Electrical Circuit Design for Virtual Quality Control Robot

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Yinlong Gao, ECE, University of BC, Vancouver, BC, Canada

Quinlan Cheng, ECE University of BC, Vancouver, BC, Canada

Eric Wu, ECE, University of BC, Vancouver, BC, Canada

Abstract

A PCB for feeding motors from a microcontroller is developed. The circuit consists of four amplifiers, two connected to a smaller motor and the other two connected to a bigger motor.

In this paper, Section 1 describes motor selection. Section 2 describes sensor selection. Section 3 describes the design of the circuit. Section 4 describes the linearized matlab model. Section 5 describes the PCB layout.

Nomenclature

ϕ	Diameter
cpt	Counts Per Turn

1. Motor selection

The two motors are customer-specified and are not free design parameters. The two specified motors are found on p.79 and p.91 of the Maxon™ Motor catalog [1].

The first motor is a Maxon 12mm DC motor. The motor is 19.4mm long x 12mm ϕ and has a 1.5mm ϕ output shaft. The 12V program has a maximum speed of 9020 rpm and a stall torque of 3.21mNm.

The motor is shown in Fig. 1.

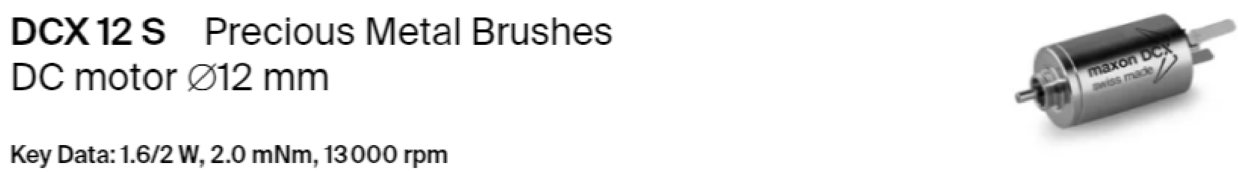

Figure 1: Maxon motor – DCX12S

The second motor is a Maxon 22mm DC motor. The motor is 47.2mm long x 22 ϕ and has a 3mm ϕ output shaft. The 12V program has a maximum speed of 4980rpm and a stall torque of 0.15Nm.

The motor is shown in Fig. 2.

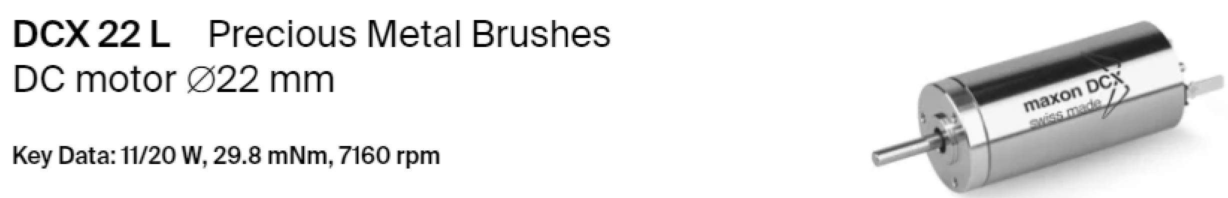

Figure 2: Maxon motor – DCX22L

2. Sensor selection

The sensor is an optical encoder from Maxon™ Motor. The encoder is found on p.1 of the Encoder 16 EASY XT catalog [2].

The encoder has a resolution of 1024 cpt and is 8.5mm long x 15.8mm ϕ.

The encoder is shown in Fig. 3.

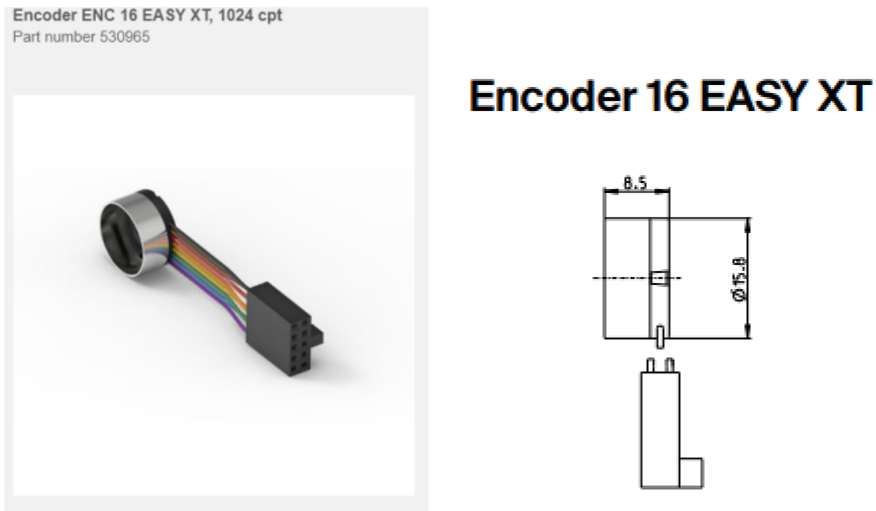

Figure 3. Optical encoder – ENC 16 EASY XT

3. Circuit design

The amplifier circuit is designed using Multisim. An inverting amplifier design with two BJT's and a bypass capacitor is used. The amplifier circuit amplifies the 5V input from the microcontroller to a 12V signal to feed the motors.

NJM082BD is an OPA with +/- 18V maximum supply voltage. BD787G is a NPN BJT with maximum collector current of 4A. BD788G is a PNP BJT with a maximum collector current of 4A.

The whole circuit consists of four amplifiers, two connected to DCX12S and the other two connected to DCX22L. The load resistances correspond to the motors, respectively.

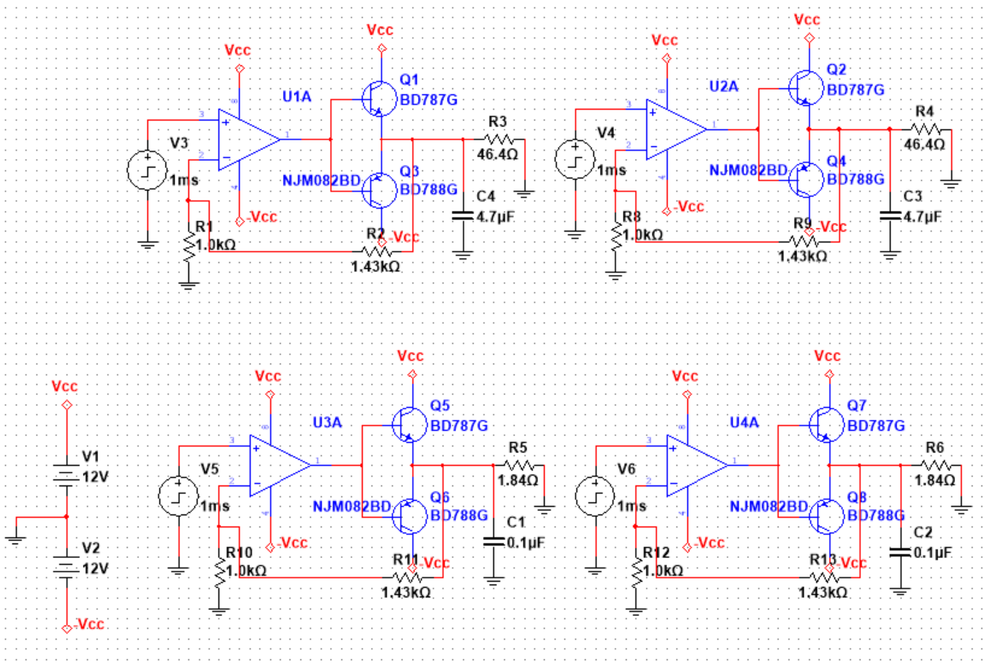

Figure 4. Multisim circuit drawing

The transient response of DCX12S with amplifier circuit is shown in Fig. 5.

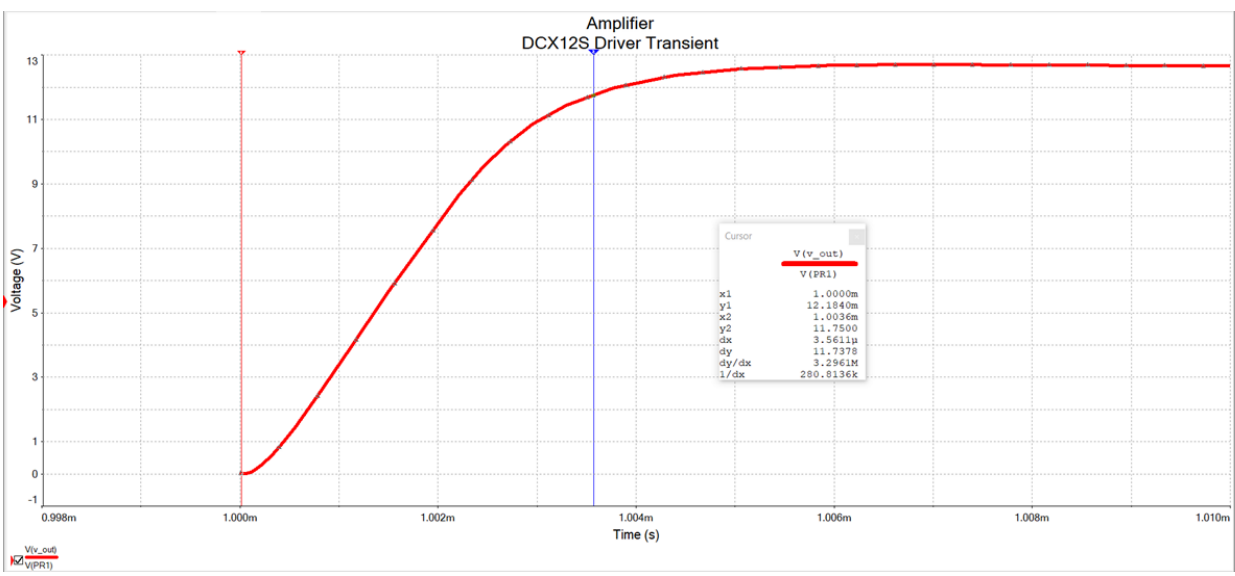

Figure 5. DCX12S + amplifier circuit transient response

The transient response can be linearized as a first order transfer function by calculating its time constant. The time constant is the time interval between the step time and the time when the signal reaches 63% of its steady-state value.

The linearized transfer function for this response is $\frac{2.4\times112348}{(s+1123248)}$.

The transient response of DCX22L with amplifier circuit is shown in Fig. 6.

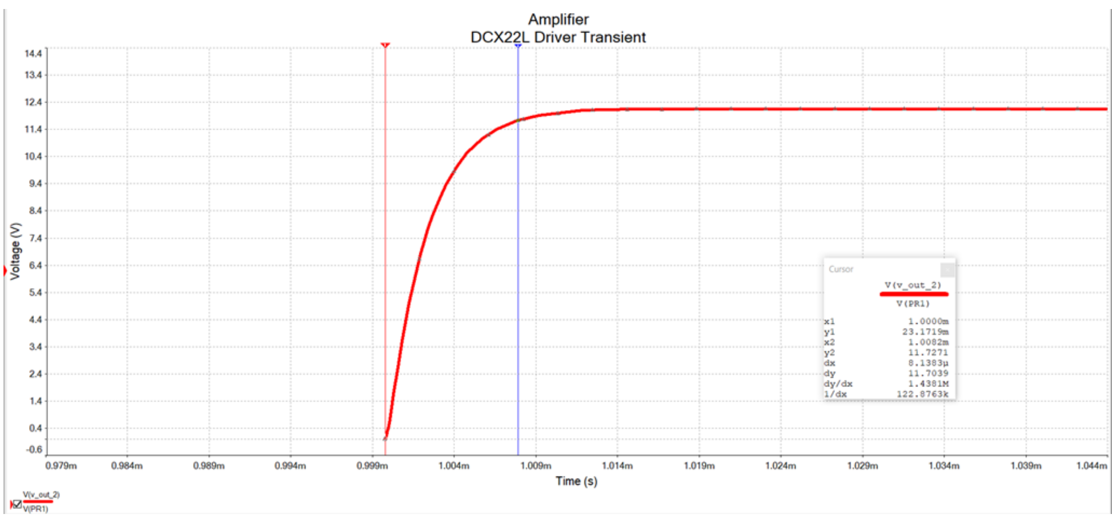

Figure 6. DCX22S + amplifier circuit transient response

The linearized transfer function for this response is $\frac{2.4\times4913503}{(s+4913503)}$.

The current of the motor load is checked to make sure it matches the motor’s nominal voltage.

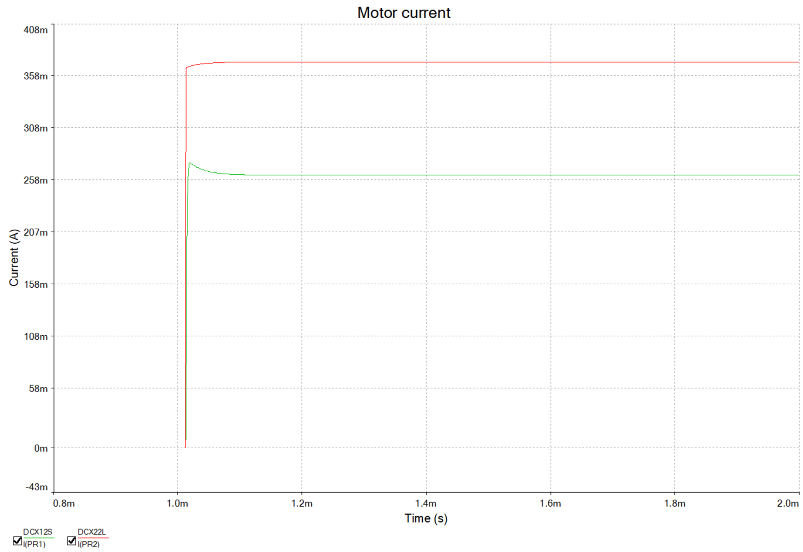

Figure 7. Motor current

The HDR1X2 connector is used to replace sources and loads for actual physical connection.

Two fuses were connected to input power for protection and safety issues.

The modified circuit is shown in Fig. 8.

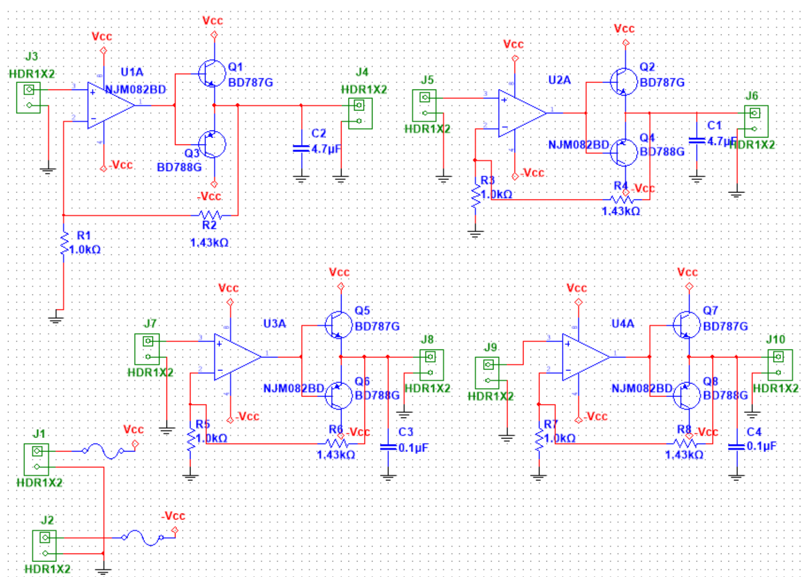

Figure 8. Multisim circuit drawing (source replaced)

4. Matlab Model

The Simulink model of the linearized transfer function (DCX12S) from the previous section and its output signal is shown in Fig. 9.

The input is a step function with a step size of 5.

The model has a similar rise time and curve as the actual response.

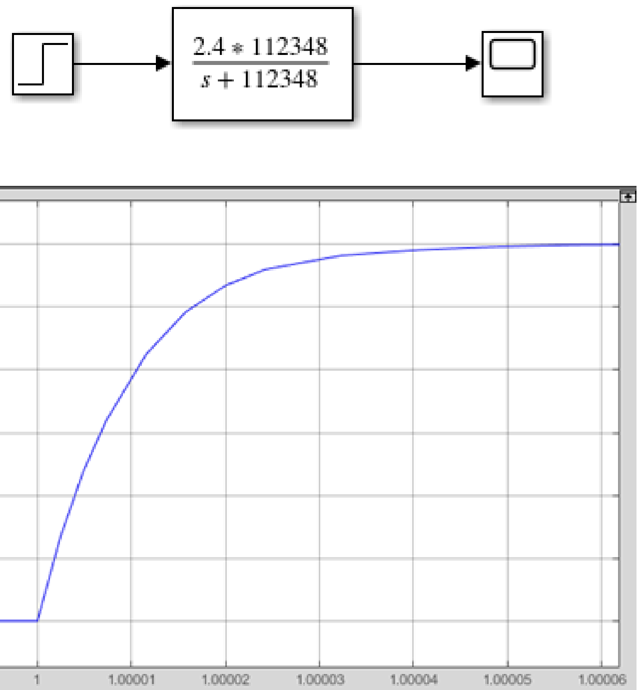

Figure 9. Simulink model of amplifier with DCX12S as load

The Simulink model of the linearized transfer function (DCX22L) from the previous section and its output signal is shown in Fig. 10.

The input is a step function with a step size of 5.

The model has a slight overshoot but is stable when it reaches steady-state. The rise time and overall curve is similar to the actual transient response.

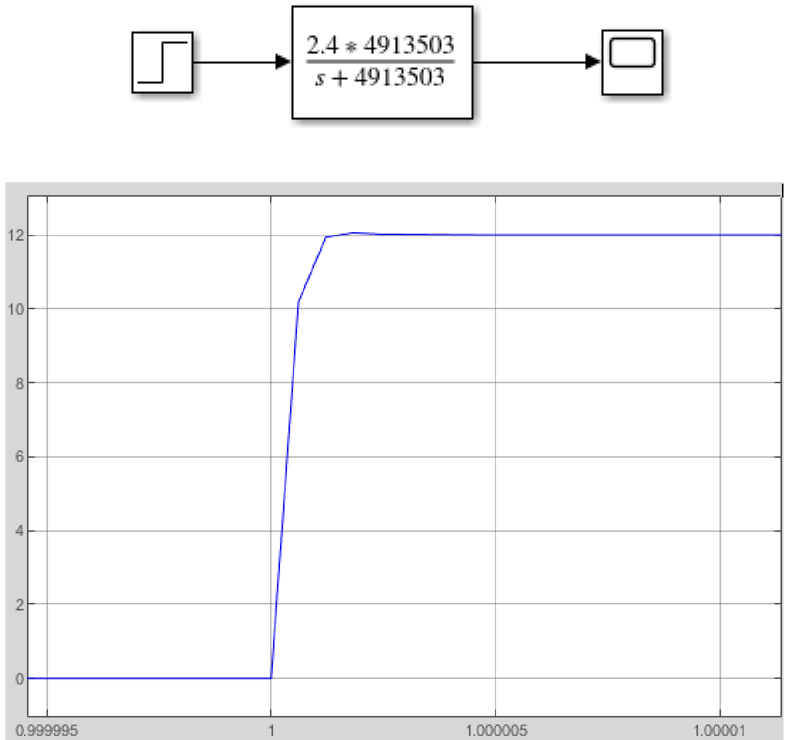

Figure 10. *Simulink model of amplifier with DCX22L as load*

5. PCB layout

The PCB layout is done with Ultiboard using the circuit from Fig. 8.

The design is done by separating the four amplifiers into four parts and connect parts using wires with suitable widths.

Four holes are implemented for connection to the control robot.

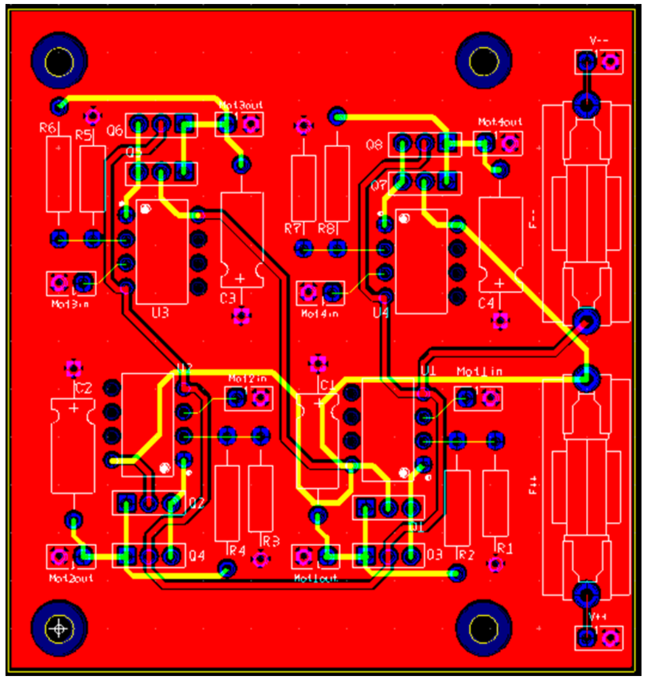

Figure 11. PCB layout

References

[1] Maxon motor catalog, 2020/2021, https://online.flippingbook.com/view/1042987/

[2] Encoder 16 EASY XT catalog, EN-451-452.pdf (maxongroup.com)