Application Note: AN00118

Supporting your BLDC motor

This application note shows how a custom BLDC motor can be integrated with the XMOS Motor and Motion control kit and use the software available in xSOFTip as Synapticon Motion Control.

The SOMANET platform provides the flexibility to build the desired distributed control system based on their SOMANET nodes. SOMANET nodes are the basic units, each placed directly at the resource it shall control, like an electrical motor or a sensor of any kind. With each node here are a variety of options available, supporting any mechatronic application, from simple sensor data acquisition up to sophisticated multi-axis motion control.

This application provides an example motor configuration for the *SOMANET Standalone Profile Velocity Control Demo*

Note: The same configuration is applicable for the position and torque control.

Required tools and libraries

- xTIMEcomposer Tools - Version 13.1.0
- Modules and Applications available under Synapticon Motion Control in xSOFTip
- EtherCAT master software and associated makefiles from Synapticon[1]. Get the software from the Synapticon site.

Required hardware

- XMOS Motor & Motion Control Development Kit (XK-SN-1BH12-E or XK-SN-1BQ12-E) developed by Synapticon[2].
- A linux PC to run the EtherCAT MASTER application
- A suitable regulated power supply of delivering more than but can be set for current limits based on loaded operating conditions during development and testing.

Prerequisites

- This document assumes familiarity with the XMOS xCORE architecture, the XMOS tool chain and the xC language.
- Assembling the SOMANET IFM-Drive hardware module. For more details refer[3]
- Successful running of SOMANET Standalone Profile Velocity Control Demo.

[1] http://doc.synapticon.com/wiki/index.php/File:IgHEthercatLinuxMaster.zip
[2] https://www.xmos.com/download/public/XMOS-Motor-Motion-Development-Kit-Product-Brief(1.1).pdf
[3] https://www.xmos.com/download/public/XMOS-Motor-Motion-Development-Kit-User-Guide(1.0).pdf

1 Overview

1.1 Introduction

The XMOS Motor & Motion Control development kits are integrated board and software packages which contain everything embedded systems designers need to begin developing single and multi-axis motion control applications on the powerful xCORE™ multicore microcontrollers.

The kits include an xCORE powered control module (CORE), a communications module (COM), and a motor interface drive module (IFM Drive DC 100), a BLDC motor as well as the interconnect cables.

The table below details the contents of the XMOS Motor & Motion Control Kits.

Description	Motor & Motion Control Kit (EtherCAT/Hall Sensor)	Motor & Motion Control Kit (EtherCAT/Quadrature Encoder)
Control Module	SOMANET Core C22	SOMANET Core C22
Motor IFM Module	SOMANET IFM Drive DC 100	SOMANET IFM Drive DC 100
Motor	Moons 42BL30L2-5	Nanotec DB42S03
Sensor Type	Hall Sensor	Hall & Quadrature Encoder
COM Module	EtherCAT slave	EtherCAT slave
Part Number	XK-SN-1BH12-E	XK-SN-1BQ12-E

Table 1: XMOS Motor & Motion Control Kits

The IFM Drive DC 100 implements latest power transistor technology to efficiently drive one Brushless DC motor with up to 120 W. It supports input supply voltage range of 12-24 V. The IFM Drive DC 100 which comes with the XMOS Motor and Motion Control kit provides the connectors to connect the motor phase windings, Hall Sensor interface and Quadrature Encoder Interface. Refer to the appendix section for the detailed datasheet of the motors supplied with the kits.

Note: The optical Encoder assembly WEDL5541-B14 in Nanotec DB42S03 provides 1000 cycles per revolution.

The assembly and the motor connection is shown in Figure below to run the example.

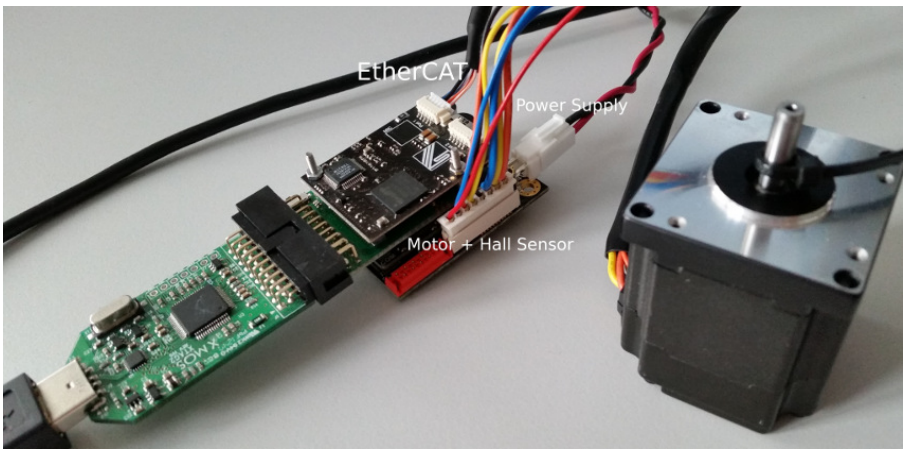


Figure 1: XMOS Motor control kit assembly and motor connection

1.2 Motor Phase Winding Connection

The motor phase windings connector is an 8-pin Molex SPOX HSG 8P header. The pin details are shown in Figure below.

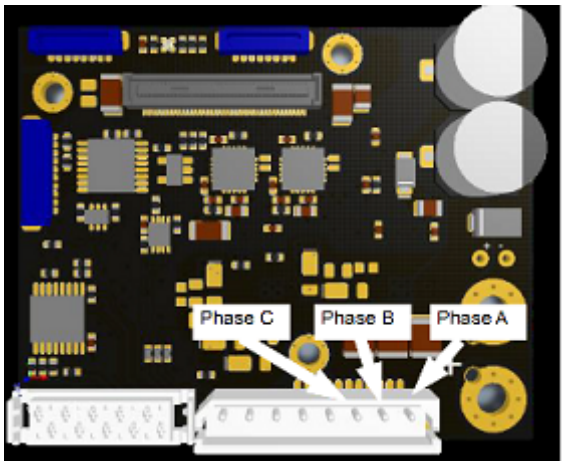


Figure 2: Phase Windings connector pins

1.3 Hall Sensor Interface Connection

The IFM Drive DC 100 provides a standard motor Hall sensor interface, which is the most frequently used method for rotor position and speed feedback. The connector is an 8-pin Molex SPOX HSG 8P header.

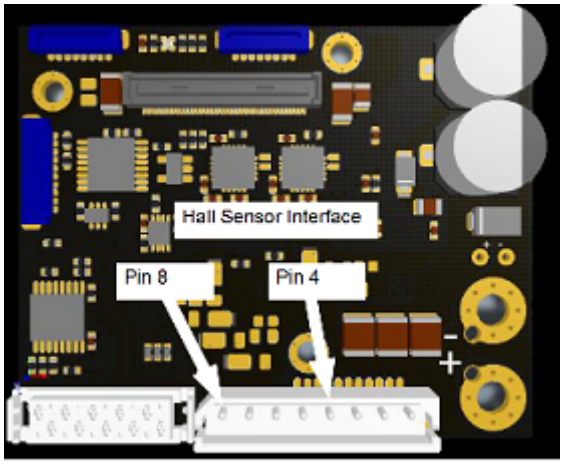


Figure 3: Hall Sensor connector pins

1.4 Quadrature Encoder Interface Connection

The IFM Drive DC 100 is equipped with a RS-422-compatible quadrature encoder interface. Inputs are converted by a differential line receiver. This connector is a 10-pin TE MicroMatch.

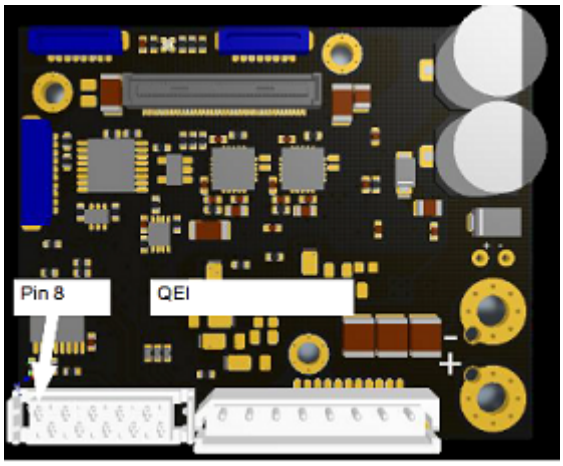


Figure 4: Quadrature Encoder Interface connector pins

2 Configure your motors for a SOMANET Standalone Profile Velocity Control Demo

The Standalone profile control software component must contain a motor configuration file. This file, called **bldc_motor_config.h**, must be located at the folder **config/motor/** on your application. Since It defines the features of your BLDC motor, it is important to set it properly before running any motor control application.

As an example the configuration is done for *MOONS 42BL30L2-5* BLDC motor. The values are taken from the motor datasheet.

The main parameters to define in our configuration file will be:

- Number of pole pairs:

```
#define POLE_PAIRS 3
```

- Maximum nominal speed (in rpms):

```
#define MAX_NOMINAL_SPEED 4000
```

- Maximum nominal current (A):

```
#define MAX_NOMINAL_CURRENT 2
```

- Motor torque constant (required for torque control):

```
#define MOTOR_TORQUE_CONSTANT 36 // mNm/A
```

- Your motor winding type (star or delta):

```
#define WINDING_TYPE DELTA_WINDING // or STAR_WINDING
```

- Your DC board (DC100 or DC300):

```
#define IFM_RESOLUTION DC100_RESOLUTION // or DC300_RESOLUTION
```

- Sensor used for control (Hall or Quadrature Encoder):

```
#define SENSOR_USED HALL // or QEI
```

- If QEI sensor is used then set the type (w/ or w/o index), resolution, or polarity (to match the hall sensor polarity):

```
/* Polarity is used to keep all position sensors to count ticks in the same direction
     *  (QEI_POLARITY_NORMAL/QEI_POLARITY_INVERTED) */
     #define QEI_SENSOR_POLARITY         QEI_POLARITY_NORMAL

     #define ENCODER_RESOLUTION 4000 // 4 x Max count of Quadrature Encoder

     /* Define your Incremental Encoder type (QEI_INDEX/ QEI_WITH_NO_INDEX) */
     #define QEI_SENSOR_TYPE             QEI_WITH_INDEX
```

- If you are using a gear, specify the ratio, otherwise set to 1:

```
#define GEAR_RATIO 1 // e.g. 26, or 1 if no gear is attached
```

3 BLDC Motor Tuning Guide

After you have set up most of your motor parameters according to the previous section you can further fine tune your motors efficiency and performance. Inside the bldc_motor_config file you will find following lines:

```
#define COMMUTATION_OFFSET_CLK      683
#define COMMUTATION_OFFSET_CCLK     2731
```

The angle value [0-4095] corresponds to the angle in degrees [0-360]. For eg., the value 683 corresponds to 60 degrees.

Steps:

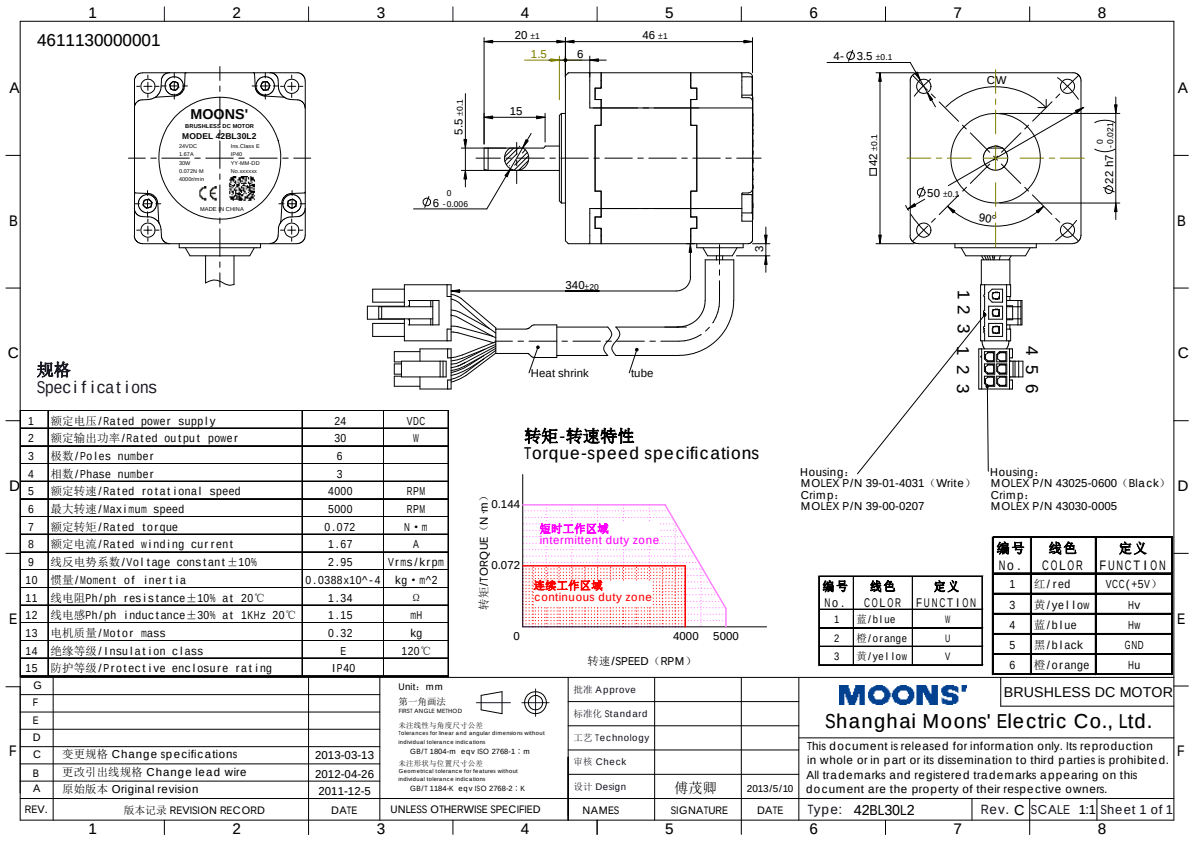
1. Run your motor in Standalone Profile Velocity Control Demo at half of it's maximum nominal speed (MAX_NOMINAL_SPEED / 2) in the clock-wise direction
2. Monitor the current consumption on you power supply
3. Modify the parameter COMMUTATION_OFFSET_CLK by gradually increasing its original vale (683 + X). You should not add more than 342 to it (X <= 342)
4. Repeat the previous step as long as the current drained is decreasing, and thereby find the optimum COMMUTATION_OFFSET_CLK angle.
5. Set the COMMUTATION_OFFSET_CCLK to its original value 2731 minus the identified value X (2731 - X)

4 Running the SOMANET Standalone Profile Velocity Control Demo

Please refer SOMANET Standalone Profile Velocity Control Demo Quick Start Guide[4] to import, build and run the application.

[4] http://www.xmos.com/published/somanet-standalone-profile-velocity-control-demo-quick-start-guide-%28documentation

APPENDIX A - Datasheet of Moons 42BL30L2-5 BLDC motor



1	额定电压/Rated power supply	24	VDC
2	额定输出功率/Rated output power	30	W
3	极数/Poles number	6	
4	相数/Phase number	3	
5	额定转速/Rated rotational speed	4000	RPM
6	最大转速/Maximum speed	5000	RPM
7	额定转矩/Rated torque	0.072	N·m
8	额定电流/Rated winding current	1.67	A
9	线反电势系数/Voltage constant±10%	2.95	Vrms/krpm
10	惯量/Moment of inertia	0.0388x10^-4	kg·m^2
11	线电阻Ph/ph resistance±10% at 20℃	1.34	Ω
12	线电感Ph/ph inductance±30% at 1KHz 20℃	1.15	mH
13	电机质量/Motor mass	0.32	kg
14	绝缘等级/Insulation class	E	120℃
15	防护等级/Protective enclosure rating	IP40	

编号 No.	线色 COLOR	定义 FUNCTION
1	蓝/blue	W
2	橙/orange	U
3	黄/yellow	V

编号 No.	线色 COLOR	定义 FUNCTION
1	红/red	VCC(+5V)
3	黄/yellow	Hv
4	蓝/blue	Hw
5	黑/black	GND
6	橙/orange	Hu

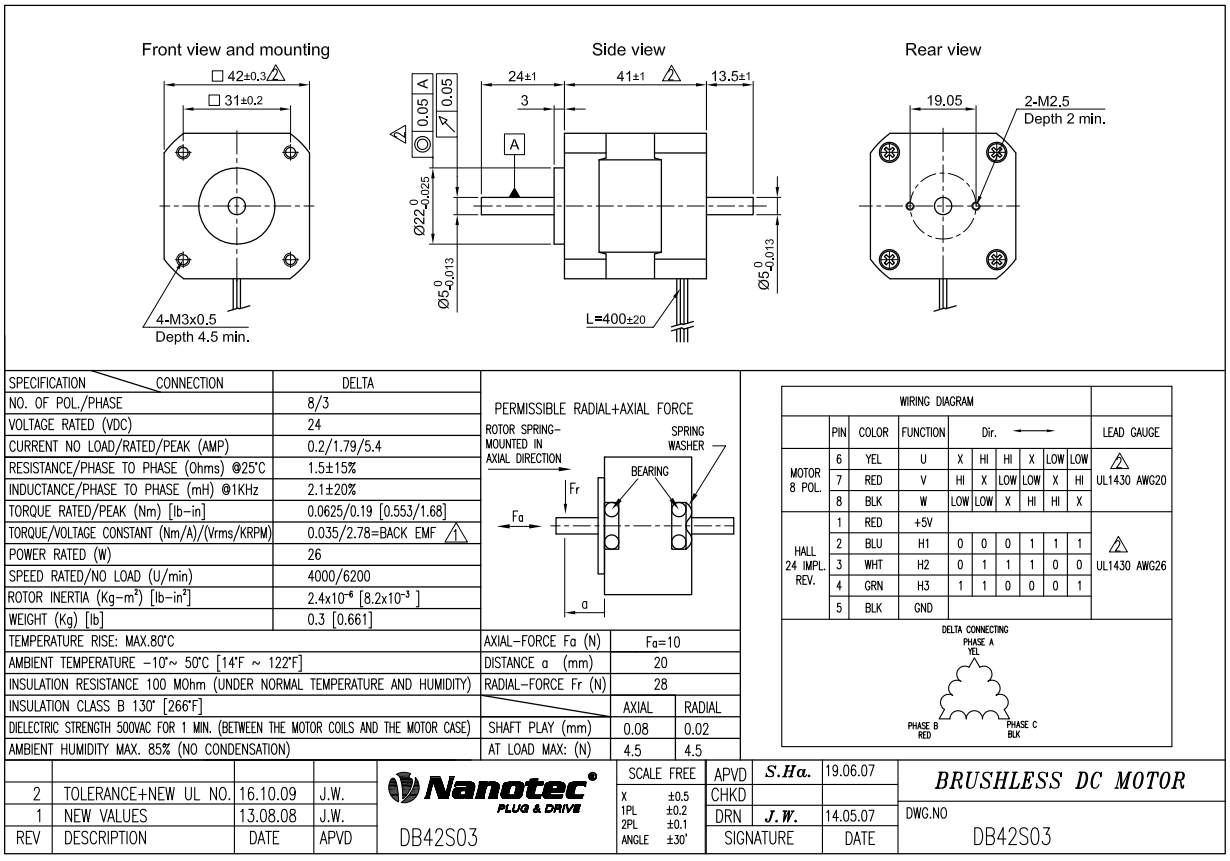
REV.	版本记录 REVISION RECORD	DATE
G		
F		
E		
D		
C	变更规格 Change specifications	2013-03-13
B	更改引出线规格 Change lead wire	2012-04-26
A	原始版本 Original revision	2011-12-5

Unit: mm
第一角画法 FIRST ANGLE METHOD
未注线性与角度尺寸公差 Tolerances for linear and angular dimensions without individual tolerance indications GB/T 1804-m eqv ISO 2768-1 : m
未注形状与位置尺寸公差 Geometrical tolerance for features without individual tolerance indications GB/T 1184-K eqv ISO 2768-2 : K
UNLESS OTHERWISE SPECIFIED

	NAMES	SIGNATURE	DATE
批准 Approve			
标准化 Standard			
工艺 Technology			
审核 Check			
设计 Design	傅茂卿		2013/5/10

Figure 5: Moons 42BL30L2-5 BLDC motor

APPENDIX B - Datasheet of Nanotec DB42S03 BLDC motor



SPECIFICATION / CONNECTION	DELTA
NO. OF POL./PHASE	8/3
VOLTAGE RATED (VDC)	24
CURRENT NO LOAD/RATED/PEAK (AMP)	0.2/1.79/5.4
RESISTANCE/PHASE TO PHASE (Ohms) @25°C	1.5±15%
INDUCTANCE/PHASE TO PHASE (mH) @1KHz	2.1±20%
TORQUE RATED/PEAK (Nm) [lb-in]	0.0625/0.19 [0.553/1.68]
TORQUE/VOLTAGE CONSTANT (Nm/A)/(Vrms/KRPM)	0.035/2.78=BACK EMF
POWER RATED (W)	26
SPEED RATED/NO LOAD (U/min)	4000/6200
ROTOR INERTIA (Kg-m²) [lb-in²]	2.4x10⁻⁶ [8.2x10⁻³]
WEIGHT (Kg) [lb]	0.3 [0.661]

TEMPERATURE RISE: MAX.80°C	
AMBIENT TEMPERATURE -10°~ 50°C [14°F ~ 122°F]	
INSULATION RESISTANCE 100 MOhm (UNDER NORMAL TEMPERATURE AND HUMIDITY)	
INSULATION CLASS B 130° [266°F]	
DIELECTRIC STRENGTH 500VAC FOR 1 MIN. (BETWEEN THE MOTOR COILS AND THE MOTOR CASE)	
AMBIENT HUMIDITY MAX. 85% (NO CONDENSATION)	

	AXIAL	RADIAL
AXIAL-FORCE Fa (N)	Fa=10	
DISTANCE a (mm)	20	
RADIAL-FORCE Fr (N)	28	
SHAFT PLAY (mm)	0.08	0.02
AT LOAD MAX: (N)	4.5	4.5

WIRING DIAGRAM	PIN	COLOR	FUNCTION	Dir.						LEAD GAUGE
MOTOR 8 POL.	6	YEL	U	X	HI	HI	X	LOW	LOW	UL1430 AWG20
	7	RED	V	HI	X	LOW	LOW	X	HI	
	8	BLK	W	LOW	LOW	X	HI	HI	X	
HALL 24 IMPL. REV.	1	RED	+5V							UL1430 AWG26
	2	BLU	H1	0	0	0	1	1	1	
	3	WHT	H2	0	1	1	1	0	0	
	4	GRN	H3	1	1	0	0	0	1	
	5	BLK	GND							

REV	DESCRIPTION	DATE	APVD
2	TOLERANCE+NEW UL NO.	16.10.09	J.W.
1	NEW VALUES	13.08.08	J.W.

Nanotec PLUG & DRIVE

DB42S03

SCALE FREE

X	±0.5
1PL	±0.2
2PL	±0.1
ANGLE	±30'

APVD	S.Ha.	19.06.07
CHKD		
DRN	J.W.	14.05.07
SIGNATURE		DATE

DWG.NO DB42S03

Figure 6: Nanotec DB42S03 BLDC motor

APPENDIX C - References

XMOS Tools User Guide

http://www.xmos.com/published/xtimecomposer-user-guide

XMOS xCORE Programming Guide

http://www.xmos.com/published/xmos-programming-guide