Homework N° 3

The 3rd Assignment of Programmable Logic Controller Design

1

Write the discrete form of such a controller expression by back Euler method,

$$G(s) = \frac{2(1 + \frac{1}{5s} + 2s)}{1 + 0.2s}$$

With $T_s = 1$.

Solution:

In backward Euler method, the relation between z-domain and s-domain may be expressed as,

$$s = \frac{1 - z^{-1}}{T_s} = 1 - z^{-1}$$

Substituting the result into $G(s)$ would one acquire,

$$G(z) = \frac{2(1 + \frac{1}{5(1-z^{-1})} + 2(1 - z^{-1}))}{1 + 0.2(1 - z^{-1})} = \frac{6 - 4z^{-1} + \frac{2}{5}\frac{1}{1-z^{-1}}}{1.2 - 0.2z^{-1}}$$

Which could be turned into a difference equation by inverse Laplace transformation,

$$(1.2 - 0.2z^{-1})Y(z) = (6 - 4z^{-1} + \frac{2}{5}\frac{1}{1 - z^{-1}})X(z)$$

$$\rightarrow \begin{cases} 1.2y(k) - 0.2y(k-1) = 6x(k) - 4x(k-1) + \frac{2}{5}v(k) \\ v(k) = v(k-1) + x(k) \end{cases}$$

With the very difference equation being the discrete controller.

2

Design a circuit to convert 0-0.5 volt DC signal into 4-20 milliamp current signal.

Solution:

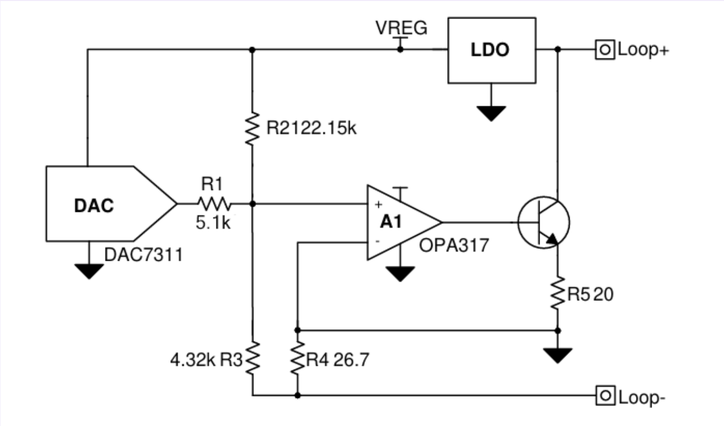

Fig.1 Converter

With $V_{REG} = 3.0V, V_{DAC} = 0 - 0.5V$. Validate the result,

$$I_{out,zs} = \frac{V_{REG}}{R_2}(\frac{R_3}{R_4} + 1) = 3.9983mA \approx 4mA$$

$$I_{out,fs} = (\frac{V_{DAC}}{R_1} + \frac{V_{REG}}{R_2})(\frac{R_3}{R_4} + 1) = 19.9589mA \approx 20mA$$

...it is evident that the circuit satisfies the needs.