0.0.1 Background

A state feedback regulating system is depicted in Figure 0.1. It contains the hardware plant as well as the inverted system feedback gains.

The *additional dynamics* are added in Figure 0.2. In the figure, the output vector of the plant is demuxed into its individual output components such that certain outputs may additionally be used as inputs to the additional dynamics state-space representation. This is represented using flags; connections exist between flags with equivalent labels. The outputs of the plant as well as the outputs of the additional dynamics are then muxed to form an output vector representing the output of a larger system.

Thus, the larger system [*containing the plant and the additional dynamics*] may temporarily be considered as new plant, as depicted in Figure 0.3. It may therefore be characterized and expressed in a state-space representation, and thus, state-feedback regulation techniques may be used to control the system, now with the addition of any benefits which the additional dynamics provide. A representation of the larger system is depicted in Figure 0.4. Note the increased size of the output vector.

From this point, the system depiction may be rearranged such that the true input, the user-defined reference command, is on the left, while the plant outputs remain on the right. A sequential description of the process, and the figure number which corresponds to each step is provided below:

1. The feedback gains are separated into those with respect to the original plant outputs x and those with respect to the additional dynamics $x.a$. [Figure 0.5]

2. The gains are shifted such that they are forward facing. [Figure 0.6]

    - In this configuration, the original plant may be separated from the components used to control it, including the additional dynamics. [Figure 0.7]

3. The plant is shifted to the right side of the system depiction. [Figure 0.8]

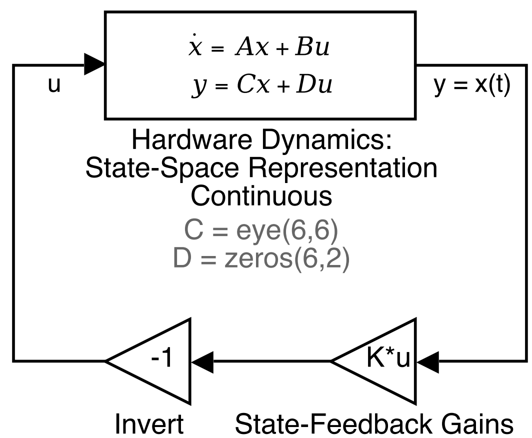

Figure 0.1: [Additional Dynamics]: State Feedback Regulator

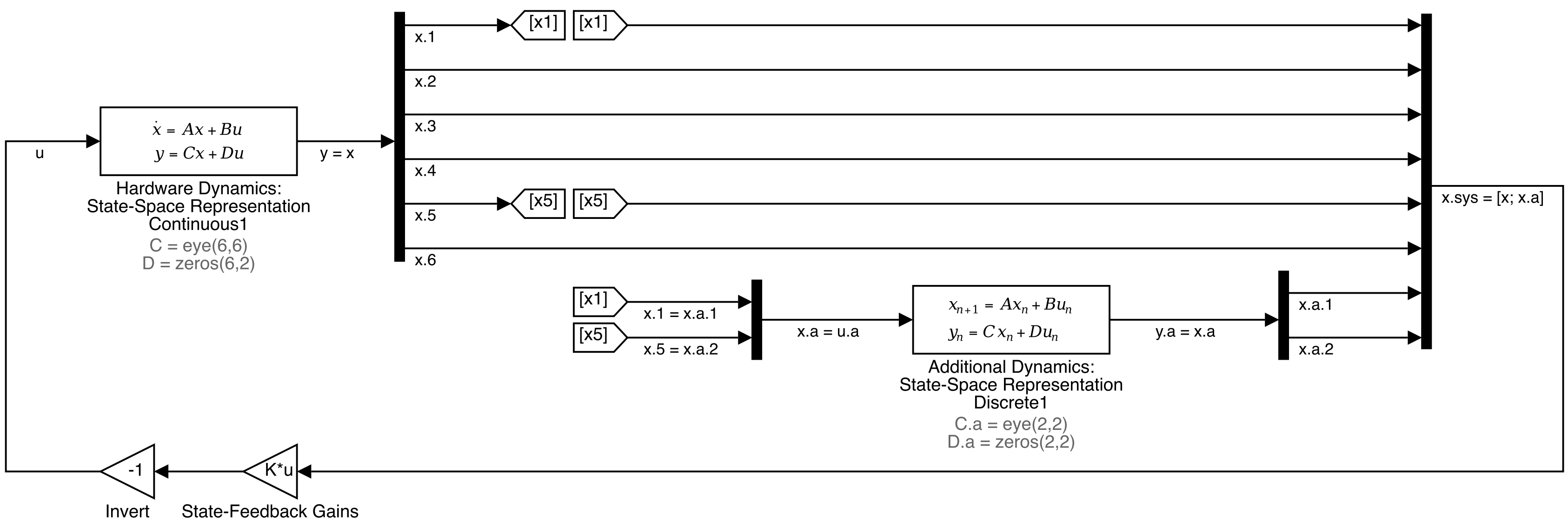

Figure 0.2: [Additional Dynamics]: 1.0 Additional Dynamics (Design View)

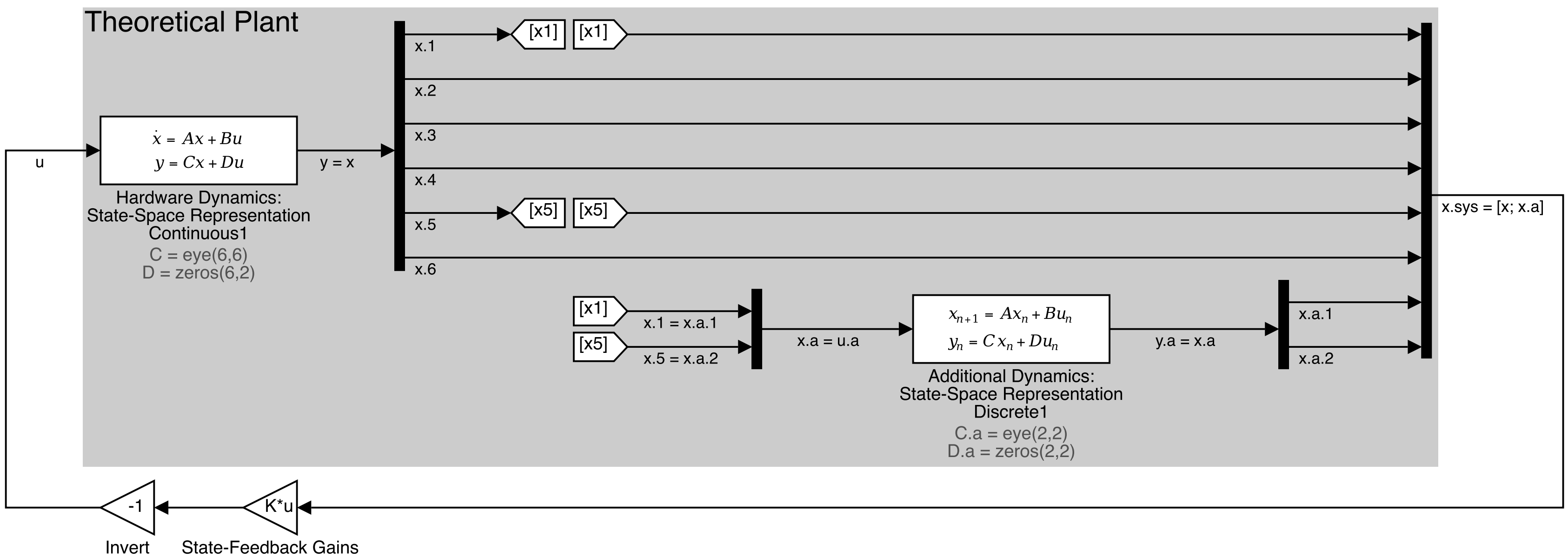

Figure 0.3: [Additional Dynamics]: 1.1 Additional Dynamics (Design View)

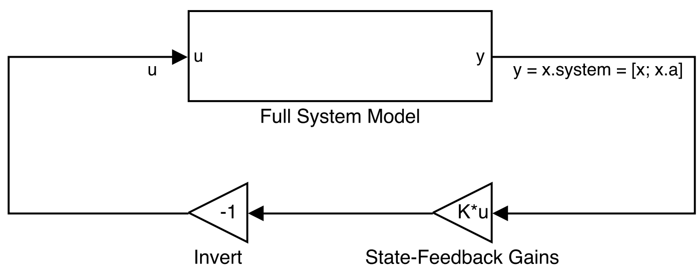

Figure 0.4: [Additional Dynamics]: 1.2 Additional Dynamics (State Feedback Regulator View)

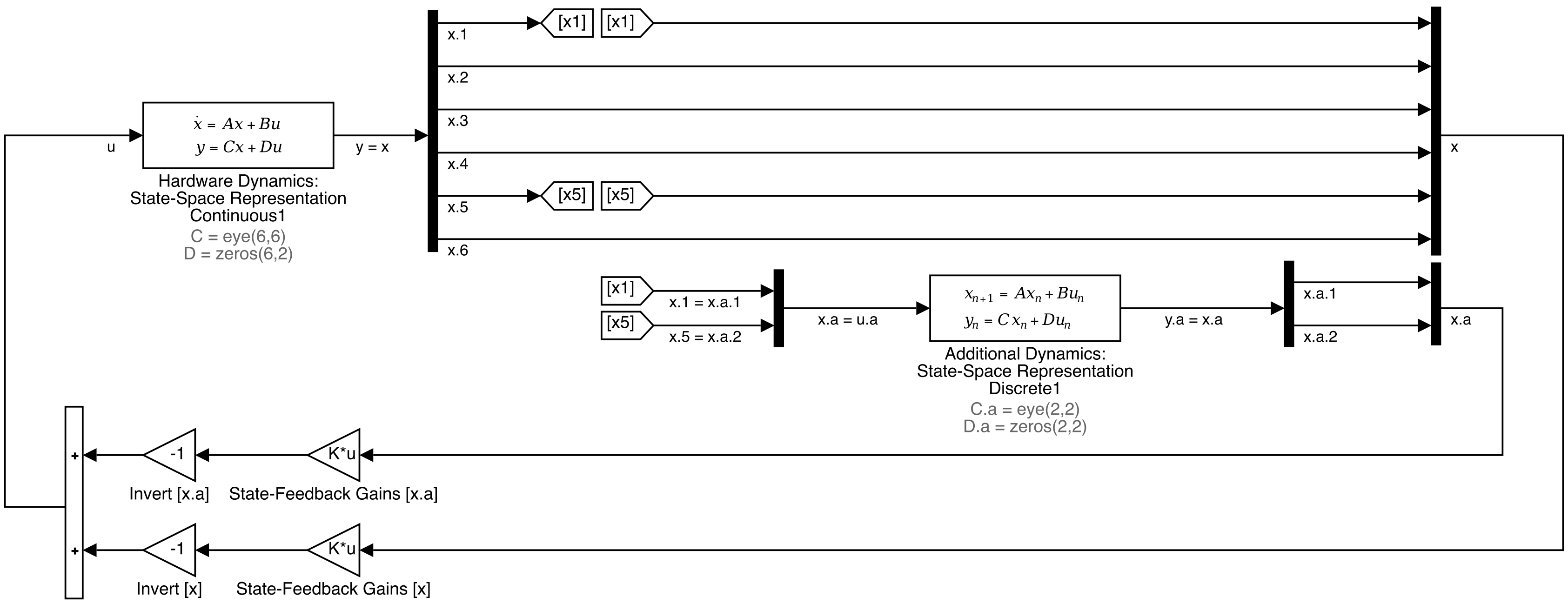

Figure 0.5: [Additional Dynamics]: 2.0 Additional Dynamics (Split Gains)

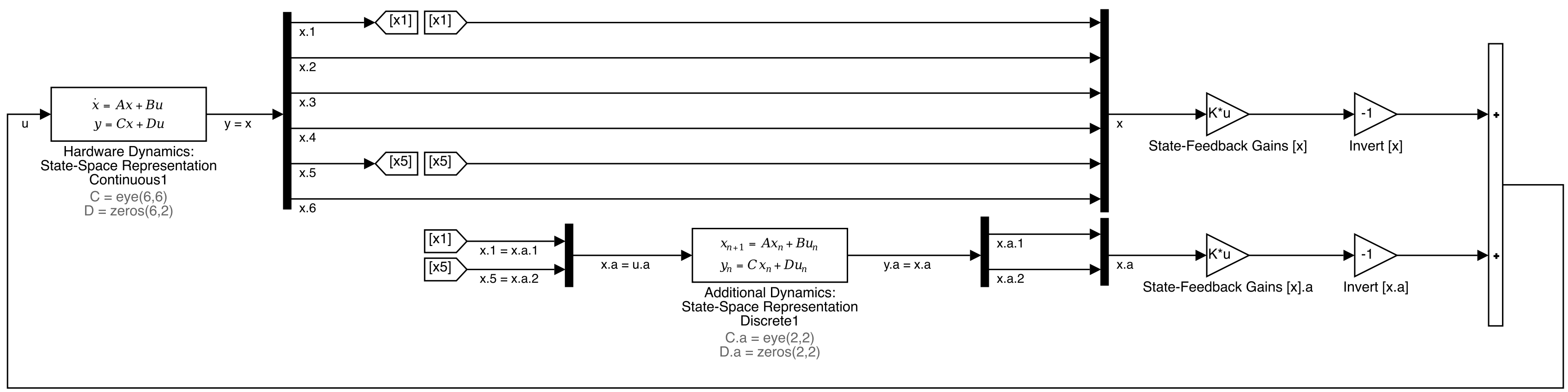

Figure 0.6: [Additional Dynamics]: 3.0 Additional Dynamics (Linear View: Plant)

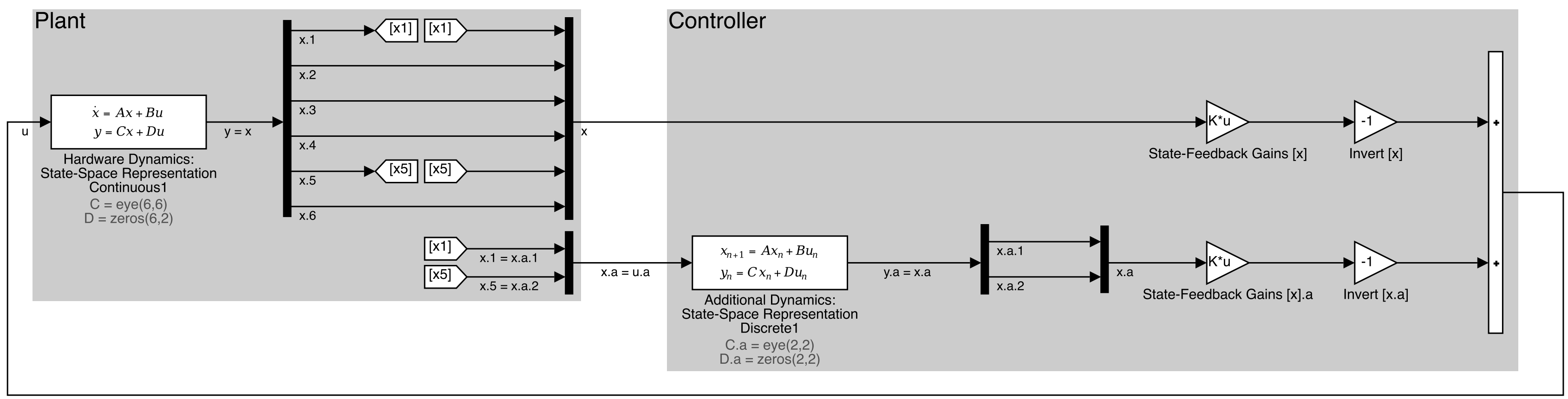

Figure 0.7: [Additional Dynamics]: 3.1 Additional Dynamics (Linear View: Plant)

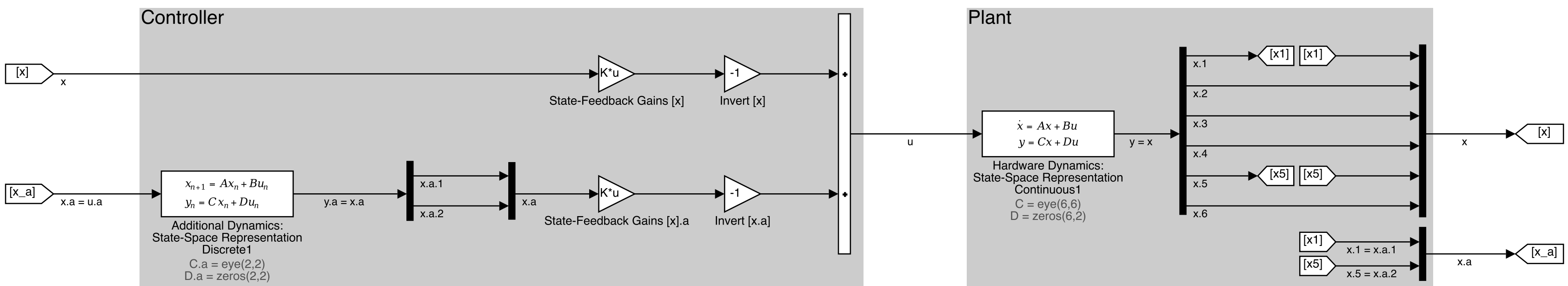

Figure 0.8: [Additional Dynamics]: 4.0 Additional Dynamics (Linear View: Controller)

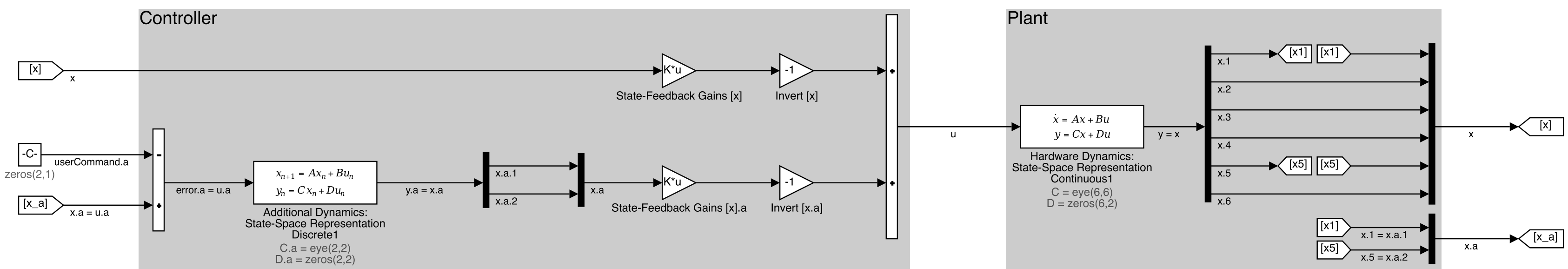

Figure 0.9: [Additional Dynamics]: 4.0 Additional Dynamics with Reference Signal (Linear View: User)

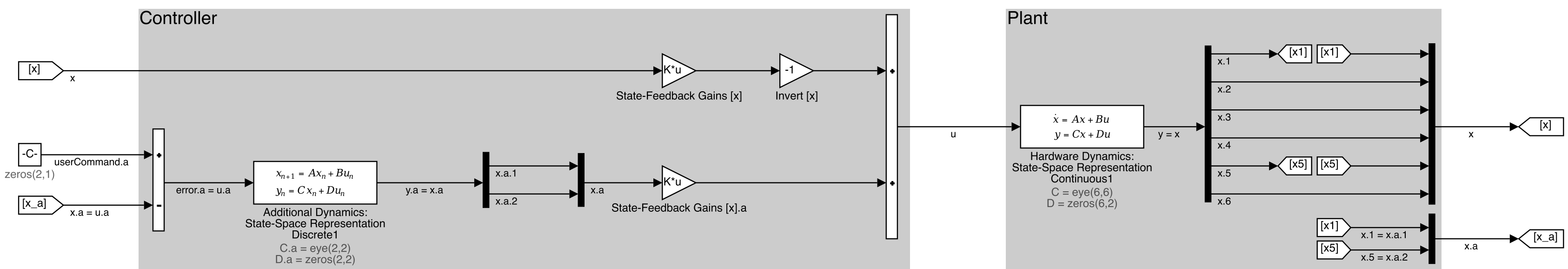

Figure 0.10: [Additional Dynamics]: 4.0 Additional Dynamics with Reference Signal (Linear View: User)

0.0.1.1 Reference Signal

Recall that a standard state-feedback regulator simply brings its inputs, [*in this case, system states* x *and* x_a], to zero. If it is desired that a controller input be brought to a value other than zero, a reference signal may be implemented.

In these cases, rather than input the controller with a state which the controller will bring to zero, the controller is input with the difference between the state value and the reference [*desired*] value. This difference is commonly known as the error signal. Once the error signal is brought to zero for a given state, the state will be equivalent to the desired reference value.

Returning to system depiction, a reference command is implemented, as depicted in Figure 0.9.

Note that the reference signal receives the negative. Inverting the system state alters the system equation, and could cause the system to become unstable.

Despite this fact, it is sometimes more common to see the system state subtracted from the reference signal. To correctly achieve this, once the reference signal is implemented, either side of the difference equation is multiplied by -1. The negative on the input side is distributed to both inputs. The output of the difference equation is the input of the additional dynamics; thus, when the negative appears on the output side of the difference equation, a negative exists on either side of the additional dynamics equation.

Recall that all state-space representations are linear; therefore, the input and the output may be multiplied by the same value. In this case, the negative may be divided out on both sides.

These changes are depicted in Figure 0.10.