Motor Starter Kit

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Introduction

This document is a report describing the design and functionality of the Motor Starter Kit, a device that enables users control of a motor under given specifications. This device is reads a motor's position at a maximum resolution of 540 cpr and controls the shaft position over a range of 1024° clockwise and counterclockwise with a resolution of 1° and an accuracy of ±2°. The device controls the motor's shaft speed from a range of 8-82 rpm with a resolution of 1 rpm and an accuracy of ±5 rpm. This product also enables simultaneous control of both position and speed of the motor.

The Motor Starter Kit prioritizes the performance of the motor, such as the smoothness of rotation over accuracy, and the capabilities of the motor, such as simultaneous position and velocity control. The final product exceeds the required specifications by providing a greater range for both the position and velocity control of the motor at greater resolutions, and meets the objectives described in the initial proposal by providing simultaneous control of speed and position of the motor's shaft.

Device Functionality

Users control the motor through three subroutines (can be called under no order) within the Combined.asm file. Before calling the "VelocityControl", "PositionControl" or "SimultaneousControl" subroutine, storing integer values in the "TargetRotationalDegree" and "TargetVelocity" variables will change the motor's rotational degree or/and rpm , respectively. Combining these inputs can produce results shown below in Figure 1.

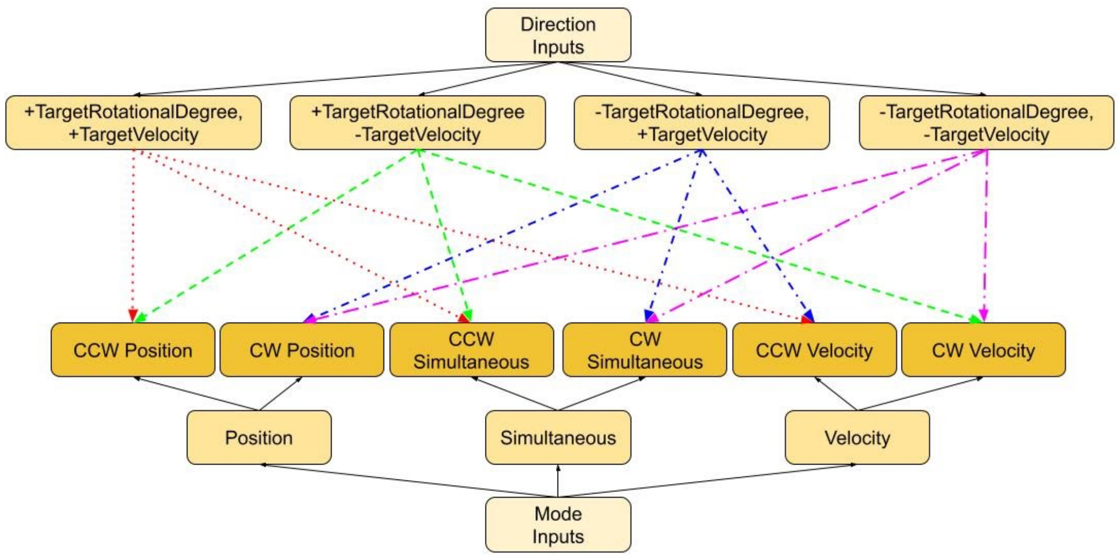

Figure 1. Depending on the user's direction and mode inputs, six types of control can be accomplished.

Although Figure 1 depicts the control users have over the motor, it should be noted that limits exist in controlling velocity. The velocity of the motor can only be controlled within the range of $8 - 82\ rpm$. With a velocity command lower than $8\ rpm$, the motor will not spin. With a velocity command greater than $82\ rpm$, the motor will only spin at $82\ rpm$. Additionally, if the motor output shaft is used in a load-bearing manner, the minimum velocity under which the motor will run as expected may be greater than $8\ rpm$.

Design Decisions

The Bang-Zero-Bang control method is used to control the motor's position due to its simplicity in implementing it within the given timeframe, and its ability to improve the basic requirements. This method outputs a full PWM duty-cycle to the motor, rotating it towards the target direction if the current position is less than the target position, opposite to the target direction if its current position is greater than its target position, or stopping the motor if its current position is within a reasonable range ($\pm 1.3°$) of its target position. This method was initially used to control velocity but was changed to “PWM-Mapping”, due to its advantages depicted in Table 1 below.

TABLE 1

COMPARING CONTROL METHOD FOR VELOCITY

	BANG-ZERO-BANG	PWM-MAPPING
JITTIRINESS	Increase as RPM decreases	None
ACCURACY	$\pm 3\ rpm$	$\pm 4\ rpm$
RESOLUTION	$1\ rpm$	$1\ rpm$
SIMULTANEOUS CONTROL	✗	✓

With PWM-Mapping, a specific PWM duty-cycle is mapped to respective RPM ranges. Additionally, an artificial jump-starting of the motor before velocity control is needed to overcome the motor stiction (previously solved by Bang-Zero-Bang). This method trades off accuracy for simultaneous control, which uses the target velocity’s corresponding PWM duty-cycle for the Bang-Zero-Bang position control.

Conclusions

The final product of the Motor Started Kit meets and exceeds the initial requirements and provides additional functionality through simultaneous control of the motor’s position and velocity. Future additions could be the usage of an accelerometer to control position or velocity of the motor based on values outputted from the accelerometer. In revisiting this product, changes can be made to the PWM

Mapping technique used for velocity control to increase its degree of accuracy. Although the velocity control used is adequate for the final product, bettering this feature could optimize performance of the device.