1- Creation of a "DC Permanent Magnet Motor" SimPower block in library.

1.1. Function Block DC_PM_motor_SimPower
The given simulation model is built using resources from the SimPowerSystems and Simulink libraries (there is no permanent magnet DC motor function block available in SimPowerSystem Library). The function block is derived from the "DC machine" function block.

Referring to the procedure describe in practice 3, include the Bloc Function DC_PM_motor_SimPower in the library PPU_WS_lib
1.2. Test of the Function Block DC_PM_motor_SimPower

Using the block from the library, with internal parameter $R_a=0.5$ ohm, $L_a=10$ mH, $K_e=0.5$, $T_f=0.1$ N.m, $B_m=0.01$ N.m.s, $\omega_0=0$, with external parameter $J=0.05$ Kgm$^2$, $T_L=4$ N.m connect the motor to a 100 volts DC source.

Start simulation. The results should be the same than those obtained for the same parameter in practice 3, section 1.5.

2- 1Q Chopper Control

2.1. Open loop,

Using the component of the SimPowerSystem library, design the following simulation model (Chopper_1Q_open_loop.mdl).

Set the pulse width of the pulse generator alpha to 70%.

Select the option "discretize electrical model" (10 µs) in the powergui interface.

Select "fixed step" (10 µs) in simulation / configuration parameters, Ode1 (Euler) solver.

Start simulation.

The steady state numerical value of omega is displayed. Repeat the simulation for different values of alpha and TL and note this value.
Justify the decrease 4 rad/s.N.m (for a given value of alpha) of the rotational speed of the motor.
Justify the slope 190 rad/s (for a given value of TL) of the curves.

2.2. Closed loop: speed control and current limitation, current margin chopper command.
In the following simulation model the current reference is obtained by amplification of the angular rotational speed error. This reference is limited to the maximum value tolerable by the motor. The thresholds relay assures a current in the motor equal to the current reference ± ε.

Simulate the model and play with the regulation parameter G and ε and the system parameters TL and J

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Replace the Constant Block reference by a Repeating Sequence Block (Simulink/Sources library). Enter the internal parameter of this block to create a sequence (50, 100, 30 rad/s).
2.3. Closed loop: PID corrector

Introduce Integral and Differential correctors in parallel with the Proportional gain. Start from $G_p=10$, $G_d=0$, $G_i=0$. Increase first $G_p$ to reduce the static error. Then increase $G_d$ to get stability. Then adjust $G_i$ to annul the static error.

2- 4Q Chopper Control: H bridge

The unidirectional IGBT switch is replaced by 4 bidirectional IGDT/DIODE switches. (Depending on the polarity of the current, IGBTs or diodes are the conducting elements).
3- Application 1: Elevator
See specification in practices 1 and 2.
4- Application 2: Arm of robot

See specification in practices 1 and 2.
5- **High level Bloc function**

Several bloc functions, developed by Matlab/Simulink users are available in the SimPowerSystem Library (Application Library, Extra Library, Power Electronics…). Among these blocks, we can find:

- **Universal Bridge block (Power Electronic Lib.)** which may be configured as 1, 2 or 3 arms bridges with ideal, diodes, thyristors, GTO, MOSFET or IGBT switches,

- **Discrete PWM generator (Extra Lib./Discrete Control Blocks)** which may be configured to send triggering pulses to the Universal Bridge:

These 2 blocks are used in the following 2 models:

The first one (**Universal_Bridge1.mdl**) refers to a speed regulation without current limitation loop. The speed error is used as input for the PID controller. It's output is the reference voltage for the PWM generator:
In the second simulation model (Universal_Bridge2.mdl) are introduced:
- a current limitation loop between the PID controller and the PWML generator
- a model for a AC/DC converter to supply the chopper. Note the 10 Ω resistor allowing the reversibility of the 4Q Chopper.