

# **SERVO OUTPUT EXTENSION FOR THE RAPCON PLATFORM**

**User Manual**

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## 1. Introduction

Hobby servos are often used in various robotics applications due to their simplicity and reliability. They are usually controlled by a periodic pulse and the width of the pulse determines either the angular position or angular velocity of the servo. The servo output capability is added to the RAPCON platform to facilitate control of hobby servos with the RAPCON platform.

The servo output capability requires the RAPCON platform with the servo output extension. The servo outputs J0–J1 are 0 – 5 V digital signals. Each servo output has absolute maximum ratings of –25 mA minimum and +25 mA maximum.

The servo output extension comes with its own library block fully integrated into Matlab/Simulink/Real-Time Windows Target. The library contains 1 output block, namely Servo Output Block. A snapshot of the block library is shown in Figure 1. The block library is created when the RAPCON software with the servo extension pack is installed. To install the RAPCON software, double click on the installer that comes with the platform and follow the on-screen instructions. The input of the block is in SI units for convenience.

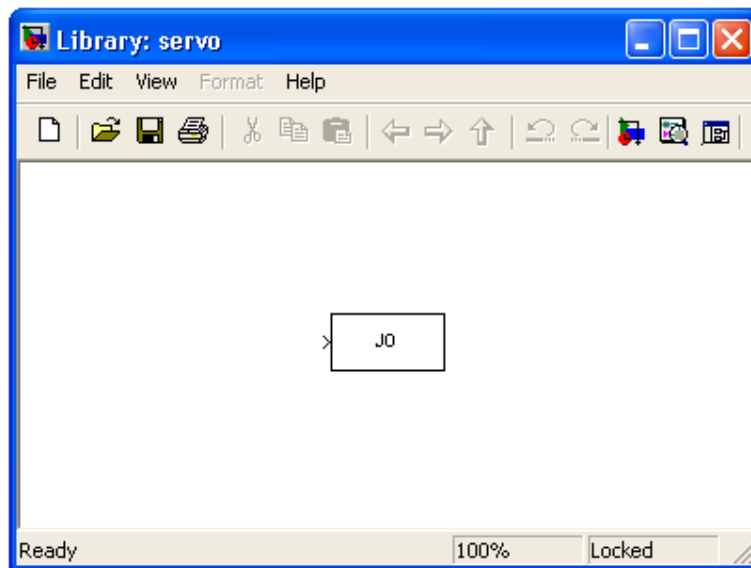


Figure 1. RAPCON servo output block library.

## 2. Servo Outputs

The board has 2 servo output channels J0–J1. Each servo output is a 0 – 5 V range digital signal. The connector CON4 provides access to each servo output channel. For convenience, GND is also provided with each channel. The pinout of CON4 is shown in Figure 2, where J0–J1 are the Servo outputs.

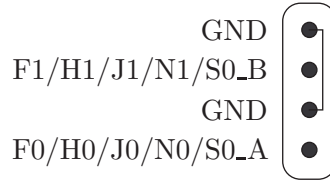


Figure 2. Servo outputs connector CON4.

The pulse width of each servo output is synthesized from its digital representation by the pulse-width modulator. The maximum frequency of the servo output module is  $117.92 \times 10^6 / 65536 = 1.7993$  kHz and the minimum frequency of the servo output module is  $117.92 \times 10^6 / 16777216 = 7.0286$  Hz. The resolution of the pulse-width modulator module is 16 bit. The servo outputs are multiplexed with the pulse outputs and frequency outputs. The pulse outputs have precedence over the servo outputs and the servo outputs have precedence over the frequency outputs.

### 3. Servo Output Block

This block connects the selected servo output channel from the Simulink model to the real-time control board. The block parameters are as shown in Figure 3. Sample time is the sample time of the block. Com port is the serial communication port number. Servo output channel is the specific servo output channel selectable among J0–J1. Width/duty is the conversion mode of the selected servo output channel. Fundamental frequency is the carrier frequency of the servo output.

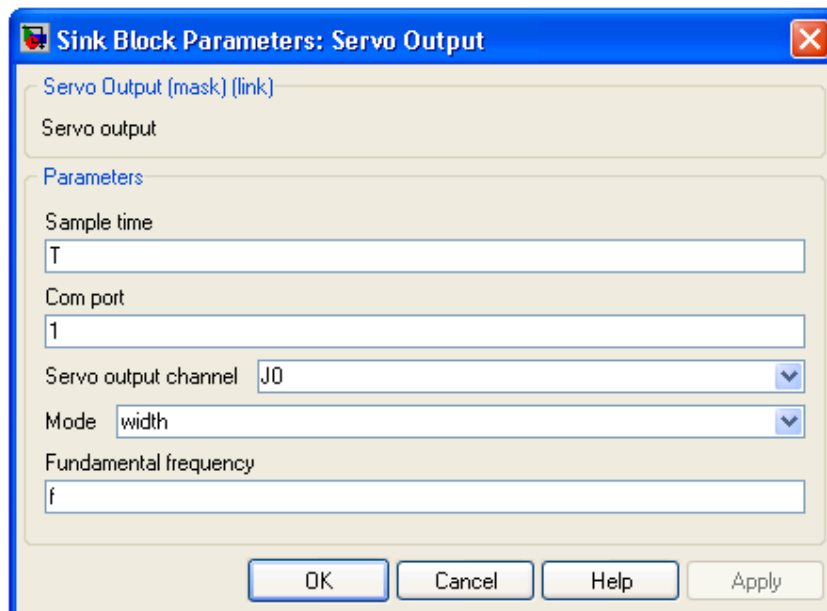


Figure 3. Servo Output Block parameters.

Suppose a signal  $v$  is connected to the J0 input of the Servo Output Block and the block is used in a Simulink model as shown in Figure 4. The input signal  $v$  is sent to the real-time control board and converted to a pulse signal with width  $w$  and duty-cycle  $\delta$  by the pulse-width modulator to form the output signal  $u$ . The pulse width  $w$  of the signal  $u$  is related to the signal  $v$  through

$$w \approx \begin{cases} \tau, & v \geq \tau, \\ v, & 0 < v < \tau, \\ 0, & v \leq 0 \end{cases} \quad (1)$$

with width conversion mode, where  $\tau$  is the period of the pulse and the duty-cycle  $\delta$  of the signal  $u$  is related to the signal  $v$  through

$$\delta \approx \begin{cases} 1, & v \geq 1, \\ v, & 0 < v < 1, \\ 0, & v \leq 0 \end{cases} \quad (2)$$

with duty conversion mode.

The width  $w$  is related to  $\delta$  through

$$w = \frac{\delta}{f} = \delta\tau, \quad (3)$$

where  $f$  is the fundamental frequency of the pulse-width modulator and  $\tau = 1/f$  is its period. The frequency  $f$  is in the range  $117.92 \times 10^6 / 16777216 = 7.0286 \leq f \leq 117.92 \times 10^6 / 65536 = 1799.3164$  Hz. When both servo outputs are used, their fundamental frequencies must be the same.

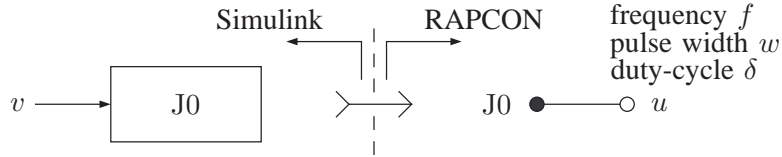





Figure 4. Servo Output Block usage.

The maximum pulse width interpolation error is  $256 / 117.92 \times 10^6 = 2.1710 \mu\text{s}$  in width conversion mode and the duty-cycle resolution is  $\lfloor \log_2(117.92 \times 10^6 / 256 / f) \rfloor = \lfloor \log_2(460625 / f) \rfloor$  bits (16 bits when  $f = 7.0286$  Hz and 8 bits when  $f = 1799.3164$  Hz) in duty conversion mode. The frequency interpolation error is  $f - 117.92 \times 10^6 / 256 / k = f - 460625 / k$  Hz, where  $k = \lfloor 117.92 \times 10^6 / 256 / f \rfloor = \lfloor 460625 / f \rfloor$  in both modes. These errors are negligibly small in most practical applications and are inherent in all pulse-width modulators.

#### 4. Usage

The purpose of this example is to illustrate some basic features of the servo output of the RAPCON platform with a simple servo control system. The angular position (or angular velocity) of a hobby servo

is controlled through the servo output. This example also illustrates how a hobby servo can be connected to the RAPCON board.

1. Open the Simulink model test6.mdl and setup the board as shown in Figure 5 with the external connections.
2. Enter  $\gg T = 1/2048$  as the sampling time and  $\gg S = \text{inf}$  as the stop time at the Matlab Command Window.
3. Build the model by clicking on “Tools → Real-Time Workshop → Build Model...” or by pressing Ctrl+B.
4. Click on “Connect to target” button  to connect the board to the model and then click on “Start real-time code” button  to run the model.
5. Vary the value of the slider gain between 0.001 and 0.002, and observe the movement of the servo.
6. As the value of the slider gain increases from 0.001 to 0.002, the angular position (or angular velocity) of the servo changes.
7. Click on “Stop real-time code” button  to stop the model.

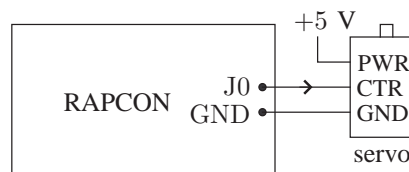
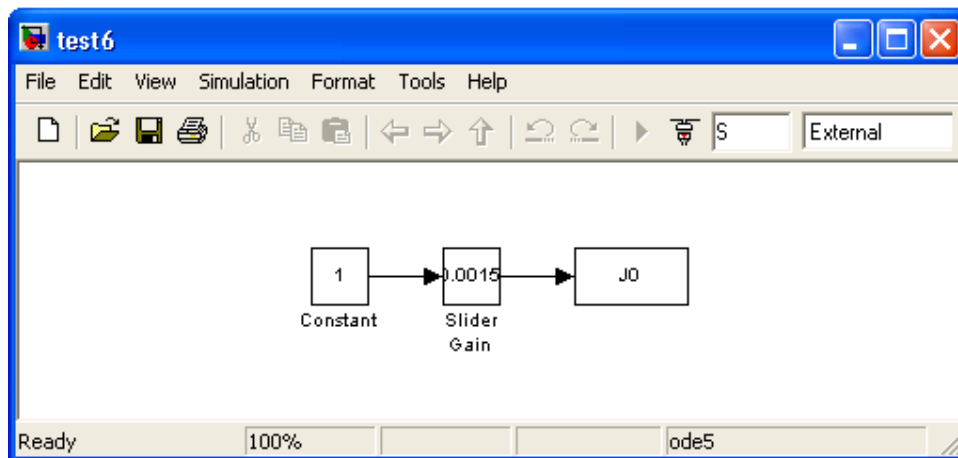


Figure 5. Setup for test6.mdl.