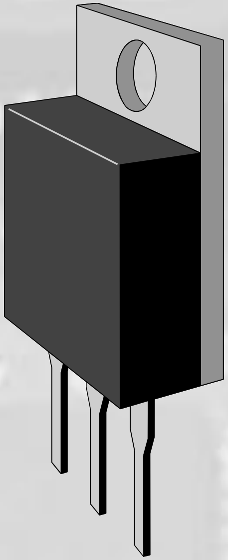
Texas Instruments

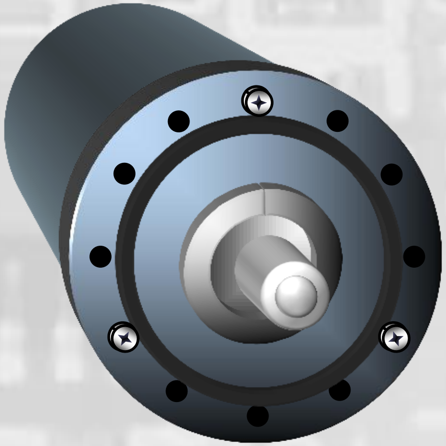
Evolution of Sensorless Drive Technology



InstaSPIN-FOC Solution

"M" or "F" suffix





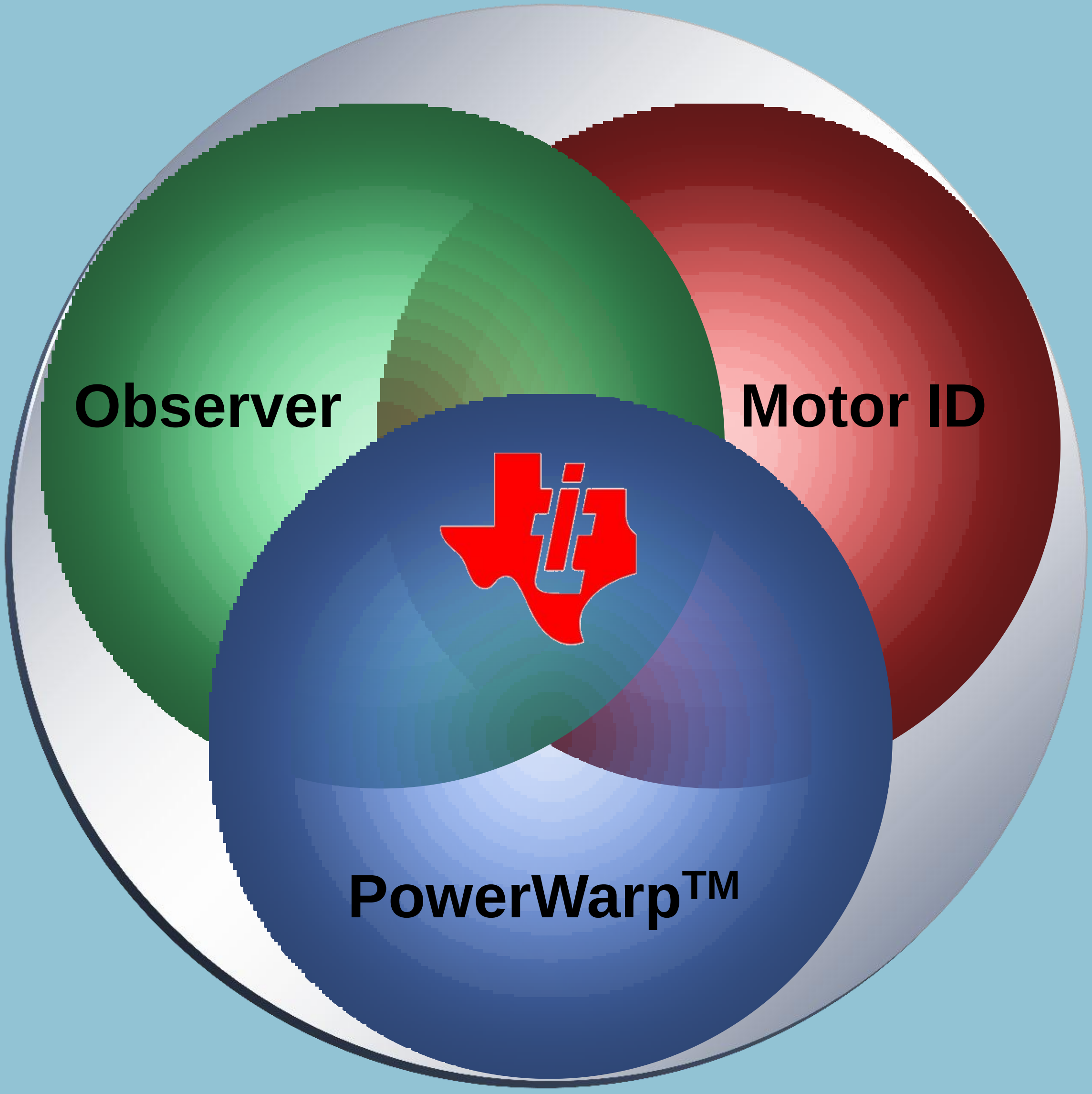
DRV8301 DRV8312 Kits

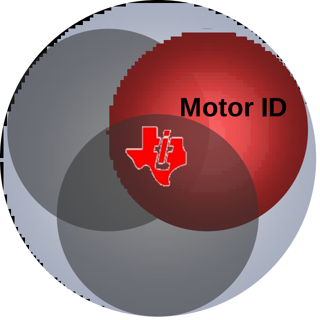
High Voltage Motor Control + PFC Kit

InstaSPIN-FOC

BLDC FOC
ACIM FOC
PMSM FOC
IPM FOC
Stepper FOC (under study)
SR (under study)

InstaSPIN-FOC



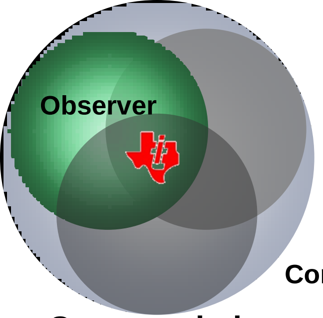


Motor Identification

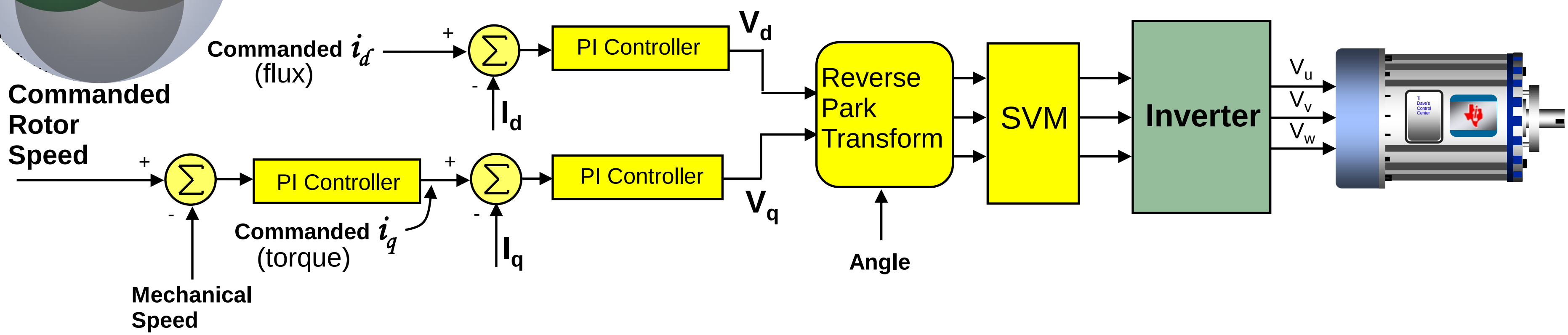
No datasheet required!

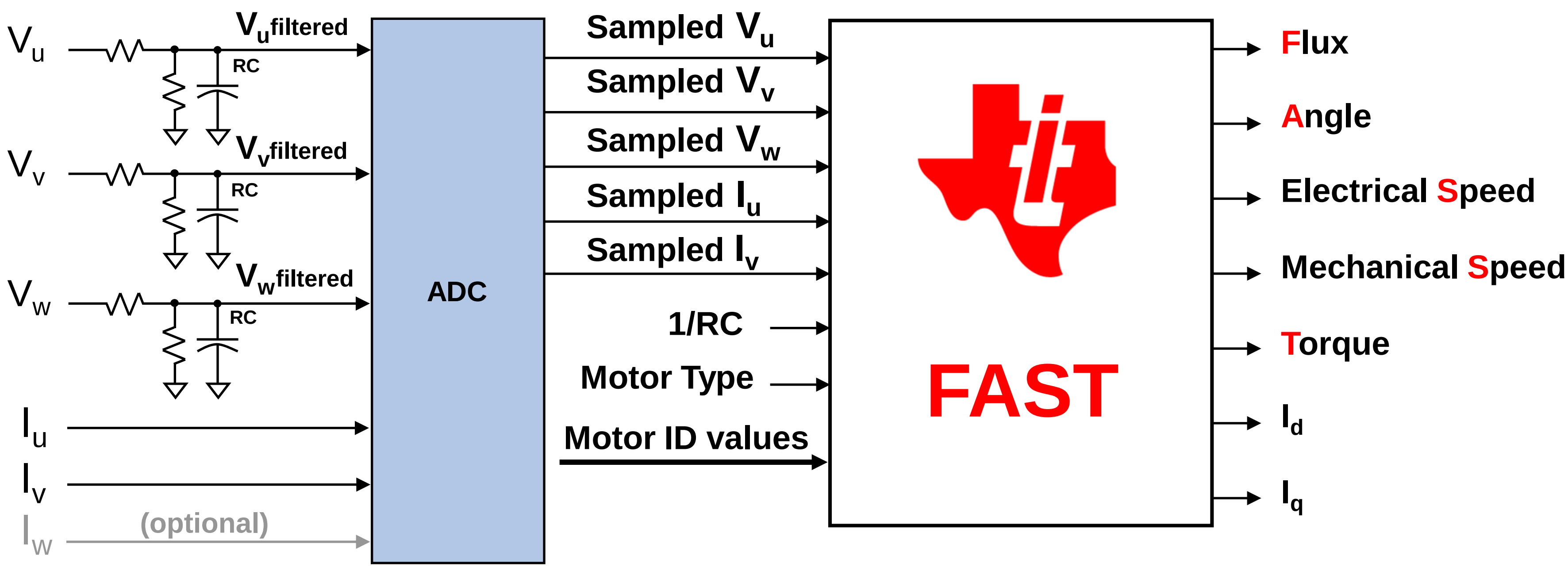
- For permanent magnet machines, FOC operation requires only the current rating from the user. Motor ID takes care of the rest. †
- For ACIM FOC operation, the user provides only the rated current, rated voltage, and rated frequency. Motor ID takes care of the rest. †
- For ACIM FOC operation, rotor parameters are not required. †*
- Automatic offset correction for all voltage and current measurements.
- Automatic current loop tuning
- Dynamic Rs observer running in real time.

† *For speed control applications, additional information is required about motor pole-pairs and load inertia.*
* *For speed control applications, rotor resistance is automatically calculated for use in determining motor slip.*



Observer / Estimator





Angle Estimation Error: 750 RPM with Dynamic Load

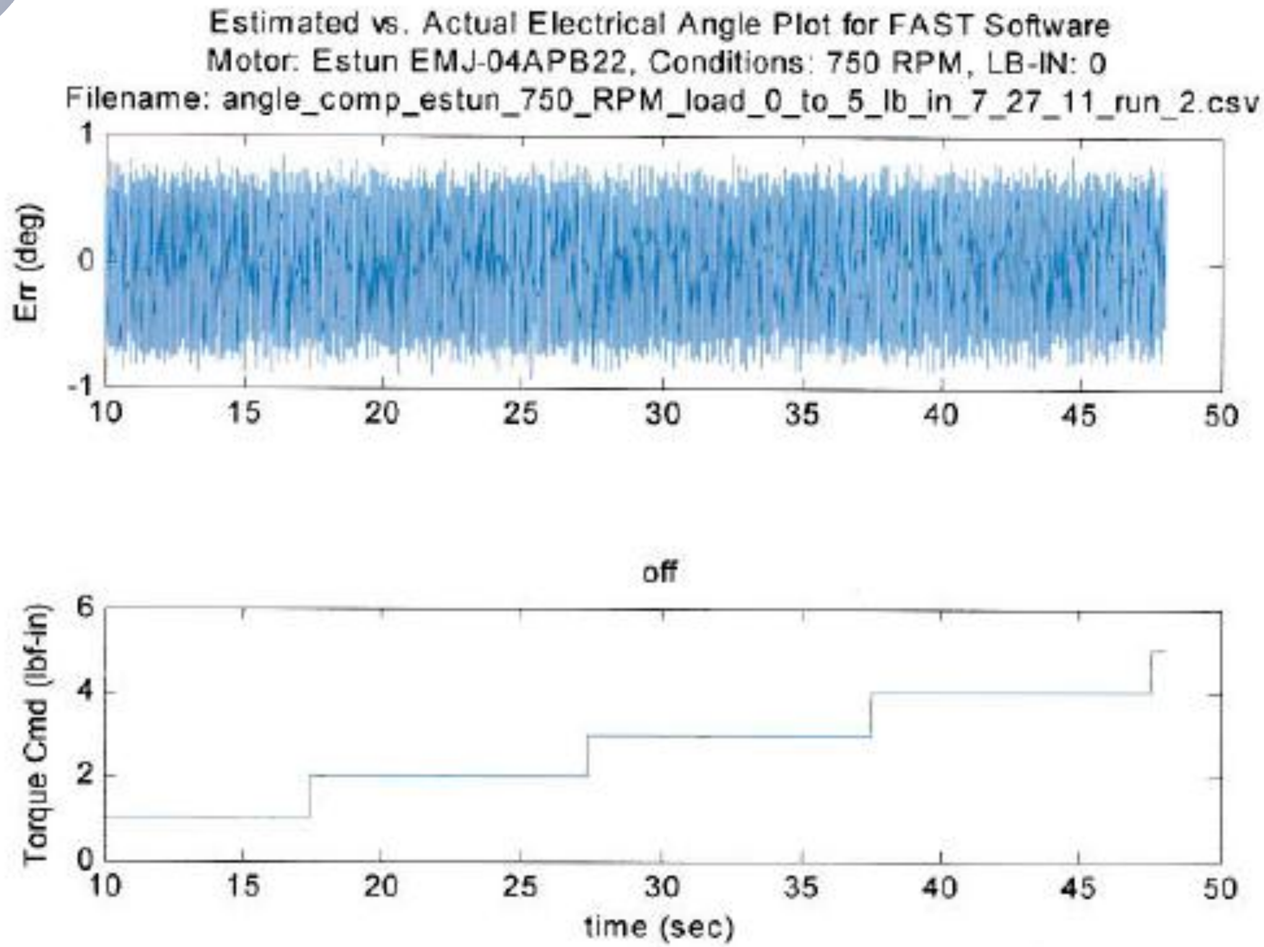
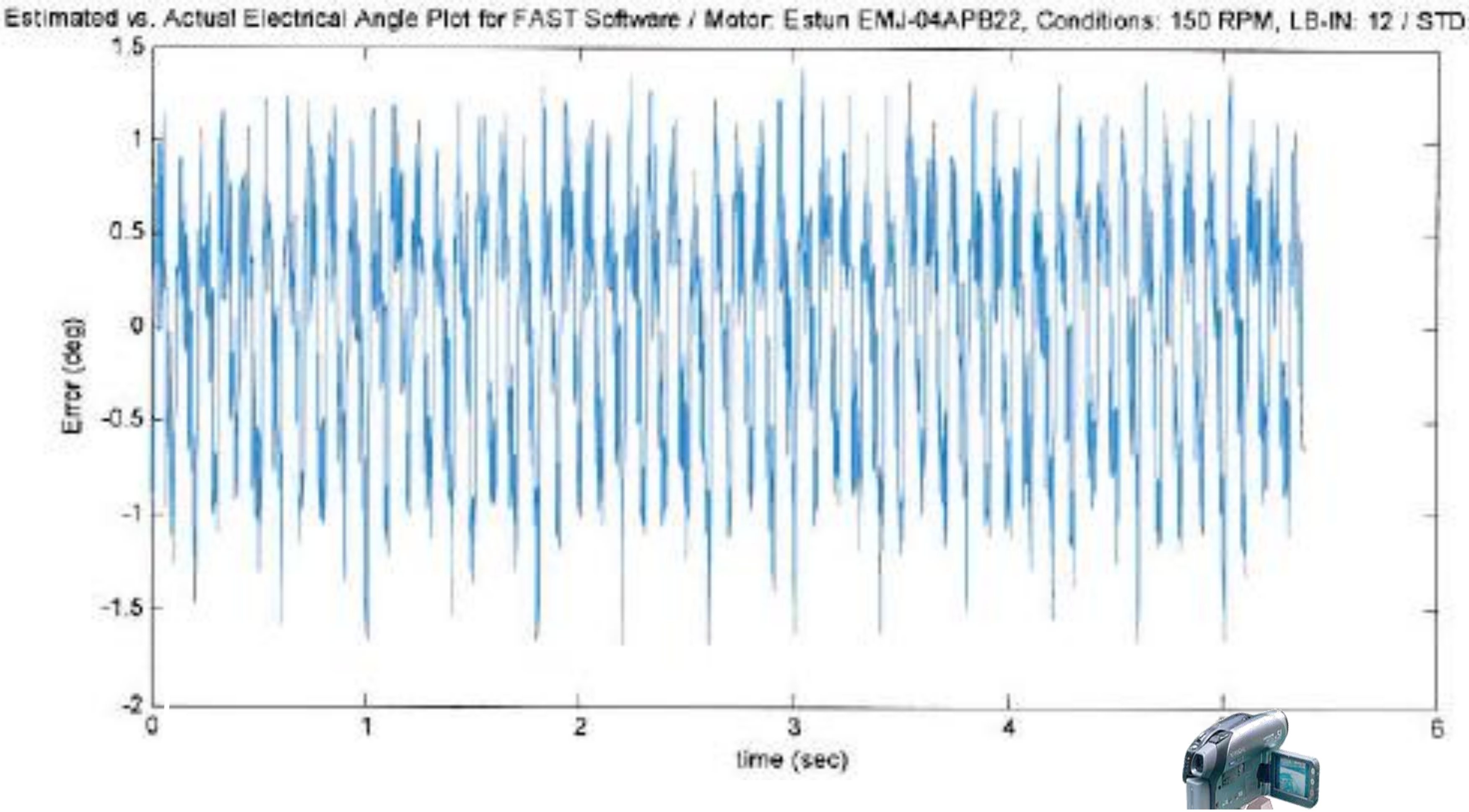
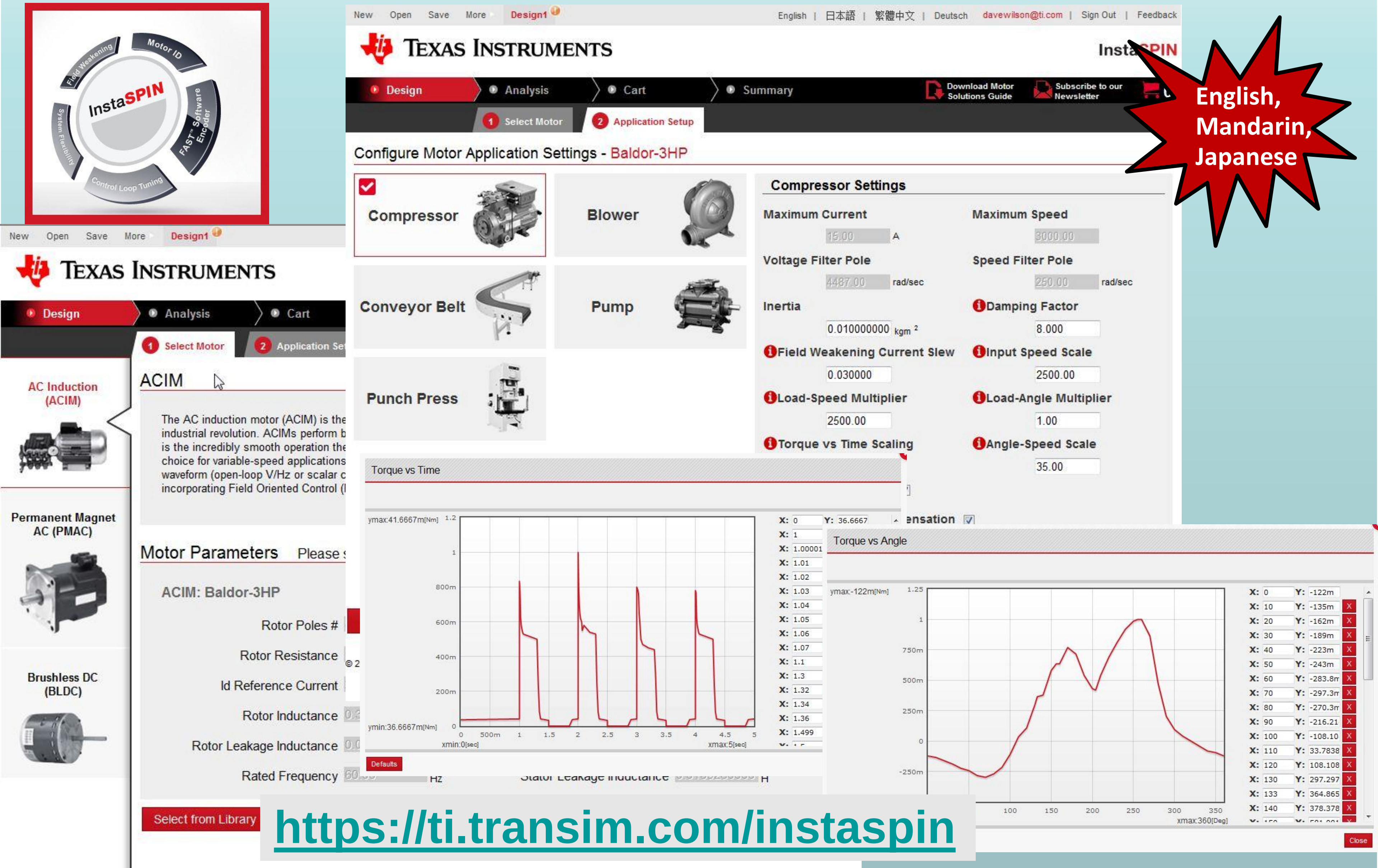


Fig. 29: Estimated Angle Error with Staircase Load

Angle Estimation Error: 150 RPM (10 Hz), Full Load



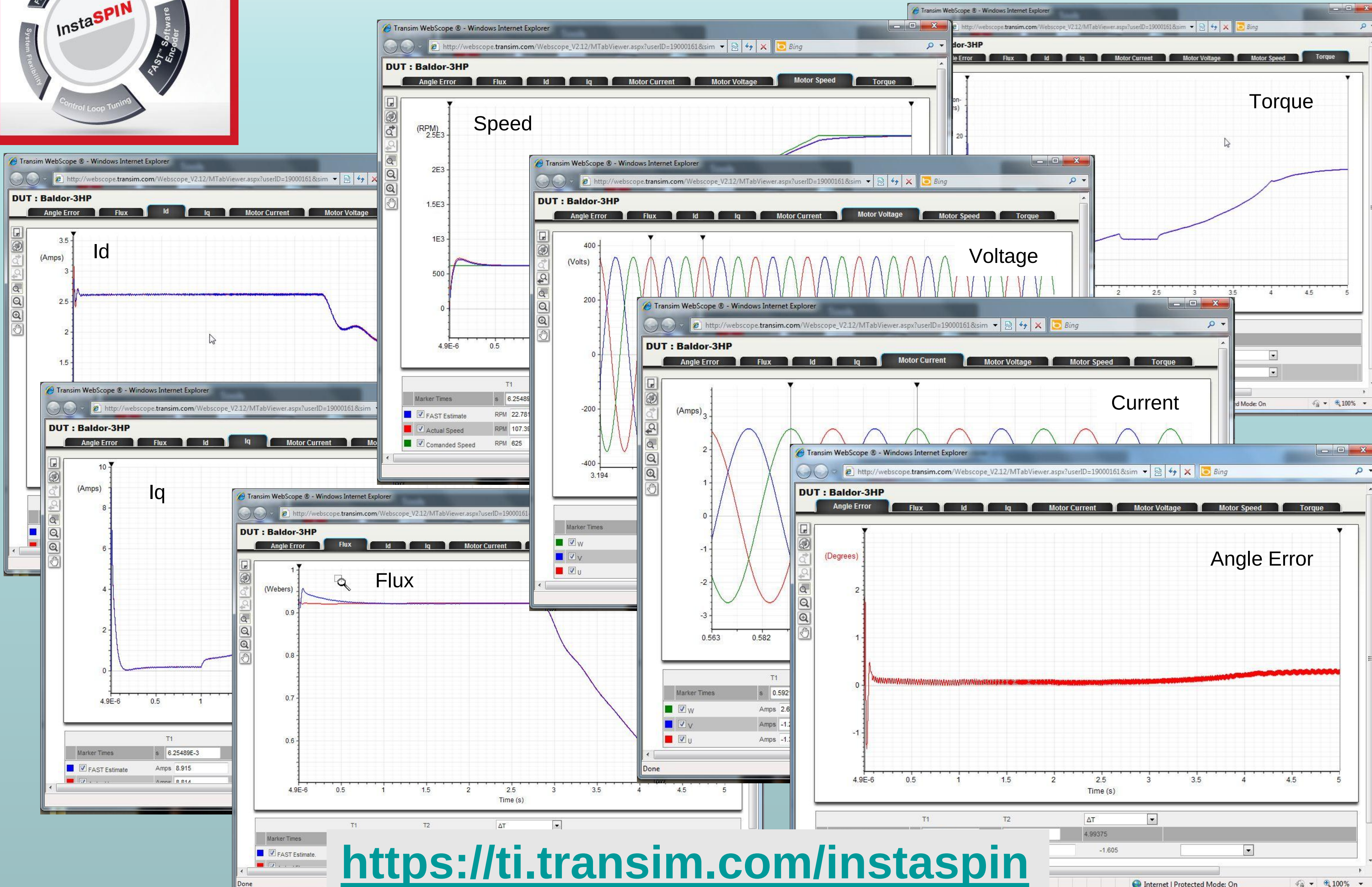
On-line Simulation: Evaluate FAST from your desk!



English, Mandarin, Japanese

https://ti.transim.com/instaspin

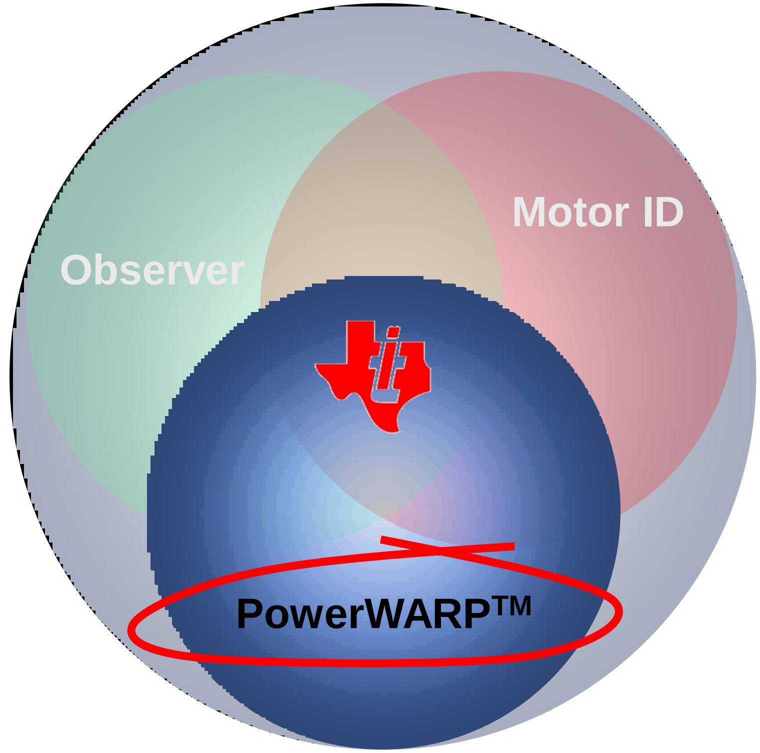
Sim Results within 5 Minutes!



https://ti.transim.com/instaspin

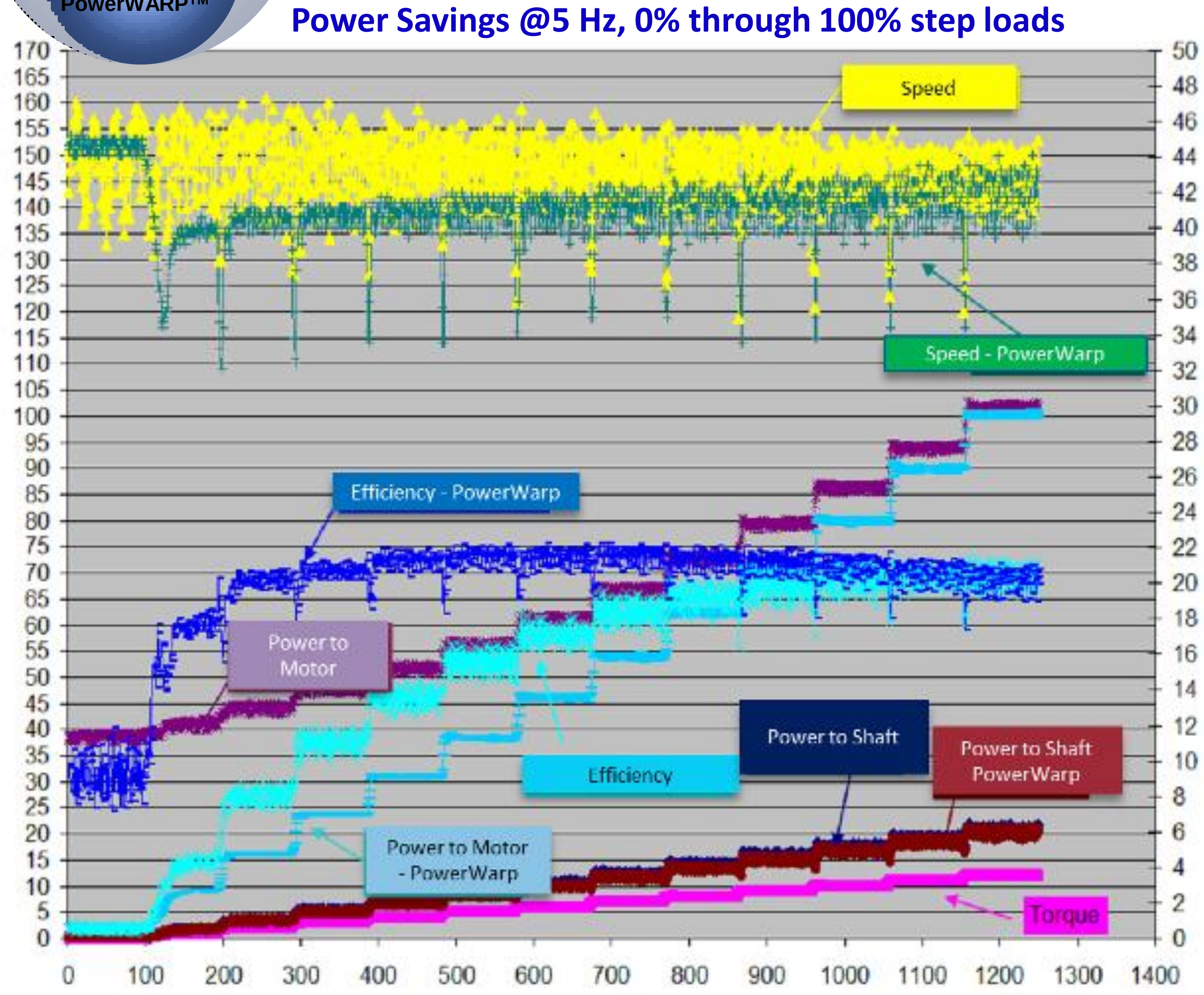
ACIM Energy Savings Mode

Old Way (Triac Drive)



New Way

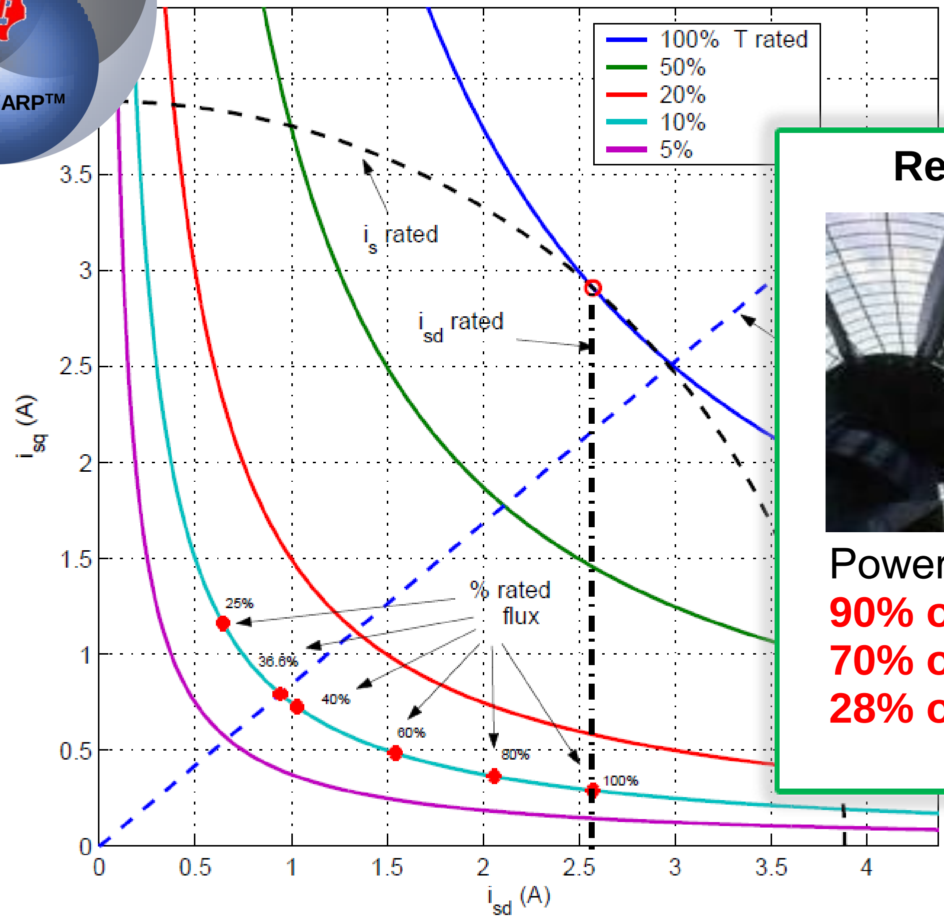
PowerWARP™ Lab Testing



- PowerWarp™ is a capability of InstaSPIN™-FOC designed to improve induction motor efficiency at partially applied loads.
- Motor efficiency with PowerWarp™ is dramatically improved from 5% to 20% at 1 lb.in. load
- The efficiency improvement decreases with increasing torque as expected.
- At rated torque, the efficiency curves for PowerWarp™ on and off are identical
- Note that output power is maintained with PowerWarp™ mode enabled.

Motor efficiency is boosted dramatically at lower loads, with a trade-off in dynamic torque and speed response, though the control system remains stable

PowerWARP™ Operation



Real World Field Trial

Induction Motors used for Agriculture Air & Humidity Control

PowerWarp™ Savings

90% of energy vs. Traditional Triac Drive

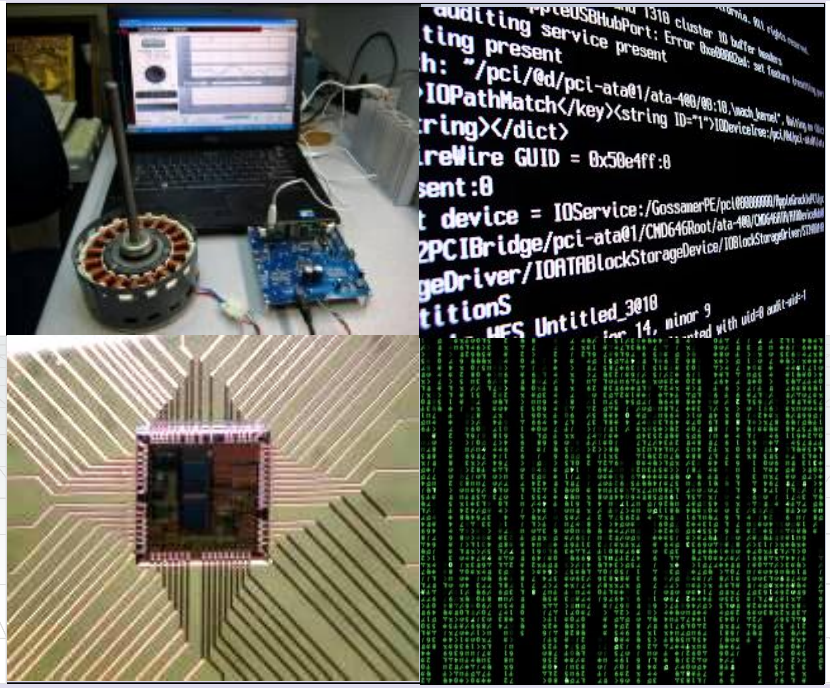
70% of energy vs. Standard VFD

28% of energy vs. Energy Optimized Drive

Algorithm is based on reducing motor copper losses in the stator AND the rotor!

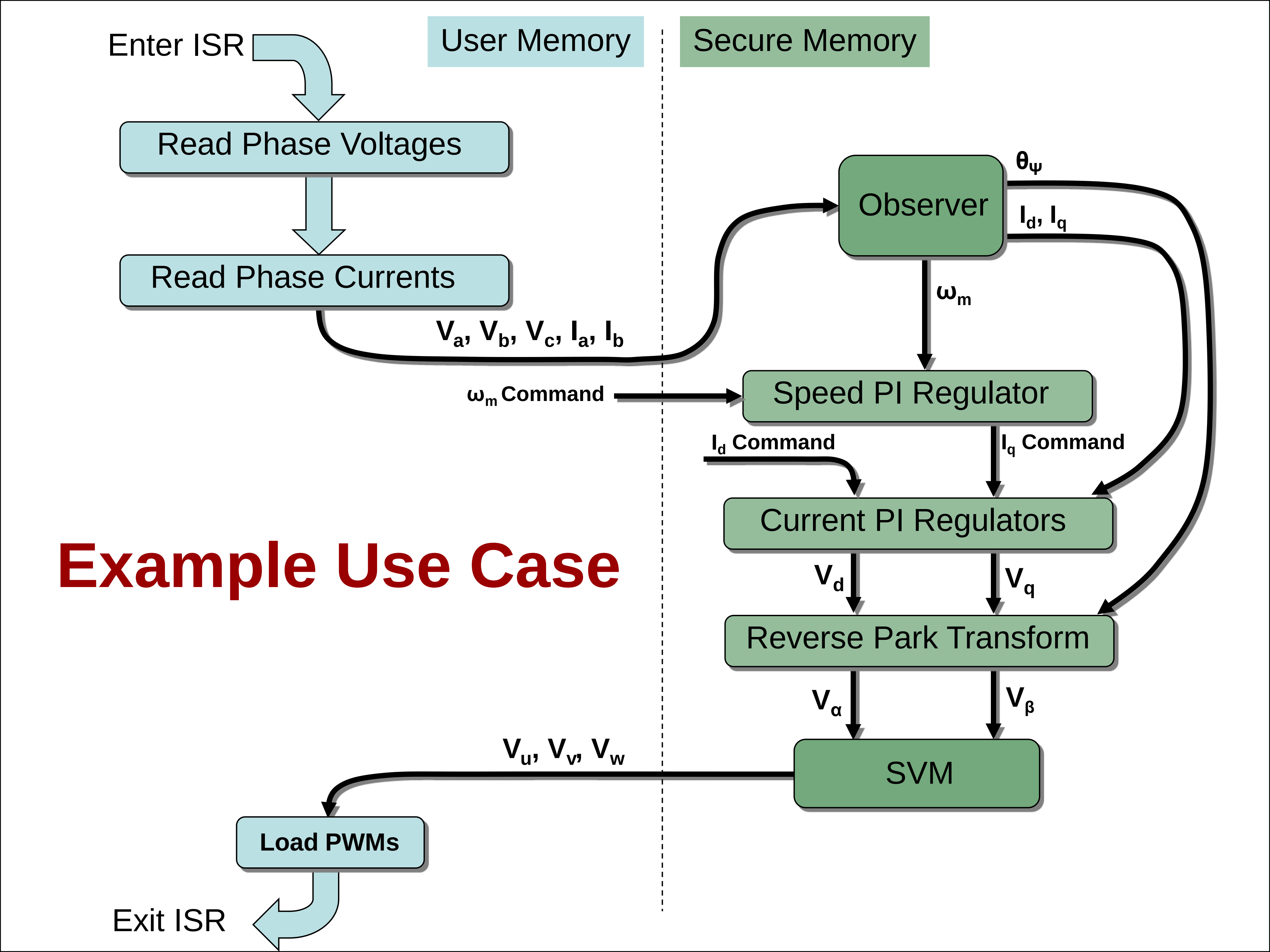
Angle observer will accurately track flux angle under load transient conditions (smooth stall recovery even when motor has been defluxed).

Software Discussion



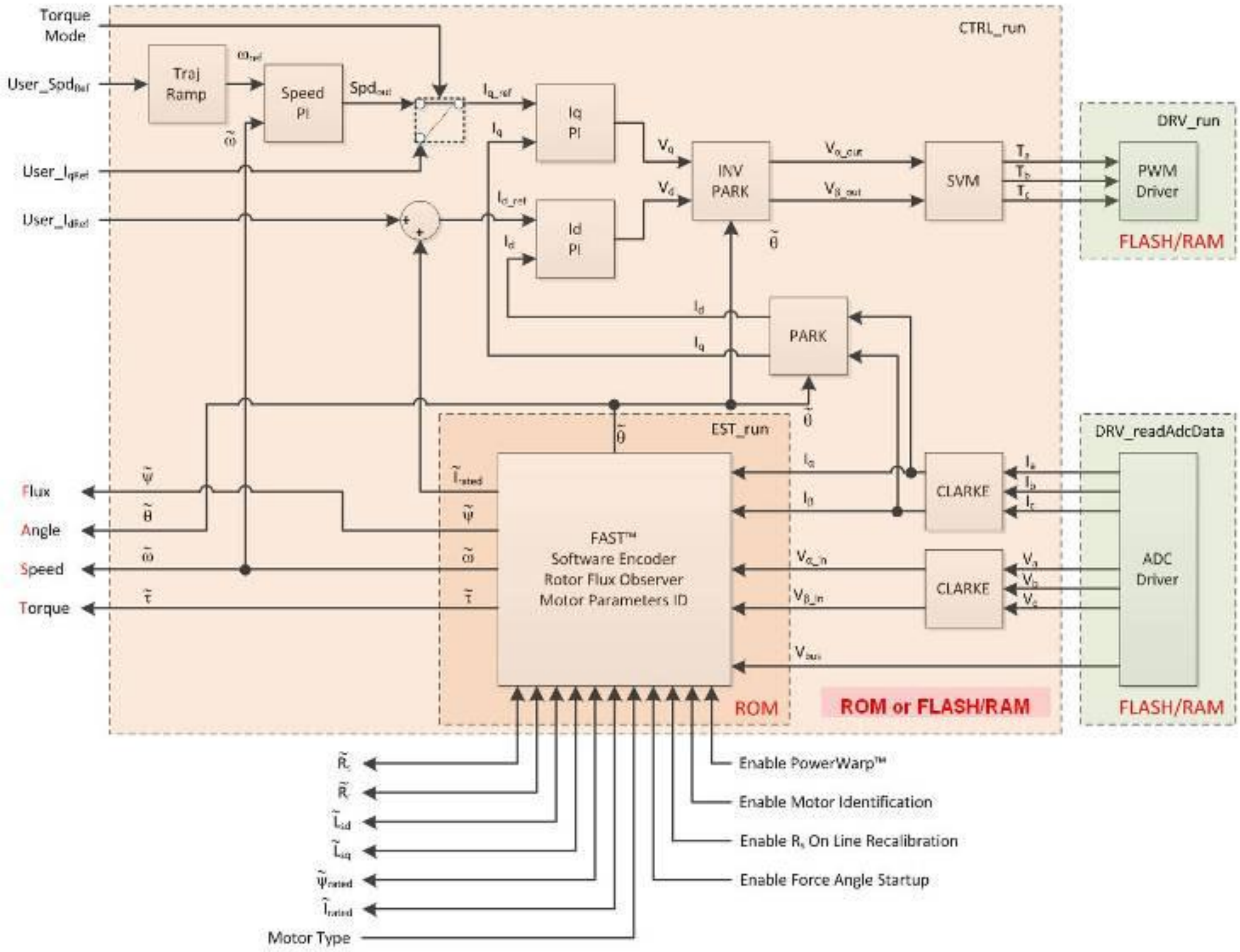
Dave Wilson

TEXAS INSTRUMENTS

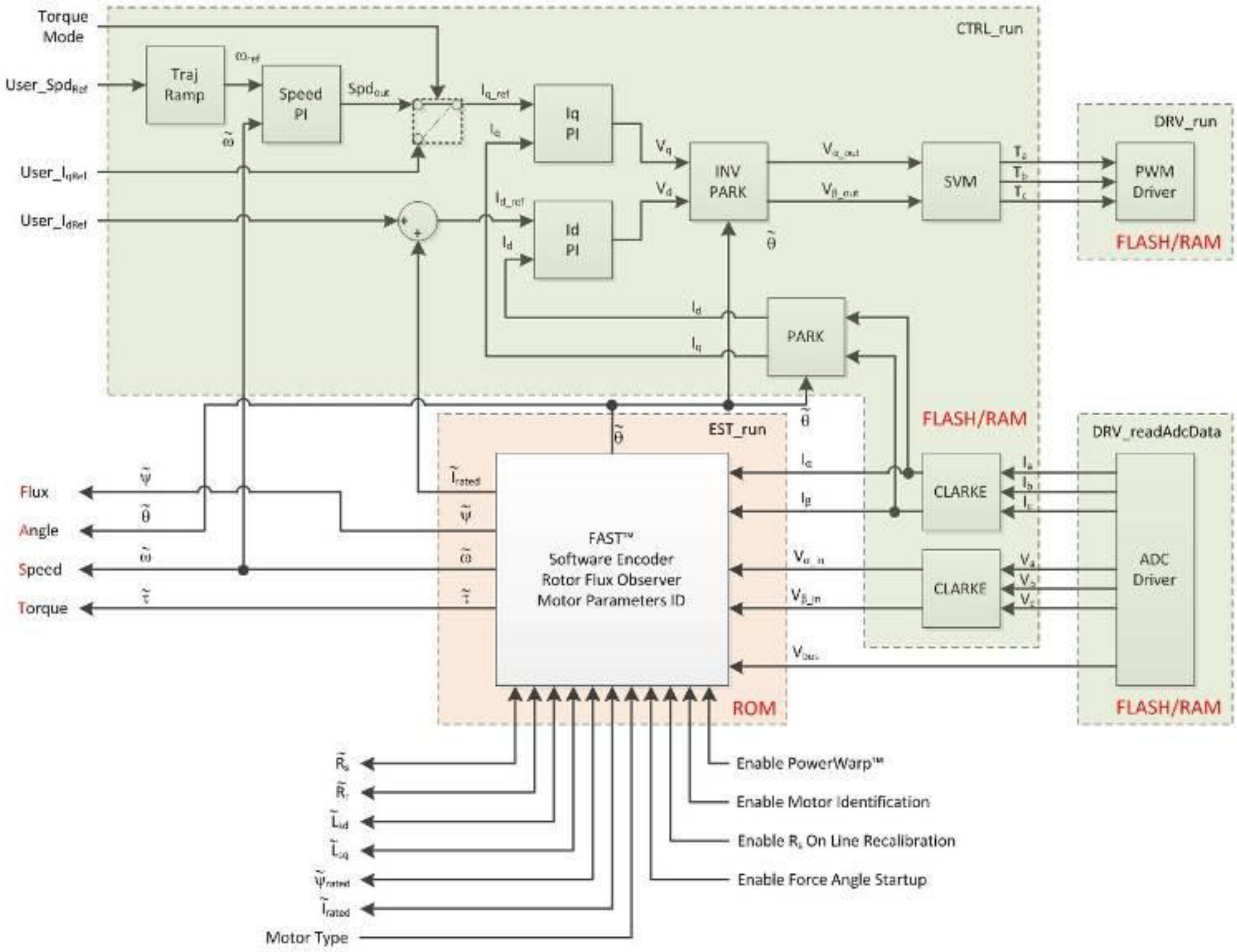


User Memory
Secure Memory
Enter ISR
Read Phase Voltages
Read Phase Currents
V_a, V_b, V_c, I_a, I_b
Observer
θ_ψ
I_d, I_q
ω_m
ω_m Command
Speed PI Regulator
I_d Command
I_q Command
Current PI Regulators
V_d
V_q
Reverse Park Transform
V_α
V_β
SVM
V_u, V_v, V_w
Load PWMs
Exit ISR
Example Use Case

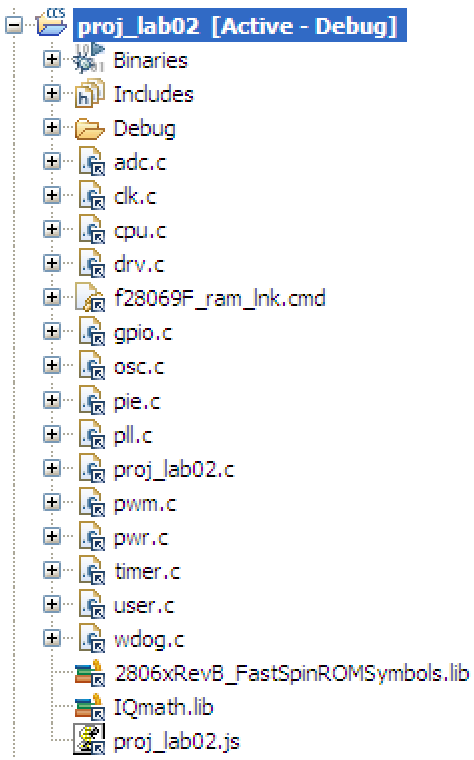
All FOC in ROM

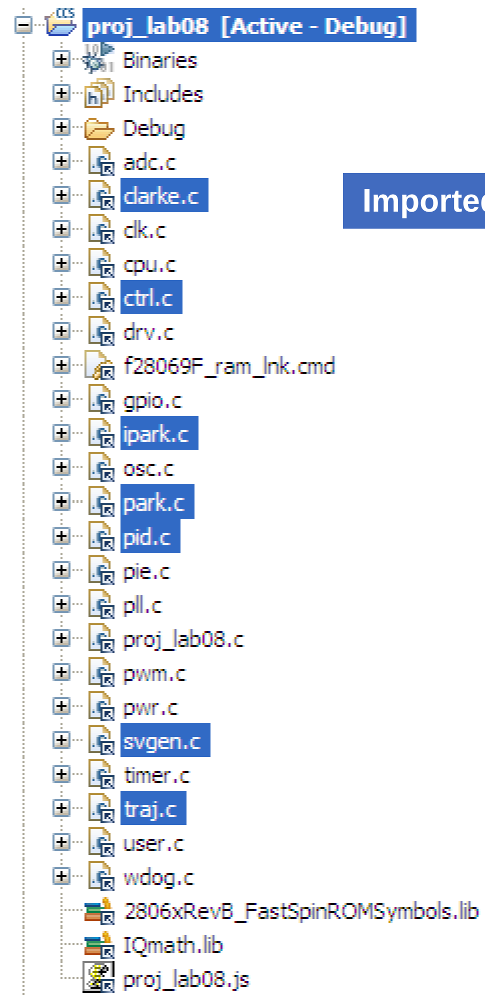


Estimator Only in ROM



All in ROM, and Estimator-only Projects

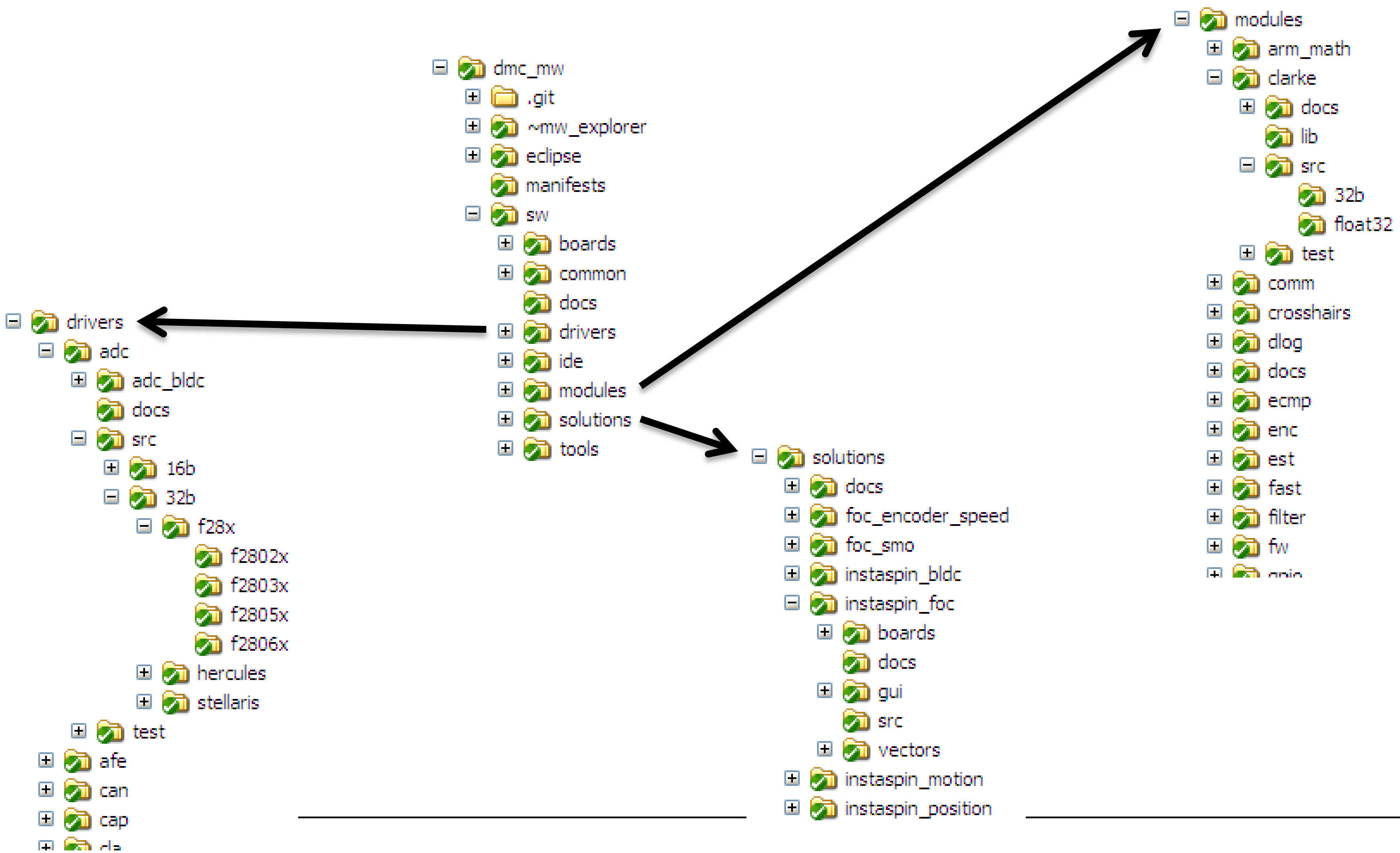




Imported Routines

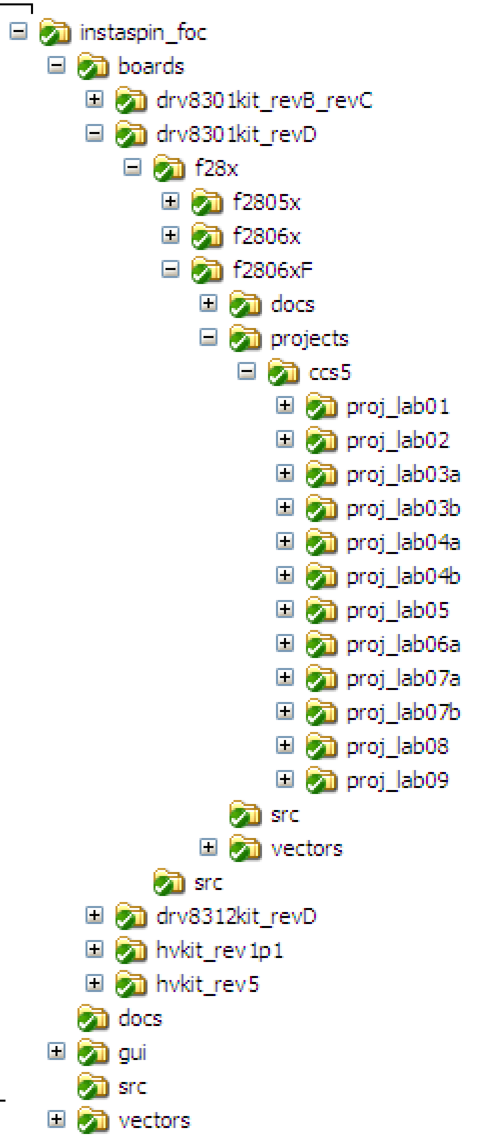
MotorWare™

- MotorWare™ is a directory structure



MotorWare™

- MotorWare™ contains several example projects for each solution
  - Lab 1 - CPU and Inverter Setup
  - Lab 2 - Using InstaSPIN™-FOC for the first time
  - Lab 3 - Using your own board and motor parameters (user.h)
  - Lab 4 - Looking at the details of the speed loop
  - Lab 5 - Field weakening
  - Lab 6 - Looking at the details of the current loop
  - Lab 7 - Replacing FAST SVPWM with user PWM modulator
  - Lab 8 - Replacing FAST FOC calculations with user software
  - Lab 9 - Looking at the details of Rs online recalibration



MotorWare™

- MotorWare™ contains code that produces html documentation using Doxygen

```
//! \brief     Gets the angle value from the estimator in per unit (pu), IQ24.
//! \details   This function returns a per units value of the rotor flux angle. This value wraps around
//!            at 1.0, so the return value is between 0x00000000 or _IQ(0.0) to 0x00FFFFFF or _IQ(1.0).
//!            An example of using this angle is shown:
//! \code
//! _iq Rotor_Flux_Angle_pu = EST_getAngle_pu(handle);
//! \endcode
//! \param[in] handle  The estimator (EST) handle
//! \return    The angle value, pu, in IQ24.
extern _iq EST_getAngle_pu(EST_Handle handle);
```

_iq EST_getAngle_pu (EST_Handle handle)

Gets the angle value from the estimator.

This function returns a per units value of the rotor flux angle. This value wraps around at 1.0, so the return value is between 0x00000000 or _IQ(0.0) to 0x00FFFFFF or _IQ(1.0). An example of using this angle is shown:

```
_iq Rotor_Flux_Angle_pu = EST_getAngle_pu(obj->estHandle);
```

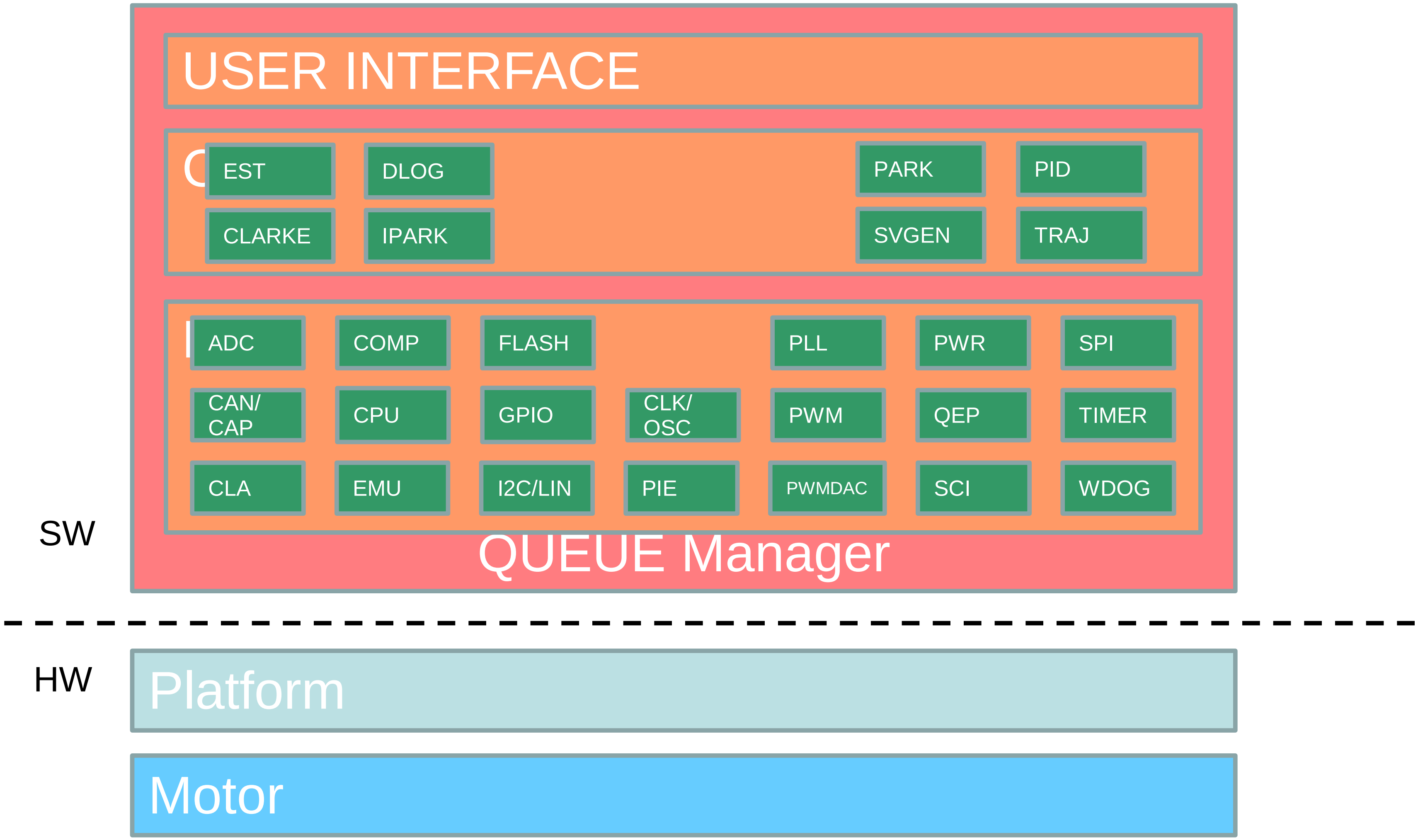
Gets the angle value from the estimator.

Parameters:
[in] *handle* The estimator (EST) handle

Returns:
The angle value, pu, in IQ24.

MotorWare™

- MotorWare™ contains a software architecture ready to be used with an RTOS, with minimum performance hit

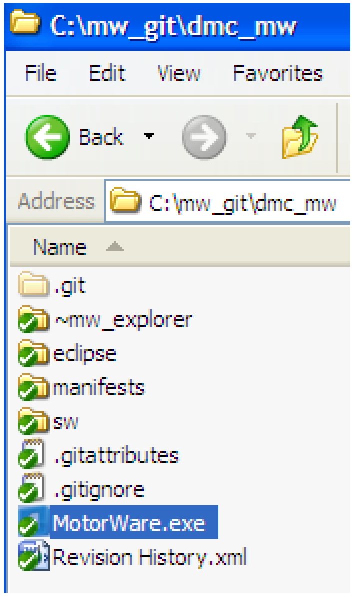


- MotorWare™ uses inlined functions.
- Inline Function Performance using Objects with module API structure

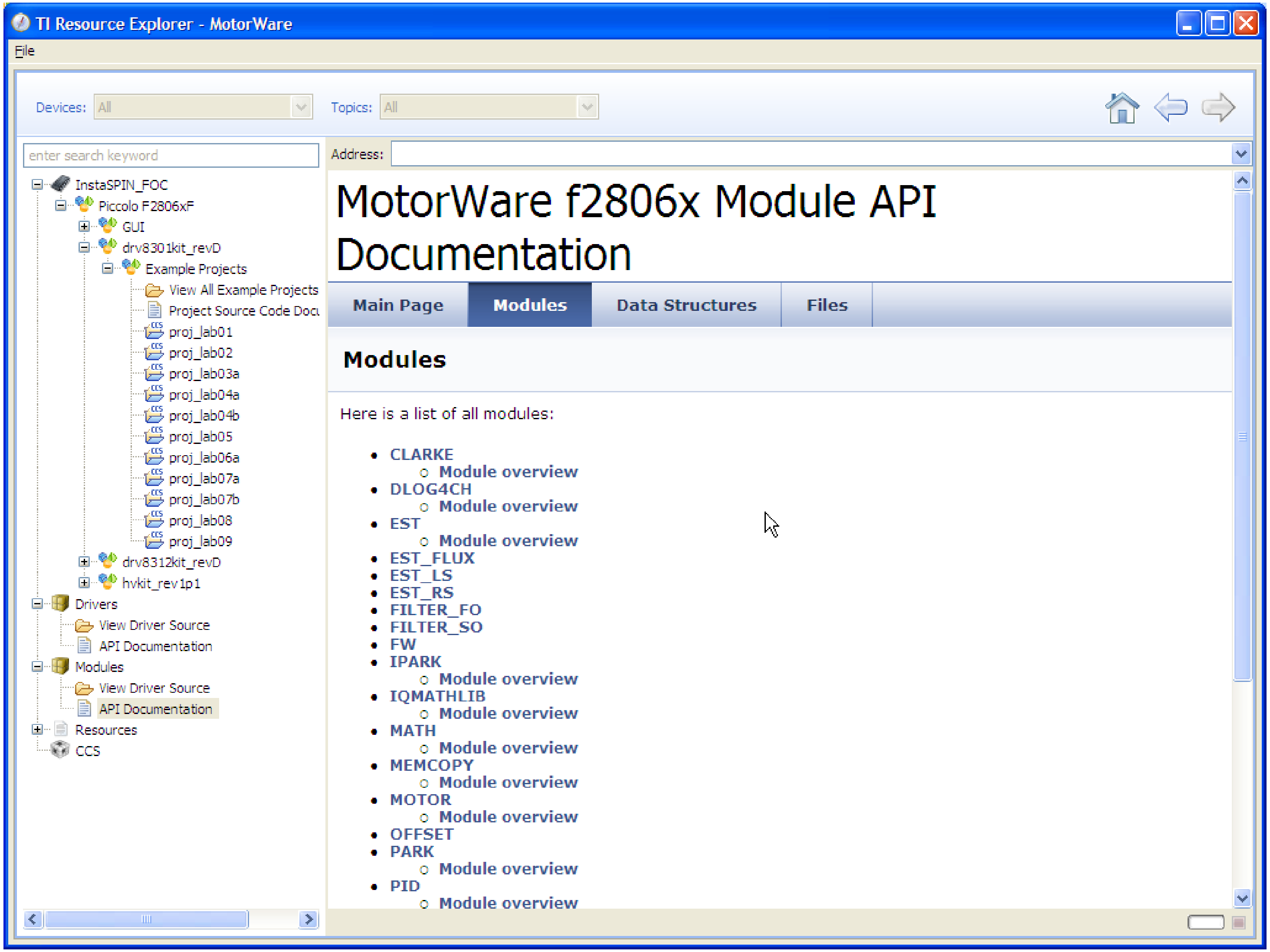
Function	Macro	Inline C
Clarke	18	16
PID	39	30
SVGEN	118	101

- Advantages of Inlined Structure:
  - Inline C vs Macro
    - Better API definition (inputs and outputs are allocated to registers)
    - More efficient C functions
    - With inlined functions we can step through the code
      - Macros are a single line of code, not possible to step through it

MotorWare™ Explorer



MotorWare™ Explorer



InstaSPIN Review Quiz

Q: What are the three sub-modules of InstaSPIN-FOC?

Q: List at least three types of motors that InstaSPIN-FOC can control.

Q: What component of InstaSPIN-FOC results in energy savings with an ACIM?

Q: List at least five system ADC measurements that are required by FAST.

InstaSPIN Review Quiz

Q: List the four outputs of the FAST observer.

Q: How are FAST enabled processors distinguished from non-FAST devices?

Q: TRUE or FALSE: MotorWARE™ uses macros instead of inline code to enable easier debugging.

Q: List at least two development boards for use with InstaSPIN software.