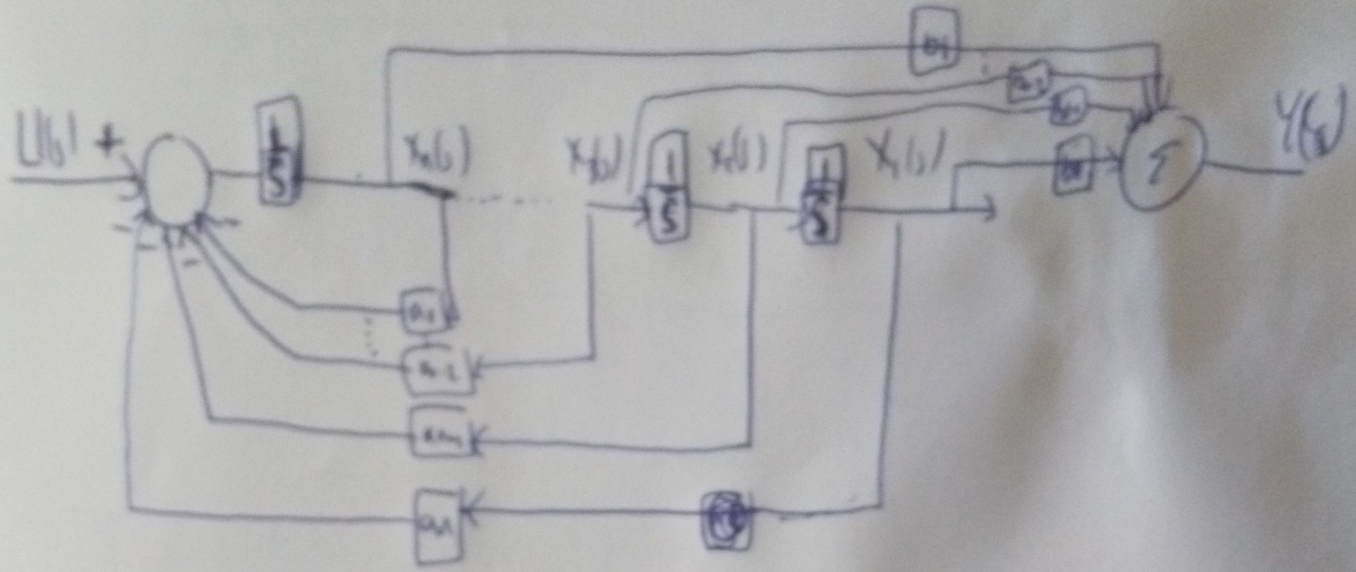


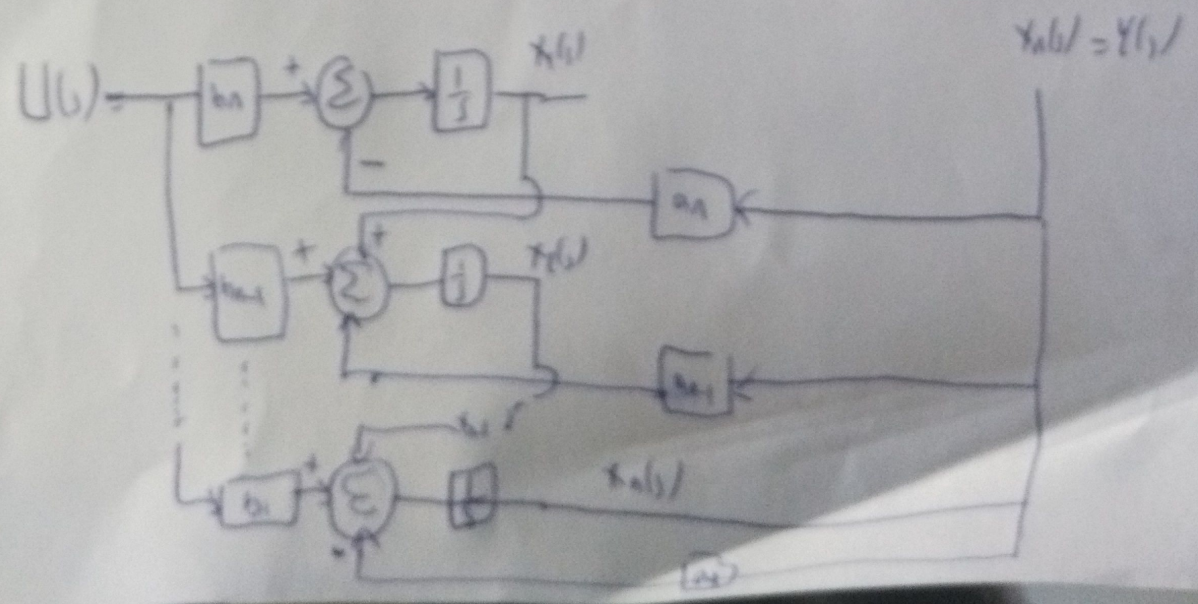
② Controllable canonical form block diagram (with integrators)

$$T(s) = \frac{b_n s^{n-1} + b_{n-1} s^{n-2} + \dots + b_1 s^0}{s^n + a_{n-1} s^{n-1} + a_{n-2} s^{n-2} + \dots + a_1 s^0}$$

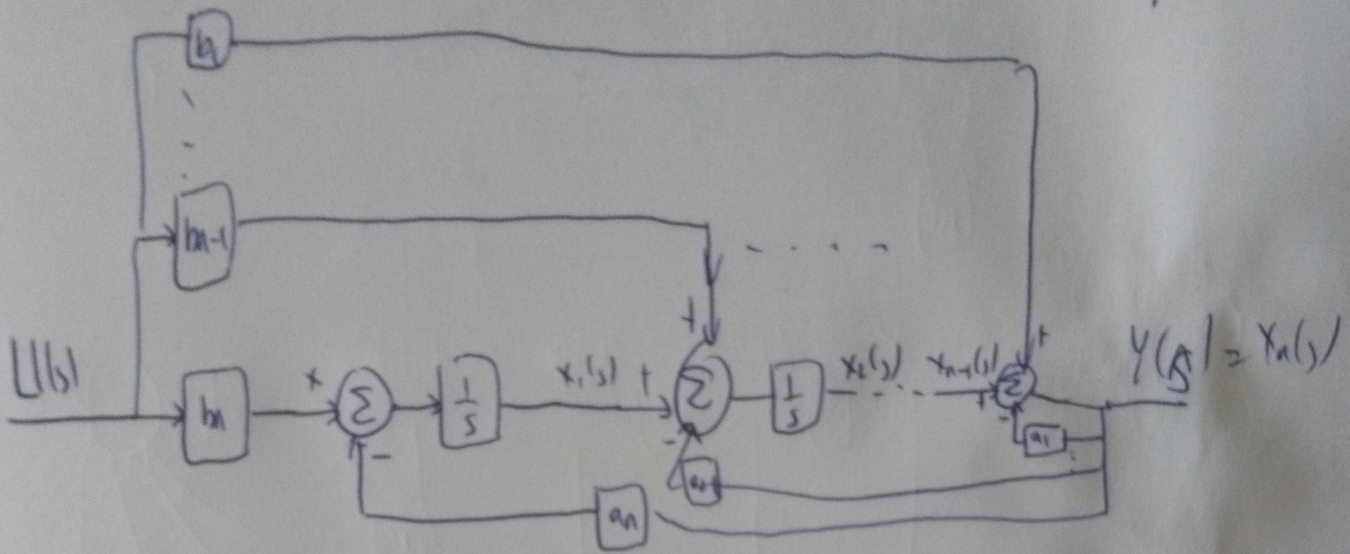
(with integrators)



③ Observable canonical form block diagram (with integrators)



or another representation of observable canonical form



Controllable canonical form equations

$$X(s) = \frac{U(s)}{s^n + a_{n-1}s^{n-1} + \dots + a_1s + a_0} = \frac{U(s)}{d(s)} \quad d(s) \rightarrow \text{characteristic equation}$$

$$x_i(s) = s^{i-1} \frac{U(s)}{d(s)}$$

$$sX_n(s) = -a_n X_1(s) - a_{n-1} X_2(s) - \dots - a_2 X_{n-1}(s) - a_1 X_n(s) + U(s)$$

$$X_1(s) = \frac{U(s)}{d(s)} \quad X_2(s) = s \frac{U(s)}{d(s)} = sX_1(s) \quad , \quad X_3(s) = s^2 \frac{U(s)}{d(s)} = s^2 X_1(s) = sX_2(s)$$

$$Y(s) = b_1 X_n(s) + b_2 X_{n-1}(s) + \dots + b_n X_1(s)$$

** Controllable canonical form block diagram (with ~~integrator~~ ^{differentiator})

$$X_n(s) = \frac{1}{s} \left\{ -a_n X_1(s) - a_{n-1} X_2(s) - \dots - a_2 X_{n-1}(s) - a_1 X_n(s) + U(s) \right\}$$

$$\frac{1}{s} X_2(s) = X_1(s) \quad \frac{1}{s} X_3(s) = X_2(s) \quad \frac{1}{s} X_n(s) = X_{n-1}(s)$$

