



Features:

- Control Unit with Arduino Due Board, power bridge and input/output buffers
- Designed to drive inductive loads like electromagnetic actuators or DC-motors
- Over load protection
- Stand alone working without connected Computer
- Power bridge: up to 30 W (max 1A @ 30V), controlled by pulse width modulated output (PWM) of Arduino Due or by external signal generator
- Measuring of Bridge current
- 2 Analog inputs for sensors, voltage range 0...5V
- Slider for manual adjustment of control values
- Buffered Analog output 0...5V, 100mA
- Programmable with Matlab/Simulink¹ or Arduino IDE²

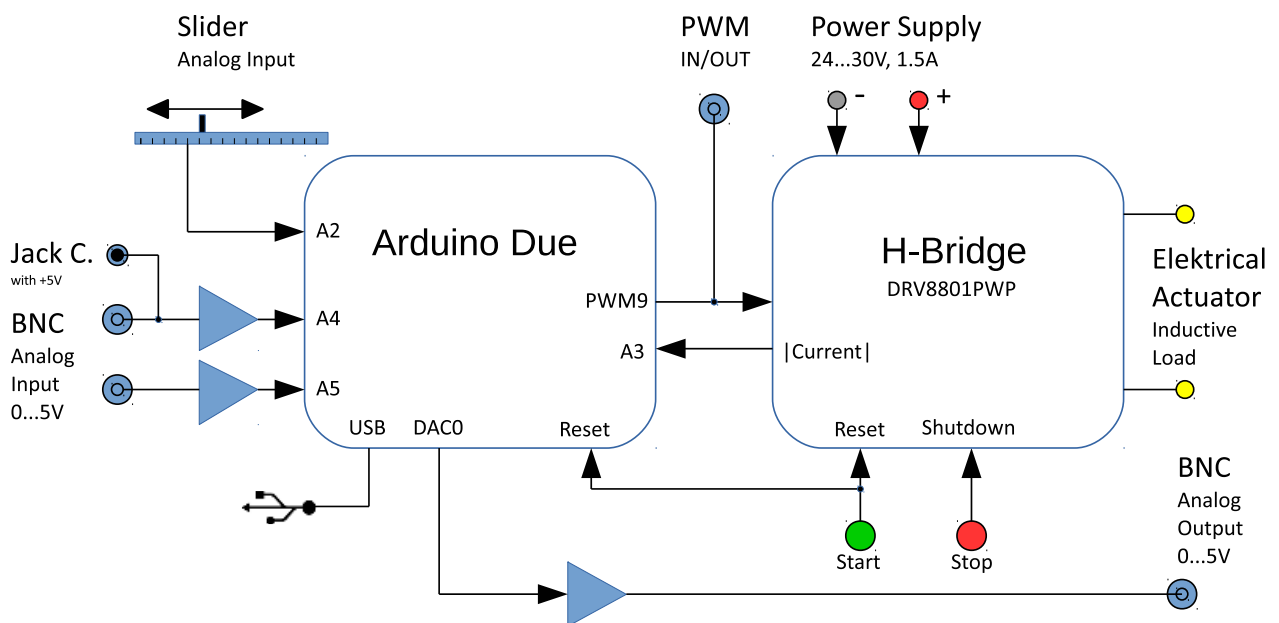


Figure 1: Block Diagram of Control Unit.

¹Matlab Simulink from MathWorks (www.mathworks.com)

²www.arduino.cc/en/Main/Software

Applications

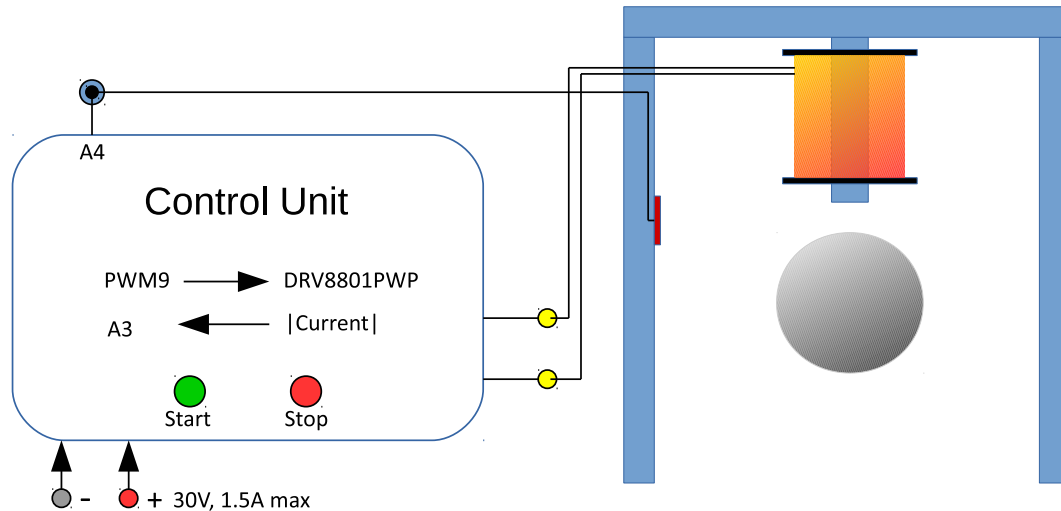


Figure 2: Experimental Setup Levitated Sphere.

Figure 2 shows a realization of feedback control loop for a magnetically levitated control system (Maglev) in a well-known way: an iron ball is held in levitation with the magnetic force of an electromagnet.

- The actuator coil is driven from H-bridge of the control unit.
- An IR-sensor measures the gap between coil and ball. The received analog voltage is routed to A4-input of control unit. With using the A4 Jack Connector a supply voltage of 5V is available for sensor electronics.
- Software routines on Arduino Due will calculate the PWM-value, which leads to levitating of the ball, using the gap width from the sensor signal.
- To realize a State Space control system the coil current as state variable is also measured and can be gripped from A3 input of the Arduino Due.

Alternatively the Control Unit can handle other inductive loads, for example DC motors. A PWM duty cycle of 50 % results an average current of zero Ampere. Varying the duty cycle to upper or lower values allows motor rpm-control in both directions.

Input/Output Specification

Inputs

- **Power Supply.** A DC-Voltage between 24V and 30V is needed to supply the power stage and all other electronic components, like protection and sensor circuits and Arduino Due Board. Take care that no current limiter from your DC-source drops the voltage lower than 24 V. In this case the H-Bridge is switched to Shut Down.
The presence of power supply is indicated by green LED on PCB board.
The maximum current depends on the driven load and will not exceed 1.5 A.

- **Analog Input A4 and A5.** The incoming voltage is buffered and connected with ADC ports of Arduino.
Input range 0...5 V similar to ADC full scale range.
Input resistance greater then 2 k Ω .
Chanel A4 has an additional 2.5 mm Jack connector with three pins: analog input, Ground and +5V power supply. The BNC connector can be used to monitor the received analog voltage of Jack Connector.
Input voltages greater +12V and lower -8V can destroy the Control Unit.
- **Analog Input A2 (Slider).** Slider position controls the input voltage of ADC-channel A2.
Full slider range corresponds to full ADC range.
- **Analog Input A3 (intern).** The absolute value of current through the load is measured and can be read with Analog Input A3.
Full scale of ADC corresponds to a current of 5A. The sign of the current respectively the current direction through the load is not detectable.
- **PWM IN/OUT.** This connector can be used either to monitor the PWM-output of the Arduino board or to control the H-bridge with an external digital PWM-signal. By using standard TTL (0...5V, max. 50 Ω source resistance) the external signal overwrites the Arduino PWM signal.
If the external voltage remains on low or high level longer than 100 milliseconds the H-bridge is switched to standby. So you must not use 100% or 0% PWM values.
- **USB.** The cable is connected to the programming port of the Arduino Due board.
During programming procedure the Arduino board can be supplied with 5V over the USB interface. It is not necessary to activate the main power supply of the Control Unit.
- **START knob.** Releasing the Start knob will reset the Arduino board and set the H-bridge in active mode.
- **STOP knob.** Pressing the Stop knob switches the H-bridge immediately into standby mode. The red LED on PCB board indicates the standby mode.



Outputs

- **Analog Out (DAC0).** This port can be controlled by software using the DAC channel 0 of Arduino.
Full DAC range corresponds to 0...5V output voltage.
The output is protected with internal 51 Ω series resistance.
- **Electrical Actuator.** These pins are connected to the power stage of the H-Bridge DRV8801 circuit of Texas Instruments. For detailed information see the data-sheet from TI³. The voltage is nearly equal to the supply voltage of the Control Unit. The current depends on PWM ratio and on the resistance of the inductive load .
If the current exceeds a value of 1.2 A for longer than 500 milliseconds the bridge is switched to shut down to avoid overheating of connected actuator. The shut down mode is indicated by a red LED on PCB-board.

Programming Hints

The Arduino Due Board is programmable directly from graphical Simulink software without typing programming language. Therefore the free Simulink Support Package for Arduino Hardware⁴ must be

³www.ti.com

⁴<http://mathworks.com/help/supportpkg/arduino/index.html>

installed, it is an additional library with specific input/output blocks for easy access to hardware ports. Sample Simulink diagrams are to be found on www.leviball.com/downloads/.

A constant loop time is essential especially for digital feedback control. The sample time of the loop is given from used sources blocks. The same sample time must be used for all source blocks as well as for other blocks which need sample time specification (for instances the Discrete-Time Integrator block: use "-1" for inherited time or the above value).

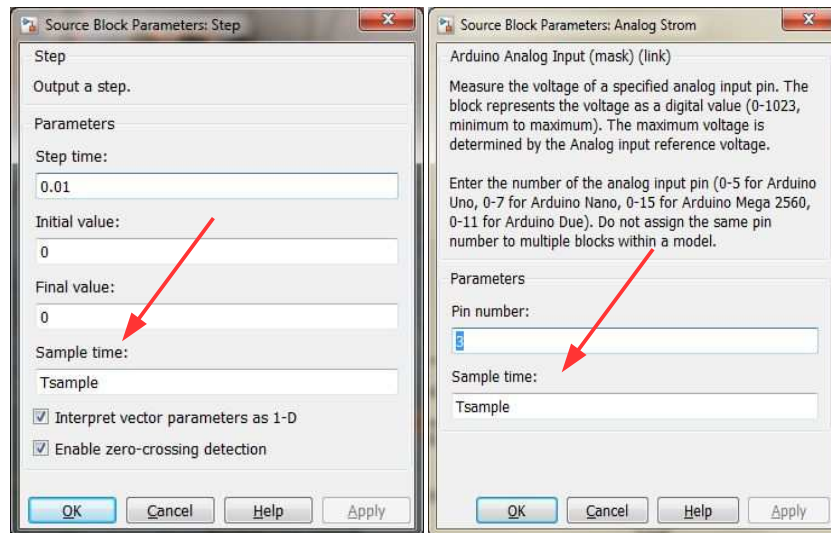


Figure 3: The same value of sample time must be used for all input blocks, here for the step input function (left) and the analog input block. You can use fixed values (e.g. 0.001 for a loop time of 1 millisecond) or define the variable "Tsample" from Matlab command line or with executed m-file.

By using Arduino Due hardware of the Control Unit the least sample time was 0.001 seconds to achieve stable control loops without failure.

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The described Control unit must not be used for dangerous setup. No warranty is given for faultless function.

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