1. Application note description

This application note describes the limit switches inputs default behavior and how it can be disabled, to use these special inputs as general purpose inputs.

Inside this application note is also shown how the load movement can be restricted using the software limit switches.

2. EasyMotion Studio implementation

2.1 Hardware Limit Switches – Default Behavior

The "LSN" (negative limit switch) and "LSP" (positive limit switch) digital inputs were designed to allow the physical connection of the system limit switches.

By default, when one of the limit switches became active, the drive stops the motor (using a quick stop profile), sets the correspondent bits, in the MER error register, to 1 and executes the code inside the correspondent limit switch interrupt routine (if it is active on the inactive to active limit switch transition).

<u>Remark</u>: The active level for the limit switches inputs can be set through the "Drive Setup" dialog.

Guideline assistant			- Control mode	- External re	ference			(enouroning	
	Previous	Next	Position	€ No	C Ye	s Seti	ap	0	JK
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you want to control: posi < <commutation method=""></commutation>	ion, speed or torque. In > group box, choose sini	the usoidal or	C Torque	☐ Autor	natically a	ctivated after Power	0n	He	elp
trapezoidal mode. The tra motor is equipped with di	apezoidal mode is possibl gital Hall sensors.	le only if your	Advanced	Commutati	ion method ezoidal	G Sinusoidal		Mo	tor
		÷	Drive Info	Axis ID sel	lection et / chang	e axis ID 1	•	Set	up
CANbus			Protections	L					Booglada
✓ Baud rate 1 Mb	ps 🔻 CA	Nopen settings	🔽 Over current			_			
Drive operation paramete			Motor current >	10.6	A	💌 for more than	0.01	s	•
Power supply 24	V •	Detect	Control error Position error >	0.4995	rot	✓ for more than	3	s	•
Current limit 4	A		Control error	loro.		<u> </u>			
			Speed error >	1210	rpm	for more than	3	\$	
Current controller			Motor over ten	nperature					
Kp 3.031			0 Ver current	3.872	A	• for	14.001	\$	w
Ki 0.36372		Tune & Test	External brake resis	tor	Activat	t noisier sunnlu s	49.999	- <u>Iv</u>	
Speed controller			1 Connected		CINES AND	in power supply 7	10.000		
Kp (417.47 Ki (31.311	Integral limit 41	× <u>×</u>	Active high (Connec	cted to +Vlog	ן)	imit switch+ Limit sv ເຈົ້	vitch- Ty	/pe Sink (P	NP)
			Active low (Open/N	o connection	1)	с с	· (Source	(NPN)
		Tune & Test	Software limits - r	estrict mover	ment	Position range	e limits —		
Position controller			Negative limit -1073	3741.82 rot	Ψ.	Minimum			Ŧ
K = 20	Juba and Kasik 10		Positive limit 1073	3741.82 rot	Ψ.	Maximum			v
Ki Acocz		^ •	- Start mode	1800.00					
4.0307	Feedforward	(Acceleration)	Move till aligned	ed with phase	A	Settings			
	lu	(speed)	G BLDC with Ha	Il sensors	-				
Na nicer (0. 10001			C PMSM with Ha	all sensors					
			C Direct start usi	ng absolute r	position se	nsot			
		Tune & Test	C	ng decontro p					

Figure 1. Limit switches polarity configuration

The limit switches default behavior can be easily observed when a motion profile is executed and the correspondent limit switch input is changed to the active state.

<u>Remark</u>: If the test system does not have a limit switch, the user needs to simulate it by connection the "IN2/LSP" drive terminal to "GND" or to "Vlog" as is described in the drive user manual.

Below is an example where the drive executes a trapezoidal position profile with a position increment of 10000 rot, a speed of 100 rpm and an acceleration of 1500 rad/s^2.

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🗆 🚯 Untitled	Main
E B LSP and LSN - part 2	LSP status reading - only for LOGGER display purpose.
S Setup	//Position profile
Homing Modes	CACC = 0.47746;//acceleration rate = 1500[rad/s^2]
Functions	CPOS = 2000000L;//position command = 1000[rot]
	CPR; //position command is relative
	TUM1; //set Target Update Mode 1 (1)
	UPU; // execute immediate IMC; WAITI; // wait for completion
	······································
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Figure 2. Main section of the TML program

When the positive limit switch became active, the quick stop profile is executed and the motion stops. This moment can be also captured using the Logger function in EasyMotion Studio.



Figure 3. Quick Stop procedure cached on the Logger

The load positon (red line) in the above figure, starts from 0 rpm and follows the imposed motion profile. After \sim 0.6 s, the positive limit switch (the yellow line) became active and the drive enters in the quick stop mode. As can be seen in the second plot, the motor decelerated until the motor speed (white line) became 0 rpm.

While the positive limit switches is active, the bit 6 - "LSP (limit+) active" in the MER error register is also set to 1.

SRH - Status Register High	SRH - Status Register High SRL - Status Register Low			DER - Detail Error Registe	er	DER2 - Detail Error Re	
15 - Fault 0	15 - Axis is ON	15 - STO 1 or 2 is inactive	0	15 - EEPROM Locked	0	15 - Reserved	1
14 - In Cam 0	14 - Event set has occured 1	14 - Command error	0	14 - STO hardware error	0	14 - Reserved	1
13 - In freeze control	10 - Motion is completed 1	13 - Under voltage	0	13 - Self check error	0	13 - Reserved	(
12 - In Gear 0	8 - Homing/CALLS active	12 - Over voltage	0	12 - TML heartbeat ignored	0	12 - Reserved	(
11 - I2t warning - Drive 0	7 - Homing/CALLS warning 0	11 - Over temp Drive	0	11 - Start mode failed	0	11 - Reserved	1
10 - I2t warning - Motor 0	Registers legend:	10 - Over temp Motor	0	10 - Encoder broken wire	0	10 - Reserved	(
9 - Target reached 1	1 - Yes / True ENDINIT	9 - I2 t	0	9 - UPD ignored for S-curve	0	9 - Reserved	1
8 - Capture event/interrupt 0		8 - Over current	0	8 - Invalid S-curve profile	0	8 - Reserved	(
7 - LSN event/interrupt	IMPORTANT! Check SRH.0 !	7 - LSN (limit -) active	0	7 - Software LSN active	0	7 - Reserved	T
6 - LSP event/interrupt	or error bits are set ONLY after	6 - LSP (limit +) active	1	6 - Software LSP active	0	6 - Reserved	(
5 - Autorun enabled	ENDINIT is executed.	5 - Feedback error	0	5 - Cancelable call ignored	0	5 - Hall sensor missing	(
4 - Over position trigger 4 1	If SRH.0 = 0 and you use Fasy SetUp, download a setup.	4 - Serial comm. error	0	4 - UPD ignored	0	4 - AEI interface error	(
3 - Over position trigger 3 1	reset the drive and press the	3 - Control error	0	3 - Function not available	0	3 - BiSS sensor missing	1
2 - Over position trigger 2 1	nearby button to send an ENDINIT	2 - Invalid setup data	0	2 - Homing not available	0	2 - BiSS data error	1
1 - Over position trigger 1 1	EasyMotion Studio, run a TML	1 - Short-circuit	0	1 - TML stack underflow	0	1 - BiSS data warning	1
0 - ENDINIT executed 1	program. This includes execution	0 - CANbus error	0	0 - TML stack overflow	0	0 - BiSS CRC error	T

Figure 4. Drive Status control panel that shows the MER error register

Remark: While the positive limit switch is active, the drive accepts only negative position commands.

2.2 How to use the limit switches digital inputs as general-purpose inputs

The limit switches default behavior can be disabled by setting the "LSACTIVE" parameter to 1.

Project		
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🗆 🚯 Untitled		
🖃 📰 Untitled Application	LSACTIVE = 1;	
S Setup ☐ M Motion M Homing Modes P Functions ☐ Interrupts CAM Tables	Assignment & Data Transfer - 16 bit Integer Data	? X
-	C With C program Guides set in pointer variable C E2ROM Image: then increment the pointer variable C With C low C high part of 32-bit variable	
	C Using AND mask h and DR mask h With checksum C data of data located in C E2RDM and And	h h
	C Set C data C program C E2ROM OK C Cancel Help	_

Figure 5. Generate the "LSACIVE = 1;" instruction

To reactivate the limit switches default behavior is enough to set the "LSACTIVE" parameter back to 0.

The application example in the previous point was modified to include the "LASCTIVE = 1" instruction.

🔁 Project		×						
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🖂 🚯 Untitled	Main	l.						
☐ ☐ ☐ LSP and LSN - part 2 S Setup	LSP status reading - only for LOGGER display purpose. Disable the default functionality	te						
M Motion	LSACTIVE = 1;							
Homing Modes	Move positive, wait for motion completed //Position profile	1						
Interrupts	CACC = 0.47746;//acceleration rate = 1500[rad/s^2] CSPD = 3.33333://slew_sneed = 100[rom]	\times						
CAM Tables	CPOS = 2000000L;//position command = 10000[rot]	{+}						
	MODE PP;	{[]}						
	TUM1; //set Target Update Mode 1 UPD; // execute immediate	1						
	IMC; WAIT; // wait for completion							
		Þ						

Figure 6. Main section for TML program

In this case, the trapezoidal position profile will not be stopped any more when the positive limit switch became active. It will simply continue until the motion will be completed (if no event or protection will be triggered).



Figure 7 The effect of the "LSACTIVE = 1;" instruction

On the Logger above can be easily seen how the motor position (red line) starts from 0 rot and increases, according to the profile reference, even the positive limit switch (yellow line) has become active. The speed is also increasing until it achieves the imposed value (100 rpm) and then remains constant.

3. Software Limit Switches

When the system is not equipped with hardware limit switches but the application requires to limit the load movement, the software limit switches can be used.

The software limit switches can be activated and configured from the "Drive Setup" dialog.

ve Setup									
Guideline assistant —	10-10-10 M	1	Control mode	External r	eference -	10	12		ОК
	Previous	Next	Position	No	C Ye	es	Setup		
Step 1. In the < <co< td=""><td>ntrol mode>> group box, sele</td><td>st what do 🛛 🔺</td><td>C Speed</td><td>C Anal</td><td>ogue 🔍</td><td>Incremental E</td><td>Encoder</td><td></td><td>Lancel</td></co<>	ntrol mode>> group box, sele	st what do 🛛 🔺	C Speed	C Anal	ogue 🔍	Incremental E	Encoder		Lancel
you want to control: p < <commutation metho<="" td=""><td>osition, speed or torque. In th od>> group box, choose sinus</td><td>.e oidal or</td><td>C Torque</td><td>Auto</td><td>matically a</td><td>ictivated after</td><td>Power On</td><td></td><td>Help</td></commutation>	osition, speed or torque. In th od>> group box, choose sinus	.e oidal or	C Torque	Auto	matically a	ictivated after	Power On		Help
trapezoidal mode. The motor is equipped with	e trapezoidal mode is possible n digital Hall sensors.	only if your	Advanced	C Trap	tion metho pezoidal	d	soidal	M	oto
		~	Drive Info	Axis ID se	election Set / chan	ge axis ID 1		3	etup
CANbus			Protections	d				<u>jeđa</u>	allerheide, bi
✓ Baud rate 1	Mbps 👻 CAN	open settings	Ver current	P					
Drive operation param	eters		Motor current	> 10.6	A	▼ for more	than 0.01	s	
Power supply 24	V •	Detect	Position error	0.4995	rot	✓ for more	than 3	s	
Current limit 4	A		Control error	Trees			1		
			Speed error >	210	rpm	for more	e than 3	\$	
Current controller			Motor over ter	nperature					
Kp 3.031			0 ver current	3.872	A	-	for 14.00	1 \$	1
Ki 0.36372		Tune & Test	External brake resis	stor	1004-04	191	/// 1 provinces		
Speed controller			Connected		Actival	e if power sup	oply > 49.999	9 V	
Kp 417,47	Integral limit 41	× -	Inputs polarity			Limit switch+	Limit switch-	Туре	
∾ <u>Jai.an</u>			Active high (Connel Active low (Open/N	cted to +Vloj lo connectio	3) m)	e C	е С	 Sink Sou 	. (PNP) rce(NPN
		Tune & Test	Software limits -	restrict move	ement	r - Positic	in range limits		
Position controller			Negative limit -100	rot	-	Mini	mum		Ŧ
v- 120	1.1		Positive limit 100	rot	•	Maxi	mum		v
Ki A cocz	Integral limit 10	_ *	Start mode						
N 4.6967	Feedforward	(Acceleration)	Move till align	ed with phas	еA	Settings	1		
	Iu	(speed)	G BLDC with Ha	Il sensors	77				
ca niter (U. 1000)			C PMSM with H	all sensors					
		Time & Test	C Direct start us	ing absolute	position se	ensor			
		Tune & Test	 Motionless sta 	art (encoder i	only]				

Figure 8 Software limit switches configuration

As functionality, the software limits switches act like the hardware limit switches: when a limit is reached, the drive executes the quick stop routine and set the correspondent bits in the DER register.

SRH - Status Register High	SRL - Status Register Low	MER - Error Register	DER - Detail Error Register	DER2 - Detail Error Reg	g. 2
5 - Fault	15 - Axis is ON 1	15 - STO 1 or 2 is inactive 0	15 - EEPROM Locked 0	15 - Reserved	Г
4 - In Cam 0	14 - Event set has occured 1	14 - Command error 0	14 - STO hardware error 0	14 - Reserved	
3 - In freeze control	10 - Motion is completed 1	13 - Under voltage 0	13 - Self check error 0	13 - Reserved	
2 - In Gear 0	8 - Homing/CALLS active 0	12 - Over voltage	12 - TML heartbeat ignored 0	12 - Reserved	
1 - 12t warning - Drive 0	7 - Homing/CALLS warning 0	11 - Over temp Drive 0	11 - Start mode failed 0	11 - Reserved	
0 - I2t warning - Motor 0	Registers legend:	10 - Over temp Motor 0	10 - Encoder broken wire 0	10 - Reserved	-
9 - Target reached	1 - Yes / True ENDINIT	9 - 12t 0	9 - UPD ignored for S-curve 0	9 - Reserved	-
8 - Capture event/interrupt	0 - NO / Taise	8 - Over current 0	8 - Invalid S-curve profile 0	8 - Reserved	
7 - LSN event/interrupt	IMPORTANT! Check SRH.0 !	7 - LSN (limit -) active 0	7 - Software LSN active 0	7 - Reserved	
6 - LSP event/interrupt	or error bits are set ONLY after	6 - LSP (limit +) active 0	6 - Software LSP active 1	6 - Reserved	1
5 - Autorun enabled	ENDINIT is executed.	5 - Feedback error 0	5 - Cancelable call ignored 0	5 - Hall sensor missing	
4 - Over position trigger 4	If SRH.0 = 0 and you use Fasy SetUp, download a setup,	4 - Serial comm. error 0	4 - UPD ignored 0	4 - AEI interface error	
3 - Over position trigger 3 1	reset the drive and press the	3 - Control error 0	3 - Function not available 0	3 - BiSS sensor missing	
2 - Over position trigger 2	nearby button to send an ENDINIT	2 - Invalid setup data 0	2 - Homing not available 0	2 - BiSS data error	
1 - Over position trigger 1 1	EasyMotion Studio, run a TML	1 - Short-circuit	1 - TML stack underflow 0	1 - BiSS data warning	T
0 - ENDINIT executed 1	program. This includes execution	0 - CANbus error 0	0 - TML stack overflow 0	0 - BiSS CRC error	

Figure 9 Software limit switches bits in the DER register

Using the same portion profile as in the previous examples, the following Logger results were obtained, if the positive software limit switch is set to 10 rot.



Figure 10. Software limit switches behavior

The motor position (red line) increases, according to the imposed motion profile. When it reaches 10 rot (software limit - yellow line), the motion is stopped. This can also be seen in the second plot, where the motor speed (white line) is plot.