ELEC-E8116 Model-based control systems
Intermediate exam 1. 20. 10. 2022

- *Write the name of the course, your name and student number to each answer sheet.*
- *There are three (3) problems and each one must be answered.*
- *No literature is allowed. A calculator can be used as a calculating aid. However, it must not be used for advanced calculations, e.g. matrix calculus, Laplace transformations, connection to the Internet etc.*

1. a. Explain briefly the following concepts

- Conservative control law	(1 p.)
- Robust stability	(1 p.)
- "Push through"-rule	(1 p.)

1. b. Explain shortly the concept "Fundamental restrictions in control". Name and discuss the main items there. (2 p.)

2. Consider a multivariable control configuration.
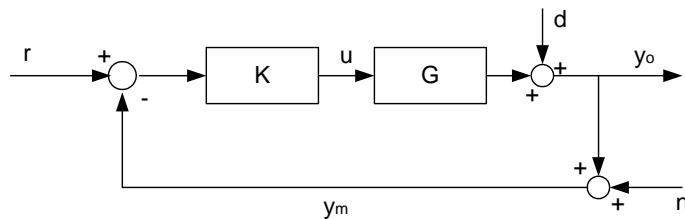
Write the equations describing the system and identify

- **a.** the closed loop transfer function (1 p.)
- **b.** the sensitivity function (1 p.)
- **c.** the complementary sensitivity function. Show that $S + T = I$ and explain the result. (1 p.)
- **d.** show and discuss the meaning of the identity (MIMO case)

$$u = G^{-1}\left[G_c r - (1-S)d\right]$$ (2 p.)

3. Find the poles, zeros and a minimal realization to the system

$$G(s) = \begin{bmatrix} \dfrac{2}{s+1} & \dfrac{2s-3}{(s+1)(s+2)} \\[3mm] \dfrac{s-2}{s+1} & \dfrac{s}{s+2} \end{bmatrix}$$ (1+1+3 p.)

Hint to the last part: You should know the number of states in the minimal realization. Write the terms in the transfer function matrix by means of weighted sums of terms $1/(s+1)$, $1/(s+2)$ and control inputs. Then choose the state variables.