Application Brief

Precision ADCs in Servo Drives

Taiwo Arojojoye

Introduction

A servo drive powers a servo motor to maintain speed and torque set by a servo drive controller. Servo motors are powered using a 3-phase AC voltage that creates a rotating magnetic field. A controller tells the servo drive how fast the motor can spin and in what direction the motor can move. On the motor, there is an encoder, which detects and feeds the motor's actual speed and position back to the servo drive, and the servo drive can now continually adjust the speed and position data. The use cases for an analog-to-digital converter (ADC) in a servo drive include:

1. Measuring the output of a current sensor
2. Analog control input from a PLC or motion controller
3. Interpolating Sin/Cos signals from an incremental sin/cos encoder

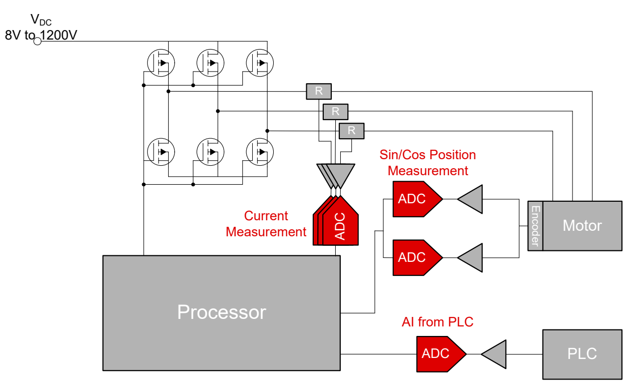

Figure 1. Servo Drive Block Diagram

Measuring Output of Current Sensors

Within the servo drive, there is an internal 3-phase inverter that takes in DC voltage from a power supply and converts to AC voltage through a pulse width modulator (PWM). The duty cycle of the PWM controls the current/torque applied to the motor. When the duty cycle is close to 0%, the current/torque is at a minimum. When the duty cycle is close to 100%, the current/torque is at a maximum. The PWM continuously changes the duty cycle to create a sinusoidal AC signal. This AC signal powers and rotates the motor. The processor uses the current measurement to update the PWM duty cycle. A current sensor is paired with an ADC to measure the current, and covert the analog output into a digital output, which is sent to the processor, as seen in Figure 2.

There are many different types of current sensors, such as LEM current sensors, VAC current sensors, Hall-effect current sensors, current sense amplifiers, and so on, such as the TMCS1123, AMC1300 and INA241A that TI offers. The output of these current sensors is analog and needs to be digitized by an ADC for the processor to read. Current sensors have a variety of output types including differential, pseudo-differential, and single-ended. These output types require analog circuitry to convert them to single-ended signals, thus easier to use ADCs with pseudo-differential/differential inputs. The ADS8350, ADS7850, ADS7250, and ADS704x/ADS705x families offer multiple devices with differential and pseudo-differential inputs. The input range of the ADC is also essential and can match the current sensor's output range. Some sensors, such as LEM sensors, can have a -10V to 10V output. The ADS8681 can take this voltage directly without external components because the ADS8681 has an integrated PGA. Table 1 goes into further detail with a few ADCs that cover multiple input ranges and voltages.

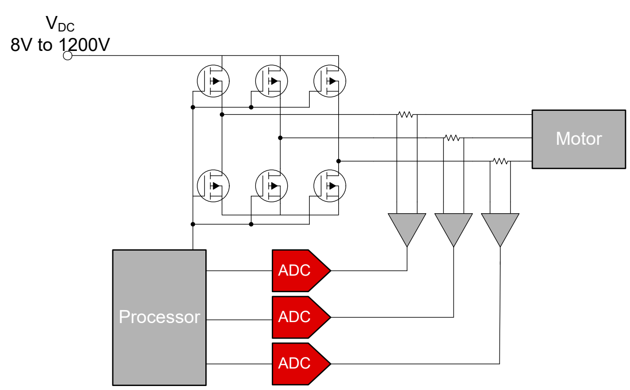

Figure 2. Measuring Output of Current Sensors

Table 1. Current Sensor ADC Device Recommendations

Device	Resolution (bits)	Sampling Rate (kSPS)	Channel Count
ADS7850 ADS8350	14 / 16	750	2
ADS86xx	10 / 12 / 14	1000 / 500 / 100	1
ADS704x ADS705x	8 / 10 / 12 / 14	3000 / 2500 / 2000 / 1000	1

Analog I/O

A controller, such as a PLC or motion controller, can communicate with the servo drive using analog or digital outputs. Analog control is often used in legacy systems and low-cost systems. The controller can commonly have a ±10V output. These analog inputs need to be converted to digital for the processor on the servo drive to read, which is where an ADC is required. The ADC needs to have a wide input voltage range to make sure the ADC can read the outputs from the PLC. Figure 3 depicts an example of how the ADC can be used in circuit form, and the devices listed in Table 2 all have ±10V input ranges.

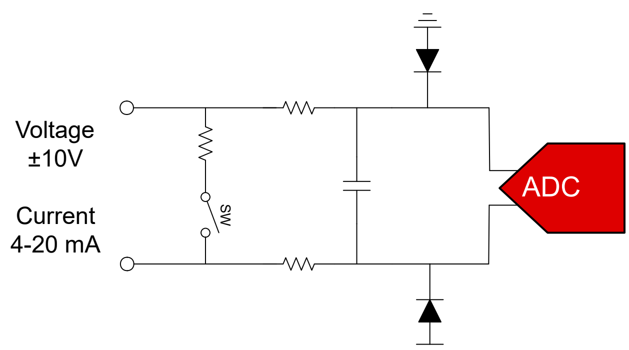

Figure 3. Analog I/O

Table 2. Analog I/O Device Recommendations

Device	Resolution (bits)	Sampling Rate (kSPS)	Channel Count
ADS8681 / 85 / 89	16	1000 / 500 / 100	1
ADS8681W / 5W / 9W	16	1000 / 500 / 100	1
ADS8684 / 88	16	500	4 / 8

Servo Drive Position Feedback

The encoder of the motor is used to detect the motor's actual speed and position. The encoder reads this information as voltage signals and sends them back to the servo drive to implement speed or position control of the motor. The analog signal that the encoder outputs is a $1V_{PP}$ sine/cosine signal, so a 2-channel amplifier plus a 2 channel ADC can be a good design, as seen in Figure 4. The processor uses the digital output of the ADC to determine the speed and position of the motor, so resolution on the ADC is an essential spec. The typical encoder has a 500kHz bandwidth; in applications with faster motors, the bandwidth of the sine or cosine signals from the encoder can be higher. A higher ADC sampling rate is important because the ADC can be used to improve noise performance by averaging. For every factor of 2, averaging improves signal-to-noise ratio (SNR) by approximately 3dB. In Table 3, there are amplifier plus ADC pairs that meet the specifications required of an encoder feedback signal chain.

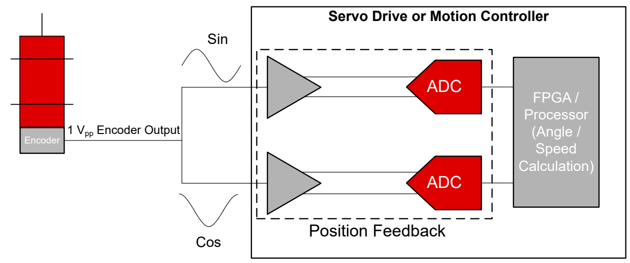

Figure 4. Servo Drive Position Feedback

Table 3. Encoder Output ADC Device Recommendations

Bandwidth	Device	Resolution (bits)	Sampling Rate (kSPS)	Channel Count
>1MHz	THS4541 + ADS9218 / ADS9219	18	10000 / 20000	2
<1MHz	THS4552 + ADS9327 / ADS9326	16	5000 / 3000	2
<200kHz	THS4552 + ADS8354	12 / 14 / 16	700	2

Conclusion

Servo drives require ADCs in many different use cases. ADCs can be used to measure the output of current sensors on the power lines, digitize the analog outputs of the PLC and convert the analog data received by the encoder to digital. TI has a strong portfolio of devices to take these measurements. The following is an article for further information on servo drives.

Related Articles

Texas Instruments, *Precision ADCs for Motor Encoders and Position Sensing*, product overview.

Texas Instruments, *Encoder Signal Chain,*, application brief.

Texas Instruments, *Position Feedback: Capturing 1VPP Sin or Cos Encoder Signals With a Simultaneous-Sampling SAR ADC,*, application brief.

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