RTx Controller Board Design

# Axis Position Feedback

## Analog-to-Digital Converters (ADC’s) for Feedback circuits

### Component List

#### ADC1

|  |  |  |  |
| --- | --- | --- | --- |
| C1 | C4 | C5 | ADC1 |

#### ADC2

|  |  |  |  |
| --- | --- | --- | --- |
| C2 | C6 | C7 | ADC2 |

#### ADC3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| C3 | C8 | C9 | R16 | ADC3 |

#### ADC4

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| C40 | C41 | C42 | R20 | ADC4 |

#### Analog Reference Voltage Regulator

|  |  |  |  |
| --- | --- | --- | --- |
| C23 | C24 | C25 | REF1 |

### Design Overview

#### ADC Resolution

The resolution of the axis position feedback ADC’s corresponds to the resolution of measurement of the angular position of the axis. Assuming the potentiometer provides a resistance through the axis range of motion which is linear with angle and corresponds to a full-range output voltage sweep through a 360-degree rotation, we have:

## Low-Pass Filters for Feedback ADC’s

### Component List

#### ADC1 Feedback LPF

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| R1 | R2 | R3 | C10 | C11 | C12 | C13 | OPAMP1-A |

#### ADC2 Feedback LPF

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| R4 | R5 | R6 | C14 | C15 | C16 | C17 | OPAMP1-B |

#### ADC3 Feedback LPF

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| R7 | R8 | R9 | C18 | C19 | C20 | C21 | OPAMP2-A |

#### ADC4 Feedback LPF

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| R17 | R18 | R19 | C36 | C37 | C38 | C39 | OPAMP2-B |

### Design Overview/Component Choice

#### Control Bandwidth and Cutoff Frequency

The control bandwidth frequency for the closed-loop control system was chosen based on the requirement to track fast-moving objects with video during manual and automated control operation. The cutoff frequency for the ADC input LPF is specified to be one decade higher than . This convention places far enough above the to prevent the LPF from limiting performance at the , while still providing satisfactory noise filtering.

#### ADC 1-bit Frequency, desired noise level and Filter Order

The frequency of the ADC’s LSB is the minimum frequency at which we will observe a change on the least significant bit. The maximum noise level desired at is -96dβ. must be a low enough frequency such that the Nyquist rate is reasonable given our choice of ADC’s and microcontroller. With a 3rd Order LPF with our , we have:

The Nyquist rate, or minimum rate we must sample the ADC’s is then , which is a reasonable sample rate for the system.

#### Topology

A Sallen-Key topology Butterworth Low-Pass Filter was chosen due to its simplicity, and the ability to attain 3rd-order filtering and a low with relatively low RLC values in combination.

#### Op-Amp

The AD861x Op-Amp was chosen to produce the Sallen-Key topology because it is recommended for use in conjunction with the chosen ADC’s.

### Consequences

#### Control Rate and ADC Sampling

A rule of thumb for minimum control rate is , then:

The Nyquist rate must also be satisfied, so the sample rate must be:

Choosing and gives us 20 samples per control loop iteration.

### Summary of Parameters

# Microcontroller

# Ethernet Port

# USB Development/Debug Port

# Input Voltage Regulation/Filtering

# Motor Driver Outputs