PIM2401-CAN

Version 1.0

Intelligent Servo Drive for DC, Brushless DC and AC Motors

TECHNOSOFT

Intelligent Servo Drive

Technical Reference

Preliminary

TECHNOSOFT

PIM2401-CAN
Technical Reference

P091.035.PIM2401.UM.0507

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Read This First

About This Manual

This book is a technical reference manual for the **PIM2401** intelligent servo drives. It describes the **PIM2401** operation and provides basic information needed by the user to program the **PIM2401** in the Technosoft Motion Language (**TML**) environment.

Notational Conventions

This document uses the following conventions:

- The Technosoft Motion Language will be referred to as TML
- TML variables, parameters or instructions are shown in special italic typeface. Here is a sample:

  SETIO#4 IN;
  UPD;

Information about Cautions

This book may contain cautions.

CAUTION !	**This is an example of a caution statement. A caution statement describes a situation that could potentially cause harm to you, or to the PIM2401 intelligent servo drive unit**

Related Documentation from Technosoft

MotionChip™ II TML Programming (part no. P091.055.MCII.TML.UM.xxxx) describes in detail TML basic concepts, motion programming, functional description of TML instructions for high level or low level motion programming, communication channels and protocols. Also give a detailed description of each TML instruction including syntax, binary code and examples.

MotionChip II Configuration Setup (part no. P091.055.MCII.STP.UM.xxxx) describes the MotionChip II operation and how to setup its registers and parameters starting from the user application data. This is a technical reference manual for all the MotionChip II registers, parameters and variables.

Help of the EasyMotion Studio software platform – describes how to use the EasyMotion Studio – the complete development platform for PIM2401 which support all new features added to revision H of firmware. It includes: motion system setup & tuning wizard, motion sequence programming wizard, testing and debugging tools like: data logging, watch, control panels, on-line viewers of TML registers, parameters and variables, etc.

Help of the IPM Motion Studio software platform – describes how to use the IPM Motion Studio – the complete development platform for PIM2401. It includes: motion system setup & tuning wizard, motion sequence programming wizard, testing and debugging tools like: data logging, watch, control panels, on-line viewers of TML registries, parameters and variables, etc.

If you Need Assistance …

If you want to …	Contact Technosoft at …
Visit Technosoft online	World Wide Web: http://www.technosoftmotion.com/
Receive general information or assistance (see Note)	World Wide Web: http://www.technosoftmotion.com/ Email: contact@technosoftmotion.com
Ask questions about product operation or report suspected problems (see Note)	Fax: (41) 32 732 55 04 Email: hotline@technosoftmotion.com
Make suggestions about, or report errors in documentation (see Note)	Mail: Technosoft SA Buchaux 38 CH-2022 Bevaix, NE Switzerland

Note: You need to register your PIM2401 system, in order to get free assistance and support. Use the License No. on your Registration Card for IPM Motion Studio.

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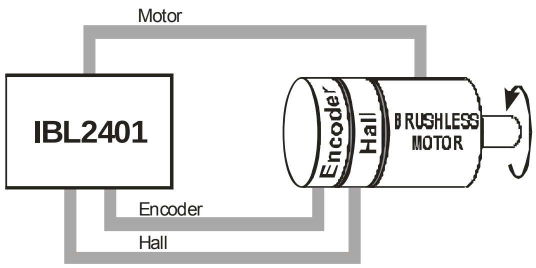
1. Key Features

- CAN-Bus 2.0B, up to 1 Mbit/s
- Single-ended, differential and/or open-collector encoder interface
- Single-ended, open collector Hall sensor interface
- Linear Hall sensor interface
- 7 dedicated digital input-output lines (5V and 24V compatible):
  - 5 digital input lines
  - 2 digital output lines
- RS-232 serial interface (up to 115200 bps)
- 1.5K × 16 internal SRAM memory
- 8K × 16 E^2ROM to store TML programs and data
- Power supplies:
  - Motor supply: 6-27 V; 1A; 3.6 A PEAK
  - Logic supply: 5 V;
- Minimal motor inductance: 0 μH (the drive has on-board inductance of 150 μH on each phase)
- Operating ambient temperature: 0-40°C
- Hardware Protections:
  - Short-circuit on motor phases
  - All I/Os are ESD protected

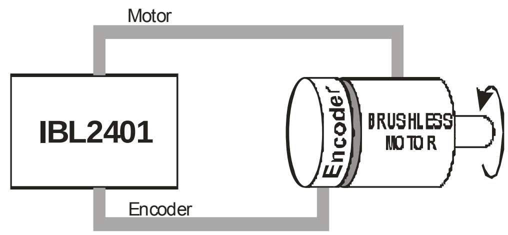
2. Supported Motor-Sensor Configurations

PIM2401 supports the following configurations:

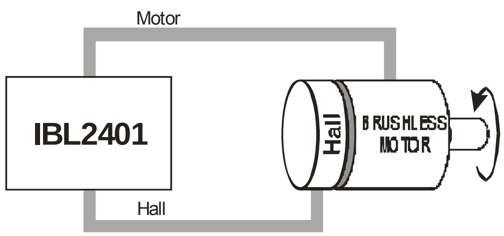
- **Brushless motor**



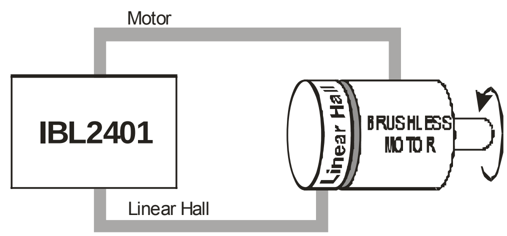
Brushless motor with encoder and Hall



Brushless motor with encoder

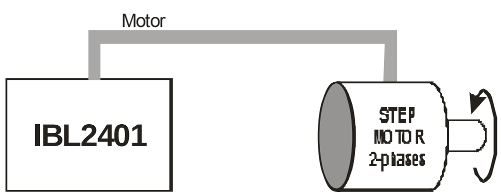


Brushless motor with Hall

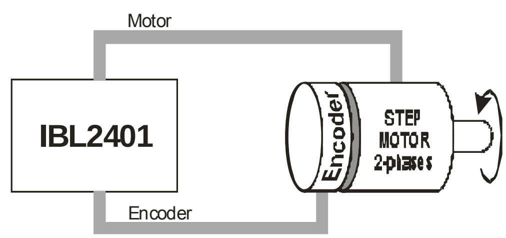


Brushless motor with Linear Hall sensor

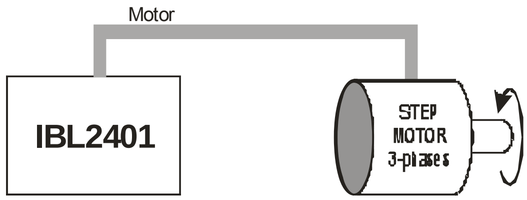
- **Step motor**



2-phase Step motor – Open loop

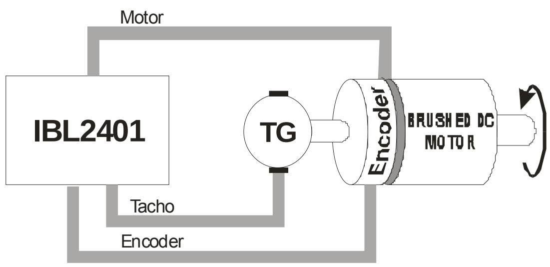


2-phase Step motor – Closed loop
(with encoder on motor, or on load)

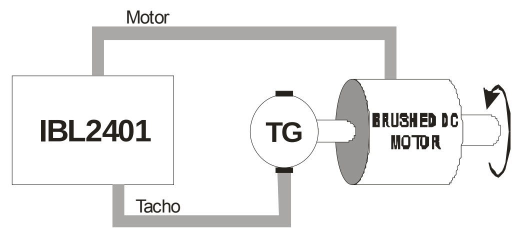


3-phase Step motor – Open loop

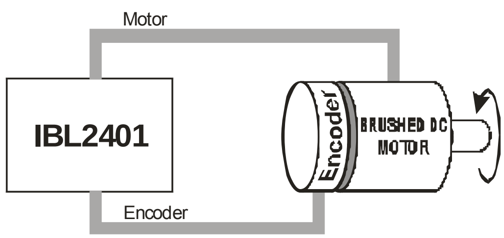
- **<u>Brushed DC motor</u>**



Brushed DC motor with tacho and encoder



Brushed DC motor with tacho



Brushed DC motor with encoder

3. Drive Drawings

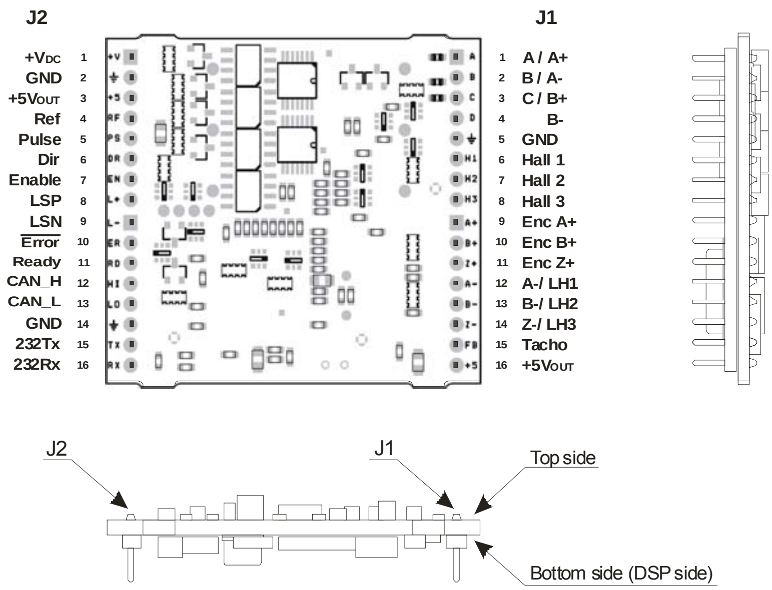


Figure 3.1.* PIM2401 v1.0 *drawing

4. Connectors and Connection Diagrams

CAUTION ! BEFORE THE CONNECTING / DISCONNECTING ANY OF THE SIGNALS PLEASE TURN OFF ALL POWER SUPPLIES. ELSE SEVER DAMAGE MAY OCCUR.

4.1. Connectors pinout

4.1.1. J1 Connector pinout

Pin	Pin name	TML name	Type	Function/Alternate function/ Comments
1	**+V_{MOT}**	-	I	• Positive terminal of the **motor supply**: 12 to 48V_{DC}
2	**GND**	-	-	• **Ground**
3	**+5V_{IN}**	-	I	• **5V** logic supply input
4	**Ref**	AD5	I	• Unipolar 0 V…+5 V analog input. May be used as analog position, speed or torque reference.
5	**Pulse**	IN#38 / PULSE	I	• **5V** or **24V** compatible digital input • Can be used as PULSE input in Pulse & Direction motion mode • Can be used as second **encoder A** signal, for single-ended encoder
6	**Dir**	IN#37 / DIR	I	• **5V** or **24V** compatible digital input • Can be used as DIRECTION input in Pulse & Direction motion mode • Can be used as second **encoder B** signal, for single-ended encoder
7	**Enable**	IN#16 / ENABLE	I	• **5V** or **24V** compatible digital input • **Enable**. Connect to high to disable PWM outputs
8	**LSP**	IN#2 / LSP	I	• **5V** or **24V** compatible digital input • **Positive limit switch**
9	**LSN**	IN#24 / LSN	I	• **5V** or **24V** compatible digital input • **Negative limit switch**
10	**/ Error**	OUT#13	O	• **5V** or **24V** compatible digital output • **Error**
11	**/ Ready**	OUT#25	O	• **5V** or **24V** compatible digital output • **Ready**
12	**CAN_H**	-	I/O	• Can-Bus positive line (positive during dominant bit)
13	**CAN_L**	-	I/O	• CAN-Bus negative line (negative during dominant bit)
14	**GND**	-	-	• **Ground**
15	**232Tx**	-	O	• RS-232 Data Transmission
16	**232Rx**	-	I	• RS-232 Data Reception

4.1.2. J2 Connector pinout

Pin	Pin name	TML name	Type	Function/Alternate function/ Comments
1	**A / A+**	-	O	• **Phase A** for brushless motors • **Phase A+** for step motors • **Motor+** for DC brush motors
2	**B / A-**	-	O	• **Phase B** for brushless motors • **Phase A-** for step motors • **Motor-** for DC brush motors
3	**C / B+**	-	O	• **Phase C** for brushless motors • **Phase B+** for step motors
4	**B-**	-	-	• **Phase B-** for step motors
5	**GND**	-	-	• **Ground**
6	**Hall 1**	-	I	• **Hall 1** signal for digital Hall sensor • **Not-autorun**. Connect all 3 Hall signals to GND in order to disable the Autorun
7	**Hall 2**	-	I	• **Hall 2** signal for digital Hall sensor • **Not-autorun**. Connect all 3 Hall signals to GND in order to disable the Autorun
8	**Hall 3**	-	I	• **Hall 3** signal for digital Hall sensor • **Not-autorun**. Connect all 3 Hall signals to GND in order to disable the Autorun
9	**Enc A+**	-	I	• Single-ended encoder A signal • Differential encoder positive A input
10	**Enc B+**	-	I	• Single-ended encoder B signal • Differential encoder positive B input
11	**Enc Z+**	-	I	• Single-ended encoder Z signal • Differential encoder positive Z input
12	**A- / LH1**	-	I	• Differential encoder **negative A** signal • **Linear Hall 1** signal
13	**B- / LH2**	-	I	• Differential encoder **negative B** signal • **Linear Hall 2** signal
14	**Z- / LH3**	-	I	• Differential encoder **negative Z** signal • **Linear Hall 3** signal
15	**Tacho**	AD2	I	• Unipolar 0 V…+5 V analog input. May be used as analog position or speed feedback (from a tachometer)
16	**+5 V_{OUT}**	-	O	• **5V** logic supply (from J1 / pin3)

4.2. 24V Digital I/O connection

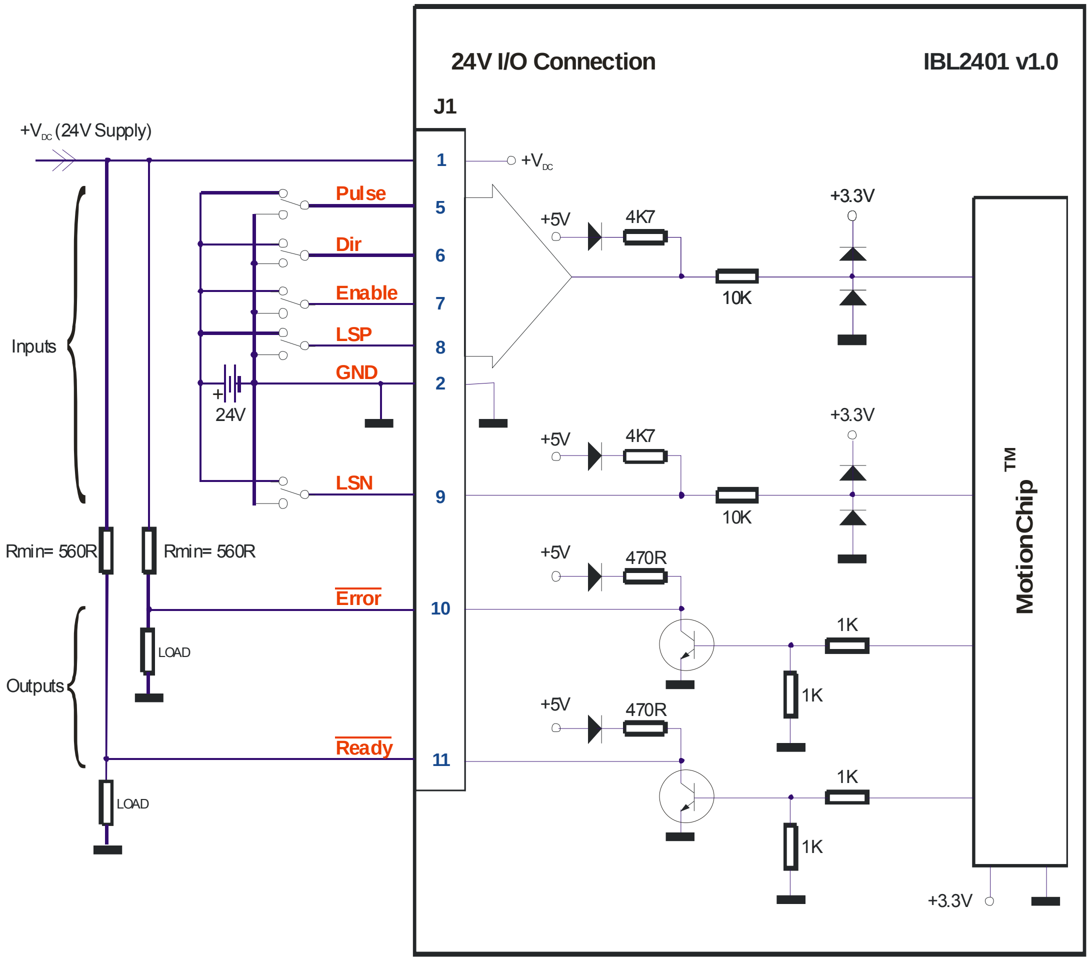


Figure 4.1. 24V Digital I/O connection

Note1: In order to use 24V outputs, an external resistor needs to be connected to a supply of $+V_{DC}$

Note2: The minimum value of external resistors must be 560 Ω.

4.3. 5V Digital I/O connection

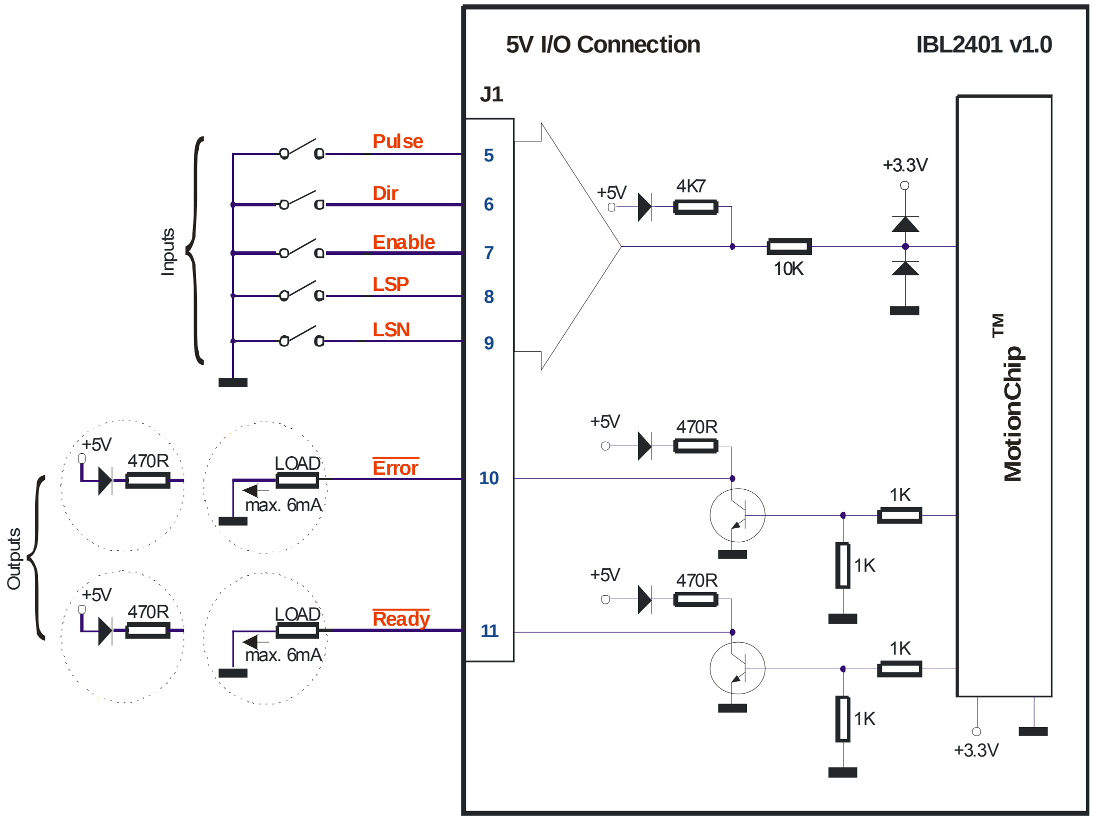


Figure 4.2. *5V Digital I/O connection*

4.4. Analog inputs connection

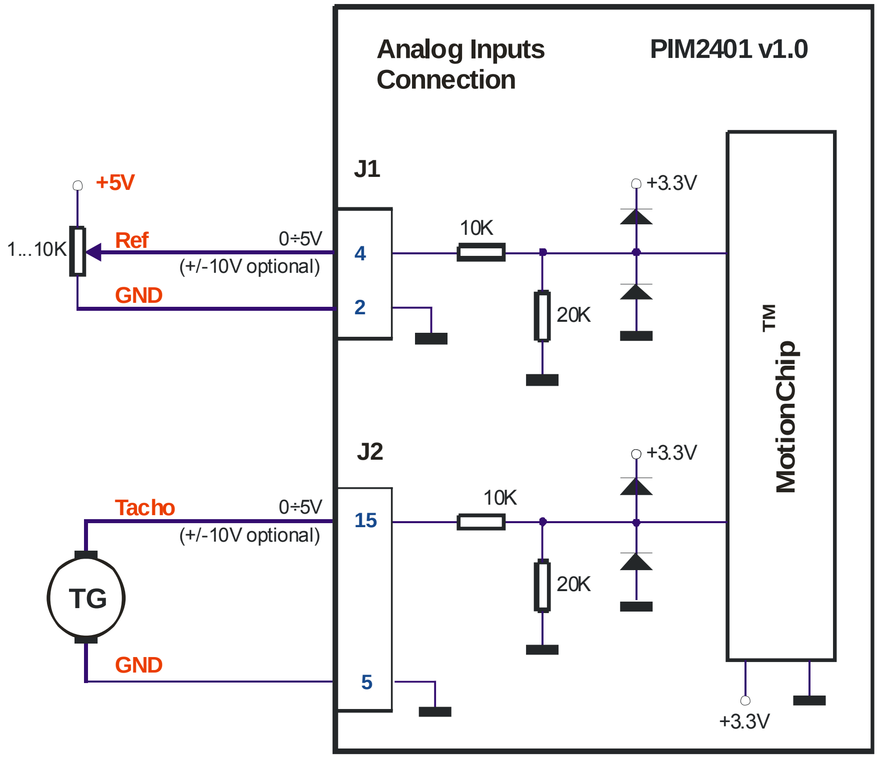


__Figure 4.3.__ Analog inputs connection

Note 1: *Default input range for analog inputs is 0÷5 V.*
For a +/-10 V range, please contact Technosoft.

4.5. Brushless Motor connection

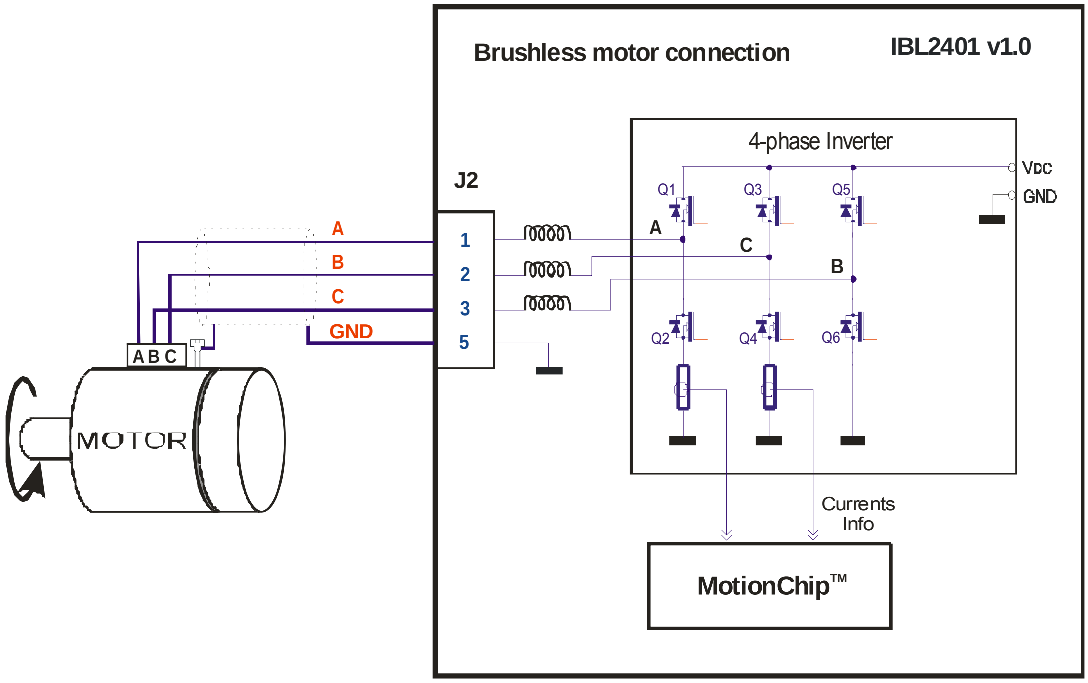


Figure 4.4. *Brushless Motor connection*

CAUTION !	**Before connecting the motor, be sure you have the right application programmed to E2ROM, else you can damage the motor and drive. At power-on, the TML application is automatically executed. See Section *4.15. Special connection* on how to disable this feature.**

4.6. 2-phase Step Motor connection

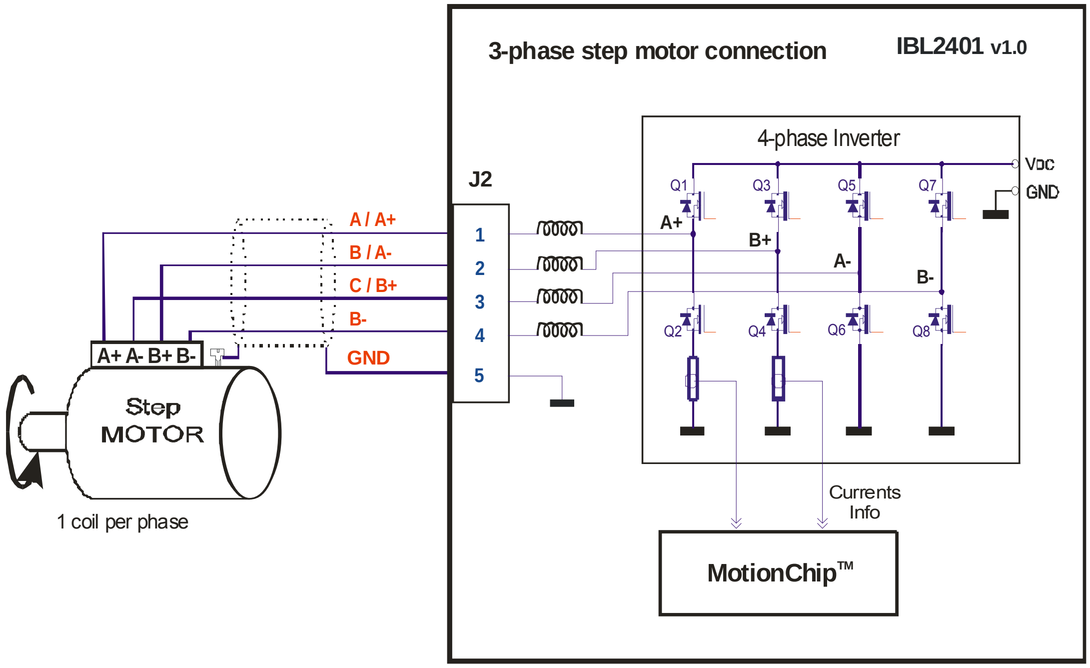


Figure 4.5. *Step Motor connection*

CAUTION !	**Before connecting the motor, be sure you have the right application programmed to E2ROM, else you can damage the motor and drive. At power-on, the TML application is automatically executed. See Section *4.17. Special connection* on how to disable this feature.**

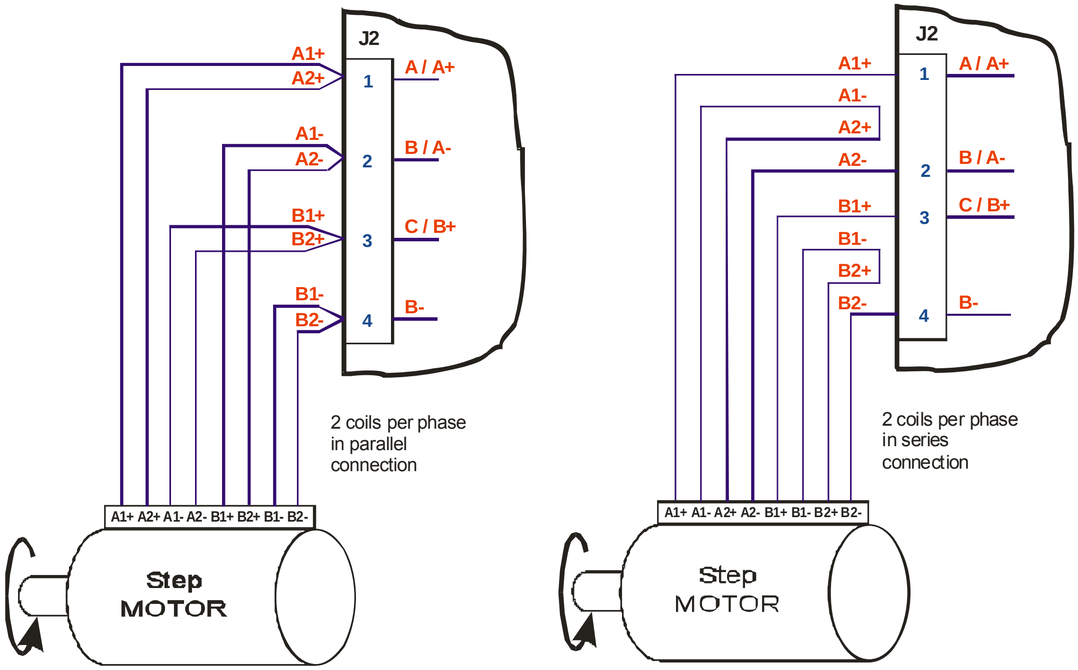


Figure 4.6. *Step Motor connection*

CAUTION !	**Before connecting the motor, be sure you have the right application programmed to E2ROM, else you can damage the motor and drive. At power-on, the TML application is automatically executed. See Section *4.17. Special connection* on how to disable this feature.**

4.7. 3-phase Step Motor connection

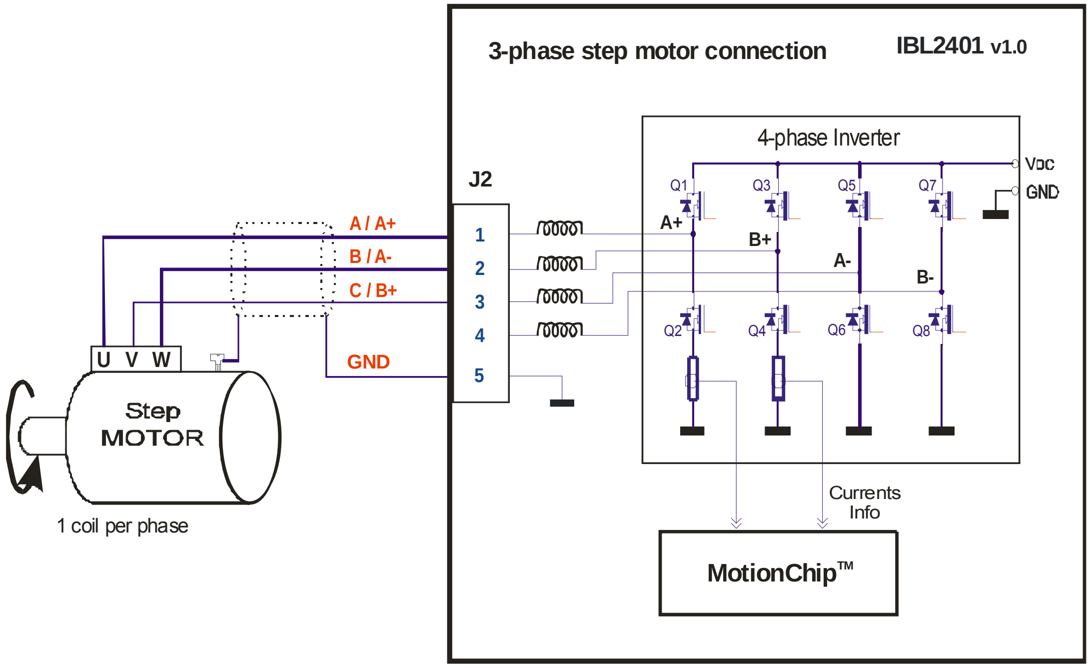


Figure 4.7. *3-phase Step Motor connection*

CAUTION !	**Before connecting the motor, be sure you have the right application programmed to E2ROM, else you can damage the motor and drive. At power-on, the TML application is automatically executed. See Section *4.17. Special connection* on how to disable this feature.**

4.8. DC Motor connection

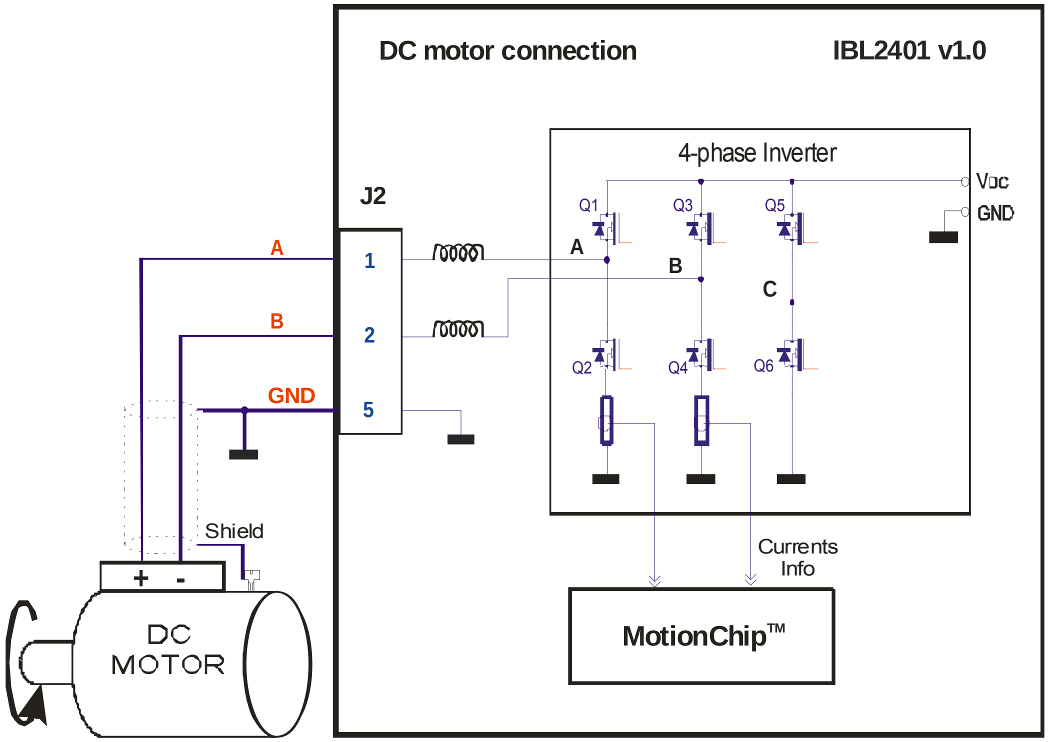


Figure 4.8. *DC Motor connection*

CAUTION !	**Before connecting the motor, be sure you have the right application programmed to E2ROM, else you can damage the motor and drive. At power-on, the TML application is automatically executed. See Section *4.15. Special connection* on how to disable this feature.**

4.9. Single-ended encoder connection

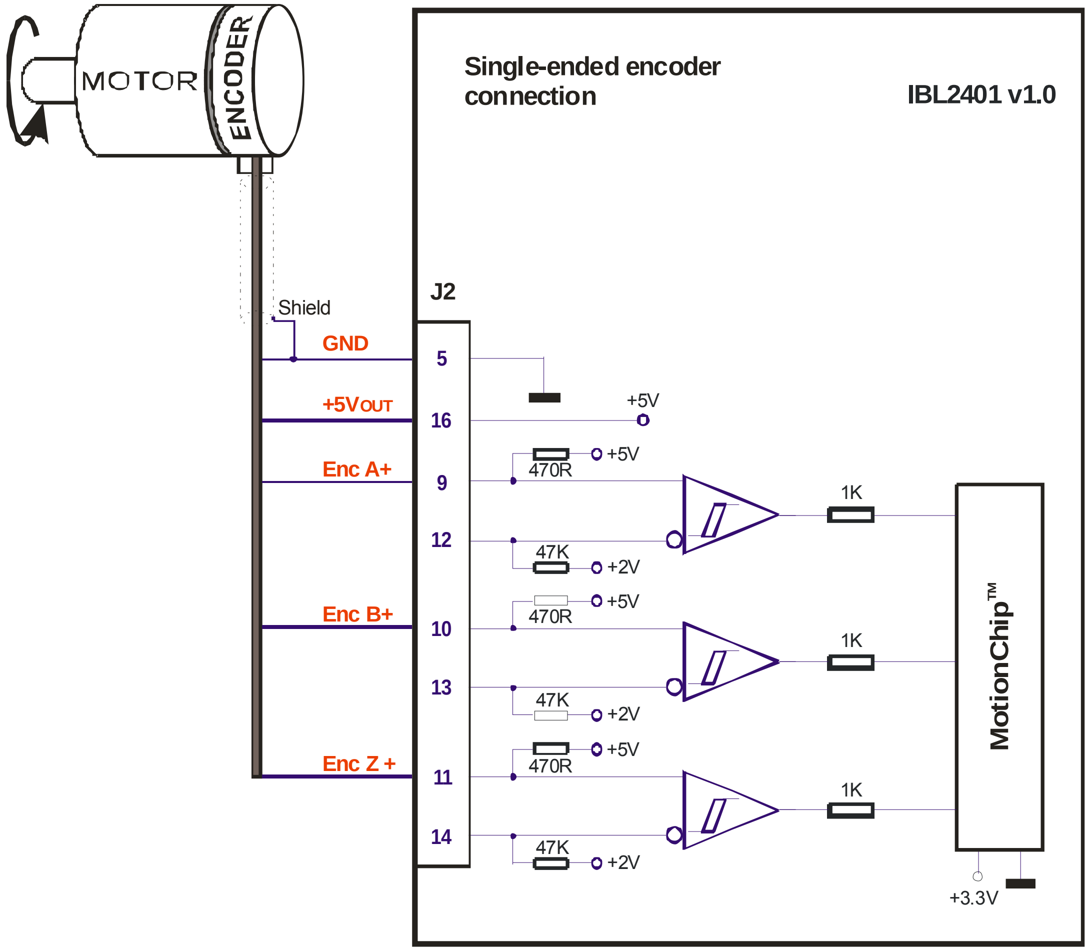


Figure 4.9. Single-ended encoder connection

4.10. Differential encoder connection

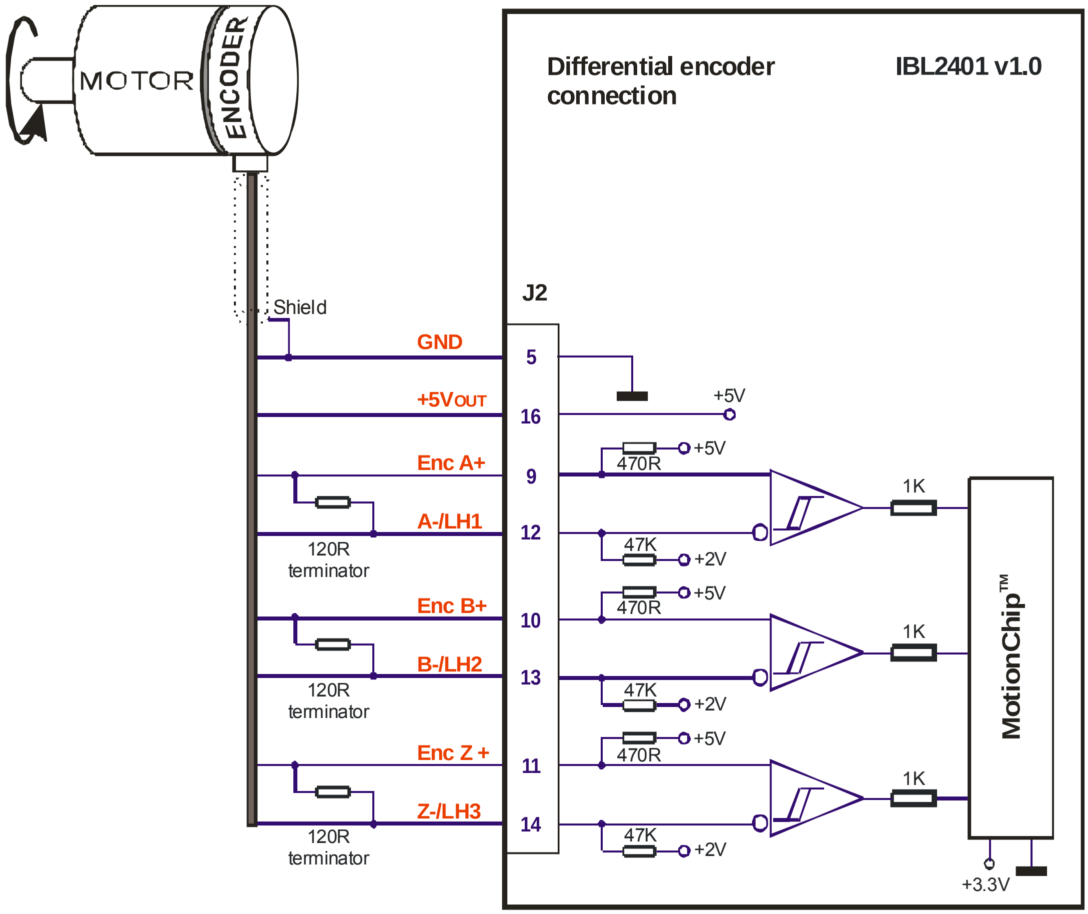


Figure 4.10. *Differential encoder connection*

Note 1: *120-Ω (0.25-W) terminators are required for long encoder cables, or noisy environments.*

4.11. Hall connection

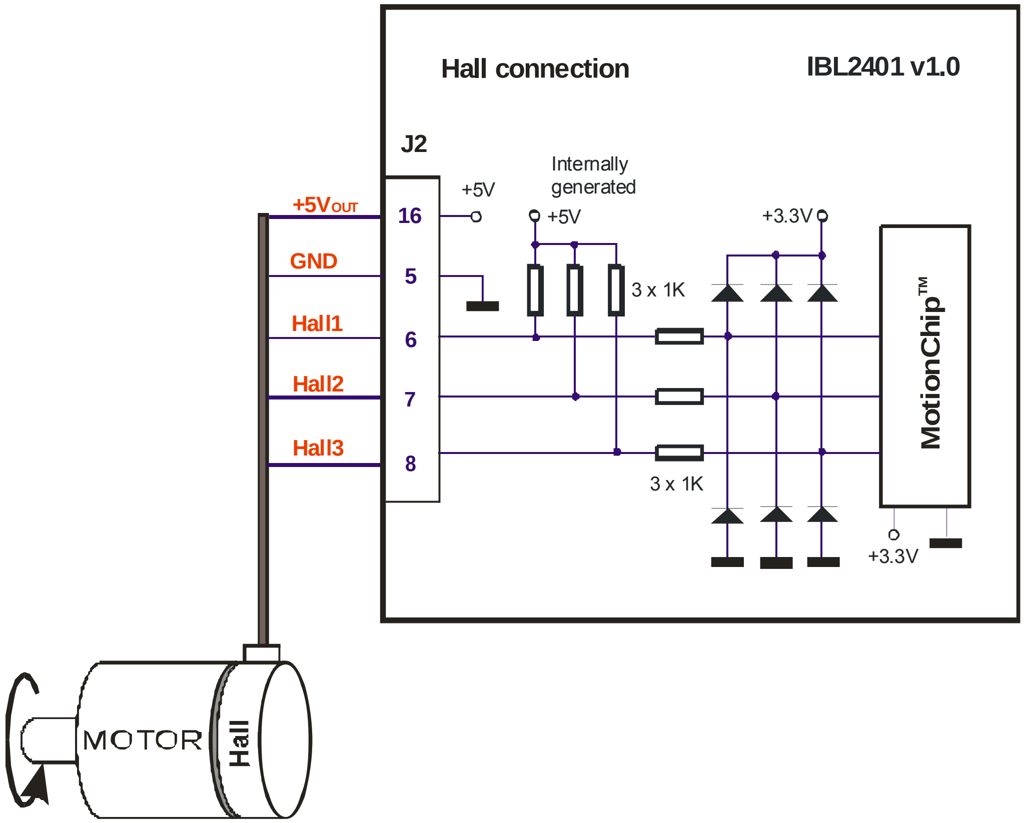


Figure 4.11. *Hall connection*

4.12. Linear Hall connection

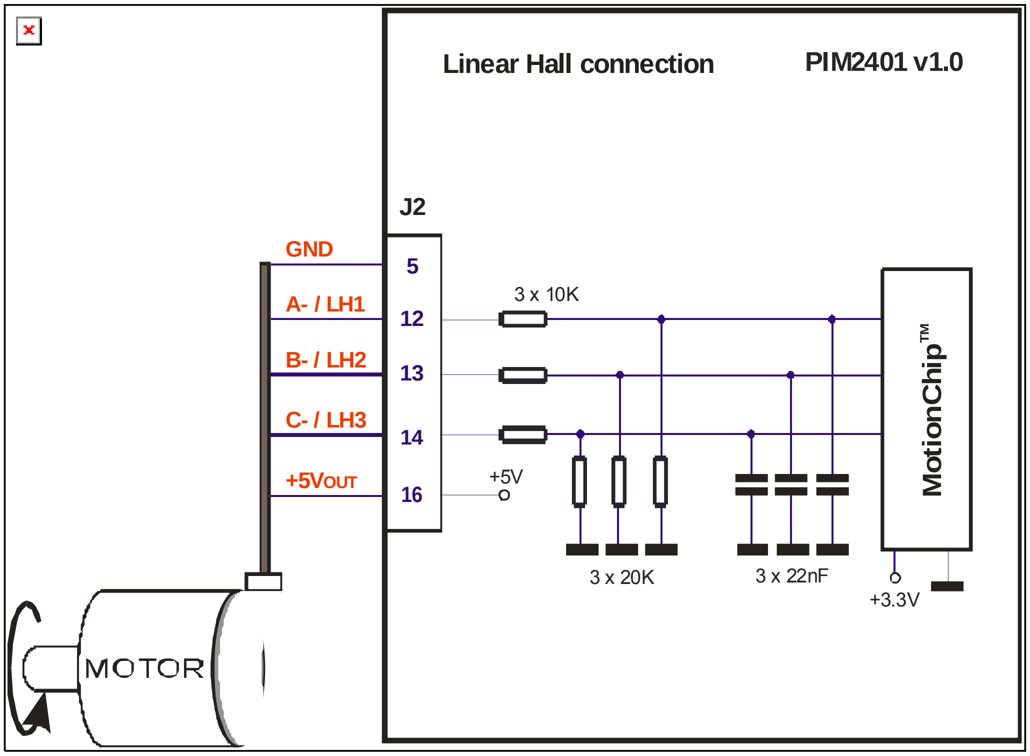


Figure 4.12. Linear Hall connection

4.13. Linear Hall Auto-Setup connection

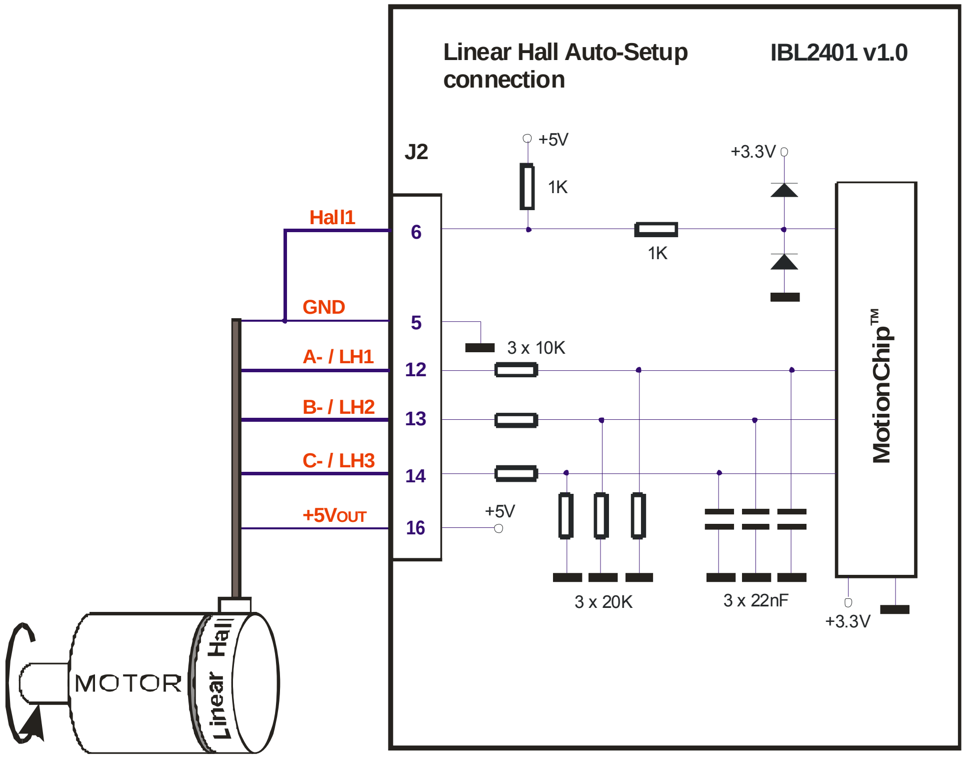


Figure 4.13. *Linear Hall Auto-Setup connection*

Hardware Auto-setup procedure

1. Create an application based on **PIM2401 \ Brushless Motor – Linear Hall** template and set Motor parameters.
2. Set the 'No. Lines/rev' to value *512 * pole_pairs* in the **Motor** dialog.
3. Select **Build | Rebuild all** command menu and **Application | Download program** command menu for the current application.
4. Power off and connect the **Hall 1** input to **GND** for Auto-setup.
5. Power on and wait for Auto-setup to finish.
6. Power off and disconnect the **Hall 1** input.
7. Power on and program your application.

Software Auto-setup procedure

1. Run the **Detect Hall Configuration** test from the **Motor** dialog and wait for Auto-setup to finish. ***Remark:*** All Tests from the **Motor** and **Drive** dialogs don't work if **Hall 1** is configured for hardware Auto-Setup.

4.14. Supply connection

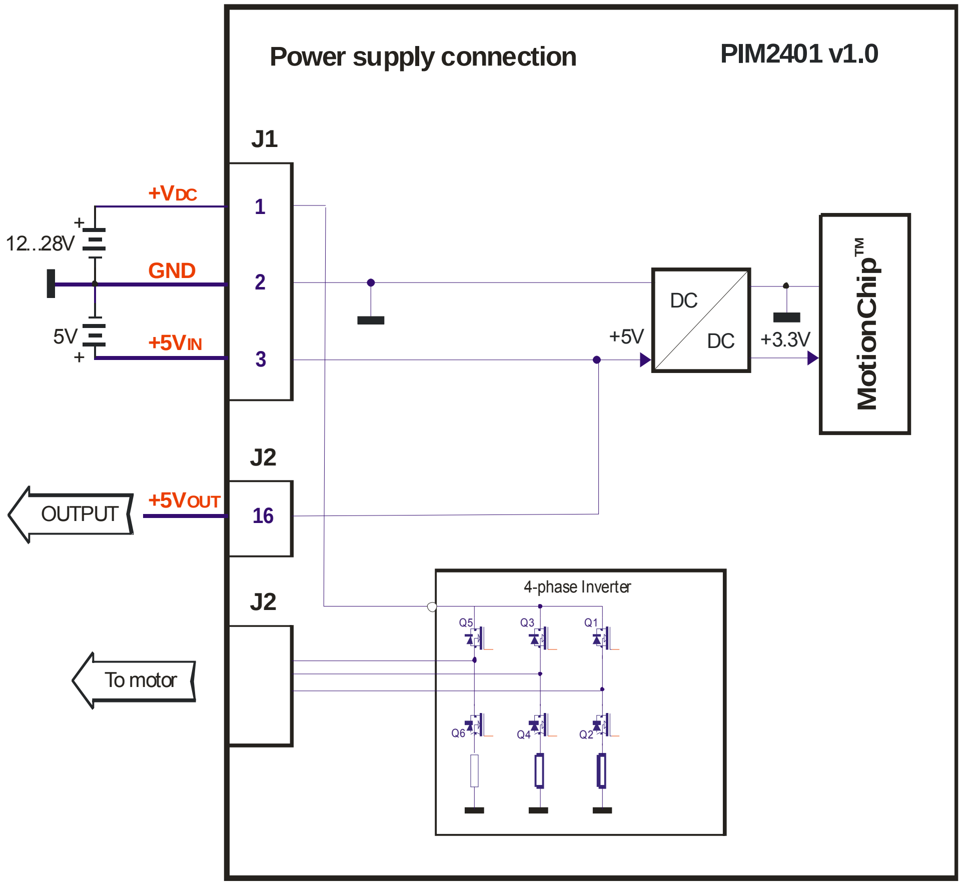


Figure 4.14. *Supply connection*

4.15. Serial RS-232 connection

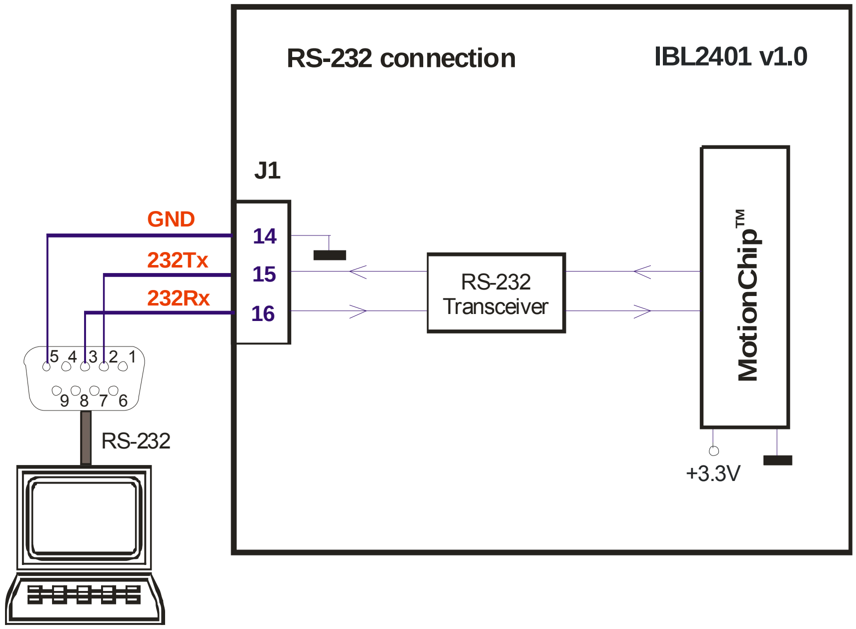


Figure 4.15 *Serial RS-232 connection*

4.16. CAN connection

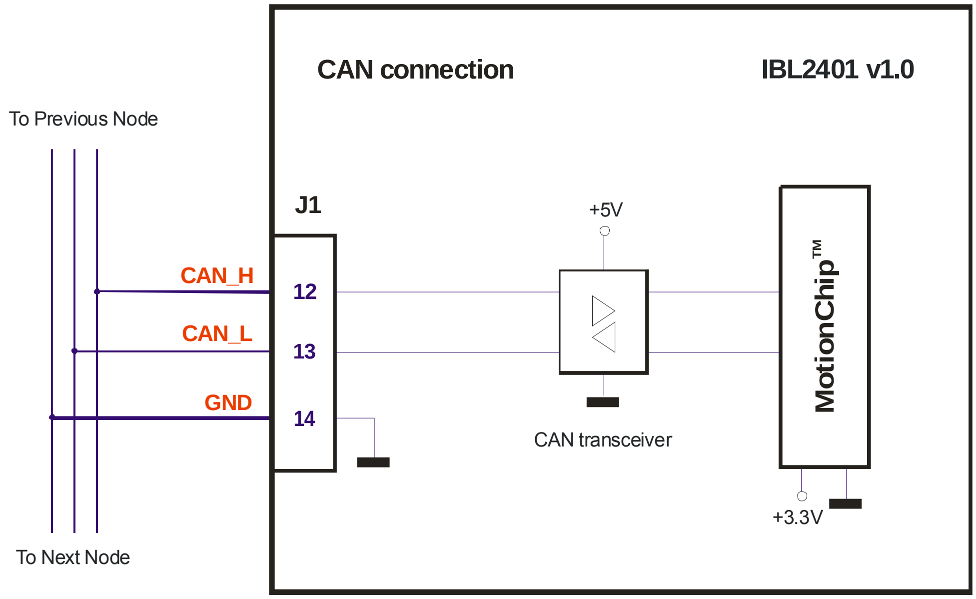


Figure 4.16. *CAN connection*

Note1: The CAN network requires a 120-Ohm terminator. This is not included on the board. See Figure 4.17.

Note2: CAN signals are not insulated from other PIM2401 circuits.

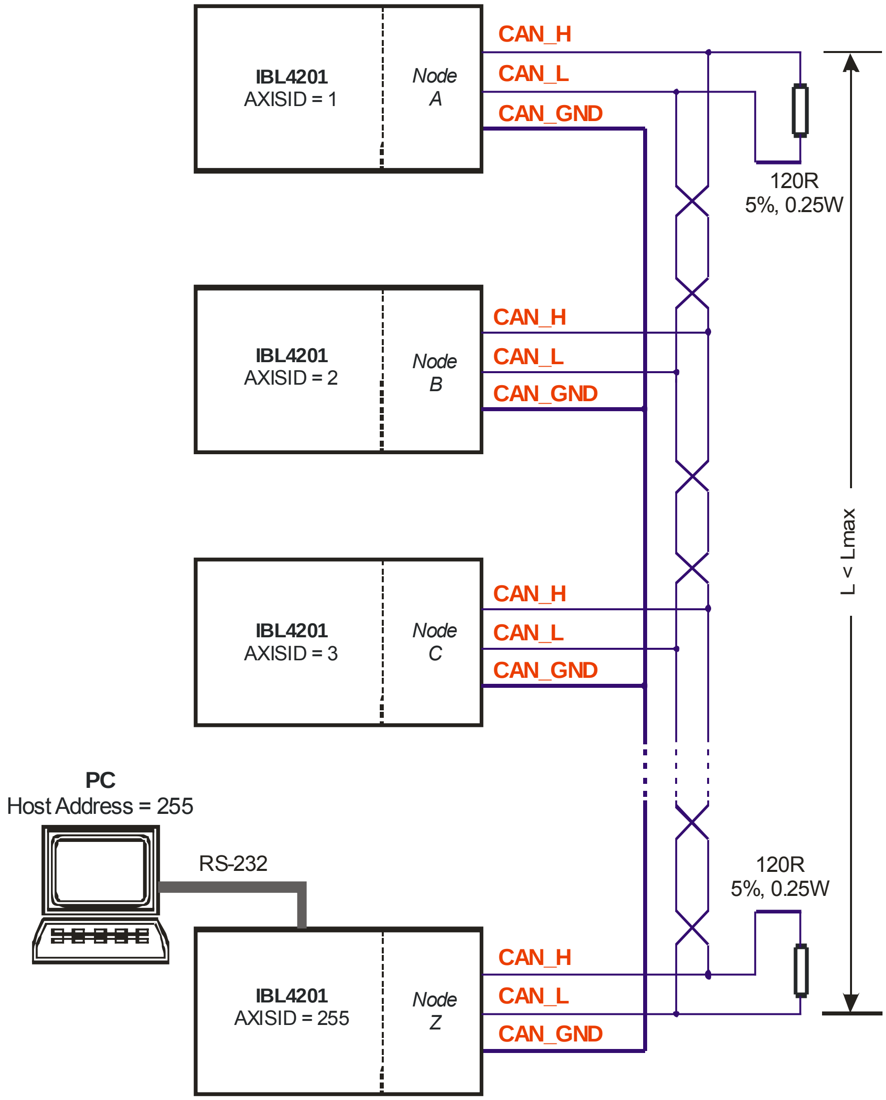


Figure 4.17. *Multiple-Axis CAN network*

Note1: The AxisID must be set by software, using instruction *AXISID number*.

4.17. Special connection (Non-Autorun)

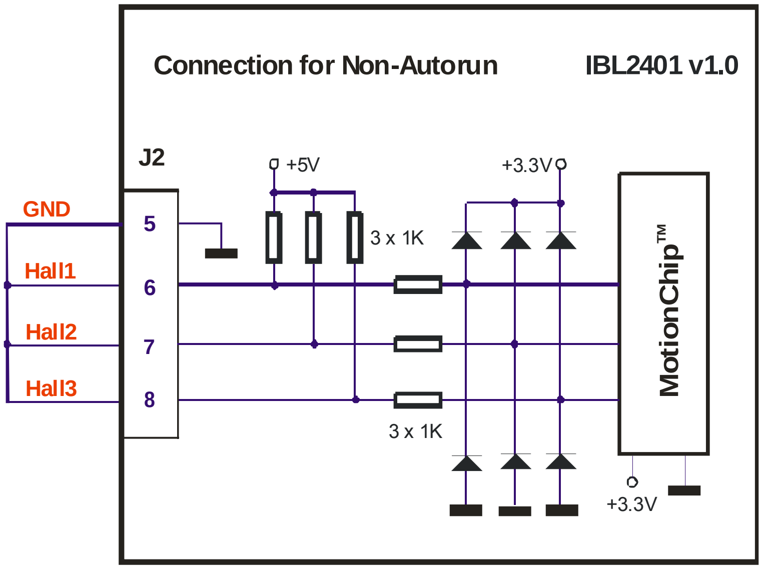


Figure 4.18. *Connection for Non-Autorun*

This connection can be used to automatically stop the execution of your application located in E2ROM memory. You need this connection when your application in the E2ROM is corrupted and the RS232 communication is lost.

4.18. Master - Slave encoder connection

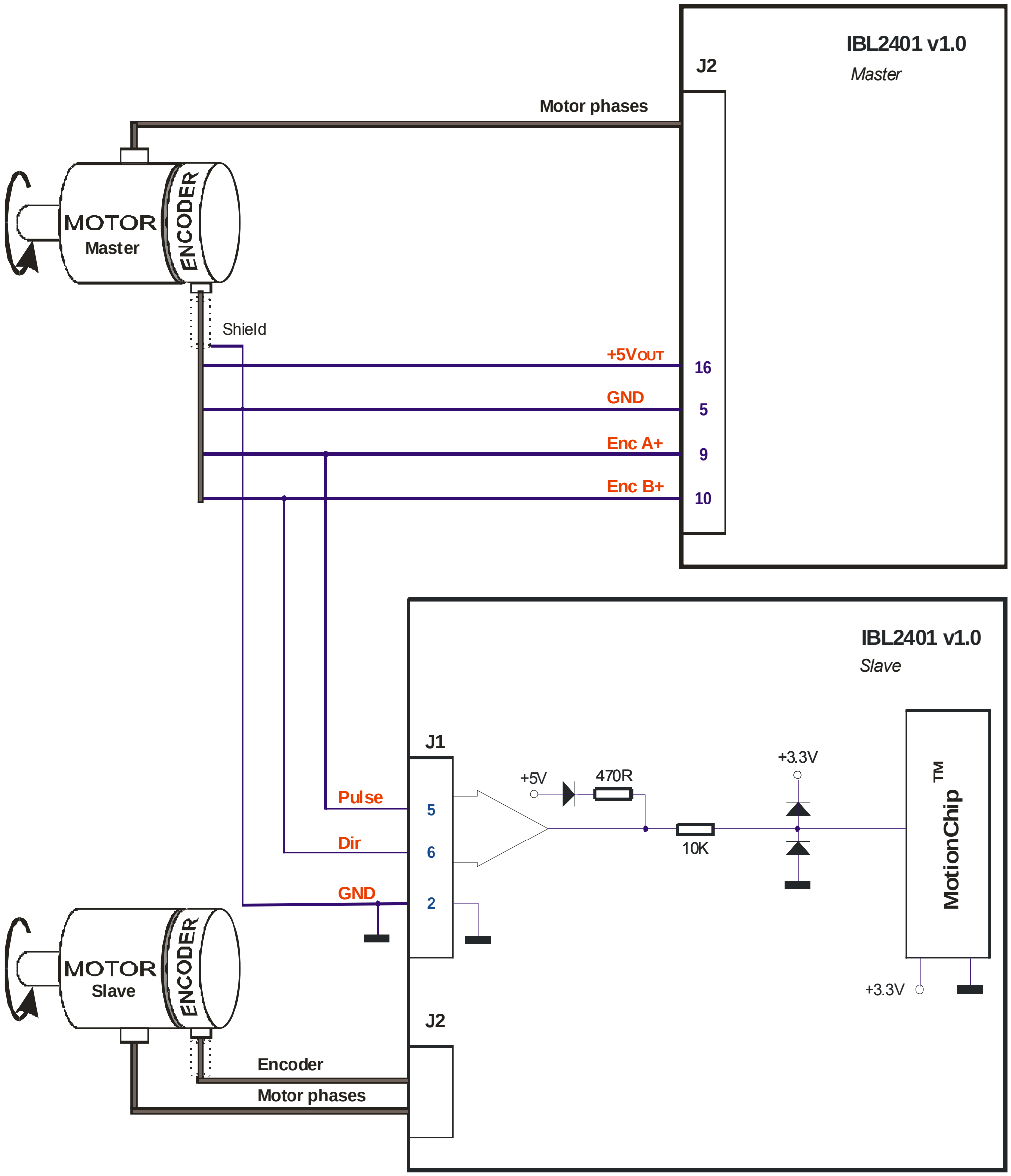


Figure 4.19. *Master – Slave encoder connection using second encoder input*

5. Electrical Specifications

Electrical characteristics:

All parameters were measured under the following conditions (unless otherwise specified):
T_{amb} = 25°C, power supply (V_{DC}) = 24V_{DC};
Supplies start-up / shutdown sequence: *-any-* ;
Load current 1 A_{RMS} .

5V Logic Supply Input

	Measured between +$5V_{IN}$ and GND.	Min.	Typ.	Max.	Units
Supply voltage	Nominal values	4.75	5	5.25	V_{DC}
	Absolute maximum values, continuous †	-0.5		7	V_{DC}
Supply current	It depends by sensor consumption			500	mA

Supply Input

	Measured between +V_{DC} and GND.	Min.	Typ.	Max.	Units
Supply voltage	Nominal values	6	24	27	V_{DC}
	Absolute maximum values, continuous †	-0.5		30	V_{DC}
Supply current	Normal operation		100	250	mA
	Idle		0.5	1	mA
	Operating	-3.7	±1	+3.7	A

Motor Outputs

	All voltages referenced to GND.	Min.	Typ.	Max.	Units
Motor output current	Continuous operation, +V_{DC} = 24 V, F_{PWM} = 20 kHz	-1		+1	A_{RMS}
Motor output current, peak	Thermal limited to <= 0.5 s	-3.63		+3.63	A
H/W short-circuit protection threshold			4.8		A
H/W short-circuit protection delay			22		μs
On-state voltage drop	Output current = ±1 A	-900	±250	+300	mV
Off-state leakage current		-1	±0.1	+1	mA
On-board phase inductance			150		μH
Motor inductance		0			μH
Total electrical time constant	F_{PWM} = 40 kHz, including on-board inductance	TBD			μs

Digital Inputs

	All voltages referenced to GND.	Min.	Typ.	Max.	Units
Input voltage	Logic “LOW”	-0.5	0	0.8	V

	Logic “HIGH”	2	5÷24	28	
	Absolute maximum, surge (duration ≤ 1S) †	-25		+30	
Input current	Logic ‘HIGH’; Internal 4.7 KΩ pull-up to +5V	0	0	0	mA
	Logic “LOW”	0.8	1	1.3	
Input frequency		0		250	KHz
Minimum pulse width		5			µS

Digital Outputs

	All voltages referenced to GND.	Min.	Typ.	Max.	Units
Output voltage	Logic “LOW”	-0.5	0	0.2	V
	Logic “HIGH” ; Output current = 0	2.4	4.4	$+V_{DC}$	
	Absolute maximum, duration < 1 ms	-1		$+V_{DC}$ + 0.5	
Output current	Logic “HIGH”; Load connected to GND			10	mA
	Logic “LOW”			50	
ESD Protection	Human Body Model (100 pF, 1.5 kΩ)			±25	KV

Encoder Inputs

		Min.	Typ.	Max.	Units
Standards compliance		Differential / TTL / CMOS / open-collector			
Low level input current	Internal 470 Ω pull-ups to +5 V_{DC}		10	12	mA
Input threshold voltage	In single-ended mode (TTL / CMOS / / open-collector)	1.8	1.9	2	V
Input hysteresis		0.1	0.2	0.5	V

Analog Inputs (Ref, Tacho)

	Referenced to GND	Min.	Typ.	Max.	Units
Voltage range		0		+5	V
Input impedance			16		KΩ
Resolution			10		bits
Differential linearity	Guaranteed 10-bit no-missing-codes			0.09	% FS[1]
Offset error				±0.3	% FS[1]
Gain error				±5	% FS[1]
Bandwidth (-3 dB)			250		Hz

Linear Hall Inputs (LH1, LH2, LH3)

	Referenced to GND	Min.	Typ.	Max.	Units
Voltage range	Maximum range	0		+5	V
	Operating range	Programmable			
Input current		-0.5		+0.5	mA
Bandwidth (-3 dB)			1		KHz

Hall Inputs (digital)

	All voltages referenced to GND.	Min.	Typ.	Max.	Units
Input voltage	Logic "LOW"	-0.5	0	0.8	V
	Logic "HIGH"	2	5	5.5	
	Absolute maximum, surge (duration ≤ 1ms)[†]	-8		+8	

RS-232

		Min.	Typ.	Max.	Units
Standards compliance		TIA/EIA-232-C			
Bit rate	Depending on software settings	9600		115200	Baud
ESD Protection	Human Body Model (100 pF, 1.5 kΩ)			±15	KV
Input voltage	RX232 input	-25	-	+25	V
Output short-circuit withstand	TX232 output to GND	Guaranteed			

CAN-Bus

	All voltages referenced to GND	Min.	Typ.	Max.	Units
Standards compliance		CAN-Bus 2.0B error active; ISO 11898-2			
Recommended transmission line impedance	Measured at 1MHz	90	120	150	Ω
Bit rate	Depending on software settings	125K		1M	Baud
Number of network nodes	Depending on software settings			64	-
ESD Protection	Human Body Model			±15	KV

Supply Output

		Min.	Typ.	Max.	Units
$+5V_{OUT}$ Voltage		4.75	5	5.25	V
$+5V_{OUT}$ available current				150	mA

Others

		Min.	Typ.	Max.	Units
Operating temperature		0		40	°C
Dimensions	Length x Width x Height	58 x 44 x 16			mm
Weight			TBD		Kg
Storage temperature	Not powered	-40	85	°C	
Humidity	Non-condensing	0	90	%RH	

[1] "FS" stands for "Full Scale"

[†] Stresses beyond values listed under "absolute maximum ratings" may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

T.B.D. = To be determined

6. PIM2401 Dimensions

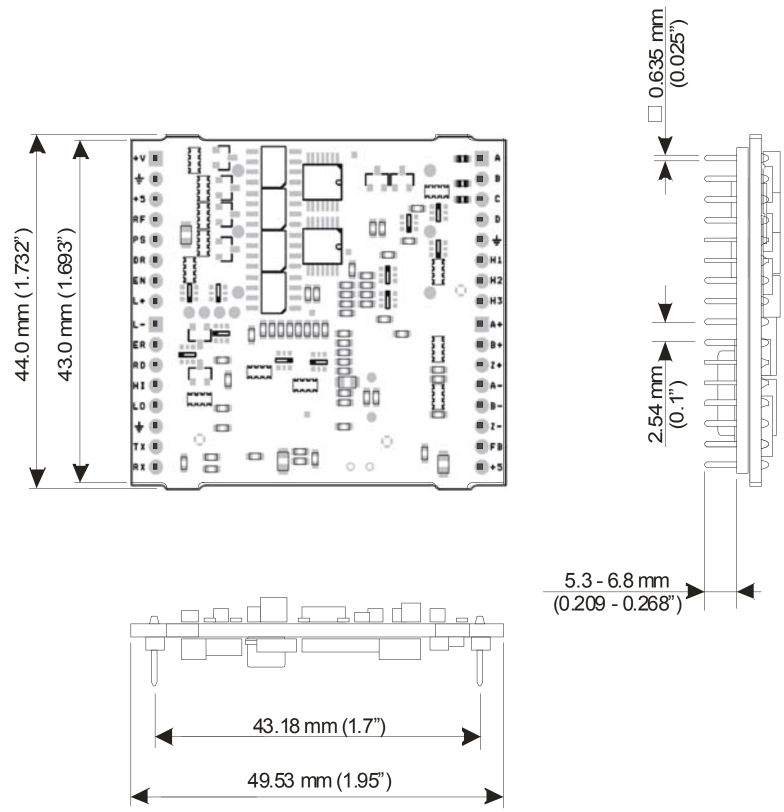


Figure 6.1. *PIM2401 dimensions*

7. Scaling factors

7.1. Supply / DC-bus Voltage Measurement Scaling

PIM2401 include a supply / DC-bus voltage feedback. In the TML environment, the A/D converted value of the supply / DC-bus voltage feedback can be read as TML variable *AD4*.

The scaling factor for the DC-bus voltage measurement is:

$$\text{DC-bus [V]} = \frac{V_{mm}[V]}{65472[bits]} \times \text{AD4 } [bits]$$

where:

V_{mm} is the maximum measurable DC-bus voltage; this value is 30.8V
65472 is the AD4 value for DC-bus voltage = V_{mm}

Remark: The *AD4* value is the result of a 10-bit A/D conversion, left-shifted by 6. The 6 LSB of *AD6* are always 0. If the A/D conversion result varies by 1 LSB, this translates into a variation of the *AD4* value by $2^6 = 64$.

7.2. Motor Currents Scaling

PIM2401 measure motor currents through shunts placed in the lower legs of the inverter. Only currents measured on phases A and B are connected to 2 A/D inputs with a current gain factor of 0.1V/A. The shunt on phase C is only used to sense a short-circuit. In applications with 3-phase AC motors, TML variables *IA* and *IB* provide the motor currents in phases A and B. In applications with DC or brushless DC motors, the TML variable *IQ* gives the motor current. The scaling factor for the motor currents is:

$$\text{Motor current [A]} = \frac{1.65[V]}{32704[bits] \times 0.455[V/A]} \times \text{TML current [bits], or}$$

$$\text{Motor current [A]} = \frac{3.63[A]}{32704[bits]} \times \text{TML current [bits]}$$

Remark: The A/D conversion result has a 10-bit resolution and is used left-shifted by 6. The 6 LSB of TML currents are always 0. If the A/D conversion result varies by 1 LSB, this translates into a variation of the TML current value by $2^6 = 64$.

7.3. Motor Speed Scaling

The TML variable ASPD gives the motor speed. The scaling factor depends on the speed sensor.

When the motor has a position sensor like an encoder, the speed can be estimated as position increment per speed-loop sampling period (set by default to 1 ms). In this case, the scaling factor is

$$\text{Motor speed [rpm]} = \frac{60}{4 \times \text{N [lines]} \times \text{T[s]}} \times \text{ASPD [bits]}$$

where N is the number of encoder lines
T is the speed-loop sampling period [in seconds]
4 is the multiplication ratio of the position resolution done in the encoder interface

Example: If T = 1ms, and N = 500 lines, motor speed [rpm] = 30 × ASPD [bits]

If the speed feedback is provided by a tachometer connected to the PIM2401 analog input **FEEDBACK**, the scaling factor is (for unipolar operation, i.e. 0…+ max.speed):

$$\text{Motor speed [rpm]} = \frac{3.3[V]}{1024[bits] \times 0.66[V/V] \times K_T\,[V/rpm]} \times ASPD \text{ [bits]}$$

where K_T is the tachometer constant
0.66 [V/V] is the PIM2401 feedback gain factor

Remark: In speed control motion modes, the speed reference should be provided in the same units as ASPD, i.e. based on the same scaling as for the speed measurement.

7.4. Motor Position Scaling

The TML variable *APOS* gives the motor position. When encoder feedback is used, *APOS* is measured in encoder counts (1 encoder count = 1 bit). The scaling factor is:

$$\text{Motor position [revolutions]} = \frac{1}{4 \times \text{N [lines]}} \times \text{APOS [bits]}$$

where N is the number of encoder lines

4 is the multiplication ratio of the position resolution done in the encoder interface.

8. Available Memory Areas

The drive has 2 types of memory: a 1.5K×16 SRAM (internal) memory and an 8K×16 serial E²ROM (external) memory.

The SRAM memory is mapped both in the program space (from 8270h to 87FFh) and in the data space (from A70h to FFFh). The data memory can be used for real-time data acquisition and to temporarily save variables during a TML program execution. The program space can be used to download and execute TML programs. It is the user's choice to decide how to split the 1.5-K SRAM into data and program memory.

The E²ROM is seen as 8K×16 program memory mapped in the address range 4000h to 5FBEh. It offers the possibility to keep TML programs in a Non-volatile memory. Read and write accesses to the E²ROM locations, as well as TML programs downloading and execution, are done from the user's point of view similarly to those in the SRAM program memory. The E²ROM SPI serial access is completely transparent to the user.

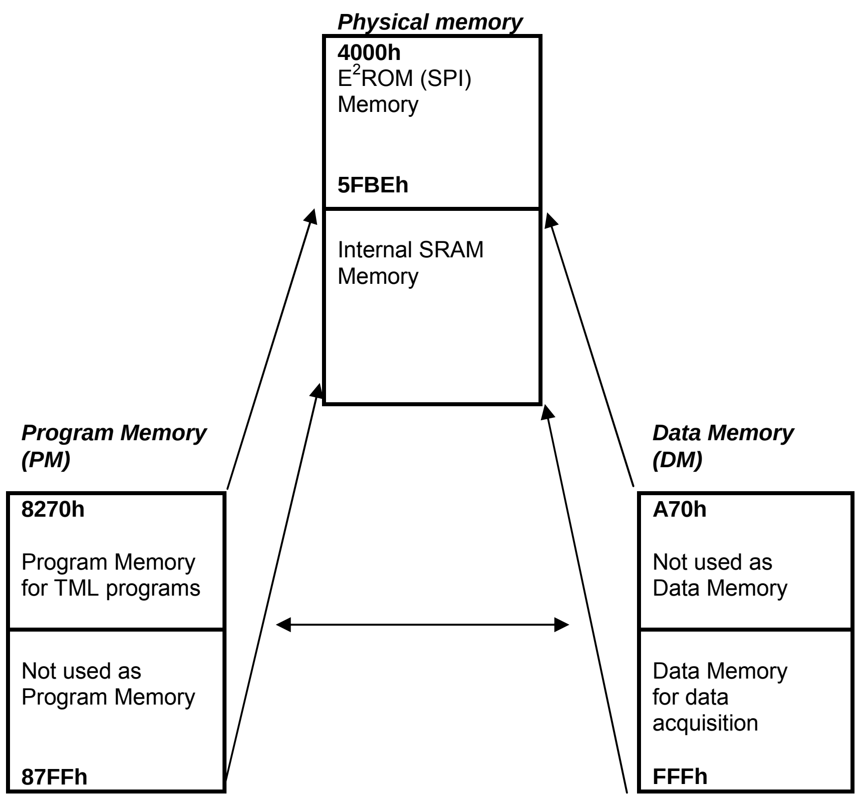


Figure 8.1. *PIM2401 Memory Map*

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