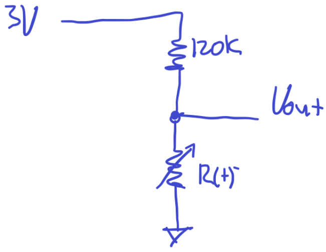
1. $R(t) = -2 \cdot t + 200 [k\Omega]$



$$V_{out} = \left(\frac{R(t)}{R(t) + 120k} \right) 3v$$

Max freq = 3 Hz
min sampling freq = 6 Hz

expected range: 40-80°F

as $t\uparrow$, $V\downarrow$

$R(80) = 40 k\Omega$

$V_o = \frac{40}{160} \cdot 3 = \boxed{0.75 V}$ min

$R(40) = 120 k\Omega$

$V_o = \frac{120}{120+120} \cdot 3 = \boxed{1.5v}$ max

$R(70) = 60 k\Omega$

$V_0 = \frac{60}{180} \cdot 3 = 1v$

how many s can you buffer?

1,200 Bytes available

10-bit samples w/o optimization become 16-bit (padded)
2Byte per samp.

1,200/2 = 600 buffered samples/6 Hz = 100 s

1,200 · 8 = 9,600/10-bits = 960 buffered samples with optimization/6 Hz = 160 s

Q step: $\frac{2.5v}{2^{10}} = 2.44 mV$

max error: (if optimized) $\frac{40°}{2^{10}} = 0.039 °F$

AD output @ 70°:

$V_o = 1v$ $\quad \frac{V_o}{Q_{step}} = \frac{1v}{2.44mV}$

$= 409.836 \rightarrow 409$

$\rightarrow$ 01 1001 1001

clk = 1 MHz

20k cyc/samp

$\frac{20{,}000 \text{ cycles/samp}}{1{,}000{,}000 \text{ cycles/sec}} = 0.02$ s per sample

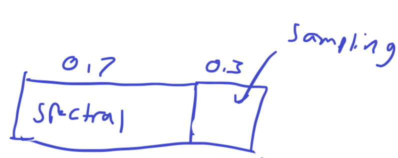
time per sample

data acq. time < 1 ms

$0.02 + 0.001 = 0.021$ s

$F_s = 10 Hz$, $T_s = 0.1 s$

Spectral = 0.7 s/s



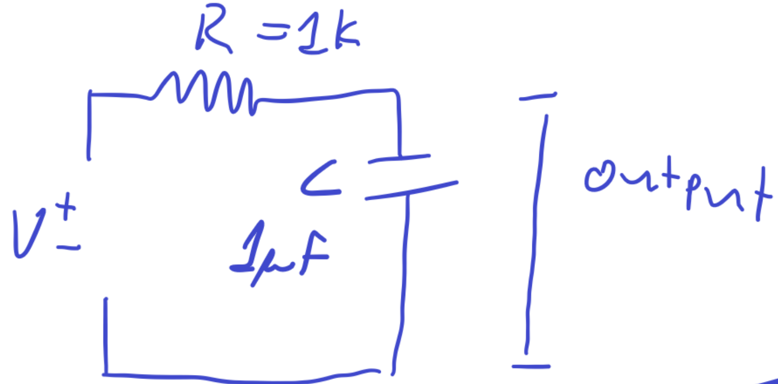
Ratio avg proc. to sampling $\frac{0.021}{0.1} + \frac{0.7}{1} = 0.91$

System can run in Real-time

Sample processing takes 21% of t
Spectral takes 70%

21 + 70 = 91 < 100

2.



$$V_c = \frac{\frac{1}{Cs}}{\frac{1}{Cs} + R} \cdot V$$

Transfer func.

let $s = j\omega = 2000j$

$$\frac{1}{1 + CRS} = \frac{1}{1 + (1k)(1\times10^{-6})(2kj)} = H(2k)$$

$$|H(s)| = \frac{1}{\sqrt{1^2 + (1k)^2(1\times10^{-6})^2(2kj)^2}} = 0.447$$

3. $x[n] = \{0, 1, 2, -1, 0\}$ $h(n) = \{0.4, 1, 0.6\}$

find $y[n] = x[n] * h[n]$

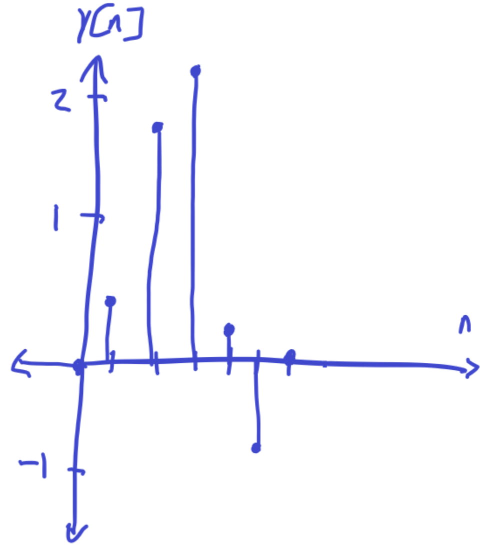
$$y[n] = \sum_{i=0}^{N-1} x[i]\,h[n-i]$$

0.4 1 0.6

0 1 2 -1 0

0	0	0				
	0.4	1	0.6			
		0.8	2	1.2		
			-0.4	-1	-0.6	
				0	0	0

$y[n] = \{0\ \ 0.4\ \ 1.8\ \ 2.2\ \ 0.2\ \ -0.6\ \ 0\}$



What is val of 4^{th} sample of output $y[3 \cdot T_s]$

take $y[3] = 2.2$

5. 4-pt average: $\frac{1}{4}X(n) + \frac{1}{4}X(n-1) + \frac{1}{4}X(n-2) + \frac{1}{4}X(n-3) = Y(n)$

A coeffs are for Y , $A[0] = 1$

B coeffs are for X , $B[0] = 1/4$

4. $\frac{d^2y(t)}{dt} + 3\frac{dy(t)}{dt} + 2y(t) = x(t)$, init cond. are $\emptyset$

imp. response:

let $x(t) = \delta(t)$

$\mathcal{L}\left[\frac{d^2y(t)}{dt}\right] = s^2Y(s) - sy(0-) - y'(0-) = s^2Y(s)$

$\mathcal{L}\left[\frac{dy(t)}{dt}\right] = sY(s) - y(0-) = sY(s)$

$\mathcal{L}[y(t)] = Y(s)$

$\mathcal{L}[\delta(t)] = 1$

$1 = s^2Y(s) + 3sY(s) + 2Y(s)$

$1 = (s^2+3s+2)Y(s)$

$H(s) = \frac{1}{s^2+3s+2} = \frac{1}{(s+2)(s+1)}$

$\frac{1}{(s+2)(s+1)} = \frac{1}{s+2}\cdot\frac{1}{s+1} = \frac{A}{s+2} + \frac{B}{s+1} = \frac{-1}{s+2} + \frac{1}{s+1}$

$A = \frac{1}{(s+2)(s+1)}\cdot(s+2)\Big|_{s=-2} = \frac{1}{-1} = -1$

$\mathcal{L}^{-1}\left[\frac{-1}{s+2}\right] = -e^{-2t}u(t)$

$B = \frac{1}{(s+2)(s+1)}\cdot(s+1)\Big|_{s=-1} = \frac{1}{1} = 1$

$\mathcal{L}^{-1}\left[\frac{1}{s+1}\right] = e^{-t}u(t)$

$y(t) = \boxed{h(t) = [e^{-t} - e^{-2t}]\,u(t)}$

unit-step response:

$\mathcal{L}[u(t)] = 1/s$

$S(s) = \frac{1}{s(s+2)(s+1)}$

$\frac{1}{s} = (s^2+3s+2)\,S(s)$

$= \frac{A}{s} + \frac{B}{s+2} + \frac{C}{s+1} = \frac{1/2}{s} + \frac{1/2}{s+2} + \frac{-1}{s+1}$

$A = \frac{1}{(s+2)(s+1)}\Big|_{s=0} = \frac{1}{2}$

$\mathcal{L}^{-1}\left[\frac{1/2}{s}\right] = \frac{1}{2}u(t)$

$\mathcal{L}^{-1}\left[\frac{1/2}{s+2}\right] = \frac{1}{2}e^{-2t}u(t)$

$\mathcal{L}^{-1}\left[\frac{-1}{s+1}\right] = -e^{-t}u(t)$

$B = \frac{1}{s(s+1)}\Big|_{s=-2} = \frac{1}{2}$

$C = \frac{1}{s(s+2)}\Big|_{s=-1} = \frac{1}{-1} = -1$

$\boxed{s(t) = \left[\frac{1}{2} + \frac{1}{2}e^{-2t} - e^{-t}\right]u(t)}$

4.1

$s(1.5) = \left[\frac{1}{2} + \frac{1}{2}e^{-2(1.5)} - e^{-1.5}\right]\underbrace{\cancel{u(1.5)}}_{1}$

$= \frac{1}{2} + \frac{1}{2}e^{-3} - e^{-3/2}$

$= \boxed{0.302}$

4.2 Steady state of $s(t)$

$= 1/2$

6. $f_s = 200\ Hz$

discrete fourier transform

$N = 1024$ pt. window

what is freq resolution Δf ?

$$\frac{f_s}{N} = \frac{200\ Hz}{1024} = 0.1953125$$

or $0.195\ Hz$ bins

7. After analysis, 3 main freq components.

Max mag. component is at 5.859 Hz