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I3GFV

Experiment

Motor control

Purpose

The purpose of these experiments is to understand the basic principles for controlling a DC motor and a unipolar stepper motor.

The speed of the DC motor is controlled using pulse-width-modulation (PWM) of the voltage applied to the motor, through a power MOSFET transistor.

The rotation direction of the DC motor is controlled using an H-Bridge.

The stepper motor is controlled using 4 power MOSFET transistors and the rotation direction and different drive modes are examined.

Both motors are controlled by a PSoC.

The experiments should end up with a small journal and the PSoC creator projects.

Literature

- PSoC Manuals.
- Stepper motor datasheets.

The relevant documents can be downloaded from BlackBoard.

General guidelines

Document the experiments in a journal.

Describe the experiment objective(s), results and reflect upon the results.

Document the test setup with photos and diagrams.

Note which components you use. Which type of motor, which sensor etc.

Document the electrical wiring and create oscilloscope/logic analyzer dumps, where you find it appropriate.

Include relevant parts of datasheets or other documentation. The relevant parts are often diagrams and illustrations.

Keep a good structure in the code and document the code.

Perform the experiments in a structured manner: Think -> Do -> Document -> Reflect. And possibly iterate.

Conclude upon the results:

- What worked?
- What didn't work?
- Did anything surprise you?
- What caused the most problems?

MOSFET PCB

The following quad MOSFET driver circuit is used in the experiments:

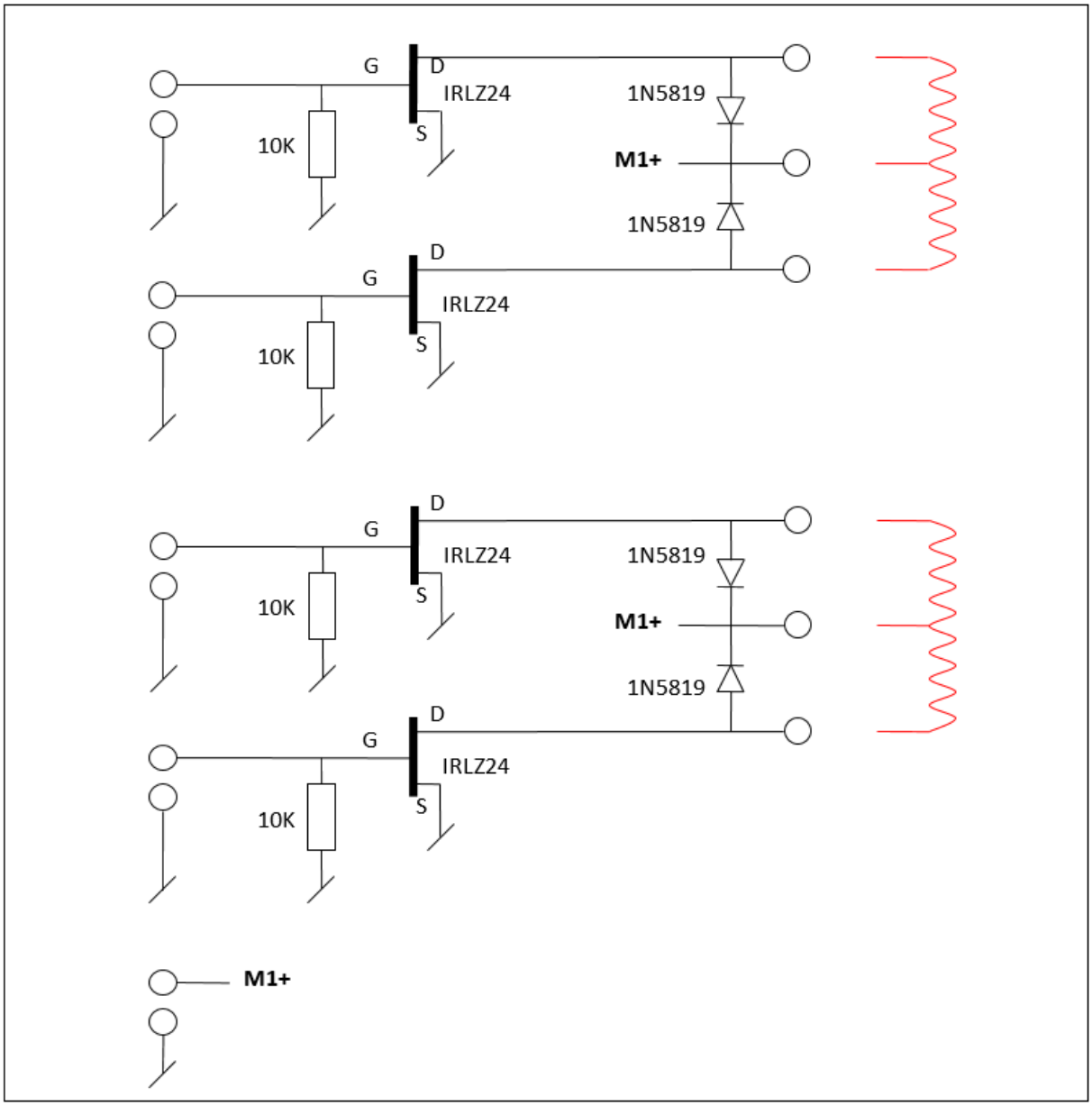

Figure 1: Quad MOSFET driver

There are two versions of the PCB. On the new version, the IRLZ24 transistors are replaced by IRLZ44L.

For the DC motor control, only one of the MOSFETs are used. The motor power supply shall be connected to the M1+ terminal.

For the stepper motor control, all four MOSFETs are used. Each of the four MOSFETs can be controlled by an output pin on the PSoC. Remember to create a common ground!

The IRLZ24 and IRLZ44 datasheets are available on Blackboard.

H-Bridge PCB

The following H-Bridge driver circuit is used to control the DC motor rotation direction.

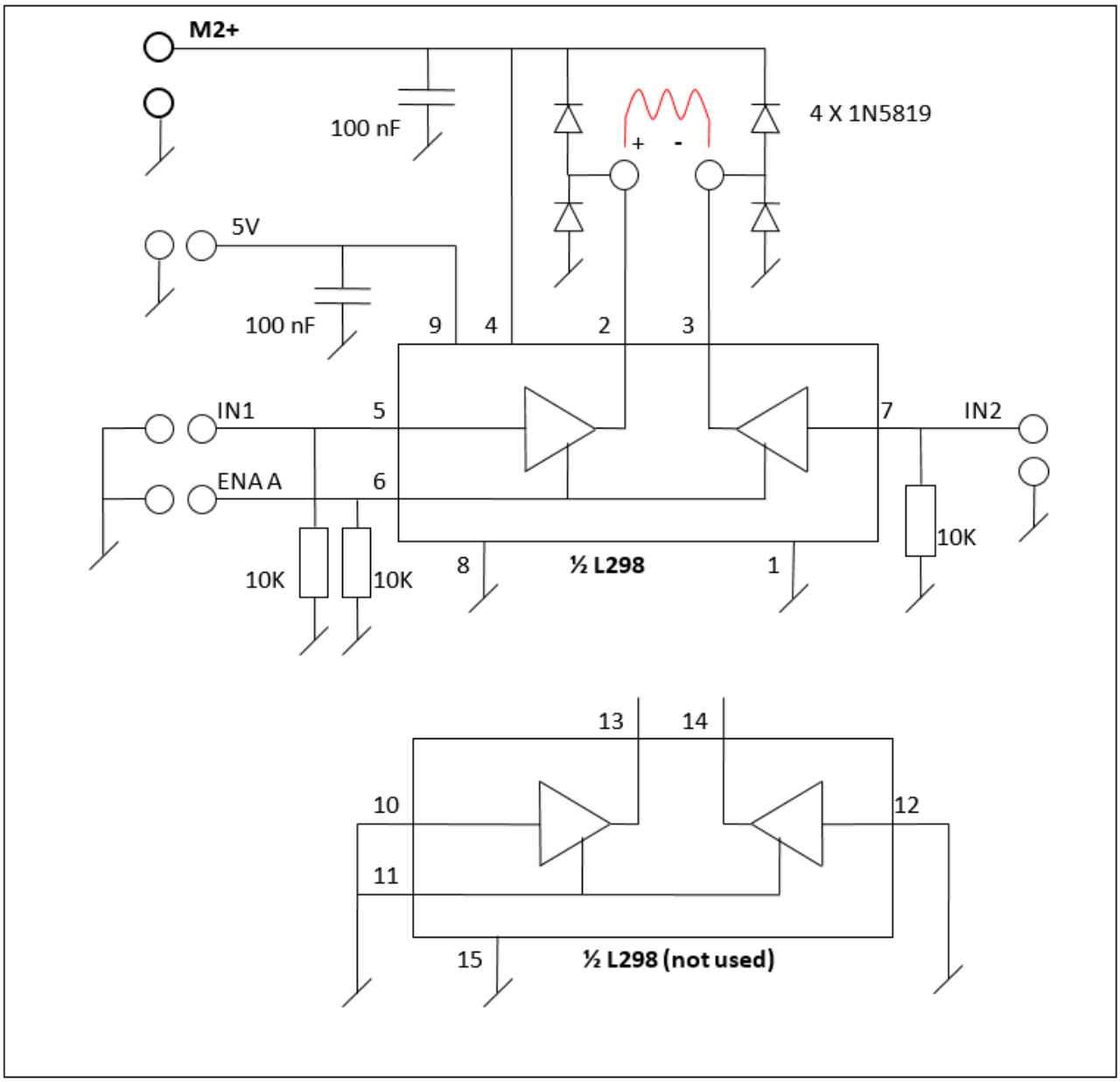

Figure 2: H-bridge driver

The datasheet for the H-Bridge L298 is available on Blackboard. Each of the input signals IN1, IN2 and ENABLE shall be controlled from output pins on the PSoC. Remember a common ground.

The internal logic circuit of the L298 shall be powered by 5V (the VDDIO pin). This can be done by connecting it to VDD on the PSoC.

Experiment 1: PWM control of a DC motor

For this experiment, you shall use a DC motor. There are different types, which can handle different supply voltages. In general, the red wire is + and the black wire is -.

It is not recommended to power the motors directly from the PSoC. It will probably not be able to provide enough current to the motor. Use a lab power supply instead.

In this experiment, you will control the rotation speed of the DC motor, using a PWM signal generated by the PSoC. One MOSFET transistor is used as driver for the motor.

Create a PSoC project with a PWM component and a UART.

Write a program, where console input on the UART is used as commands to the PSoC to start and stop the motor.

Add functionality to change (i.e. increase/decrease) the motor speed.

How do you control the motor speed?

Use the oscilloscope to plot the PWM signal. When does the motor run fast and when does it run slow? And why?

Experiment with the PWM frequency. Does the frequency affect the behavior of the motor?

Experiment 2: DC Motor rotation direction

In this experiment, you shall control the rotation direction of the DC motor using the H-Bridge L298 and at the same time control the speed of the motor using a PWM signal, generated by the PSoC.

Use the motor driver circuit with the H-Bridge L298 as shown in figure 2. (You shall not use the MOSFET driver PCB in this experiment).

How shall the IN1, IN2 and ENABLE signals be controlled, in order to both change rotation direction and control the speed of the motor?

Write a program, where console input on the UART is used as commands to the PSoC to start and stop the motor, change direction and increase/decrease the speed.

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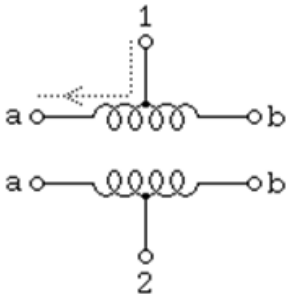
Experiment 3: Stepper motor control

In this experiment, you will control a stepper motor.

Multiple stepper motors are available. Choose one to work with. Datasheets are available on Blackboard.

UHD23 from Saia-Burgess:



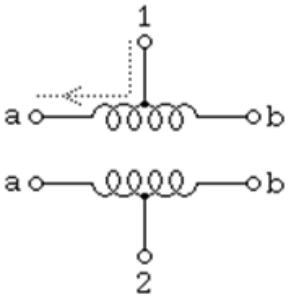
Wire coloring:

Winding 1:
Center = GREEN.
1a = YELLOW.
1b = RED.

Winding 2:
Center = GREEN.
2a = PURPLE.
2b = BLACK.

Typeid: UHD23N03RN.
Supply voltage: **12 volt**.

PF35-48L4:



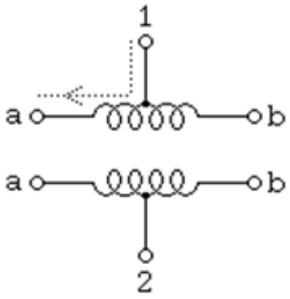
Wire coloring:

Winding 1:
Center = GREEN.
1a = BLACK.
1b = BROWN.

Winding 2:
Center = REF.
2a = ORANGE.
2b = YELLOW.

Supply voltage: **5 volt**.

28BYJ48 -5V:



Wire coloring:

Winding 1:
Center = RED (shared).
1a = BLUE.
1b = YELLOW.

Winding 2:
Center = RED (shared).
2a = ORANGE.
2b = PINK.

Supply voltage: **5 volt**.
Gearing: 1:64

Use the MOSFET driver circuit to drive the stepper motors. Connect the center of each winding to the power supply (i.e. the M1+ terminals on the PCB) and use the MOSFETs to drive either the 'a' or 'b' connections to GND by controlling the gates of the MOSFET transistors from output pins on the PSoC. This way, you can control each of the windings as you wish.

Write a program, where console input on the UART is used as commands to the PSoC to start and stop the motor, change direction and increase/decrease the speed. Add commands to switch between wave-drive, full-step (2 phases on) and half-step drive modes.

What is the difference between the wave-drive, full-step and half-step drive modes? Explain using illustrations and the relevant parts of the code. Can you feel a difference?

Add a command to do a single rotation clockwise and another command to do a single rotation counter-clockwise.

Consider the DC motor vs. the stepper motor. What are the benefits and drawbacks of each motor type? When will you choose one over the other?

What limits the speed at which you can drive the stepper motor?

Hints:

The program can include one or more state machines and a timer. One state machine can hold the position in the rotation sequence and go to the next position, when the timer times out. Another state machine can hold the drive mode and another can hold the rotation direction.

Note:

- **The wave-drive sequence for the motors is: 1a,2a,1b,2b,…..**
- **The half-step sequence for the motors is: 1a,1a+2a,2a,2a+1b,1b,1b+2b,2b,2b+1a,…..**

Experiment 4: Controlling a servo motor (optional)

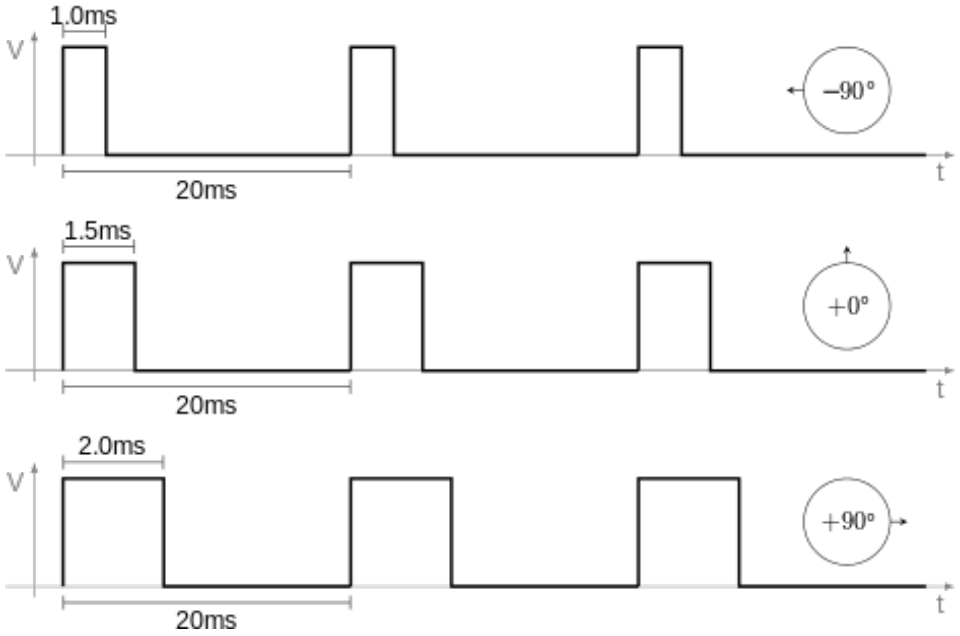
You can experiment with controlling a servo motor.

The motor MG 996R is available and the datasheet can be found on Blackboard.

Figur 3: MG 996R Servo motor outline

Write a program to control the servo motor. The motor is controlled using a PWM signal.

Which circuit shall be used to control the motor? How shall it be connected to the PSoC?



Figur 4: Typical control for servo