Control & Identification Toolbox

Input → System → Output

Perturbations

Reference $\xrightarrow{+}$ $\oplus$ $\xrightarrow{e(t)}$ Control $\xrightarrow{u(t)}$ $\oplus$ → Plant → Output

Excitation
$u(t) = u_1(t) + u_2(t) + u_3(t)$

Plant
$G(s) = \frac{\alpha_1 s + \alpha_2}{s + \alpha_3}$

Output
$y(t)$

Least Squares identification method

$$\widehat{\boldsymbol{\theta}}(k) = \widehat{\boldsymbol{\theta}}(k-1) + L(k)\epsilon(k)$$

$$L(k) = \frac{\boldsymbol{P}(k-1)\phi(k)}{\gamma + \phi^T(k)\boldsymbol{P}(k-1)\phi(k)}$$

$$\boldsymbol{P}(k) = \frac{1}{\gamma}\left[\boldsymbol{P}(k-1) - \frac{\boldsymbol{P}(k-1)\phi(k)\phi(k)^T\boldsymbol{P}(k-1)}{\gamma + \phi^T(k)\boldsymbol{P}(k-1)\phi(k)}\right]$$

$$\epsilon(k) = y(k) - \widehat{y}(k)$$

$$\widehat{y}(k) = \phi^T(k)\widehat{\boldsymbol{\theta}}(k-1)$$

Estimates
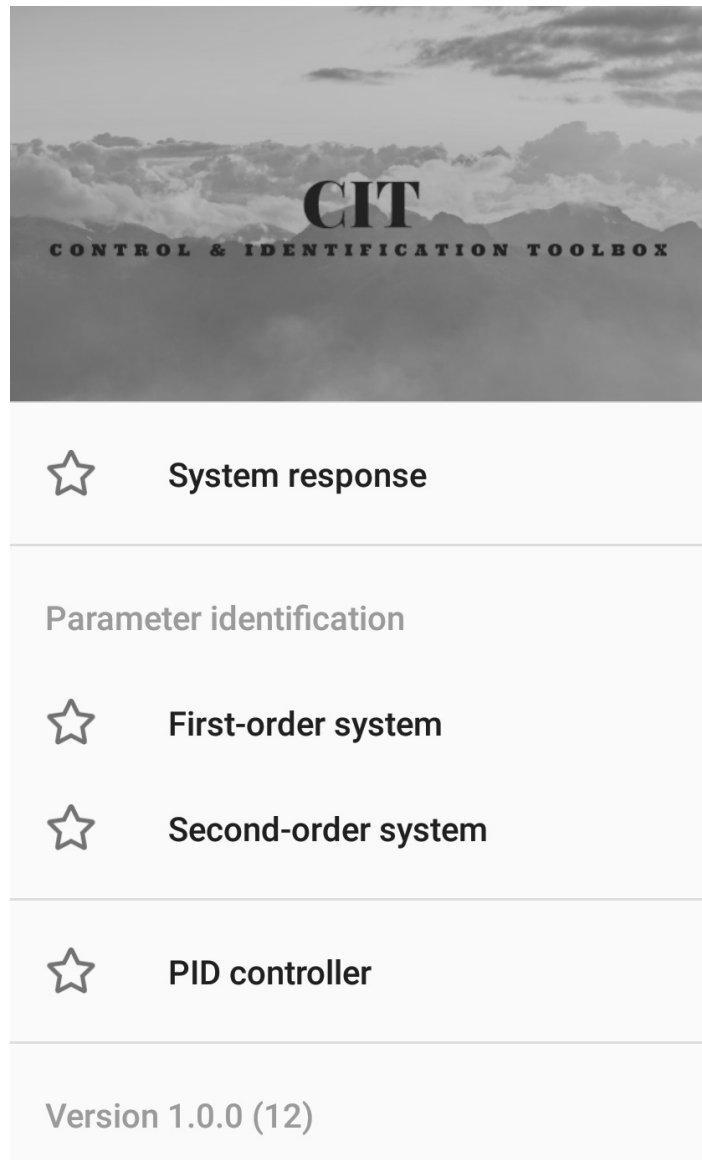$\hat{\theta}(k)$

Figure 1: Home-screen of the CIT android application

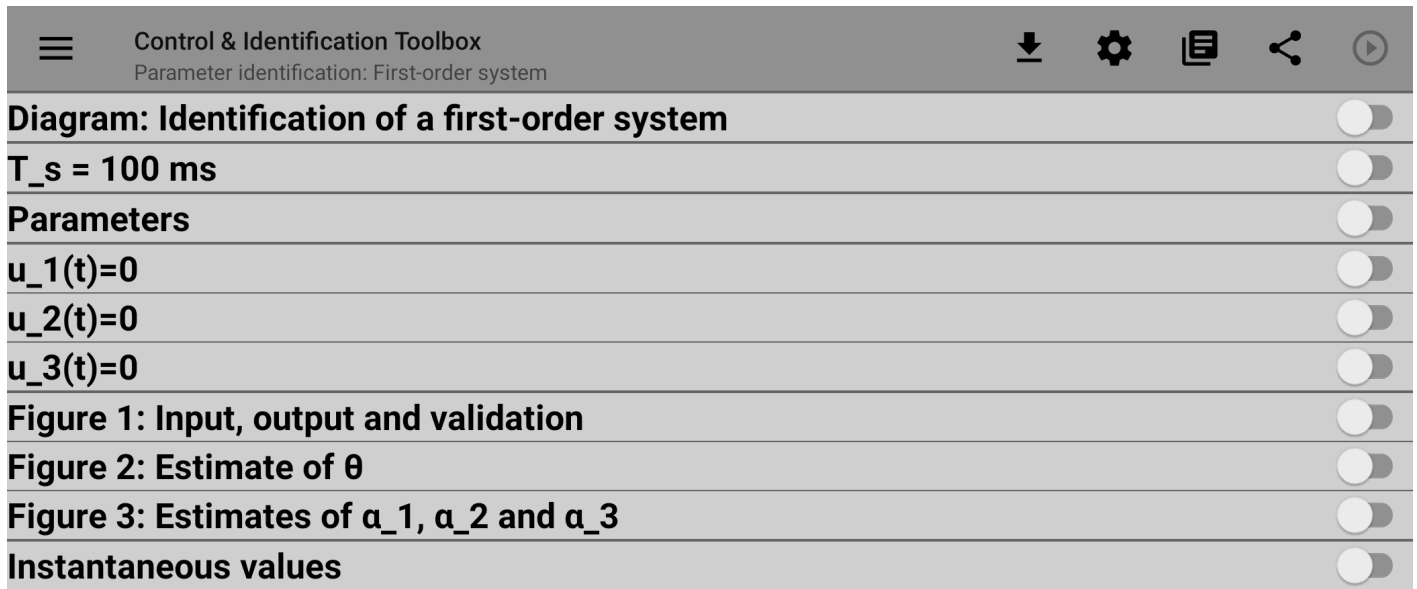Figure 2: Drawer of the CIT android application

Control & Identification Toolbox
Parameter identification: First-order system

Diagram: Identification of a first-order system

T_s = 100 ms

Parameters

u_1(t)=0

u_2(t)=0

u_3(t)=0

Figure 1: Input, output and validation

Figure 2: Estimate of θ

Figure 3: Estimates of α_1, α_2 and α_3

Instantaneous values

Figure 3: Experimental results screen (ERS) for first-order parameter identification

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 1: Initialize USB CDC to the boudrate = 115 200 bit s⁻¹
 2: while 1 do
 3:     Receive from USB and store in A
 4:     if A[0] == 0x34 then
 5:         Set the value of A[2] as PWM out to the Analog
    output port # A[1]− 0x60
 6:     end if
 7:     if A[0] == 0x33 then
 8:         Read analog value from the Analog input # A[1]−
    0x60 and send the value to USB
 9:     end if
10: end while
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Figure 4: Bridge device's firmware
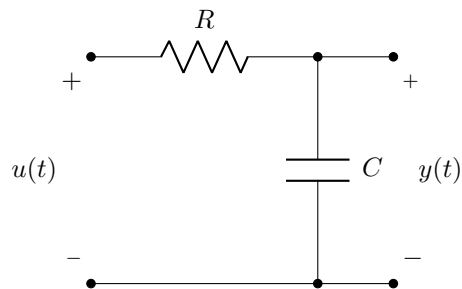
Figure 5: First order low pass filter
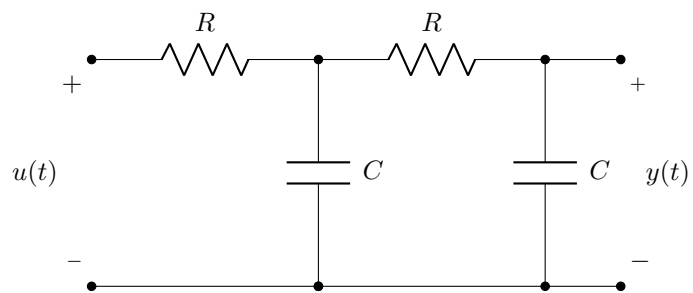
Figure 6: Second order low pass filter.
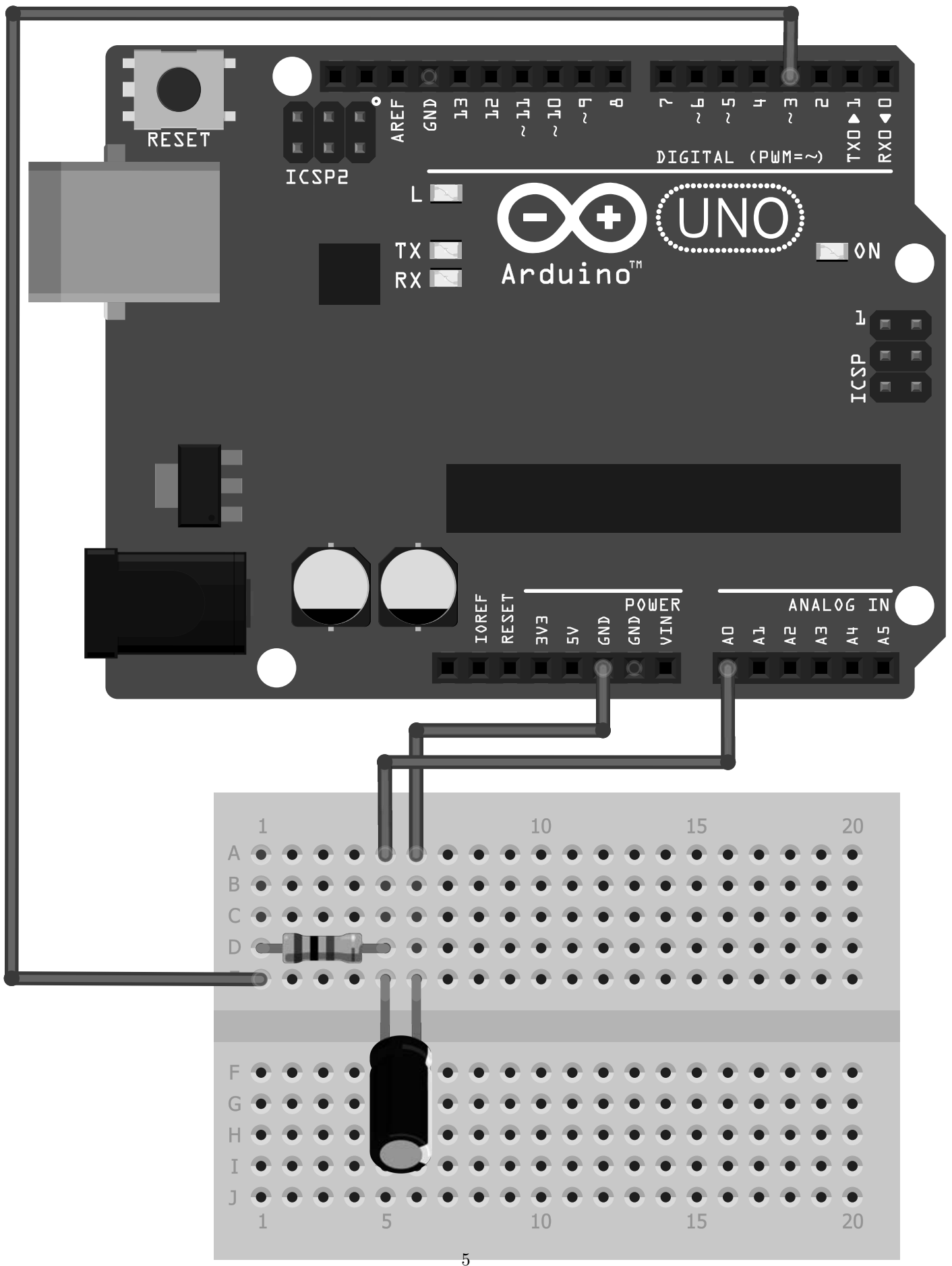
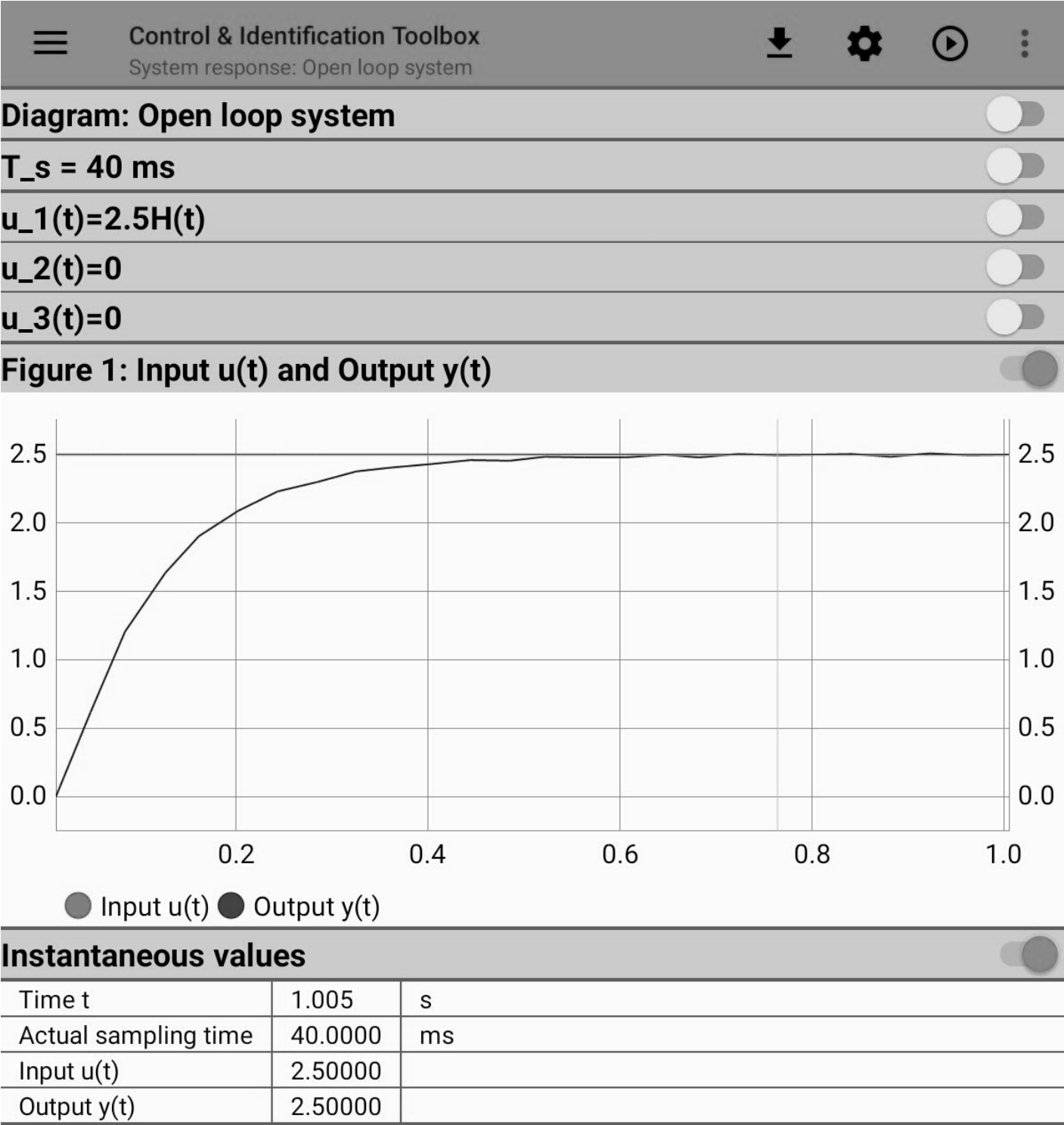Figure 7: Bridge circuit with a first order RC low pass filter

Diagram: Open loop system

T_s = 40 ms

u_1(t)=2.5H(t)

u_2(t)=0

u_3(t)=0

Figure 1: Input u(t) and Output y(t)

● Input u(t) ● Output y(t)

Instantaneous values

Time t	1.005	s
Actual sampling time	40.0000	ms
Input u(t)	2.50000	
Output y(t)	2.50000	

Figure 8: Step response of the first-order low pass filter.
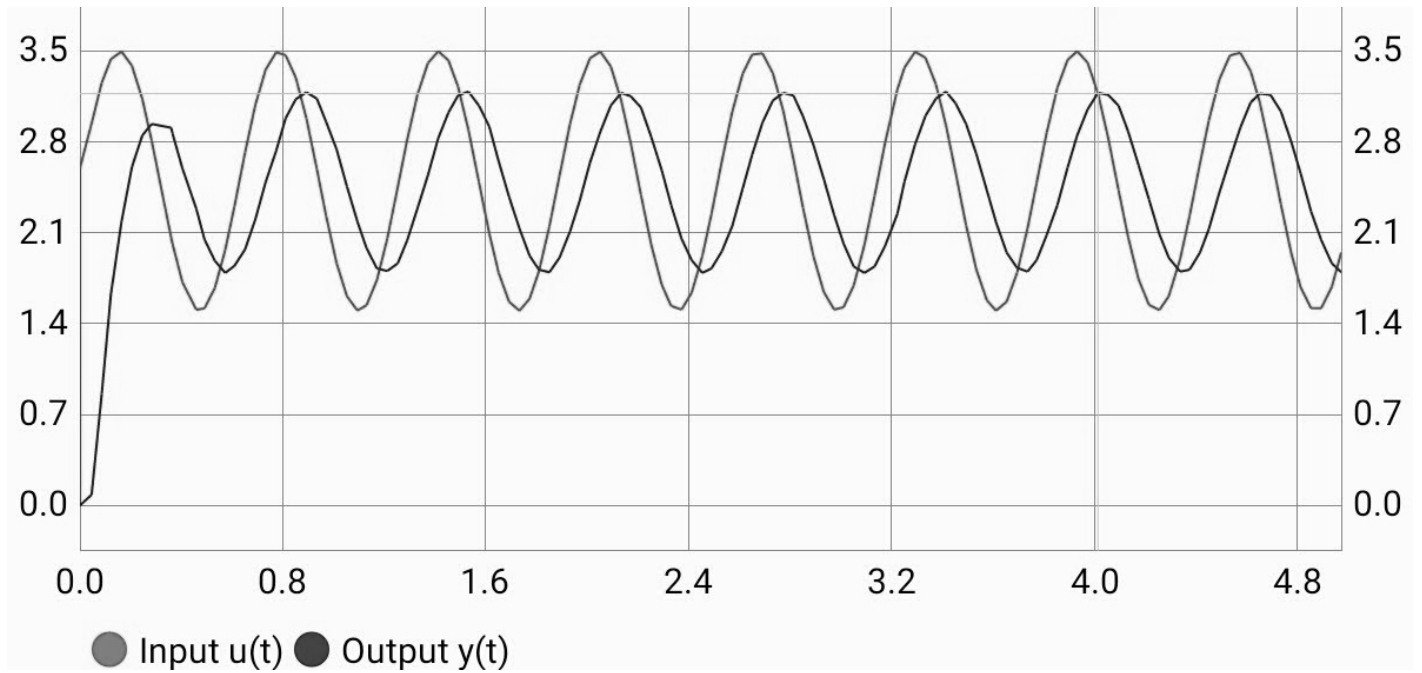
Figure 9: Sinusoidal response of the fist-order low pass filter.
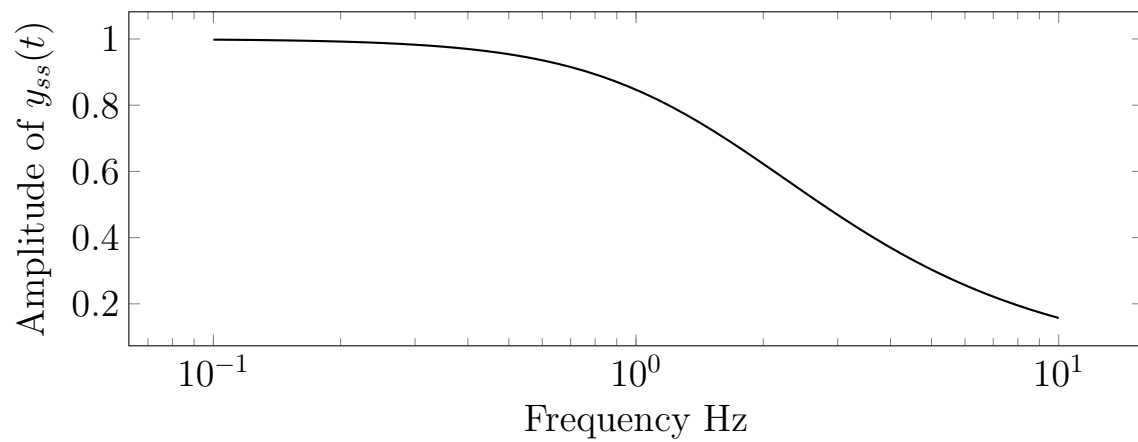
Figure 10: Magnitude of the frequency response of the first-order low pass filter.
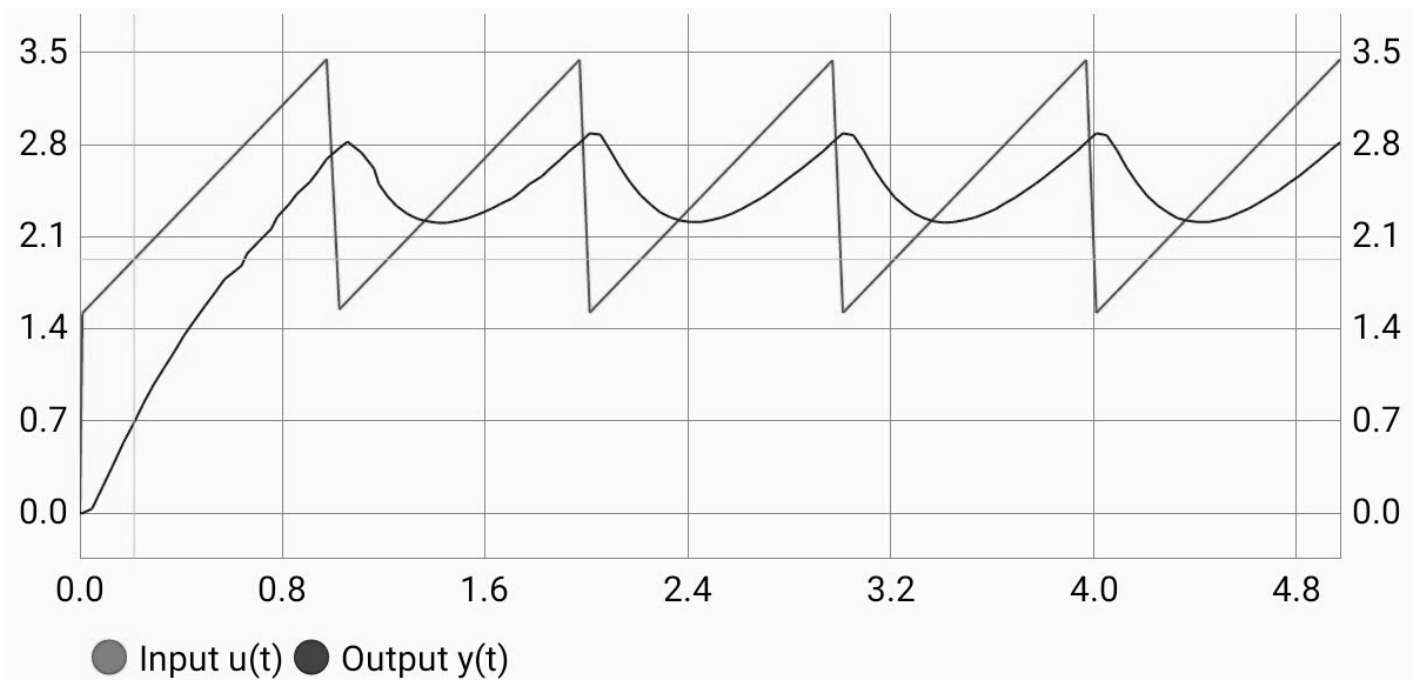
Figure 11: Response of the second-order filter to a sawtooth wave input.
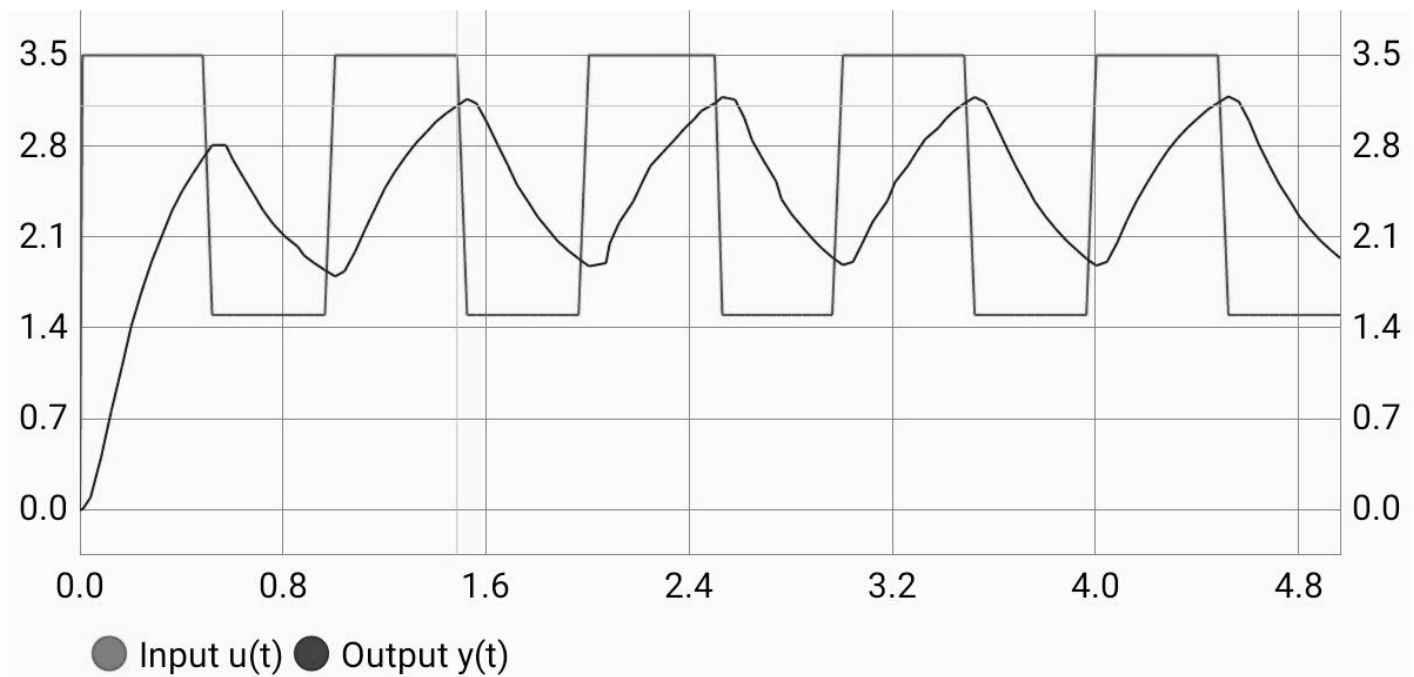
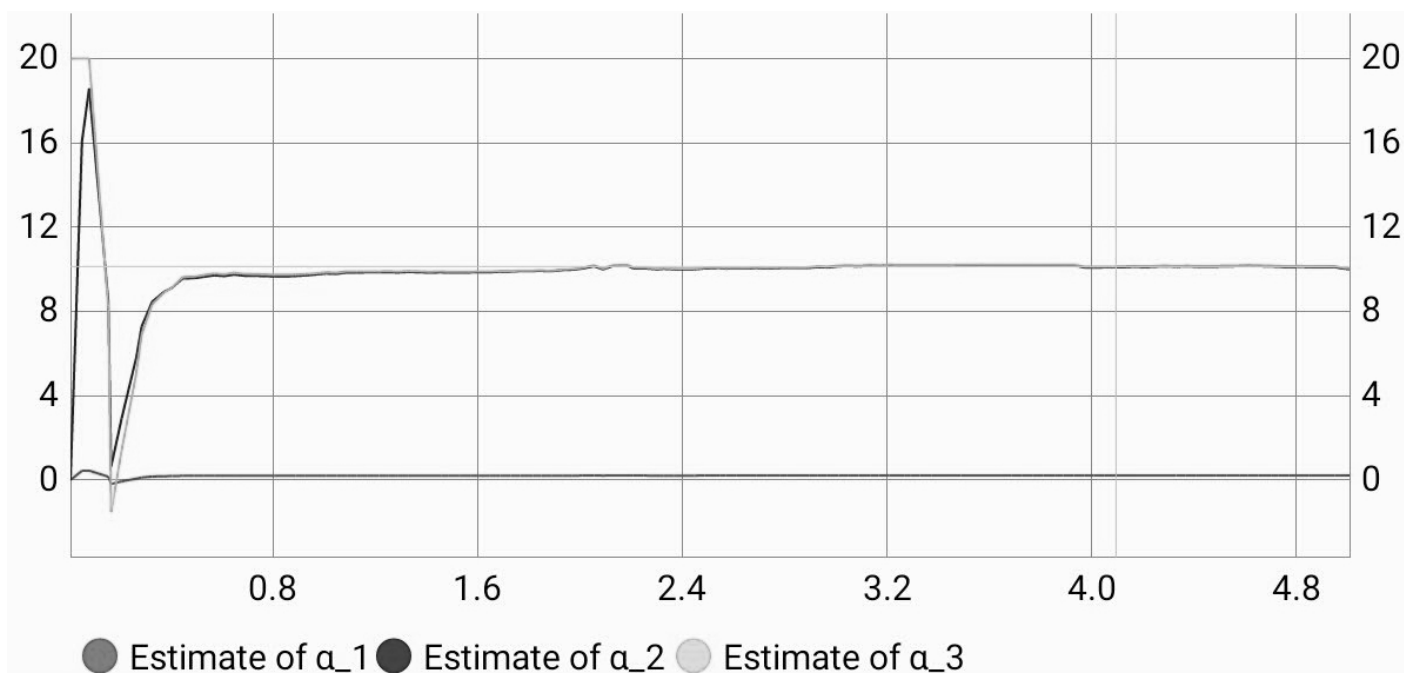Figure 12: Response of the second-order filter to a square wave input.
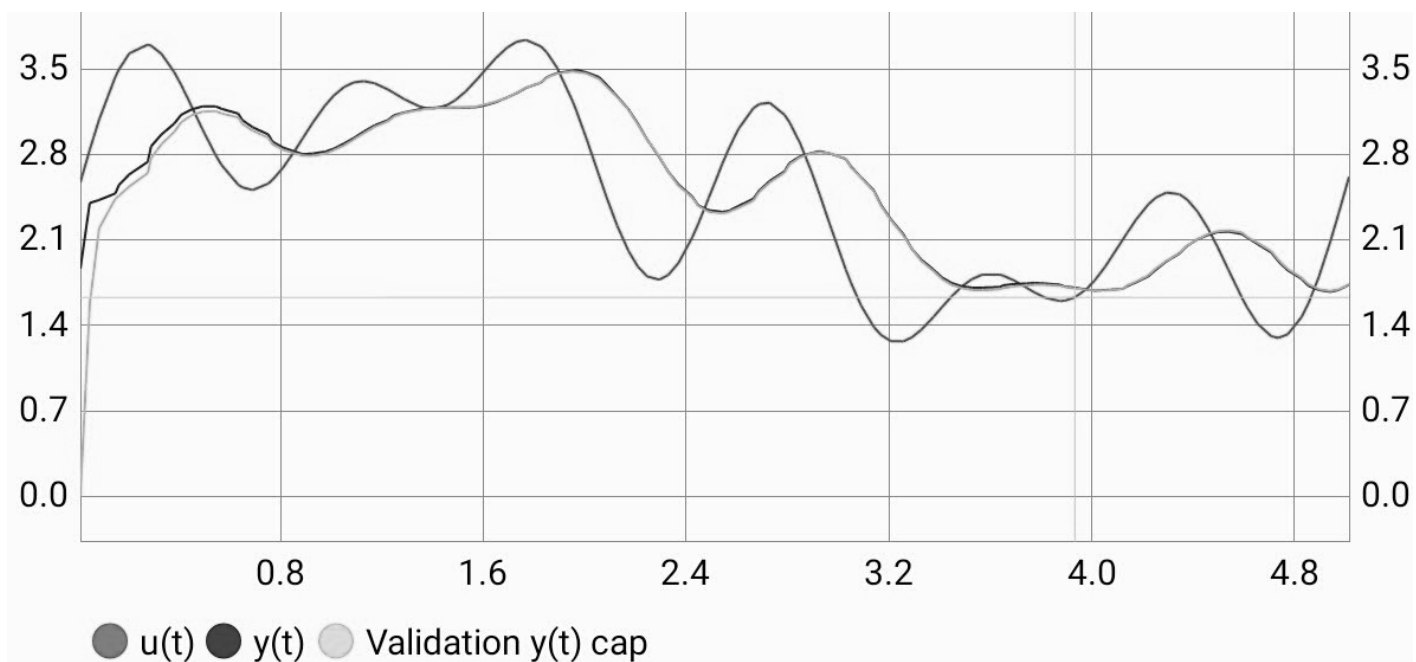
Figure 13: Signals $u(k)$, $y(k)$, $\hat{y}(k)$ and parameters $\hat{\theta}_1$, $\hat{\theta}_2$, $\hat{\theta}_3$.
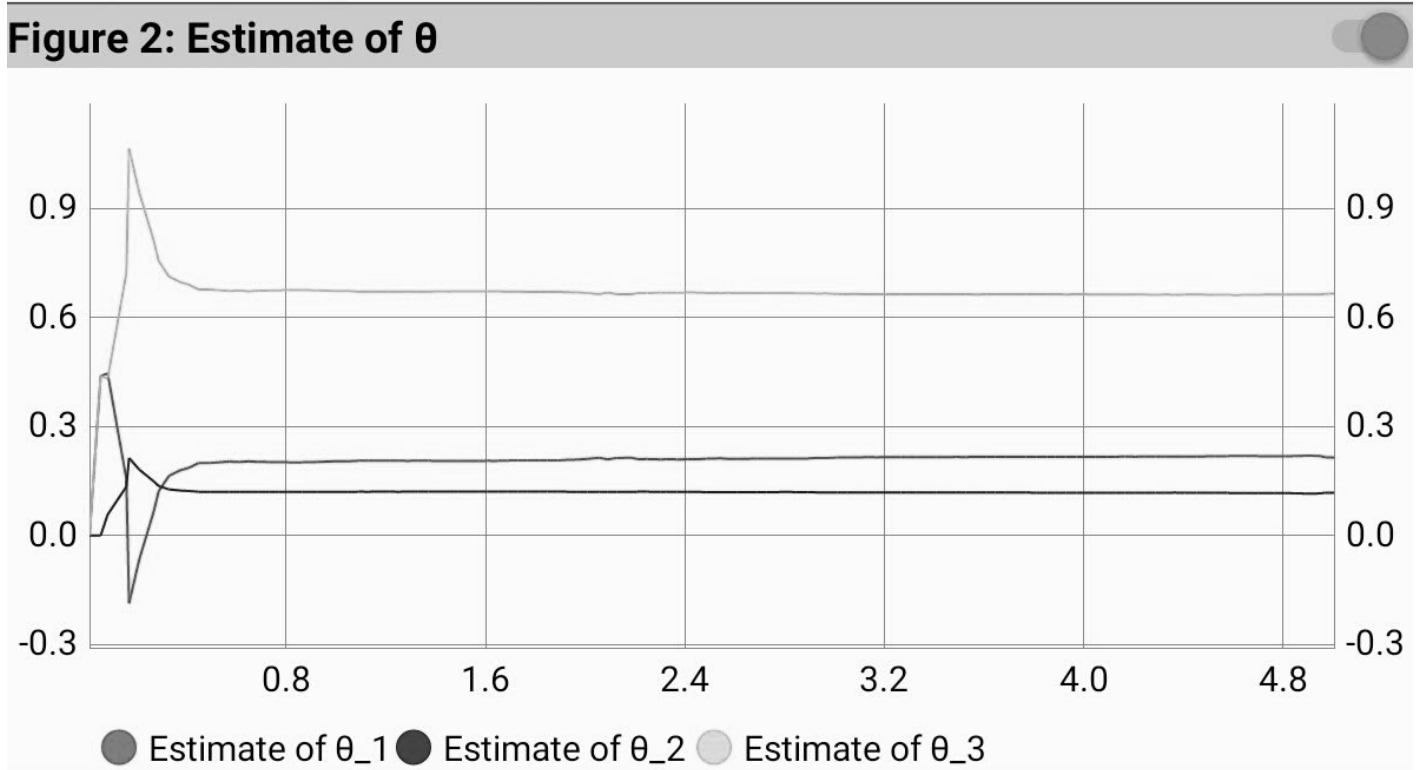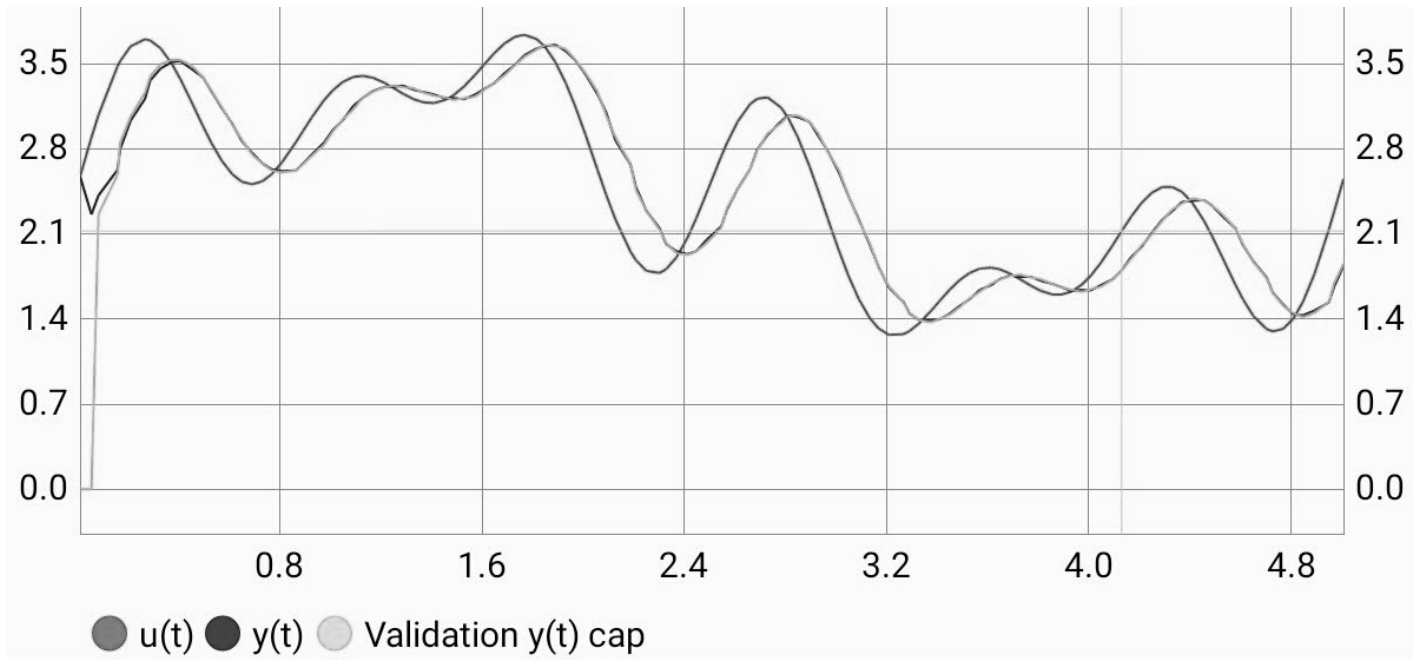
Time t	5.007	s
Actual sampling time	40.4023	ms
u(t)	2.55100	
y(t)	1.83594	
Validation y(t) cap	1.85209	
Estimate of θ_1	0.214658	
Estimate of θ_2	0.117516	
Estimate of θ_3	0.666384	
Estimate of α_1	0.214658	
Estimate of α_2	10.0028	
Estimate of α_3	10.0462	

Figure 14: Estimates $\hat{\alpha}_1(t)$, $\hat{\alpha}_2(t)$, $\hat{\alpha}_3(t)$, .and instantaneous values of signals and parameters.
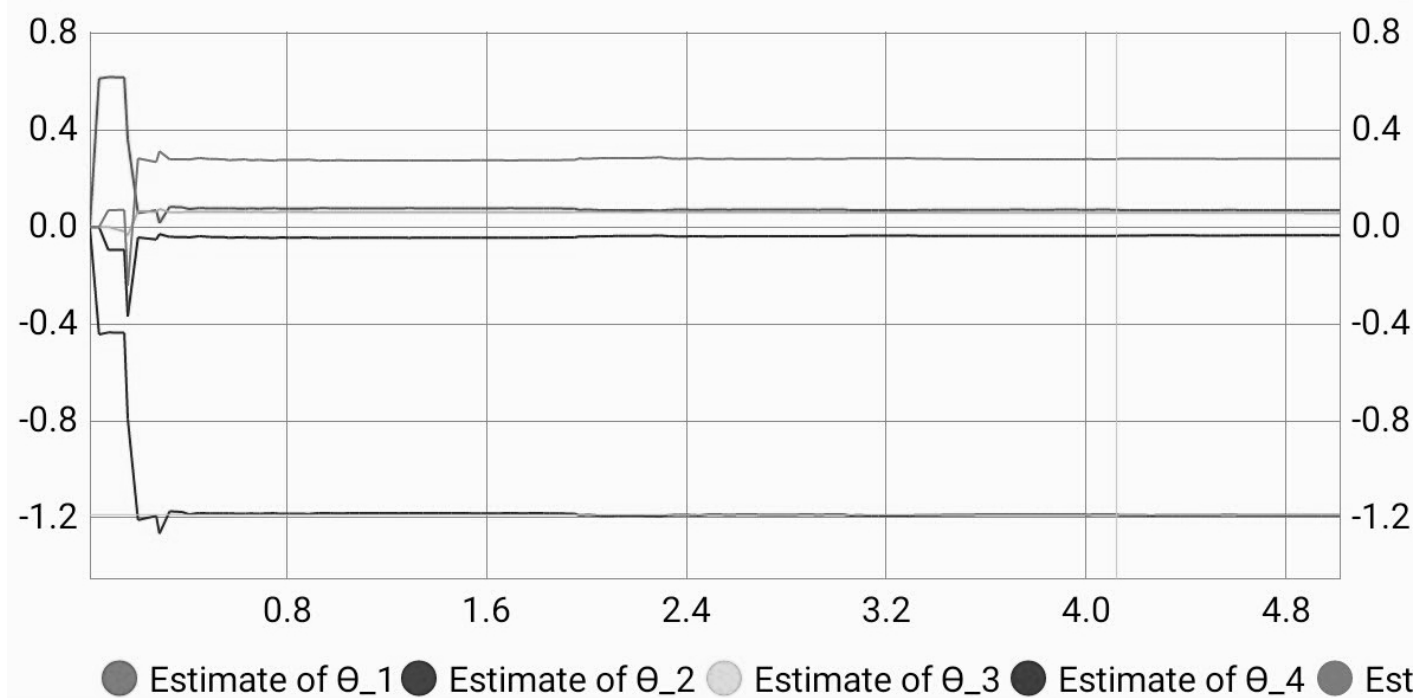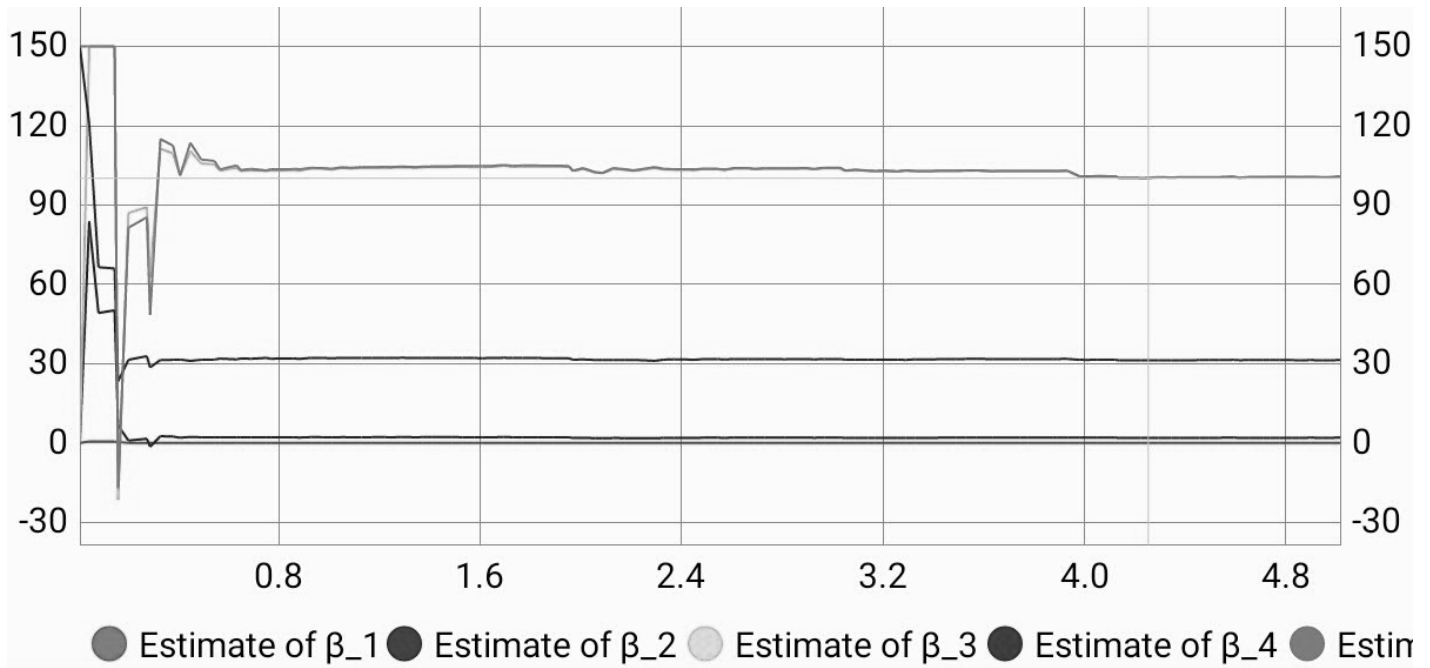
Figure 15: Signals $u(k)$, $y(k)$, $\hat{y}(k)$ and parameters $\hat{\theta}_1$, $\hat{\theta}_2$, $\hat{\theta}_3$, $\hat{\theta}_4$ and $\hat{\theta}_5$.

Figure 16: Estimates $\hat{\beta}_1$, $\hat{\beta}_2$, $\hat{\beta}_3$, $\hat{\beta}_4$, $\hat{\beta}_5$, and instantaneous values of signals and parameters.
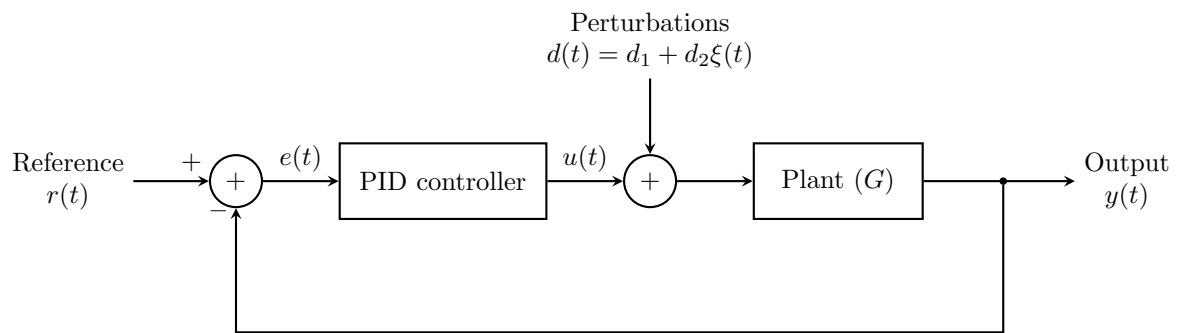
Instantaneous values

|		
Time t	5.016	s
Actual sampling time	40.4788	ms
u(t)	2.61643	
y(t)	1.73340	
Validation y(t) cap	1.73523	
Estimate of θ_1	0.0692599	
Estimate of θ_2	-0.0343029	
Estimate of θ_3	0.0572122	
Estimate of θ_4	-1.18859	
Estimate of θ_5	0.280906	
Estimate of β_1	0.0692599	
Estimate of β_2	2.00433	
Estimate of β_3	100.661	
Estimate of β_4	31.3661	
Estimate of β_5	100.821	

Figure 17: Closed loop system with a PID Controller
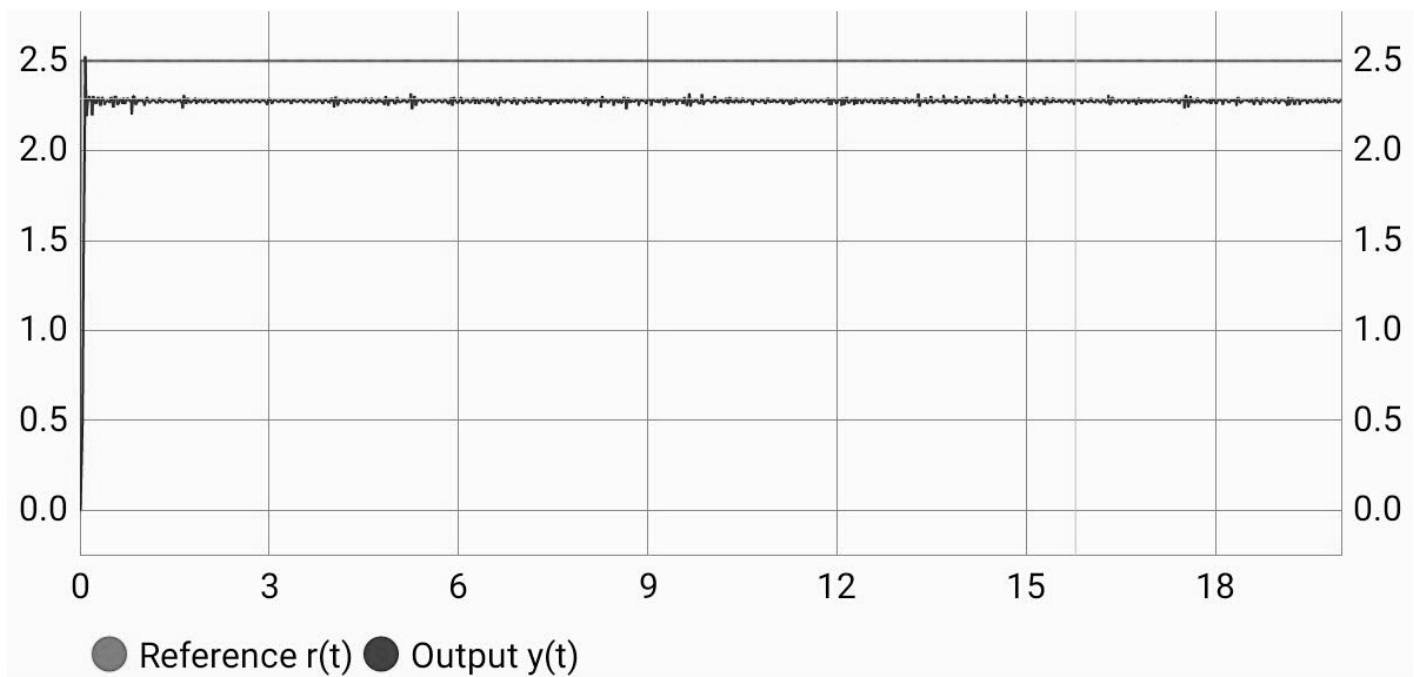
Figure 2: Error e(t) and Control u(t)
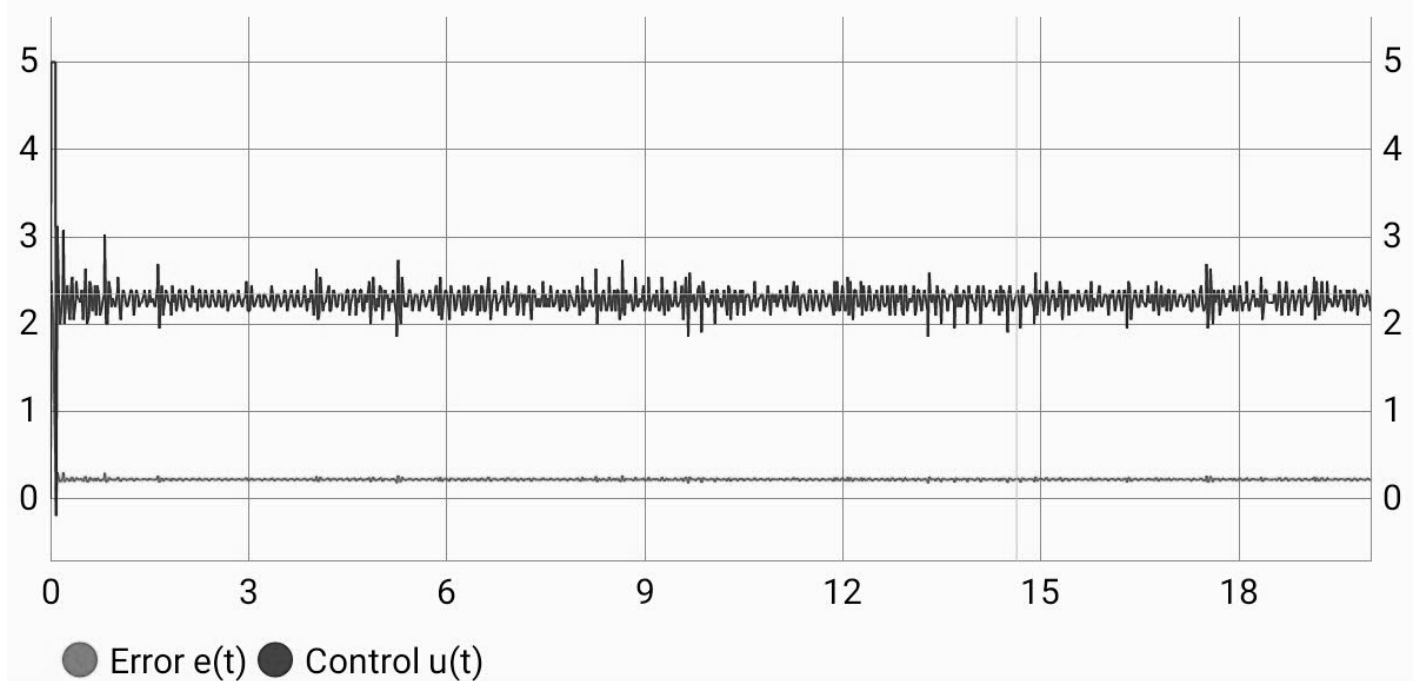
Figure 18: Signals $r(k)$, $y(k)$, $e(k)$ and $u(k)$ of the closed-loop system with $K_P = 10$, $K_I = 0$, and $K_D = 0$.
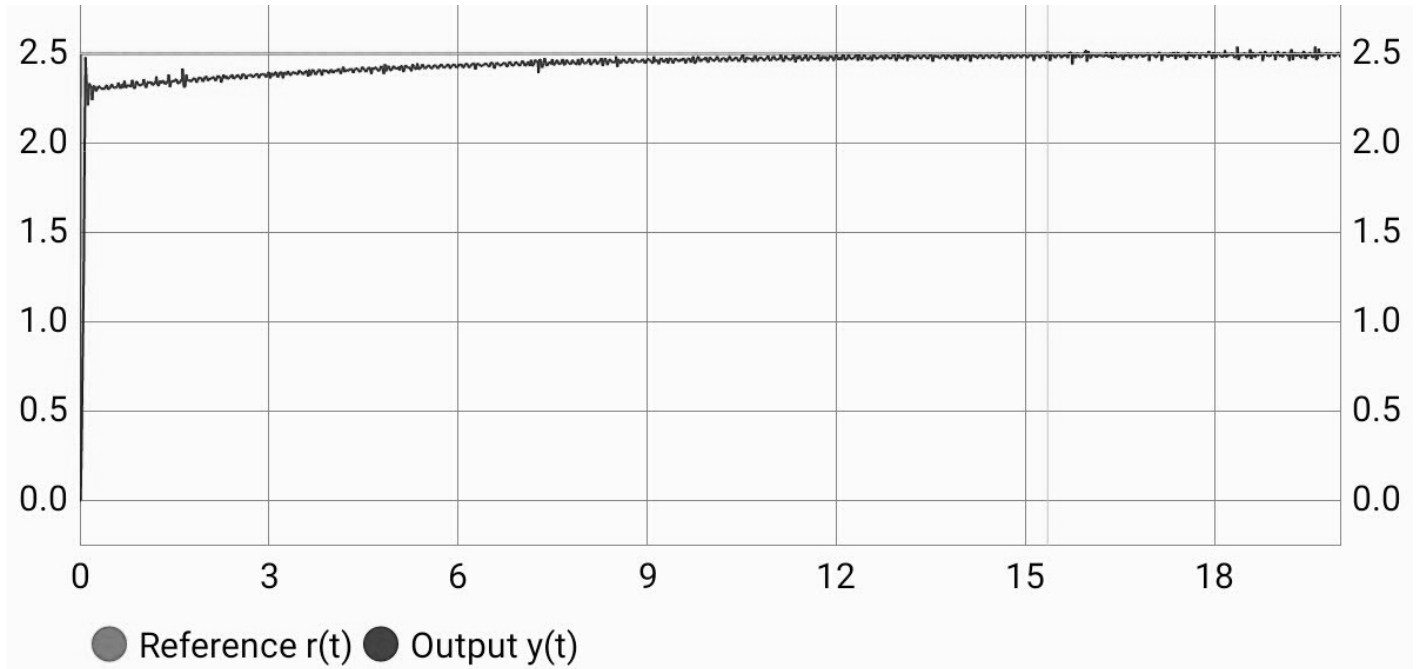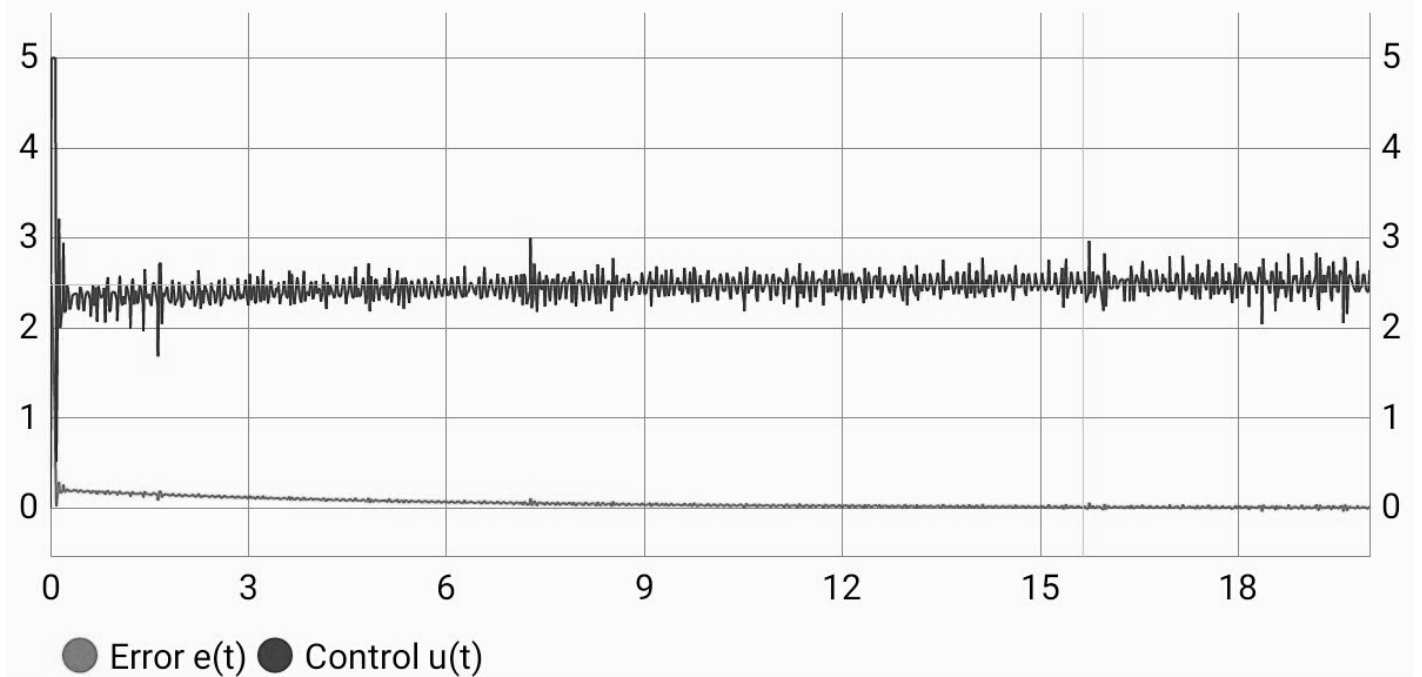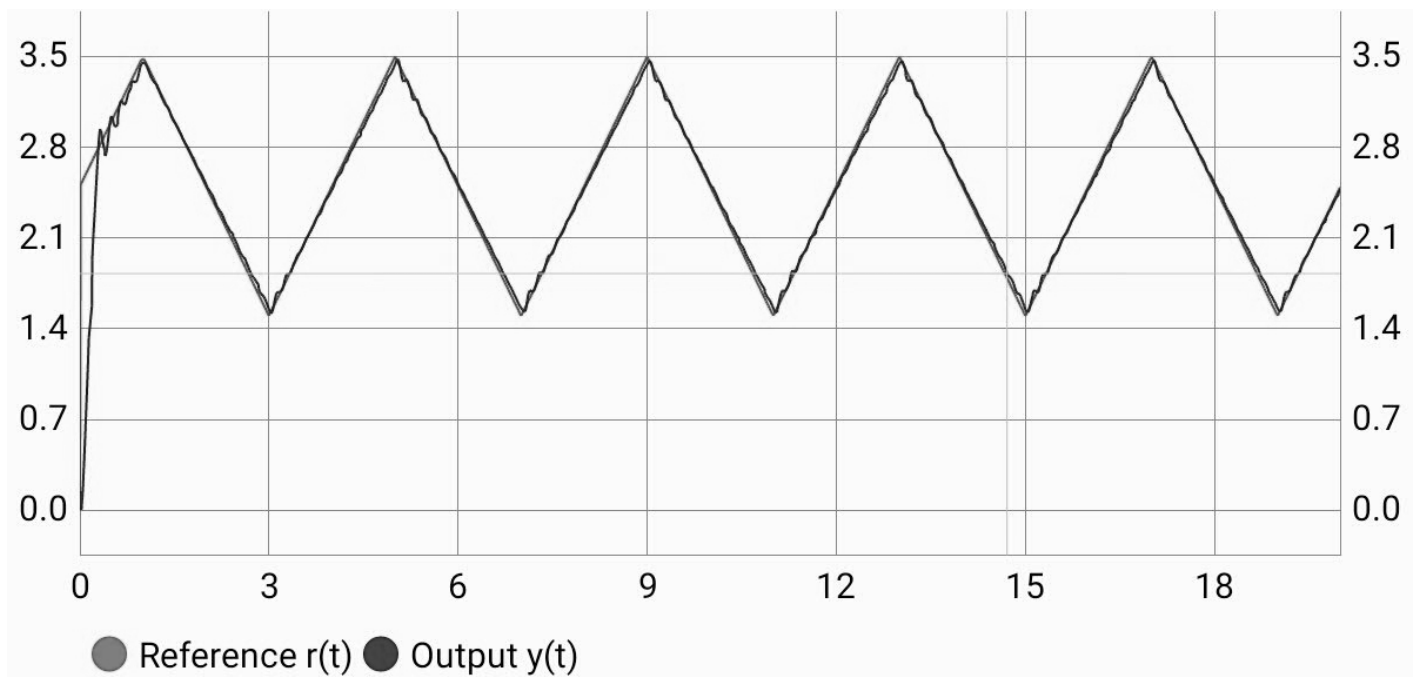
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Figure 19: Signals $r(k)$, $y(k)$, $e(k)$ and $u(k)$ of the closed-loop system with $K_P = 10$, $K_I = 2$, and $K_D = 0$.
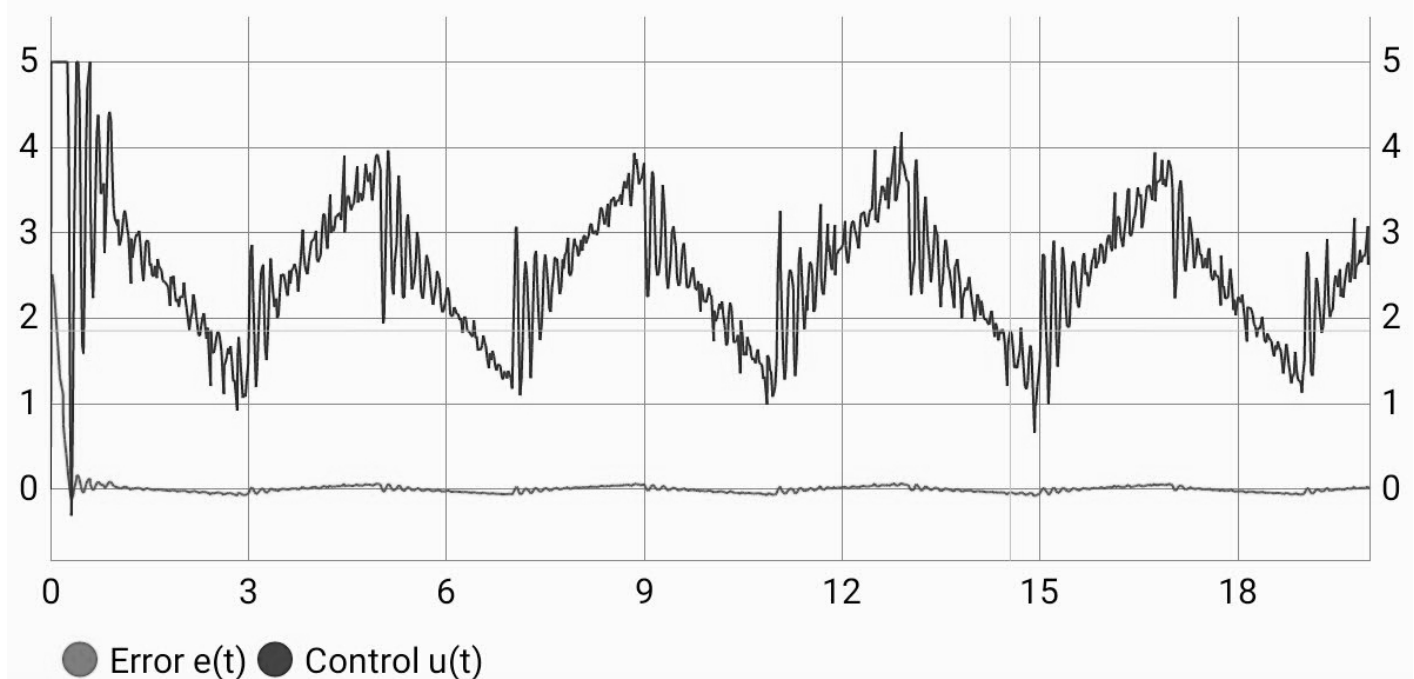
Figure 20: Signals $r(k)$, $y(k)$, $e(k)$ and $u(k)$ of the closed-loop system with $K_P = 20$, $K_I = 5$, and $K_D = 0.1$.