

MC application tuning

Lab 4 - How to Control and Tune your motor using the Motor Control Workbench and its Monitor







Motor Control Development Workflow #5 – Motor Drive Tuning





LAB 6 tasks

• Detailed description of its Monitor



- Debug functions
- FOC StartUp
- Tuning Flow





ST Motor Control Workbench Monitor





tands.on



Monitor – connection







Monitor – connection













Monitor – Fault and ACK Fault





life.augmented



life.augmented

Monitor – Plotter part

The Plotter is located in MC WB Monitor







Monitor – Advanced

🚸 ST Mo	otor Control W	Vorkben	ch [MC_WorkShop_01]							
File	Tools Help) Doc	umentation							
P		X	la 🖡 👌 🍓	. 🙆 😢	Port COM1	43 • 115200 •		Close Monitor	2	
Status			Basi Advanced Registe	ers Configuration		Firmware: ST MC SD	K Ver.	5.0.2		Generic
0	ldle	ſ	Speed		-			Sensor-less Observer+PLL		Target motor
Faults		_	opeca					Observer C1 -22530		Motor 1 -
	FOC duration		Speed		gs			Observer C2 3500		Start Motor
i i i	Over voltage		Torque				-	PLL Kp 50		
ŏ	Under voltage	i li			л с		•	PLL Ki 1		Stop Motor
ŏ	Overheat									Stop Ramp
ŏ	Start-up failure		- Current controller	and mode	Speed controller			Sensor-less Observer+Cordic		Fault Ack
õ	Speed feedbac	*	Torque ref (lg)	0	Target speed	2000 🖨 mm	1	Observer C1 0		Encoder Alian
ŏ	Over current		Flux ref (Id)	0	Duration 1	000 🚊 millise	c	Observer C2 0		All maters
ŏ	Software error			0		Exec ramp		Flux weakening tuning		Ail motors
								Kp 0		
Mantan		-11	Measured currents					Ki O		PFC
WORILOF	0		Torque (lq)	0	Kp 3/2	3		BUS Voltage allowed		PFC Enable
		.	Flux (Id)	0	N 20	1		Ref 0 ‰		PFC Disable
Measu	red speed (rpm))	Iq PID Gains	PID Gains				Meas 0 ‰		PFC Fault Ack
			Кр 3671 К	ώ <u>3671</u>						
			Кі 2445 К	û 2445						
Variable			Motor Uni ^	Time	Motor Id	Message				•
PWM freq	luency		30000 Hz	03:36:46		Command "Fault Ack" done!				
Sensor se	lection main		Sensoriess (U	03:36:47		Command "Start Motor" done				=
Tomuel	lux - Execution :	rate	1 PM	03:42:23		Command "Fault Ack" done!				
Bus voltad	ae sensina	1010	true	03:42:31		Command "Fault Ack" done!				Ψ.
<				Info / Errors / Warr	hings Change Log					





Monitor – Register

🚸 ST Motor Control Workber	nch [M0	C_WorkSI	hop_01]										
File Tools Help Doo	cument	ation											
	M		2 👢 🕙 💽 🚺	Port COM14	3 • 11520	. 00	· 🔊 🍕				Close	Monitor 🥘	
Status	Basic	Advanc	Registers onfiguration	F	irmware: S	T MC SE	OK Ver. 5	.0.2					Generic
🔘 Idle		ld	Name	Unit	Value	Min	Max	Period	Туре	Mode	Enable	Last read	Target motor
Faults	•	0x00	Target motor		0	0	255	0	U8	RW	1	never	Motor 1 👻
FOC duration		0x01	Flags		0	0	4294967	200	U32	R	1	2018-04-20 15:4. ≡	Start Motor
Over voltage		0x02	Status		0	0	255	200	U8	R	1	2018-04-20 15:4.	
Under voltage		0x03	Control mode		1	0	255	500	U8	RW	1	never	Stop Motor
		0x04	Speed reference	RPM	750	-2000	2000	200	S32	R	1	2018-04-20 15:5.	Stop Ramp
Chart un failure	0x05	0x05	Speed Kp		3723	0	65535	0	U16	RW	2018-04-20 15:1.	Fault Ack	
		0x06	Speed Ki		261	0	65535	0	U16	RW	1	2018-04-20 15:1.	Encoder Alien
Speed feedback		0x07	Speed Kd		0	0	65535	0	U16	RW	1	never	Encoder Align
Over current		0x08	Torque reference (lq)		0	-32768	32767	0	S16	RW	1	never	All motors
Software error		0x09	Torque Kp		3671	0	65535	0	U16	RW	1	2018-04-20 15:1.	
		0x0A	Torque Ki		2445	0	65535	0	U16	RW	1	2018-04-20 15:1.	PFC
Monitor		0x0B	Torque Kd		0	0	65535	0	U16	RW	1	never	PEC Enable
0		0x0C	Flux reference (Id)		0	-32768	32767	0	S16	RW	1	never	
Measured speed (rpm)		0x0D	Пих Кр	3671	3671	0	65535	0	U16 RW	RW	1	2018-04-20 15:1.	PFC Disable
		0x0E	Flux Ki		2445	0	65535	0	U16	RW	1	2018-04-20 15:1.	PFC Fault Ack
		0x0F	Flux Kd		0	0	65535	0	U16	RW	1	never	
		0x10	Observer C1		-22530	-32768	32767	0	S16	RW	1	2018-04-20 15:1.	
		0x11	Observer C2		3500	-32768	32767	0	S16	RW	1	2018-04-20 15:1.	
		0x12	Cordic Observer C1		0	-32768	32767	0	S16	RW		never	
Variable	Moto)r	Uni Time Mo	tor Id	Message								*
PWM frequency Sensor selection main	3000 Sene)U Vordess (O	Hz = 03:36:46		Command "Faul	t Ack" done!							
Sensor selection aux	Sens	or-less (O	03:36:47		Command "Star	t Motor" done	e!						=
Torque&Flux - Execution rate	1		PW 03:42:23		Command Faul	t Ack "done!							
Bus voltage sensing	true	_	The Charles Charles Ch										
			Into / Errors / Warnings Cr	lange Log									
													.:





Monitor – Configuration









life.augmented

MC debug feature – Plotter

• The Plotter is located in MC WB Monitor





Time (sec

MC debug feature – DAC channels

- DAC functionality can help to debug and tune the application.
 - CH1 PA4 pin
 - CH2 PA5 pin
- Enabling & Selecting in the DAC functionality
- Online selection is in WB Monitor Advance

Basic Advanced R	legisters Configura	tion		
-Configuration and deb	oug			
Control mode	Speed		•	
Power Board Status			- DAC Se	ettings
BUS Voltage	11	Volt	Ch1	la 🔹
Heatsink temp.	26	°C	Ch2	lb 🔻





Typical DAC waveforms of tuned system



- Green: phase A motor current
- Yellow: DAC ch1 (la)
- Pink: DAC ch2 (lb)



- Green: phase A motor current
- Yellow: DAC ch1 (Obs. BEMF Alpha)
- Pink: DAC ch2 (Obs. BEMF Beta)





Tuning Flow









FOC StartUp - Basic

- Duration depends on construction of motor higher mass, higher duration (2000ms)
- Final current ramp value from 0.5 to 1 times motor nominal current according to load
- Set speed ramp final value to around 30% of maximum application speed
- According to motor inertia it may be required to increase the speed ramp duration (1500ms)
- Set current ramp initial and final values equal to motor nominal current value / 2

ensor-less rev-up settings							
On-the-Fly startup							
rofile							
Basic							
Advanced customized							
Include alignment before ramp-up	V						
Duration	200	📥 ms					
Alignment electrical angle	90	eq deq					
Final current ramo value	0.30			600			- 1.0
Final current ramp value	0.50	▼ ^	2	-			
Speed ramp duration	1500	📥 ms	T T	400			Curr
Speed ramp final value	600	🜩 rpm	eed (-0.5 g
Current ramp initial value	0.30	A	- ^م	200			- 🖻
Current ramp final value	0.40	A 🗎					- 0.0
Connect annual de anticas	1000	· · ·			500 1000	1500	0.0
Current ramp duration	1000	The second secon	J		Duration (ms)		
					Duration (ma)		
Consecutive succesful start-up outp	ut tests	2	-	Rev-up to FOC sv	witch-over		
Minimum start-up output speed		500	i mm	Enable			
		100.05	×	Duration	25	≜ ms	
Estimated speed Band tolerance up;	ber limit	106.20	× %				
Estimated speed Band tolerance low	er limit	93.75	÷ %				





FOC StartUp - Basic

- Set minimum start-up output speed to 15% of maximum application speed (if required, decreased it later)
- Set estimated speed band tolerance lower limit to 93.75%

ensor-less rev-up settings									
On-the-Hy startup									
Profile									
Basic									
Advanced customized									
Include alignment before ramp-u	p 🔽								
Duration	200	.▲ ms							
Alignment electrical angle	90	🚖 deg							
Final current ramp value	0.30	₽ A			600			- 1.0	
Speed ramp duration	1500	ms		Ē	400 —			-	ρ
Speed ramp final value	600	mm		ed (rp	Ξ			- 0.5	rrent
Speed famp final value	000	• ipin		Spee	200	-/		-	Þ
Current ramp initial value	0.30	÷ A			= / _			-	
Current ramp final value	0.40	A			0		1 1 1 1	· · · · 0.0	
Current ramp duration	1000	📥 ms			Ó	500	1000	1500	
	-					Duratio	n (ms)		
Consecutive succesful start-up ou	tput tests	2	÷.		Rev-up to FOC	switch-over			
Ainimum start-up output speed		500		mm	Enable	[
	b a	100.05		9/	Duration		25	.▲ ▼ MS	
stimated speed Band tolerance u	upper limit	106.25	•	7.					
stimated speed Band tolerance l	ower limit	93.75	* *	%					
					-				





FOC StartUp - Advanced

Variable setting of start ramp by steps

Threshold for to switch to the close loop!

ensor-less rev-up settings On-the-Fly startup Profile Basic Advanced customized							
Duration (ms) Final s 1) 1000 ↓ 2) 1176 ↓ 3) 0 ↓ 4) 0 ↓ 5) 0 ↓ Execute sensor-less algorithm st	0 speed (rpm) Fin 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5		Speed (rpm)	400	500 1000 Duration (1500 2 ms)	2.0 1.5 1.5 1.0 Current (A 0.5 0.0
onsecutive succesful start-up o	utput tests	2	* *	Rev-up to F	OC switch-over		
linimum start-up output speed		500	₽ rpm	Duration	25	Å	ms
stimated speed Band tolerance stimated speed Band tolerance	upper limit lower limit	93.75	₩ %				



FOC StartUp - representation of set a data

StartUp ramp in the MC Worbench



• StartUp ramp read in the Monitor

The StartUp ramp in Basic mode is transferred to the table where is:

- Final **speed** in in the end of a step
- Final torque in the end of a step
- Duration of a step

The StartUp ramp can be tune and test online

Revu	Revup Configuration										
	Num	Final Speed (rpm)	Final Torque	Duration (ms)	Last read	Last write					
•	1	0	15040	1000	2018-04-24 16:15:37.921	never					
	2	588	15040	1176	2018-04-24 16:15:37.983	never					
	3	588	15040	0	2018-04-24 16:15:38.045	never					
	4	588	15040	0	2018-04-24 16:15:38.108	never					
	5	588	15040	0	2018-04-24 16:15:38.170	never					



22



Tuning Flow

- We recommend these steps for tuning
- Start-up
- The PID parameters
 - 1. Current regulator
 - 2. Observer (C2) and Observer regulator
 - Torque mode skip the Speed regulator
 - 3. Speed regulator

ST Motor Control Workbe	nch [MC_WorkShop_01]		and so welled.	
	icumentation	Port COM143 • 115200 •	🐼 🔶 📊 🌈 Close Monitor 🥙	
itatus	Basic Advanced Registers Configuration	Firmware: ST MC SDK	Ver. 5.0.2	Generic
Idle Faults FOC duration Over voltage Under voltage Overheat	Configuration and debug Control mode Power Board Status BUS Voltage 11 Volt Heatsink temp. 27 °C Competencies		Sensor-less Observer+PLL Observer C1 -22530 Observer C2 2500 PLL Kp 203 PLL Ki 4	Target moto Motor 1 Start Moto Stop Moto Stop Ramp
 Start-up failure Speed feedback Over current Software error 	Set current reference in speed mode Torque ref (lq) 465 Flux ref (ld) 0	Speed controller Speed amp Target speed 200	Sensor-less Observer+Cordic Observer C1 0 Observer C2 0 Flux weakening tuning Kp	Fault Ack Encoder Alig
onitor 0 Measured speed (rpm)	Immediated currents 0 Torque (Iq) 0 Flux (Id) 0 Id PID Gains Id PID Gains Kp 3671 Ki 2445	Ko 3200 Ki 261	Ki 0 BUS Voltage allowed Ref 0 Meas 0	PFC Enable PFC Disable PFC Fault A
riable VM frequency nsor selection main nsor selection aux rque&Flux - Execution rate	Mctor Uni ▲ Time 30000 HZ ≡	Motor Id Message		
s voilage sensing				





- Additional Tips & Tricks you can found in F.A.Q.
 located in ST web site.
- Or in the dedicated MOOC training.





25 Motor Control Development Workflow #5 – Motor Drive Tuning Image: State of the sta

