µM-H-Bridge

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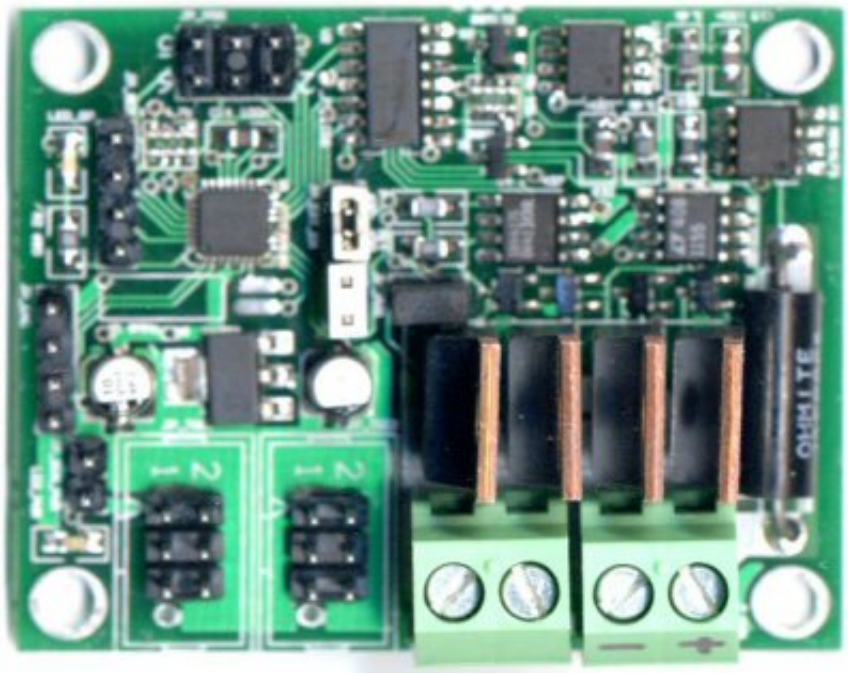

Introduction

This µModule implements a 16A H-bridge with rich feed-back options to create a closed-loop speed-controller application. The module interfaces to the external world using the TWI interface that's common among all µModules. It also has an optional CMOS-level RS-232 interface. It can control motors up to 18V.

Features

- Standard µModule TWI with optional RS-232 interface
- Integrated 3.3V power supply, 5V operation is optional using an external power source
- 16A current limit
- 7 to 18V motor voltage
- High-side short-circuit protection
- High efficiency n-channel MOSFETs
- Rich speed-feedback options for closed-loop operation
- Back-EMF feedback for sensorless motion-control
- PID control loop
- Acceleration and deceleration limits
- Traveled distance calculation
- 'Go-to-distance' support with trapezoid speed-profile
- Braking and free-wheeling support

- Parameters can be stored in permanent EEPROM storage
- Duty-cycle throttling to limit torque
- Per-cycle programmable current-limit
- Servo controller mode with external position feedback potentiometer

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Design description

The bus interface

The TWI bus interface follows the µModule standards. There are six or four-pin connectors on the board, both with identical functionality. Two wires are used for the TWI signal transmission (clock and data) while the rest provide power and ground signals. The interface can be operated at a rate up to 400kHz. This module never initiates any transactions on the bus, it operates in slave-only mode. Status information can be acquired by polling and commands can be sent to the module at any time. The module implements the standard 8-bit register bank µModule communication protocol.

Powering options

The module can source and sink power on this interface. The power to and from these sockets can be interrupted by an on-board jumper. With this there are three possible powering configurations with regards to the logic-level functions:

- The module is powered form the same power supply as the motor. The module provides power to other devices on the TWI bus
- The module is powered from the power supply of the motor however it does not power other devices on the TWI bus
- The module is powered from the TWI bus

The third powering mode has to be used if 5V operation is required.

The H-bridge

The H-bridge is comprised from 4 n-channel power MOSFETs. These transistors have extremely low on-resistance, leading to high-efficiency and low heat-generation even at high power levels. By replacing the standard IRFZ48 transistors with IRL2203 ones, no heat-sink is required up to 10A of continuous current. The efficiency of the bridge is almost 98% from a 18V supply, 96% at 10V and 94.7% at 7.2V supply voltage. The transistors are driven by LTC1155 dual-channel high-side driver ICs. These devices can deliver higher gate control voltages than the power supply thus allowing the use of n-channel MOSFETs on the high-side of the bridge as well. These chips also provide a second level of short-circuit protection by measuring the voltage drop on the sense resistor. Shot-through protection is established by monitoring the low-side gate voltage and disabling the high-side gate drives until the low-side gate voltage drops low enough. This mechanism also provides protection against opening a low and a high-side driver of the same half of the bridge at the same time. Since the drivers can provide significantly higher voltages (especially for the low-side MOSFETs) than the maximum allowable GS voltage, a zenner protection diode limits the GS voltage to 10V. All four MOSFETs can independently be turned on and off (with the exception of two MOSFETs on the same side being turned on at the same time) allowing all possible valid operating modes of the bridge to be used:

- Forward drive
- Backward drive
- Free-wheeling
- Braking

Feedback options

A wide range of feedback options are available on the module to provide additional health-monitoring and establishing closed-loop speed-control functionality. Both voltage (relative to the ground) on the motor connectors can be monitored as well as the voltage across the current-sense resistor which is proportional to the current flowing through the motor. Monitoring these values with a 10-bit resolution A/D converter precise knowledge of the current system status can be established. These measurements can be used to calculate the back-EMF response of the driven motor, which is proportional to the rotation speed. This value in turn can be used to close the control loop and create a true speed-controlled H-bridge. When more precise measurement of the rotation is required, an external quadrature encoder can be used and the signal of the optical gates can be fed back to the module. Two input pins are wired to a header for that purpose.

Miscellaneous functions

The module on the top of the standard TWI interface, that is common among all µModules also contains a (logical level) RS-232 interface as well. This interface can be used to connect the module to other microcontroller modules or (after level-shifting) to a PC which doesn't have a TWI interface.

The TWI interface

The TWI interface adheres to the standard µModule communication protocol. It implements 8-bit register-bank addressing, and defines 32 registers. Each register corresponds to a single channel.

Offset	Size	Name	Access	Comment
0	int16_t	RequestValue	R/W	Speed control request signal R/W (Scaled between -0x3fff and 0x3fff). 0x4000 is freewheeling and 0x4001 is braking.
2	int16_t	IFactor	R/W	PID control loop integrator value
4	int16_t	PFactor	R/W	PID control loop proportional value
6	int16_t	DFactor	R/W	PID control loop

				differentiator value
8	int16_t	PFFactor	R/W	Control bypass proportional value
10	int16_t	SampleOffset	R/W	Control loop input bias
12	int16_t	MaxPositiveChange	R/W	Maximum single-step change in speed in the positive direction. If a bigger change is requested in RequestValue a ramp is generated.
14	int16_t	MaxNegativeChange	R/W	Maximum single-step change in speed in the negative direction. If a bigger change is requested in RequestValue a ramp is generated.
16	int32_t	Distance	R/W	Integrated actual speed value. An approximate measurement of the travelled distance.
20	int32_t	FwDistanceLimit	R/W	Maximum distance allowed in the positive direction. When Distance approaches this value, a speed-ramp usingMaxPositiveChange is generated such that speed will reach 0 when distance reaches FwDistanceLimit
24	int32_t	BwDistanceLimit	R/W	Maximum distance allowed in the negative direction. When Distance approaches this value, a speed-

				ramp usingMaxNegativeChange is generated such that speed will reach 0 when distance reaches BwDistanceLimit
28	int32_t	DistanceToStop	R/O	Current estimated distance required to stop
32	int16_t	CurrentRequest	R/O	Actual current speed request value. This in general is equal to RequestValue except when ramp-generation is in progress
34	int16_t	Command	R/O	Command given to the H-bridge. This is the output of the control loop
36	int16_t	IValue	R/O	PID loop working set
38	int16_t	LastError	R/O	
40	int16_t	Error	R/O	
42	int16_t	VoltageSample	R/O	Last Back-EMF sample. This is the measured speed, and the input of the control loop
44	int16_t	BaseValue	R/O	Back-EMF sampling code working set
46	int16_t	SampleCnt_Snapshot	R/O	
48	int16_t	MinValue_Snapshot	R/O	
50	int16_t	MinValue	R/O	
52	int16_t	MaxValue	R/O	
54	int16_t	SampleCnt	R/O	
56	int16_t	OriginalRequestValue	R/O	Ramp-generation code working set
58	uint8_t	SampleState	R/O	Back-EMF sampling code working set
59	uint8_t	DutyCycleThrottle	R/W	Maximum duty cycle allowed on the H-bridge. This

				limits the maximum (average) voltage that can be applied to the motor
60	uint8_t	NewData	R/O	Used for debug outputs
61	bool8_t	IsForward	R/O	Set to true if the motor is energized in the forward direction
62	uint16_t	CurrentMax	R/O	Peak current drawn by the motor
64	uint16_t	CurrentDelta	R/O	Current draw
66	uint16_t	CurrentTemp	R/O	detection code
68	uint16_t	CurrentMaxSearch	R/O	working set
70	uint8_t	ADBufferEnable	R/O	When set to 0, AD sampling is in progress
71	bool8_t	ADBufferEnableHost	R/W	When set to true, host request a new set AD sampling. It will happen in the next control cycle. When sampling is done, it is reset to false
72	uint16_t	CurrentLimit	R/W	Maximum current draw allowed. If during the 'on' part of the cycle, the current draw reaches above this level, the MOSFETs are switched off and the 'on' part of the cycle is terminated
74	uint8_t	OperatingMode	R/W	Set to 0 for speed-controller, and 1 for servo-controller mode
75	uint8_t	Dummy1	R/W	Reserved
76	uint16_t*80	ADBuffer	R/W	AD sampling buffer

Legend:

int8_t
: Signed 8-bit integer

int16_t
: Signed 16-bit integer

int32_t
: Signed 32-bit integer

uint8_t
: Unsigned 8-bit integer

uint16_t
: Unsigned 16-bit integer

uint32_t
: Unsigned 32-bit integer

bool8_t
: 8-bit boolean value (possible values are 0 for false, and non-zero for true)

R/W
: Register has read/write access

R/O
: Register has read-only access

Design files

µModule Users Manual (HSOL)
Schematic and PCB in PDF format (HSNCL)
Firmware source code (HSNCL)