µM-Servo brain

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Introduction

This µModule replaces the built-in electronics of many standard R/C servos. It adds the same features to a servo that the µModule H-Bridge module offers. It is capable to drive up to 1.5A servo motors and uses the built-in potentiometer for position-feedback. For modified continuous-rotation servos it offers the same back-EMF based speed-control than it's larger cousin offers. It operates from 5V. and communicates using the TWI interface that's common among all µModules. It also has an optional logic-level RS-232 interface. Due to size constrains the module does not use the standard µModule interface headers but is electrically compatible with all other modules.

Features

- Standard µModule TWI with optional RS-232 interface
- 1.5A current limit
- Over-current protection
- High efficiency complementary MOSFET bridge
- Rich speed-feedback options for closed-loop operation
- Back-EMF feedback for continuous rotation servos
- PID control loop
- Acceleration and deceleration limits for continuous rotation servos

- Traveled distance calculation for continuous rotation servos
- 'Go-to-distance' support with trapezoid speed-profile for continuous rotation servos
- Braking and free-wheeling support
- Parameters can be stored in permanent EEPROM storage
- Duty-cycle throttling to limit torque
- Per-cycle programmable current-limit

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DAMAGE.

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 tow n-channel and two p-channel power MOSFETs. These transistors have extremely low on-resistance, leading to high-efficiency and low heat-generation even at high power levels. The high-side transistors are driven through a HW over-current protection circuit. All four MOSFETs can independently be turned on and off 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. For traditional servo control, the module uses the R/C servos integrated potentiometer as feedback.

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	Position or 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	This is the measured position or 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 detection code working set
66	uint16_t	CurrentTemp	R/O	
68	uint16_t	CurrentMaxSearch	R/O	
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)](#)