XMC PMSM FOC SENSORLESS SW V1.5.8

XMC[™] Microcontrollers May 2019



- restricted -

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PMSM FOC Agend







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Overview – PMSM FOC Sensorless SW

- This document provides information about usage of PMSM FOC Sensorless example software on Infineon's XMC13/XMC14 series microcontrollers platform.
- > PMSM FOC Sensorless control example software is offered as "simple main project in DAVE[™] IDE".
- PMSM FOC Sensorless control example project consists of Single Shunt/three shunt Field Oriented control algorithm software, targeted end applications are fans, pumps, and e-bike segment.
- This example project will provide high level of configurability and modularity to address different segments.
- This project can be easily configured as per requirements with the help of configuration files.



PMSM FOC Sensorless SW - Overview

- > Dedicate Application Note <u>AP32370</u>
- Easy partitioning of code structure, easy to understand algorithm and apply custom modification.
- Small code size, and fast execution (21usec all FOC algorithm)
- > Flexible hw configuration
- Possibility to integrate with APPs
- Easy to update existing prjs with new Library version
- Compiler Support GCC, Keil
- Complete access to source code and parameters calculation (except for PLL library, available under SLA)





Software Overview – Software Blocks



Software Blocks	Supported Options
Control Scheme	V/F control, V/F to closed loop control, direct constant speed control, direct constant torque control, direct constant Vq control
PWM Modulation (Modulator)	7 Segment SVM, Over-modulation,
Current/Voltage Measurement	DC voltage compensation, DC bus voltage clamping during fast braking

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Software Overview – Key Features

Supported Features	Description
DC bus voltage clamping	Prevent over-voltage during fast braking
Ramping	S-curve Speed ramping, Linear Speed Ramping
PI Controller	Speed PI anti-windup (local and system), Torque PI controller, Flux PI controller
Startup Algorithm	Rotor alignment (Direct FOC), Open loop to MET
Protection	Under/Over voltage C-trap with MCU hardware features





Agenda





Software Project Overview - Files Structure

V SPMSM_FOC_SL_XMC13_PUBBLIC_V1_5_0 [Active -





PMSM FOC Software Overview

> PMSM FOC motor control software is developed based on welldefined layered approach. The layered architecture is designed in such a way as to separate the modules into groups. This allows different modules in a given layer to be easily replaced without affecting the performance in other modules and the structure of the complete system





PMSM FOC Software Overview- Files Structure







PMSM FOC Software - Configuration



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Hardware supported 1/2

- KIT_XMC1X_AK_MOTOR_001
 - Infineon XMC1000 Motor Control Application Kit
- > KIT_XMC750WATT_MC_AK_V1
 - XMC 750Watt Motor Control Application Kit
- KIT_XMC14_BOOT_001
 - XMC1404 CPU card for IT_XMC1X_AK_MOTOR_001
- KIT_MOTOR_DC_250W_24V
 - XMC13/XMC14 DC with 250W Low voltage Board
- > IFX_MADK_EVAL_M1_05F310
 - MADK Low voltage board 250-300W
- > IFX_MADK_EVAL_M1_05_65D_V1
 - MADK High voltage board 100-150W
- > IFX_MADK_EVAL_M1_CM610N3
 - MADK High voltage board 750W
- > CUSTOM_KIT
 - User defined motor control system



Hardware supported 2/2

- Controller Card
 - EVAL_M1_1302
 - KIT_XMC13_BOOT_001
 - KIT_XMC1300_DC_V1
 - BOOTKIT_XMC1400_V1
 - KIT_XMC1400_DC_V1
 - CUSTOM_MCU

- Inverter Card
 - EVAL_M1_05_65A
 - EVAL_M1_05F310
 - EVAL_M1_CM610N3
 - KIT_MOTOR_DC_250W_24V
 - PMSM_LV15W
 - POWERINVERTER_750W
 - CUSTOM_INVERTER

- Motor Supported
 - MAXON_MOTOR_267121
 - NANOTEC_MOTOR_DB42S03
 - CUSTOM_MOTOR





Configuration Files of Supported HW

 Customers can reuse predefine configuration and modify them or create a new custom configuration

PMSM_FOC

✓ → Configuration

✓ → Controller_Card

- b pmsm_foc_CUSTOM_MCU.h
- b pmsm_foc_EVAL_M1_1302.h
- > h pmsm_foc_EVAL_M1_1402.h
- b pmsm_foc_KIT_XMC13_BOOT_001.h
- b pmsm_foc_KIT_XMC1300_DC_V1.h
- > h pmsm_foc_KIT_XMC14_BOOT_001.h
- > h pmsm_foc_KIT_XMC1400_DC_V1.h

✓ → Inverter_Card

- > h pmsm_foc_CUSTOM_INVERTER.h
- > h pmsm_foc_EVAL_M1_05_65A.h
- > h pmsm_foc_EVAL_M1_05F310.h
- > h pmsm_foc_KIT_MOTOR_DC_250W_24V.h
- > h pmsm_foc_PMSM_LV15W.h
- > h pmsm_foc_POWERINVERTER_750W.h

✓ → Motors

- pmsm_foc_motor_CUSTOM_MOTOR.h
- > In pmsm_foc_motor_MAXON_MOTOR_267121.h
- > h pmsm_foc_motor_NANOTEC_MOTOR_DB42S03.h



Software Overview – Example Configuration

Example Name	PMSM_FOC_SL_XMC13_PUBBLIC_V1_5_8_LIB
Kit Description	Drive 3-phase Maxon's motor using XMC1000 motor control application kit
Part Number	KIT_XMC1X_AK_MOTOR_001
Schemes	Default Configuration in Example Software
Control Scheme	SPEED_CONTROLLED_DIRECT_FOC
PWM frequency (Hz)	20000
Speed (rpm)	4200
Ramp up/down rate	500
Protection	VDC under/over voltage protection, over current protection





Hardware Overview – Application Kit Package

> Infineon's XMC1000 Motor Control Application Kit

Item	Description
XMC1300 CPU Card	MCU board with XMC1300 and detachable SEGGER J-Link debug interface
PMSM Low Voltage 15W Motor Card	12 – 24V Up to 3A On board 3-phase motor (24V, 15W) with hall sensors
Accessories	Power Supply Adaptor (24V, 1A) Micro USB connector (1x)



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pmsm_foc_user_config.h

- > In this file there are a lot of defines to set-up HW/SW configuration:
- First Define is dedicated to Hardware configuration: in this case KIT_XMC1X_AK_MOTOR_001

788 /***********************************	*************************************	******************************
79 * MACROS		
80 ************************************	***************************************	***************************************
810 #define PMSM_FOC_HARDWARE_BOARD	KIT_XMC1X_AK_MOTOR_001	/*1. KIT_XMC1X_AK_MOTOR_001
82		2. KIT XMC750WATT_MC AK V1
83		CUSTOM_KIT*/
94		

In the same file at the end KIT_XMC1X_AK_MOTOR_001 is defined as collection of MCU Board+ Inverter Card + Motor

187	<pre>#if(PMSM_FOC_HARDWARE_KIT == KIT_XMC1X_AK_MOTOR_001)</pre>	
188	#define MCUCARD_TYPE	KIT_XMC13_BOOT_001
189	#define MCUCARD_TYPE_PATH	"Controller_Card\pmsm_foc_KIT_XMC13_BOOT_001.h"
190	#define INVERTERCARD_TYPE	PMSM_LV15W
191	#define INVERTERCARD_TYPE_PATH	"Inverter_Card\pmsm_foc_PMSM_LV15W.h"
192	#define MOTOR_TYPE	MAXON_MOTOR_267121
193	#define MOTOR_TYPE_PATH	"Motors\pmsm_foc_motor_MAXON_MOTOR_267121.h"
194	<pre>#elif(PMSM_FOC_HARDWARE_KIT == KIT_XMC750WATT_MC_AK_V1)</pre>	
195	#define MCUCARD_TYPE	KIT_XMC1300_DC_V1
196	#define MCUCARD_TYPE_PATH	"Controller_Card\pmsm_foc_KIT_XMC1300_DC_V1.h"
197	#define INVERTERCARD_TYPE	POWERINVERTER_750W
198	#define INVERTERCARD_TYPE_PATH	"Inverter_Card\pmsm_foc_POWERINVERTER_750W.h"
199	#define MOTOR_TYPE	CUSTOM_MOTOR
200	#define MOTOR_TYPE_PATH	"Motors\pmsm_foc_motor_CUSTOM_MOTOR.h"
201	<pre>#elif(PMSM_FOC_HARDWARE_KIT == KIT_XMC_IFI_24V_250W)</pre>	
202	#define MCUCARD_TYPE	KIT_XMC1300_DC_V1
203	#define MCUCARD_TYPE_PATH	"Controller_Card\pmsm_foc_KIT_XMC1300_DC_V1.h"
204	#define INVERTERCARD TYPE	KIT MOTOR DC 250W 24V



Hardware Overview – XMC1300 CPU Card

> XMC1300 CPU Card



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pmsm_foc_KIT_XMC13_BOOT_001.h



- > This files contains defines related to MCU card
 - PWM output pins
 - ADC input
 - Internal hw resurces

```
* KIT_XMC1X_AK_MOTOR_001
523
   * GPIO Resources Configuration
524
    525
526 #define TRAP PIN
                          PØ 12
   #define INVERTER_EN_PIN
                        PØ 11
527
528
529 #define PHASE U HS PIN
                          P0 0
530 #define PHASE_U_HS_ALT_SELECT XMC_GPI0_MODE_OUTPUT_PUSH_PULL_ALT5
531
532 #define PHASE U LS PIN
                          PØ 1
533 #define PHASE U LS ALT SELECT XMC GPIO MODE OUTPUT PUSH PULL ALT5
534
535 #define PHASE V HS PIN
                          PØ 7
   #define PHASE V HS ALT_SELECT XMC_GPIO_MODE_OUTPUT_PUSH_PULL_ALT5
536
537
538 #define PHASE V LS PIN
                          PØ 6
   #define PHASE V LS ALT SELECT XMC GPIO MODE OUTPUT PUSH PULL ALTS
539
540
541 #define PHASE_W_HS_PIN
                          PØ 8
542 #define PHASE_W_HS_ALT_SELECT XMC_GPI0_MODE_OUTPUT_PUSH_PULL_ALT5
543
544 #define PHASE W LS PIN
                          PØ 9
545 #define PHASE W LS ALT SELECT XMC GPIO MODE OUTPUT PUSH PULL ALTS
546
547 #define TEST PIN
                       PØ 4
548
```



Hardware Overview – Motor Card

> PMSM Low Voltage 15W Motor Card



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pmsm_foc_PMSM_LV15W.h

- > This file contains all parameters related to inverter board:
 - Vdc Link
 - Dead time
 - Driver delay
 - Op-amp gain
 - Shunt resistor values
 - Polarity of Driver, Trap
 - ...

/* ************************************	* PMSM_LV15W ***	***************************************
<pre>#if(INVERTERCARD_TYPE == PMSM_LV15W)</pre>	_	
#define INTERNAL_OP_GAIN	DISABLED	<pre>/*1. ENABLED 2. DISABLED (Please configure OP-Gain manually) */</pre>
#define USER_VDC_LINK_V	(24.0f)	/* Hardware Inverter VDC link voltage in V */
#define USER_DEAD_TIME_US	(0.75f)	<pre>/* deadtime, rise(left) and fall values in us */</pre>
#define USER_CCU8_PWM_FREQ_HZ	(2000U)	/* CCU8 PWM Switching Frequency in Hz*/
#define USER_DRIVERIC_DELAY_US	(1.0f)	/* Driver IC delay. It affects ADC trigger points during high speed as
#define USER_BOOTSTRAP_PRECHARGE_TIME_MS	(20U)	/* Initial Bootstrap prechanging time in ms */
#define USER_DC_LINK_DIVIDER_RATIO	(float)(5.1	.f/(5.1f+47.0f)) /* R1/(R2+R1) ratio for DC link MCU ADC */
#define USER_VBEMF_RATIO	(float)(5.2	<pre>tf/(5.2f+47.0f)) /* R1/(R2+R1) ratio for BEMF Voltage sensing circuit ratio</pre>
#define USER_CURRENT_TRIP_THRESHOLD_A	(3.0f)	/* threshold current for trip detection in Ampere*/
#define USER_TRIP_THRESHOLD_TIME_MS	(100U)	/* threshold time for trip detection in ms */
#define USER_MAX_RETRY_MOTORSTARTUP_TRIP	(3U)	/* Max retry of motor startup if trip */
/*	Mot	or Phase Current Measurement*/
#define USER_R_SHUNT_OHM	(0.05f)	/* Phase shunt resistor in ohm */
#define USER_DC_SHUNT_OHM	(0.05f)	/* DC link shunt current resistor in ohm */
#define USER_RIN_PHASECURRENT_KOHM	(1.0f)	/* R_IN (of equivalent amplifier) kohm */
#define USER_R_PHASECURRENT_FEEDBACK_KOHM	(16.4f)	/* R_FEEDBACK (of equivalent amplifier) kohm */
#define USER_RIN_DCCURRENT_KOHM	(10.0f)	/* Rf for dc current sensing */
#define USER_R_DCCURRENT_FEEDBACK_KOHM	(75.0f)	/* Rin for dc current sensing */
#define USER_MAX_ADC_VDD_V	(5.0f)	/* VDD5, maximum voltage at ADC */
#define G_OPAMP_PER_PHASECURRENT	(USER_R_PHA	SECURRENT_FEEDBACK_KOHM / USER_RIN_PHASECURRENT_KOHM)
#define I_MAX_A	((VAREF_V/(USER_R_SHUNT_OHM * OP_GAIN_FACTOR)) / 2U) /* For IFX_XMC_LVPB_R3, I_M

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Hardware Overview – MAXON MOTOR

> MAXON MOTOR 267121



]	267121
			226006
M	otor Data		
	Values at nominal voltage		
1	Nominal voltage	V	24
2	No load speed	rpm	4530
3	No load current	mA	36.9
4	Nominal speed	rpm	2760
5	Nominal torque (max. continuous torque)	mNm	25.5
6	Nominal current (max. continuous current)	A	0.5
7	Stall torque	mNm	85.8
8	Starting current	A	1.75
9	Max. efficiency	%	74
	Characteristics		
10	Terminal resistance phase to phase	Ω	13.7
11	Terminal inductance phase to phase	mH	7.73
12	Torque constant	mNm/A	49
13	Speed constant	rpm/V	195
14	Speed/torque gradient	rpm/mNm	54.5
15	Mechanical time constant	ms	20
16	Rotor inertia	gcm ²	35

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pmsm_foc_motor_MAXON_MOTOR_267121.h



- In this file are stored default motor parameters for our evaluation board ad customer can define own motors.
- L & R parameters are used to adjust some PI parameters automatically
- PI paramters, like Ki, Kp, scaling e aniwindup values are stored here.

394	#elif (M	MOTOR_TYPE == MAXON_MOTOR)			
395	/*		Moto	r Parameters	*/
396	#define	USER_MOTOR_R_PER_PHASE_OHM	(6.8f)	<pre>/* Motor Resistance per phase in Ohm*/</pre>	
397	#define	USER MOTOR L PER PHASE uH	(3865.0f)	/* Motor Inductance per phase in uH */	
398	#define	USER MOTOR POLE PAIR	(4.0f)	/* Motor Pole Pairs */	
3996)/*		Cons	tant Speed Control Mode (Used when Constant Speed C	Control is enabled)
400	/*		POT	ADC, or PWM to Adjust Speed	*/
401	#define	USER SPEED HIGH LIMIT RPM	(4530.0f)		
402	#define	USER_SPEED_LOW_LIMIT_RPM	(uint32_t) (USER_SPEED_HIGH_LIMIT_RPM / 30U)	
403	#define	USER_SPEED_RAMPUP_RPM_PER_S	(500U)		
404	#define	USER_SPEED_RAMPDOWN_RPM_PER_S	(500U)		
405	#define	USER_RATIO_S	(10)		
406	/*		V/F	Start Up Parameters	*/
407	#define	USER_STARTUP_SPEED_RPM	(0U)		
408	#define	USER_STARTUP_SPEED_THRESHOLD_RPM	(200U)	/* threshold Speed to transit from Open loop	to closed loop */
409	//#defin	ne USER_STARTUP_VF_OFFSET_V	(float) (US	ER_VDC_LINK_V * 0.05f)	/* V/F startup offset in V *
410	//#defin	e USER_STARTUP_VF_SLEWRATE_V_PER_HZ	(float) (US	ER_VDC_LINK_V /ELECTRICAL_SPEED_FREQ_HZ)	
411	#define	USER_STARTUP_VF_OFFSET_V	(1.0f)	/* V/F startup offset in V */	
412	#define	USER_STARTUP_VF_SLEWRATE_V_PER_HZ	(0.1f)	/* V/F start up slew rate in V/Hz */	
413					



Agenda





SW Overview – XMC1302 Peripheral usage (1/2)

No	Category	Description	XMC1302 Pins	Remark
1	Mator Dhace L	High side driver Phase U MOSFET	P0.0 / CCU80.OUT00	
2		Low side driver Phase U MOSFET	P0.1 / CCU80.OUT01	
3	Motor Phace V	High side driver Phase V MOSFET	P0.7 / CCU80.OUT10	Active level - LOW
4	Motor Phase v	Low side driver Phase V MOSFET	P0.6 / CCU80.OUT11	
5		High side driver Phase W MOSFET	P0.8 / CCU80.OUT20	
6	Motor Phase W	Low side driver Phase W MOSFET	P0.9 / CCU80.OUT21	
7	Inverter Enable	Enable gate driver I/O functionality	P0.11	Active LOW
8	DC Link Current	Amplifier output for DC link single shunt	P2.7 / G1.CH1	
9	DC Link Voltage	Voltage of DC link (with voltage divider)	P2.3 / G1.CH5	Divider resistors 990K/10K
10	РОТ	ADC for potentiometer	P2.5 / G1/CH7	

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SW Overview – XMC1302 Peripheral usage (2/2)

No	Category	Description	XMC1302 Pins	Remark
11		Amplifier output for Phase U shunt	P2.9 / (G0.CH2/G1.CH4)	
12	3-Shunt Phase Current	Amplifier output for Phase V shunt	P2.10 / (G0.CH3/G1.CH2)	3-shunt 50 m Ω , with Op-Amp gain
13		Amplifier output for Phase W shunt	P2.11 / (G0.CH4/G1.CH3)	





FOC control Scheme



Table 5 CPU utilization and memory usage for three shunt current sensing with XMC1300 and XMC1400

PWM frequency	20 kHz – Interrupt Service Routine runs every 50 µsec		
DAVE [™] 4 GCC compiler optimization level	Optimized most (-O3)		
мси	XMC1300	XMC1400	
CPU utilization	31 µsec (62%)	21 µsec (42%)	
Flash code size (bytes)	10792	11148	8
SRAM code size (bytes)	348	352	00 20
SRAM data size (bytes)	1720	1716	



Hardware Interconnection

Interconnection between CCU8 (SVM PWM generation) with VADC

- To measure shunt currents in each PWM cycle
- CCU8 interrupt logic provides flexibility to group several triggers to one SR line





Current sensing Synchronous



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Software Overview - Interrupt Service Routines

Folder: Interrupts

Peripheral	Interrupt Subroutines (ISR)	NVIC node	Interval	Priority	 XMC1302_SensorlessFOC_Lib_DAVE414 [Activ Binaries Archives Includes Debug
VADC	VADC_Source_IRQHandler	18	Asynchronous (only single shunt)	1	 A Debug A Debug B Debug
CCU8	CTRAP	26	Asynchronous	0	 ControlModules FOCLib Interrupts
CCU8	One match event (Phase U)	25	1/ PWM frequency	2	 ▶ c pmsm_foc_ctrap_isr.c ▶ c pmsm_foc_error_handling.c ▶ m pmsm_foc_error_handling.h
CCU4	Period Match	21	Secondary Loop Freq., Timer starts sync to CCU8	3	 ▷ @ pmsm_foc_statemachine.c ▷ msm_foc_statemachine.h ▷ @ pmsm_foc_vadc_isr.c
VADC	Vdc boudary	19	Vdc Link, over/under voltage	1	MIDSys Startup Main.c
			· · · · ·		pmsm_foc_userinterface.c

pmsm_foc_variablesconfig.c

 Inker_script.ld

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Secondary Loop - Callback function

- Callback function can be enable or disable by changing define in configuration files
 - Secondary function by default is 1Khz \rightarrow 1ms
- Customers can write inside their own code without impact on algorithm
 void pmsm foc secondaryloop callback(){
- Start & Stop motor in the example are execute in callback function into the main.c together with Vdc_link reading.

```
if (motor_request_start & motor_off)
{
    pmsm_foc_motor_start();
    motor_off = false;
}
else if (!motor_request_start & !motor_off )
{
    pmsm_foc_motor_brake();
    motor_off = true;
}
Vdc link = pmsm foc get Vdc link();
```





Agenda





Tools Overview

- > DAVE[™] (V4.4.2 onwards)
 - Download DAVE[™] installer package from

http://www.infineon.com/dave

- Download and unzip the installer package



Free Eclipse based integrated development environment (IDE) including GNU C-compiler, debugger, comprehensive code repository, hardware resource management, and code generation plug-in. A complete download package is provided, including IDE, XMC[™] Lib, DAVE[™] APPs, EXAMPLES, and DAVE [™] SDK. DAVE [™] Release Note

Getting Started – Connecting the Board



- 1. Connect XMC1300 CPU Card to PMSM Low Voltage 15W Motor Card using SAMTEC connector interface
- 2. Connect XMC1300 CPU Card to PC via Micro USB cable
- 3. Connect power adaptor to PMSM Low Voltage 15W Motor Card



Getting Started – Download Project from DAVE [1/2]



23

- 1. Open DAVE™ 🗾
- 2. Click on File > Import to import sample code
- 3. Select Infineon > DAVE project and click "Next"

File	New Alt+Shift+N	► A C AND	of ≠ b × b × b + × + ×
	Open File		
	Close Ctrl+W Close All Ctrl+Shift+W	□ 	Select
	Save Ctrl+S	ekowivi	
	Save As Save All Ctrl+Shift+S Revert	25Apr	type filter text
	Move Rename F2 Refresh F5 Convert Line Delimiters To	 Active - Deb 	Build Settings Build Settings DAVE Project DAVE Project From Local Library Store Demonstrain Local Library Store
	Print Ctrl+P		▷ Development ▷ Development ▷ Development
	Switch Workspace Restart	•	▷ 🗁 Team ▷ 🇁 XML
2	Import		
1.23	Export		
	Properties Alt+Enter		(?) < Back
	Exit		

Cancel

Einish

Import FOC example SW to DAVETM 4 (2/2)



- > Next click on Select Archive File > Browse.
- > Select the folder containing the sample code and click "OK".
- > Click on "Finish" to import the code into DAVE[™] 4.

😜 Import DAVE Projects	Finport DAVE Projects
Import DAVE projects Select a folder/Archive to search for existing DAVE projects.	Import DAVE projects Import Existing DAVE Projects
Select Root Directory Browse	Select Root Directory Browse
Select Archive File Browse	Select Archive File C:\Workspaces\DAVE-4.2\WS_2015_03_02\Bkp\BaseCode_; Browse
Project List:	Project List:
Select All Deselect All Refresh	Image: Select All Deselect All Image: Select All Deselect All Image: Select All Deselect All Image: Select All Deselect All Image: Select All Operator Select All Deselect All Image: Select All Operator Select All O
Image: Cancel Mext > Einish Cancel	Cancel



Build FOC example SW in DAVE[™] 4

> Click "Rebuild Active Project"





> "text" in red box indicates that code size



Download FOC example SW in DAVE[™] 4

> Click "Debug Configuration" to download the code

 File
 Edit
 Source
 Refactor
 Navigate
 Project
 Search
 Run
 DAVE
 Window
 Help

 Image: Ima

> Click "Resume" to start the motor control application



> Motor is not spinning



Agenda







Uc/Probe

- The µC/Probe is a Windows application designed to read and write the memory of the embedded target processor during run-time. Memory locations are mapped to a set of virtual controls and indicators placed on a dashboard
- The µC/Probe is used to monitor the motor parameters. It can also be used to fine-tune the PI gains to get the optimum motor behavior. To start the motor, first click 'MOTOR START' button and then drag the 'Setting Target Speed' slider to the right.





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Overview

 $\mu c/Probe$ is a real-time monitor and data visualization stand alone PC tool

- ☑ Easy out of the box non-intrusive variable monitoring
- Synchronous variable monitoring
- ☑ Connects to target using SWD, UART, USB or Ethernet
- ☑ Symbol browser: parse ELF file for variable selection
- ✓ Design rich graphical interfaces to control your application
- ☑ Oscilloscope
- Scripting
- ✓ Log captured data to a file
- ☑ Save/restore session

Open .WSPX



- > Open "PMSM_FOC_SL_XMC1_uCProbe.wspx" with uc/Probe
 - This file in root folder of PMSM_FOC_SL_XMC13_PUBBLIC_V1_5_8_LIB
- If ucprobe don't find .elf file, pop-up will be open and we press "Browse" to find it

〇 1 翌 夏 〇 回 品 ※ づ 〇 〇 I	Micriµm µC/Probe		- é X
File Design View		۵	
Settings Run Stop	Select Connectors Shape String Position		Micrium µC/Probe XMC TM ver. 4,3,0,90
Application Clipboard Tools	UC/Probe Missing File	Paragraph Pi	ofessional Edition for Infineon
Workspace Explorer			
i 🕼 insert Screens * 🔄 Toois * 🛛 0 100	$\mu C/Probe$ is unable to find the following file :	600 700	800 900 1000
- 4- ₽□ Project1	PMSM_FOC_SL_XMC13_PUBBLIC_V1_5_0_LIB.elf		-
Tei DataScreen1	$\mu C/Probe found the following files in your working directory :$		
XMC1000 XMC4000	Name Modified Date		
Symbol Browser			
	d	Search by Name O Search by I	Data Type 🔯 🔝
Taalhay B			Symbol Settings
Writable Controls	Place select one of them to undate your workspace	Size Filtered Memory Address	Name Memory Address User Defined
			Size (bytes) C Data Type
	Browse		Array Configuration
PUSH TOGGLE REPERT	Selected File		Full Array SArray Element
	Cancel Update		
and the second s		1	
Gauges >			Array Configuration Struct Configuration
	101	>	Appointe to estected control Ap
	88.0		Þ

Open .elf



- .elf file is in Debug folder of Dave Project
- ..\PMSM_FOC_SL_XMC13_PUBBLIC_V1_5_8_LIB\Debug\ PMSM_FOC_SL_XMC13_PUBBLIC_V1_5_8_LIB.elf

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ucProbe Design view



- > This view allow customization of GUI interface
 - To start motor we need to press «RUN» button to switch to running mode

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ucProbe Run view



- 1. Press «Motor Start», then motor starts spinning
- 2. Change Tagert speed to increase morot speed
- 3. Play with PI value to fine tuning the motor beahviours

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Features Oscilloscope



- > Requires application changes and it is minimal intrusive
- Continuous and triggered sampling mode
- > Synchronous and asynchrnous control loop sampling mode





Tuning of Kp, Ki value using the μ C/Probe

 Adjust P and I setting of PLL Control/Speed Control for finer tuning of Motor behaviour. The final goal is to achieve sinusoidal current waveform in the Oscilloscope page of the µC/Probe GUI.





Target of tuning the P, I and SCALEKPKI values of the control loops is to achieve the target motor performance and get **sinusoidal** current shapes for the 3 motor currents I_U, I_V, I_W

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Tuning of PI Controller Gains







0.0

Rise Time

5

Time

10

15



Hint to fine tuning

- 1. Set Control Scheme VQ_CONTROLLED_DIRECT_FOC just to run motor and check HW/SW configurator
- Change control scheme to TORQUE_CONTROLLED_DIRECT_FOC and adjust Ki Kp Parameters of PLL ,Torque and Flux PI
- 3. Then set control scheme to SPEED_CONTROLLED_DIRECT_FOC if speed control is need, and adjust Ki Kp of Speed PI

PLL PI parameters Adjust



> Hints on tuning of SCALEKPKI, P, I value steps.





General Information (2/2)

- For latest updates, please refer to: <u>http://www.infineon.com/xmc1000</u>
- DAVE[™] development platform: <u>http://www.infineon.com/DAVE</u>
- > For support:

http://www.infineonforums.com/forums/8-XMC-Forum



Hardware Overview – Kit Order information

No.	Kit Name	Kit Description	Order Number
1	KIT_XMC1x_AK_Motor_001	XMC1000 Motor Control Application Kit	KIT_XMC1x_AK_Motor_001

Development Boards	Order Number
XMC1300 Boot Kit	KIT XMC13 BOOT 001
PMSM Low Voltage 15W Card	KIT XMC1x AK Motor 001



Glossary Abbreviations

- > ADC Analog Digital Converter
- > DAVE[™] Digital Application Virtual Engineer (Free development IDE for XMC[™])
- > PWM Pulse Width Modulation
- > SW Software

Disclaimer

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