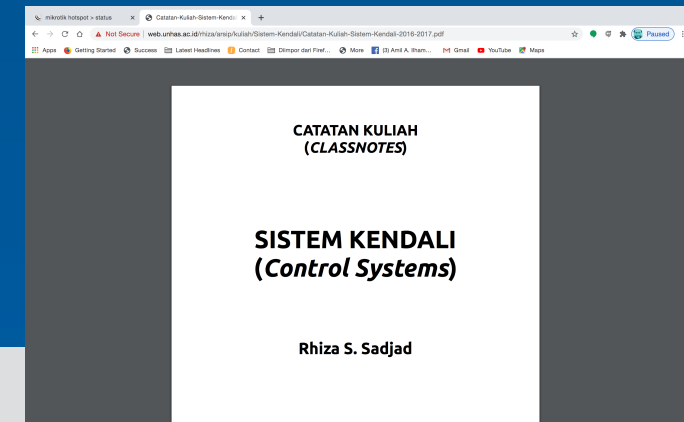


328D4103
Sistem Kendali + Praktikum
MODUL 02
KONVERSI
Model RUANG KEADAAN
ke Model NISBAH ALIH
(ss2tf)

(Semester Awal 2020-2021)



MODEL RUANG KEADAAN



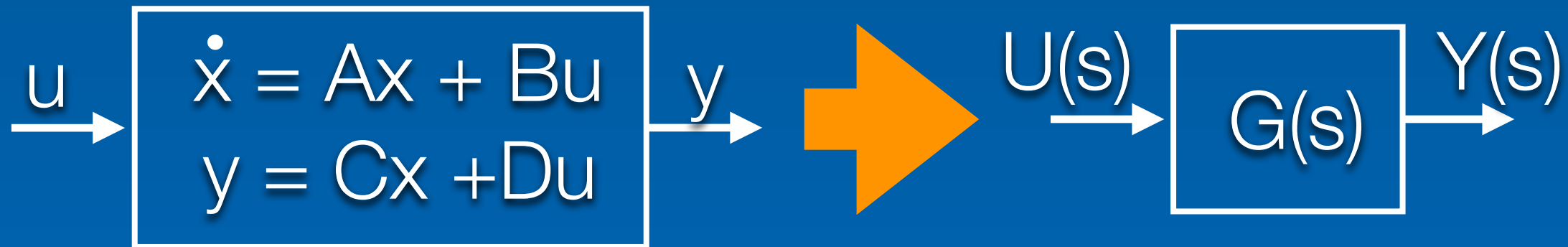
- Sumber pembelajaran: <https://web.unhas.ac.id/rhiza/arsip/kuliah/Sistem-Kendali/Catatan-Kuliah-2017/>
- Catatan Kuliah Lengkap 2016-2017: <https://web.unhas.ac.id/rhiza/arsip/kuliah/Sistem-Kendali/Catatan-Kuliah-Sistem-Kendali-2016-2017.pdf> (dibuka *on-line* saja, tidak perlu diunduh)

Jika browser anda mempermasalahkan **SECURITY**, klik saja tombol **“Advanced”**, kemudian **“Proceed”**

A screenshot of a web browser showing a directory listing. The title is 'Index of /rhiza/arsip/kuliah/Sistem-Kendali/Catatan-Kuliah-2017'. The table has columns for 'Name', 'Last modified', 'Size', and 'Description'. The files listed are 'Catatan_Sistem_Kendali_2017-1.pdf' through 'Catatan_Sistem_Kendali_2017-10.pdf'.

Name	Last modified	Size	Description
Parent Directory			
Catatan_Sistem_Kendali_2017-1.pdf	14-Oct-2017 02:13	353K	
Catatan_Sistem_Kendali_2017-2.pdf	14-Oct-2017 02:18	403K	
Catatan_Sistem_Kendali_2017-3.pdf	14-Oct-2017 03:40	443K	
Catatan_Sistem_Kendali_2017-4.pdf	14-Oct-2017 03:41	345K	
Catatan_Sistem_Kendali_2017-5.pdf	14-Oct-2017 03:41	440K	
Catatan_Sistem_Kendali_2017-6.pdf	14-Oct-2017 03:42	384K	
Catatan_Sistem_Kendali_2017-7.pdf	14-Oct-2017 03:42	277K	
Catatan_Sistem_Kendali_2017-8.pdf	14-Oct-2017 03:43	413K	
Catatan_Sistem_Kendali_2017-9.pdf	14-Oct-2017 03:43	367K	
Catatan_Sistem_Kendali_2017-10.pdf	14-Oct-2017 03:44	340K	

KONVERSI Model RUANG KEADAAN ke Model NISBAH ALIH (berlaku hanya untuk sistem SISO)

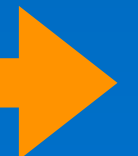


Formula:

$$G(s) = \frac{Y(s)}{U(s)} = C[sI - A]^{-1} + D$$

$$sI = \begin{vmatrix} s & 0 \\ 0 & s \end{vmatrix}$$

Penurunan FORMULA



PENURUNAN FORMULA KONVERSI SS2TF

* Mengubah dari Model Ruang Keadaan ke Model Nisbah Alih, SISO m=k=1
MATLAB command >>> ss2tf
 → A, B, C, D Linear Time Invariant konstan (bukan f(t))

Transf. Laplace
 $\int_0^\infty \dot{x} e^{-st} dt = \int_0^\infty [A x(t) + B u(t)] e^{-st} dt$
 $s \tilde{X}(s) = A \tilde{X}(s) + B U(s)$
 $s \tilde{X}(s) - A \tilde{X}(s) = B U(s)$
 $[sI - A] \tilde{X}(s) = B U(s)$ $I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

Transformasi Laplace dari
 PERSAMAAN KEADAAN:

$$sX(s) = A X(s) + B U(s)$$

$$[sI - A] X(s) = B U(s)$$

Substitusi X(s) pada:
 PERSAMAAN KELUARAN

$$\begin{aligned} [sI - A] \tilde{X}(s) &= B U(s) \\ \underbrace{[sI - A]}_{[n \times n]} \underbrace{\tilde{X}(s)}_{[n \times 1]} &= \underbrace{B}_{[n \times 1]} \underbrace{U(s)}_{[1 \times 1]} \\ [sI - A]^{-1} [sI - A] \tilde{X}(s) &= [sI - A]^{-1} B U(s) \\ I \tilde{X}(s) &= [sI - A]^{-1} B U(s) \\ \mathcal{L} y(t) &= \mathcal{L} [C x(t) + D u(t)] \\ \tilde{Y}(s) &= C \tilde{X}(s) + D U(s) = C [sI - A]^{-1} B U(s) + D U(s) \\ \underbrace{\tilde{Y}(s)}_{[1 \times 1]} &= \underbrace{C}_{[1 \times n]} \underbrace{[sI - A]^{-1} B}_{[n \times 1]} \underbrace{U(s)}_{[1 \times 1]} + \underbrace{D}_{[1 \times 1]} \underbrace{U(s)}_{[1 \times 1]} \\ \tilde{Y}(s) &= [C [sI - A]^{-1} B + D] U(s) \\ \boxed{\tilde{G}(s) = \frac{\tilde{Y}(s)}{U(s)} = C [sI - A]^{-1} B + D} \end{aligned}$$

CONTOH SOAL

* $\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$ $\left\{ \begin{array}{l} \dot{x}_1 = x_2 \\ \dot{x}_2 = u \end{array} \right.$

$y = \begin{bmatrix} 1 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \end{bmatrix} u \rightarrow y = x_1$

$G(s) = C [sI - A]^{-1} B + D$ ✓

$[sI - A] = \begin{bmatrix} s & -1 \\ 0 & s \end{bmatrix} \rightarrow [sI - A]^{-1} = \frac{\text{adj}[sI - A]}{\det[sI - A]}$

$[sI - A]^{-1} = \frac{\begin{bmatrix} s & 1 \\ 0 & s \end{bmatrix}}{s^2} = \begin{bmatrix} \frac{1}{s} & \frac{1}{s^2} \\ 0 & \frac{1}{s} \end{bmatrix}$ ✓

check: $[sI - A][sI - A]^{-1} = \begin{bmatrix} s & -1 \\ 0 & s \end{bmatrix} \begin{bmatrix} \frac{1}{s} & \frac{1}{s^2} \\ 0 & \frac{1}{s} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I$ ✓

DK!

$$A = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

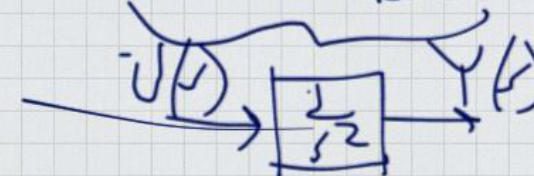
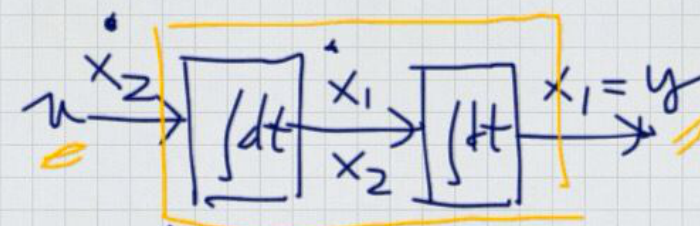
$$C = \begin{bmatrix} 1 & 0 \end{bmatrix} \quad D = 0$$

$$G(s) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} \frac{1}{s} & \frac{1}{s^2} \\ 0 & \frac{1}{s} \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} \frac{1}{s^2} \\ \frac{1}{s} \end{bmatrix} = \frac{1}{s^2}$$

(double integrator)

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{s^2}$$

double integrator



$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{s^2}$$

TUGAS MANDIRI (tidak dikumpul)

- Tentukan model Nisbah Alih $G(s)$ dari model Ruang Keadaan dengan $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$ dan $D = \begin{bmatrix} 3 \end{bmatrix}$, tanda “;” berarti ganti baris baru
- Mengapa konversi dari model Ruang Keadaan ke model Nisbah Alih tidak bisa dilakukan untuk sistem MIMO? Pikirkan.
- Carilah akses untuk menggunakan MATLAB !
- Jika sudah dapat akses untuk menggunakan MATLAB, coba gunakan perintah “ `>>> ss2tf` ” untuk mengerjakan contoh2 soal.

MODUL PEMBELAJARAN SELANJUTNYA

- MODUL 01: (Pengantar/Review) Model RUANG KEADAAN (*State Space*)
- **MODUL 02: Konversi Model RUANG KEADAAN ke NISBAH ALIH (ss2tf)**
- MODUL 03: Konversi Model NISBAH ALIH ke RUANG KEADAAN (tf2ss)
- MODUL 04: Transformasi SIMILARITAS
- MODUL 05: TANGGAPAN dan KESTABILAN
- MODUL 06: KETERKENDALIAN dan KETERAMATAN
- MODUL 07: UMPAN-BALIK PEUBAH KEADAAN
- MODUL 08: PRAKTIKUM INDIVIDU

SELAMAT BELAJAR

Semoga SUKSES meraih PRESTASI!

