3rd Semester Project - System Architectural Design

Group 2

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0.01	06.03.16	All members	First version

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1.2 General System Description

Block Definition Diagram

The Block Definition Diagram for the general system defines which general subsystems the FLEX-VAULT consists of. The subsystems in the FLEX-VAULT contain other subsystems, which are described later on in this document. The general Block Definition Diagram can be seen on figure 1.1.

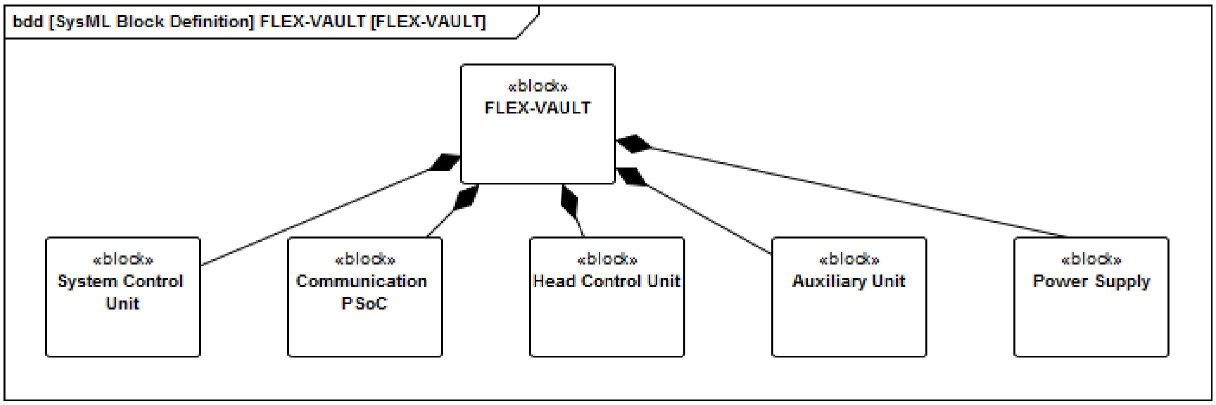

Figure 1.1: General Block Definition Diagram of the FLEX-VAULT

Internal Block Diagram

The Internal Block Diagram for the general system shows how the different subsystems in the FLEX-VAULT are connected to each other. The diagram can be seen on figure 1.2. As shown in the figure, all the subsystems are connected to the Power Supply. The System Control Unit is connected to the Communication PSoC, which is connected to the Head Control Unit and the Auxiliary Unit.

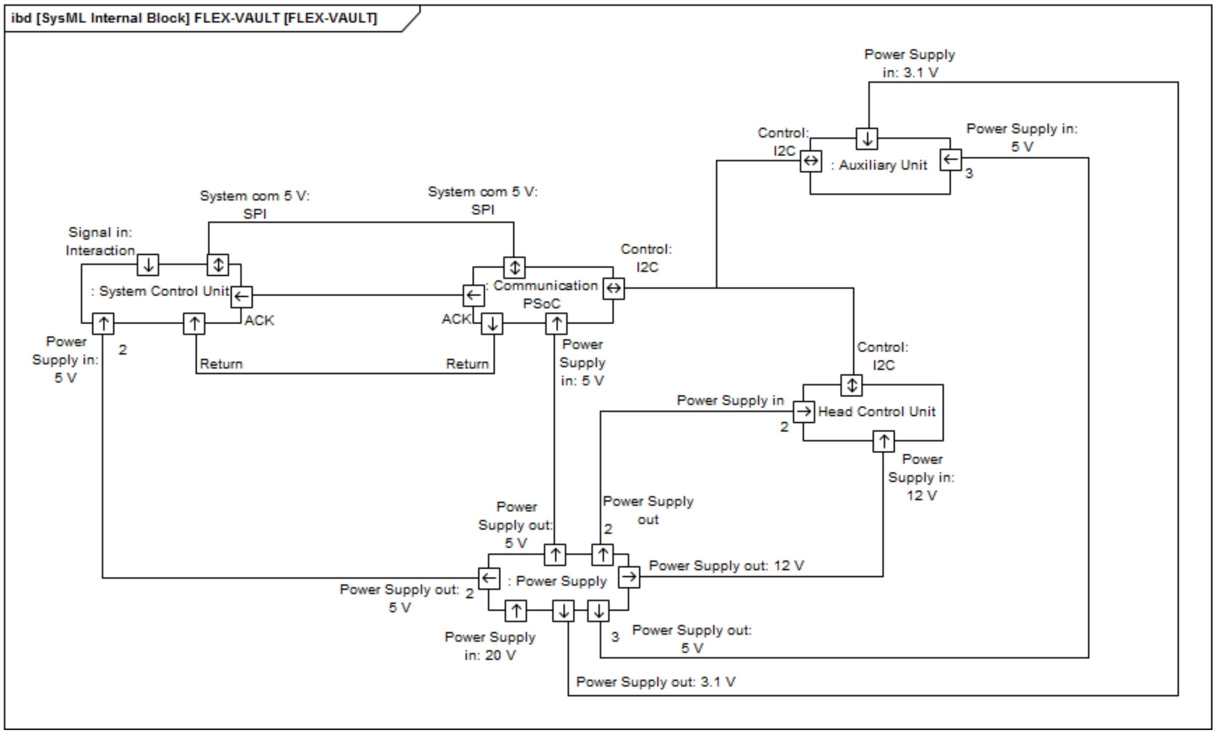

Figure 1.2: General Internal Block Diagram of the FLEX-VAULT

Allocation Diagram

The Allocation Diagram of the system can be seen on figure 1.3. The diagram shows which single-board computers that the software of the different subsystems is allocated to. As shown on the diagram, there are three PSoC boards, and one BeagleBone Black board. The BeagleBone Black is used as the System Controller, which the User or Admin interacts with. While as the three PSoC's are controlled by the BeagleBone Black. The diagram shows e.g. that the software for the System Control Unit is allocated on the BeagleBone Black.

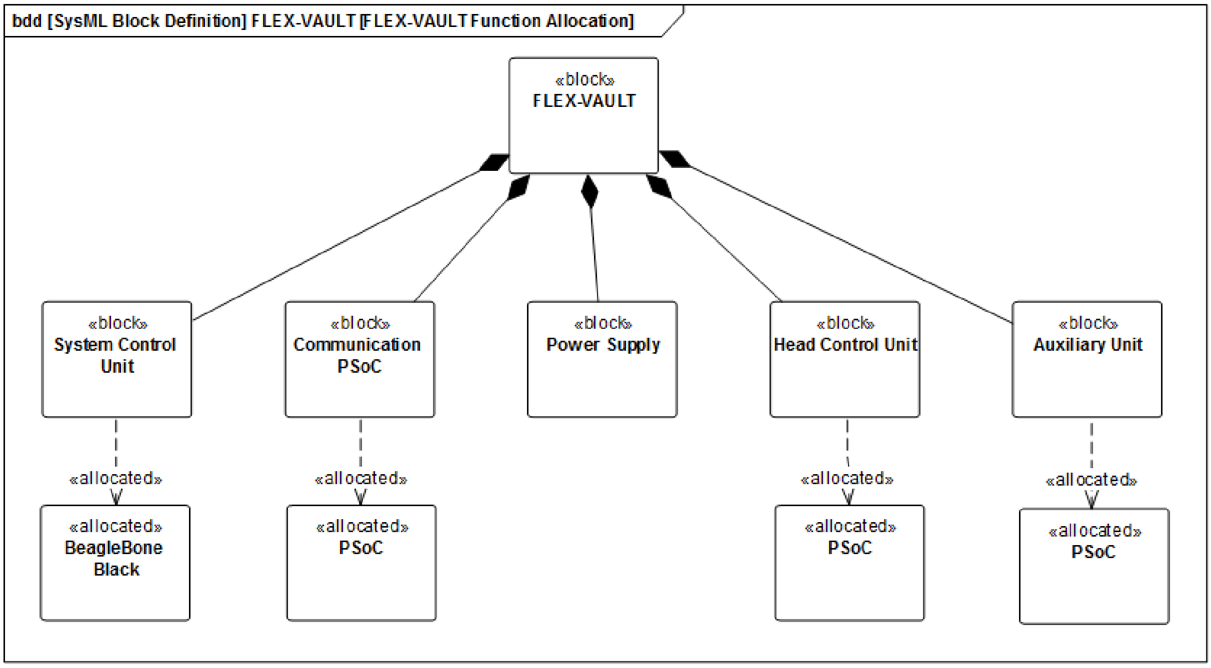

Figure 1.3: General Allocation Diagram of the FLEX-VAULT

1.3 Interfaces

SPI

For the communication between System Control Unit and Communication PSOC a SPI interface is implemented. The SPI standard is defined in "SPI.pdf" in the data sheets folder.

Table 1.1: Functions send through the SPI interface.

Description	**Function**			**SDB id**				
Bit number	0	1	2	3	4	5	6	7
retrieveSDB	0	1	0	x	x	x	x	x
returnSDB	1	0	1					

I2C

For the communication between Communication PSoC, Auxiliary Unit and System Control Unit a I2C interface is implemented. The I2C interface is defined in "I2C-standard.pdf" in the data sheets folder. The I2C bus enables the PSoC's to transmit and receive packages in an 8-bit format. The PSoC's addresses can be seen in Table 1.2.

Table 1.2: I2C addresses

Unit	**7-bit I2C Address**	**R/W bit**
Communication PSoC	1111100	1
Auxiliary unit	1111101	1
Head control unit	1111110	1

I2C interface between Communication PSoC and Head Control Unit

To control Head Control Unit the Communication PSoC has to send a SDB id between 0-20 which translates to position for the specific SDB. Therefore 5 bits are reserved for the SDB id and the rest for a function code. In this case Communication PSoC takes the role as master and Head Control Unit is the slave. The bit sequence can be seen on Table 1.3

Table 1.3: Byte description of a byte sent from Communication PSoC to Head Control Unit

Bit number	0	1	2	3	4	5	6	7
Description	Function			SDB id				

When Head Control Unit has received and executed the command it will take the role as master and Communication PSoC will become slave. Head Control Unit will transmit an ASCII value with either an acknowledgement or an error in case something has gone wrong. The bit sequence can be seen on Table 1.4

Table 1.4: ASCII values of a byte send from Head Control Unit to Communication PSoC

Bit number	0	1	2	3	4	5	6	7
Error	0	0	0	1	0	1	0	1
Success	0	0	0	0	0	1	1	0

I2C interface between Communication PSoC and Auxiliary Unit

The Auxiliary unit has multiple things that needs communication with the Communication PSoC. The data gathered from the strain gauge needs to be returned to the Communication PSoC upon request and it also has to receive commands from the Communication Psoc for moving the shelves back and fourth and locking/unlocking the hatch.

The Communication PSoC can request moving the shelves and locking/unlocking the hatch with the following commands on Table 1.5:

Table 1.5: Byte description of commands send from Communication PSoC to Auxiliary Unit

Bit number	0	1	2	3	4	5	6	7
Lock Hatch	0	0	0	0	0	0	0	1
Unlock Hatch	0	0	0	0	0	0	1	0
Move Shelves Forward	1	1	1	1	1	0	1	0
Move Shelves Back	1	1	1	1	1	0	0	1
Get Weight	1	1	1	1	0	1	0	1

When Auxiliary Unit has received and executed the command it will take the role as master and Communication PSoC will become slave. Auxiliary Unit will transmit an ASCII value with either an acknowledgement or an error in case something has gone wrong. The bit sequence can be seen on Table 1.6.

In case that the "Get Weight" command is called an extra byte will be transmitted with an 8-bit value containing the weight measurement from the Strain Gauge.

Table 1.6: ASCII values of a byte send from Auxiliary unit to Communication PSoC

Bit number	0	1	2	3	4	5	6	7
Error	0	0	0	1	0	1	0	1
Success	0	0	0	0	0	1	1	0

1.4 Hardware Architecture

System Control Unit

The System Control Unit consists of three subsystems, System Controller, Display, and Display Power Supply. The block definition diagram of the System Control Unit can be seen on figure 1.4.

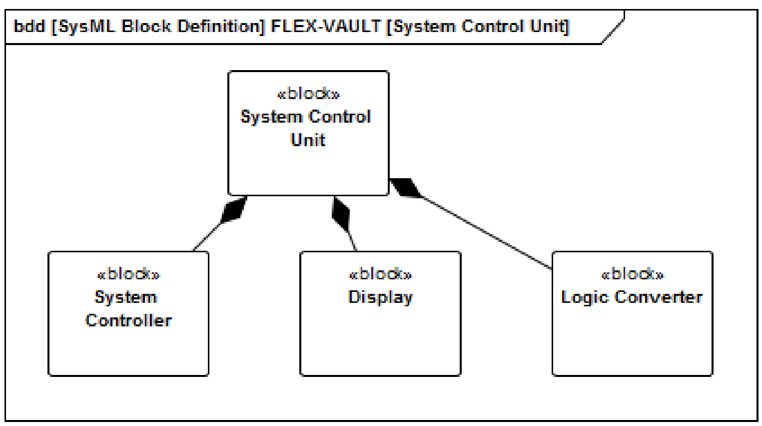

Figure 1.4: Block Definition Diagram of the System Control Unit.

The connections between the subsystems in the System Control Unit can be seen on the internal block diagram. The diagram is shown on figure 1.5.

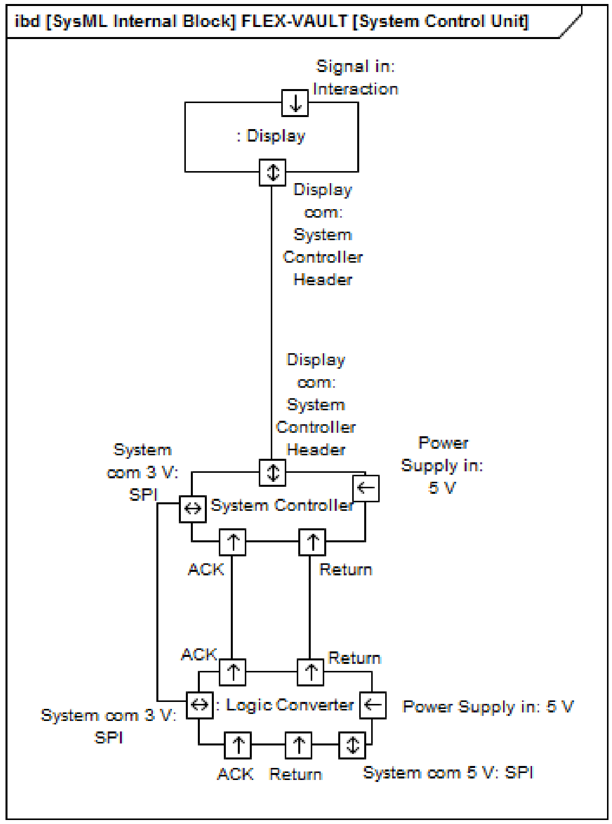

Figure 1.5: Internal Block Diagram of the System Control Unit.

Head Control Unit

The Head Control Unit consists of three subsystems, Hall Effect Sensor, Head Horizontal Motor, and Head Controller. These three subsystems themselves contain different subsystems. These are shown on the block definition diagram for the Head Control Unit on figure 1.6.

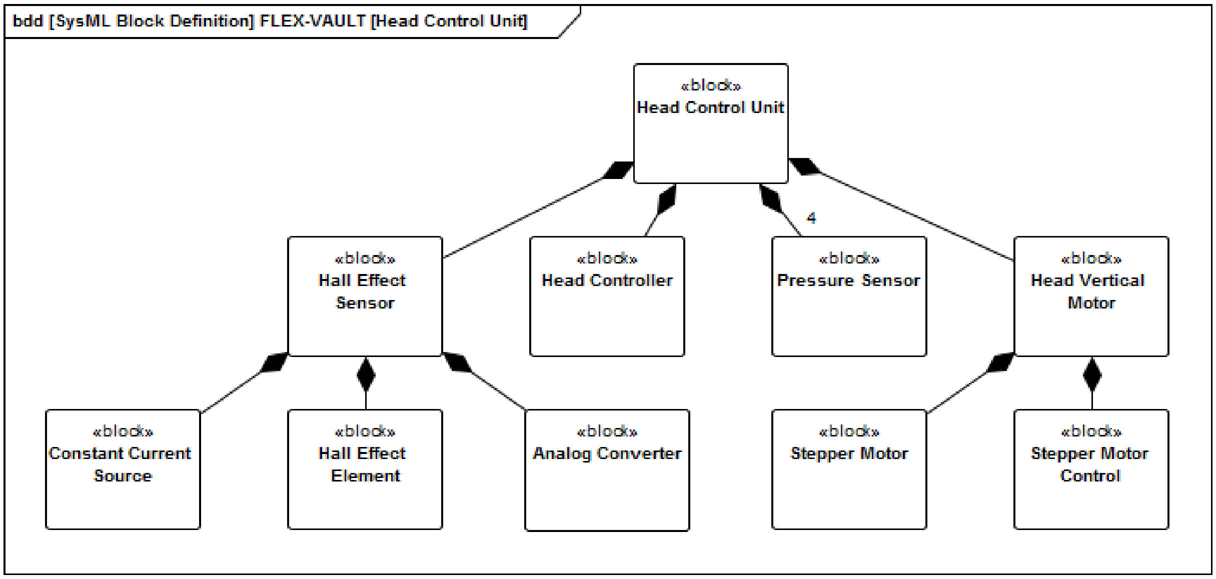

Figure 1.6: Block Definition Diagram of the Head Control Unit.

The connections between the subsystems in the Head Control Unit can be seen on the internal block diagram. The diagram can be seen on figure 1.7.

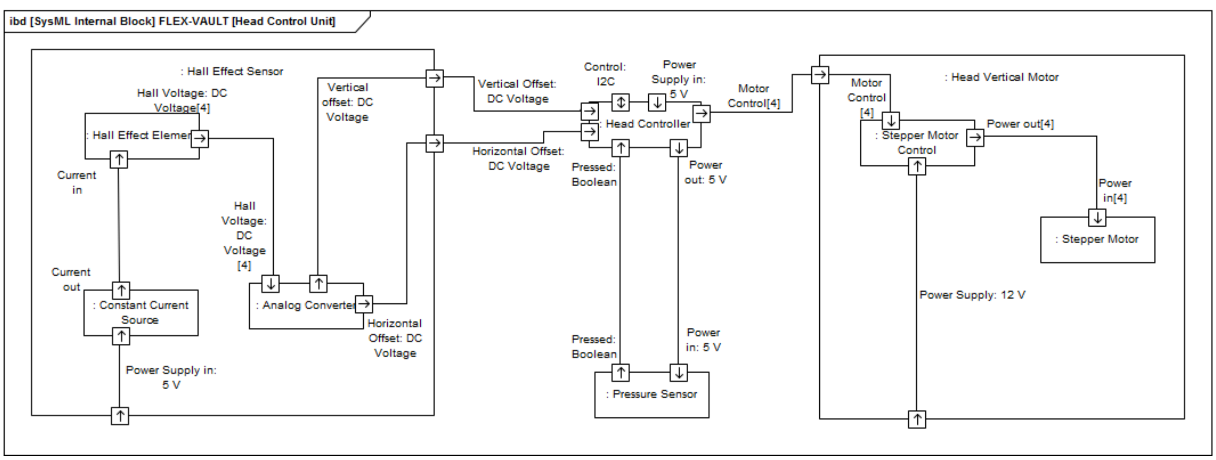

Figure 1.7: Internal Block Diagram of the Head Control Unit.

Auxiliary Unit

The Auxiliary Unit consists of 4 different types of subsystems. This subsystem doesn't have a high cohesion. It designed to control auxiliary systems. Figure 1.8 shows the block definition diagram for the Auxiliary Unit. The diagram shows the different subsystems that the Auxiliary Unit consists of.

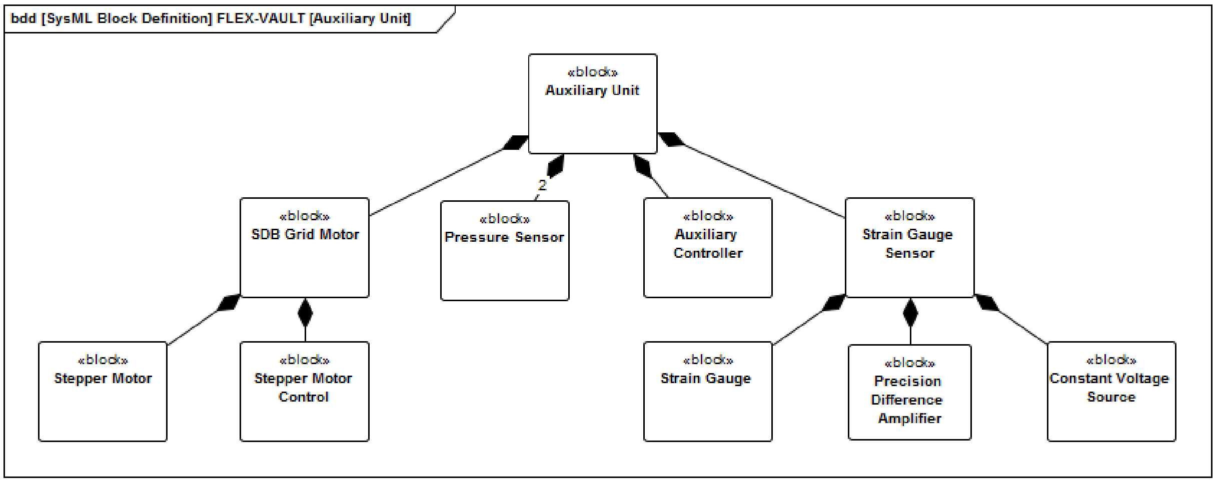

Figure 1.8: Block Definition Diagram of the Auxiliary Unit.

The connections between the subsystems in the Auxiliary Unit can be seen in the internal block diagram. The diagram can be seen on figure 1.9.

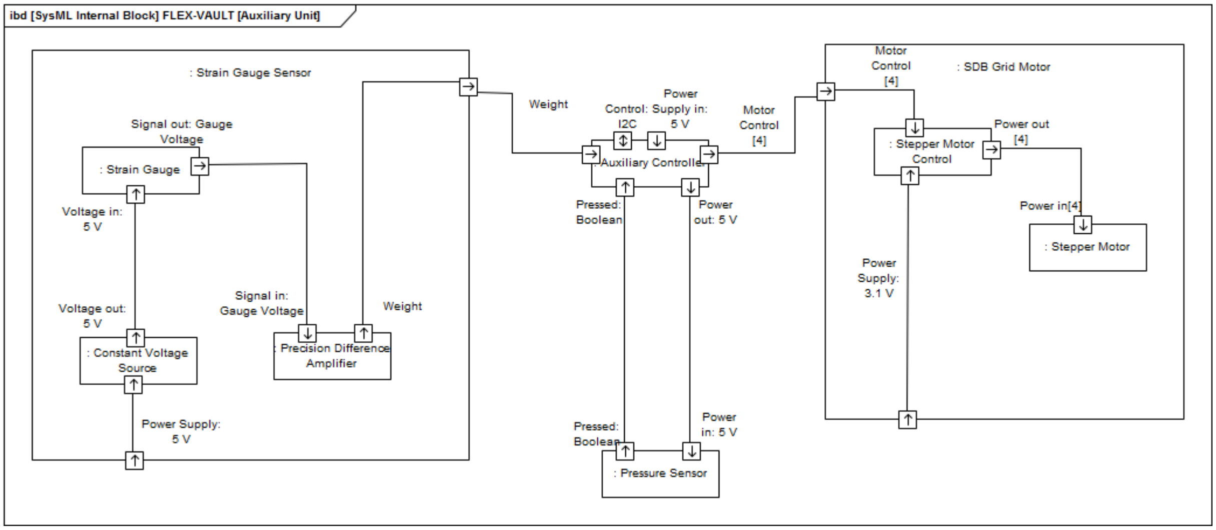

Figure 1.9: Internal Block Diagram of the Auxiliary Unit.

Signal Descriptions

The signals in the FLEX-VAULT internal block diagram are described in the following table.

Table 1.7: Signal Descriptions of FLEX-VAULT

Signal name	**Definition**	**Description**
System com 5V: SPI	5 V SPI	SPI signal connects Logic Converter to Communication PSoC.
Control: I2C	I2C	I2C signal connects Communcation PSoC to Auxiliary Controller and Head Control Unit.
Signal in: Interaction	Interaction	An interaction on the Display from an actor.
Power Supply in: 20 V	20 V +/- 1 V	20 V power supply
ACK	ACK	Acknowledgement signal sent from Communication PSoC to Logic Converter.
Return	Return	Return signal sent from Communication PSoC to Logic Converter.
Power Supply in: 5 V	5 V +/- 0.5 V	5 V power supply received from Power Supply.
Power Supply out: 5 V	5 V +/- 0.5 V	5 V power supply sent from Power Supply to other units.
Power Supply in: 3.1 V	3.1 V +/- 0.5 V	3.1 V power supply received from Power Supply.
Power Supply out: 3.1 V	3.1 V +/- 0.5 V	3.1 V power supply sent from Power Supply to other units.
Power Supply in: 12 V	12 V +/- 0.5 V	12 V power supply received from Power Supply.
Power Supply out: 12 V	12 V +/- 0.5 V	12 V power supply sent from Power Supply to other units.

The signals in the System Control Unit internal block diagram are described in the following table.

Table 1.8: Signal Descriptions of the System Control Unit

Signal name	**Definition**	**Description**
Display com: System Controller Header	Boolean	Signal for information sent between Display and System Controller.
System com 3 V: SPI	3.3 V SPI	SPI signal connects System Controller to Logic Converter.

The signals in the Head Control Unit internal block diagram are described in the following table.

Table 1.9: Signal Descriptions of the Head Control Unit

Signal name	Definition	Description
Current out	5 mA +/- 1 mA	Current sent from Constant Current Source.
Current in	5 mA +/- 1 mA	Current received by Hall effect Element.
Hall Voltage: DC Voltage	DC Voltage	DC Voltage sent out from Hall Effect Element. Voltage varies in response to a magnetic field.
Vertical Offset: DC Voltage	DC Voltage	Vertical voltage offset.
Horizontal Offset: DC Voltage	DC Voltage	Horizontal voltage offset.
Pressed: Boolean	Boolean	Sends a Boolean from Pressure Sensor to Controller, notifying if the sensor is pressed.
Motor Control	Boolean	Controller sends 5 V or 0 V out to Stepper Motor Control, to control the motors steps.
Power out	AC Voltage	Power sent to Stepper Motor from Stepper Motor Control.
Power in	AC Voltage	Power received by Stepper Motor.

The signals in the Auxiliary Unit internal block diagram are described in the following table.

Table 1.10: Signal Descriptions of the Auxiliary Unit

Signal name	Definition	Description
Voltage out: 5 V	5 V +/- 0.1 V	5 V Voltage output from Constant Voltage Source.
Voltage in: 5 V	5 V +/- 0.1 V	5 V voltage input to Strain Gauge.
Signal out: Gauge voltage	DC Voltage	Gauge Voltage signal sent from Strain Gauge.
Signal in: Gauge voltage	DC Voltage	Gauge Voltage signal received by Precision Difference Amplifier.
Weight	DC Voltage	The weight of the item is sent to the Auxiliary Controller.

Block Descriptions

The blocks in the FLEX-VAULT block definition diagram are described in the following table.

Table 1.11: Block Descriptions for FLEX-VAULT

Block name	**Description**
System Control Unit	Contains Logic Converter, Display, and System Controller.
Communication PSoC	PSoC used to communicate with System Controller, Head Controller and Auxiliary Controller.
Head Control Unit	Contains Hall Effect Sensor, Head Controller, 4 Pressure Sensors, and Head Vertical Motor. Used to control the "Head" in the system.
Auxiliary Unit	Unit contains SDB Grid Motor, 2 Pressure Sensors, Auxiliary Controller, and Strain Gauge Sensor.
Power Supply	Supplies all units with power. Can supply 3.1 V, 5 V, and 12 V.

The blocks in the System Control Unit block definition diagram are described in the following table.

Table 1.12: Block Descriptions for System Control Unit

Block name	**Description**
System Controller	System Controller is a BeagleBone Black used to control Display and save Log information.
Display	Displays the GUI.
Logic Converter	Converts a 3.3 V SPI signal to a 5 V SPI signal.

The blocks in the Head Control Unit block definition diagram are described in the following table.

Table 1.13: Block Descriptions for Head Control Unit

Block name	**Description**
Hall Effect Sensor	Sends vertical and horizontal offset DC voltage to Head Controller, expressing the position of the Hall Effect Sensor relative to a magnetic field.
Hall Effect Element	Varies its output voltage, when affected by a magnetic field.
Analog Converter	Converts DC voltage from Hall Effect Element to a vertical and horizontal DC voltage offset.
Constant Current Source	Sends current to Hall Effect Element to supply it with power.
Head Vertical Motor	Motor that controls vertically moving the "Head" in the system.
Stepper Motor	Stepper Motor used to move the "Head" in the system.
Stepper Motor Control	Circuit that controls the Stepper Motors steps.
Pressure Sensor	Detects if something is pressed against the sensor, and sends the result to the Head Controller.
Head Controller	Controls the Head Vertical Motor, and receives information from Hall Effect Sensor and Pressure Sensor.

The blocks in the Auxiliary Unit block definition diagram are described in the following table.

Table 1.14: Block Descriptions for Auxiliary Unit

Block name	**Description**
SDB Grid Motor	Motor that controls moving the shelves back and forth.
Stepper Motor	Stepper Motor used to move the shelves back and forth.
Stepper Motor Control	Circuit that controls the Stepper Motors steps.
Strain Gauge Sensor	Measures a weight, and sends it to Auxiliary Controller.
Strain Gauge	Measures an electrical resistance, and sends it out as a gauge voltage.
Precision Difference Amplifier	Makes the gauge voltage be more precise, and sends the measured weight to Auxiliary Controller.
Constant Voltage Source	Contant Voltage that sends 5 V as output.
Auxiliary Controller	Controls the SDB Grid Motor, and receives information from Strain Gauge Sensor, and from Pressure Sensor.

1.5 Software Architecture

Domain Model

The domain model was created to give an overview of the behaviour of the system and to show how the various system modules interact.

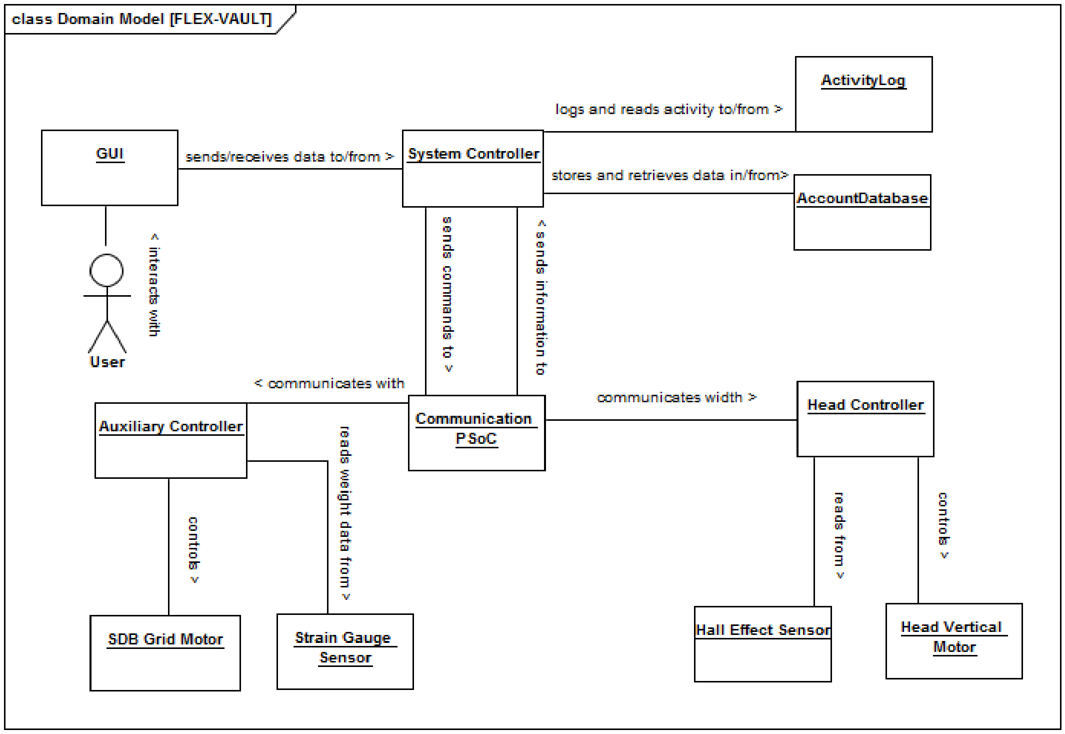

Figure 1.10: Domain Model of entire system.

System Control Unit

The System Control Unit consists of a display and a single board computer where the Linux distribution runs. The software for the GUI, activity log and the database containing account information is placed on this unit.

Sequence diagrams

Sequence diagrams related to each use case have been made in order to identify methods needed to describe the use case functionality.

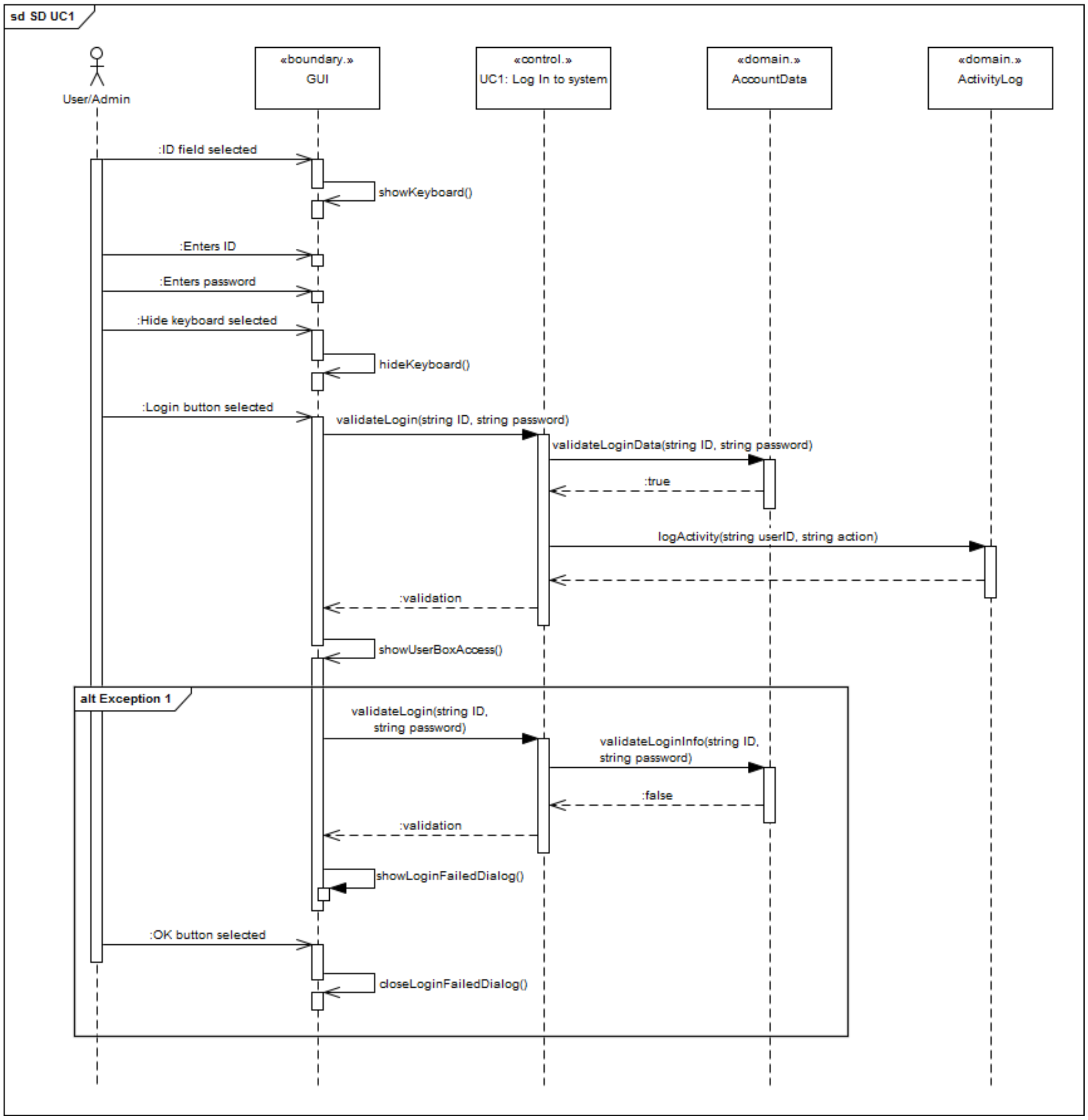

Figure 1.11: Sequence diagram of Usecase 1.

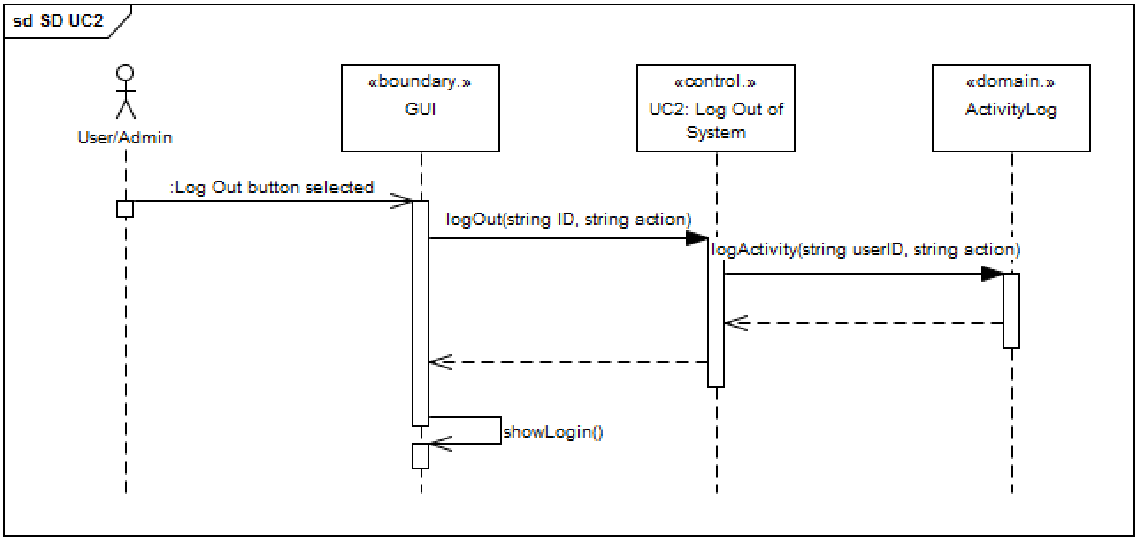

Figure 1.12: Sequence diagram of Usecase 2.

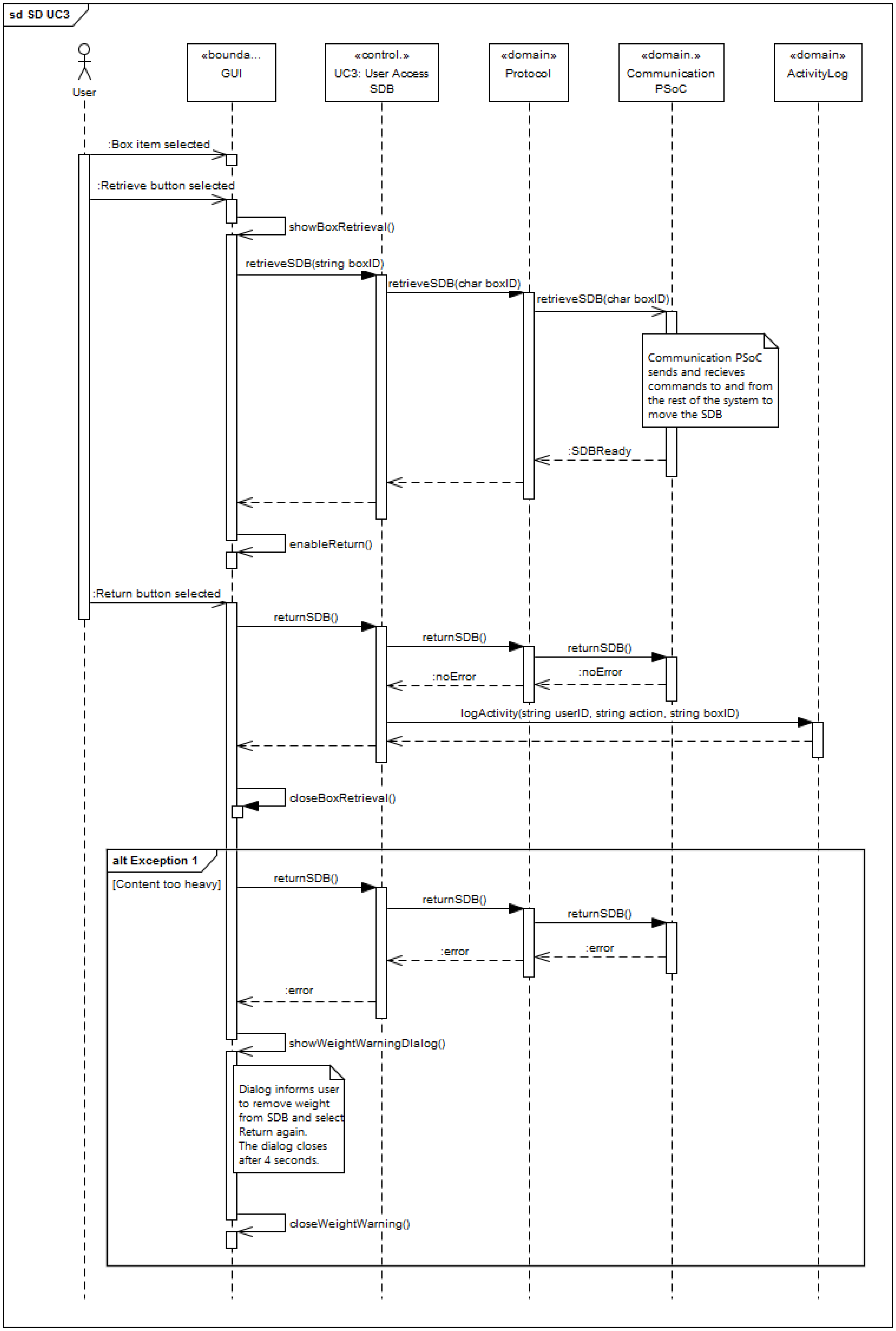

Figure 1.13: Sequence diagram of Usecase 3.

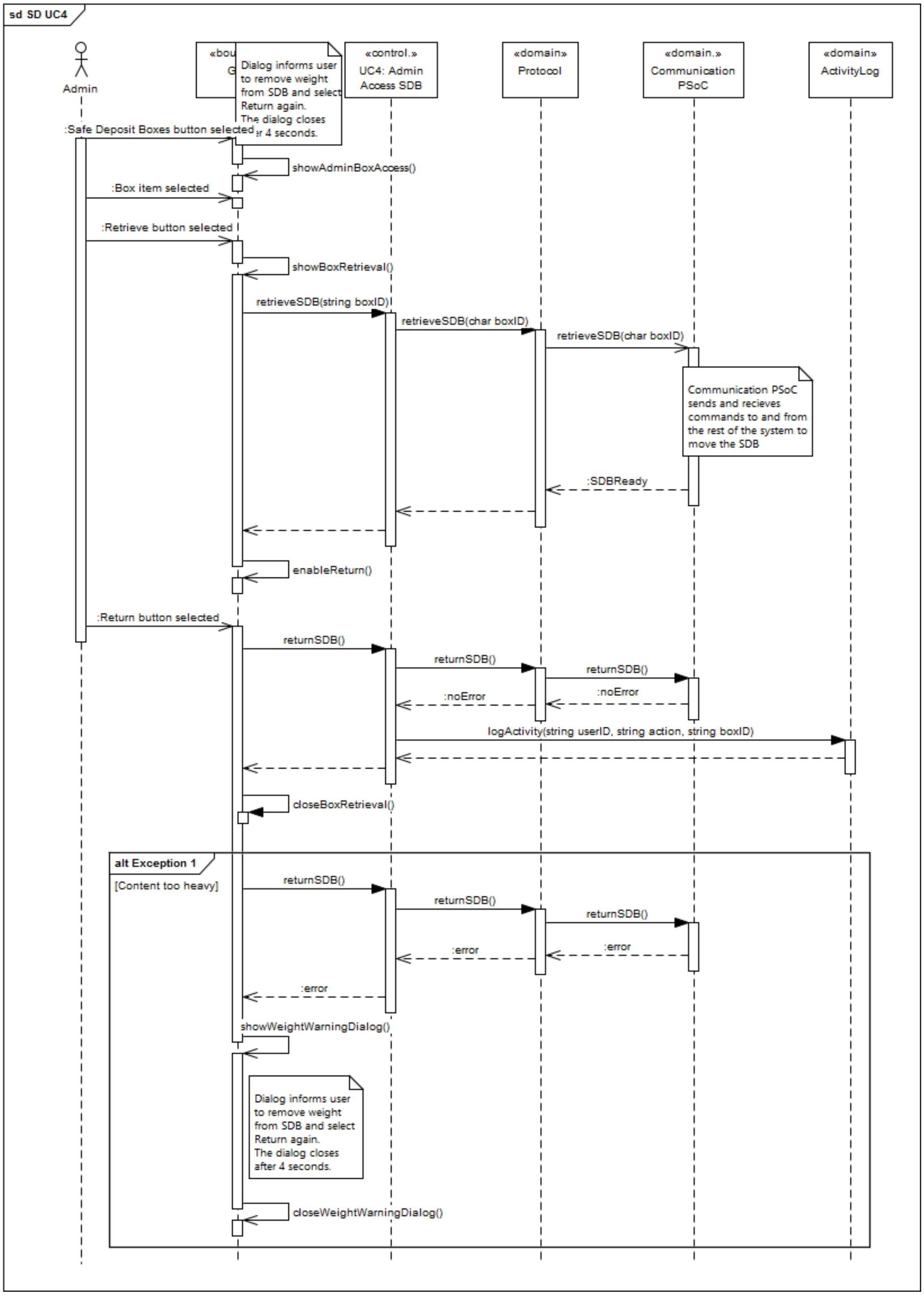

Figure 1.14: Sequence diagram of Usecase 4.

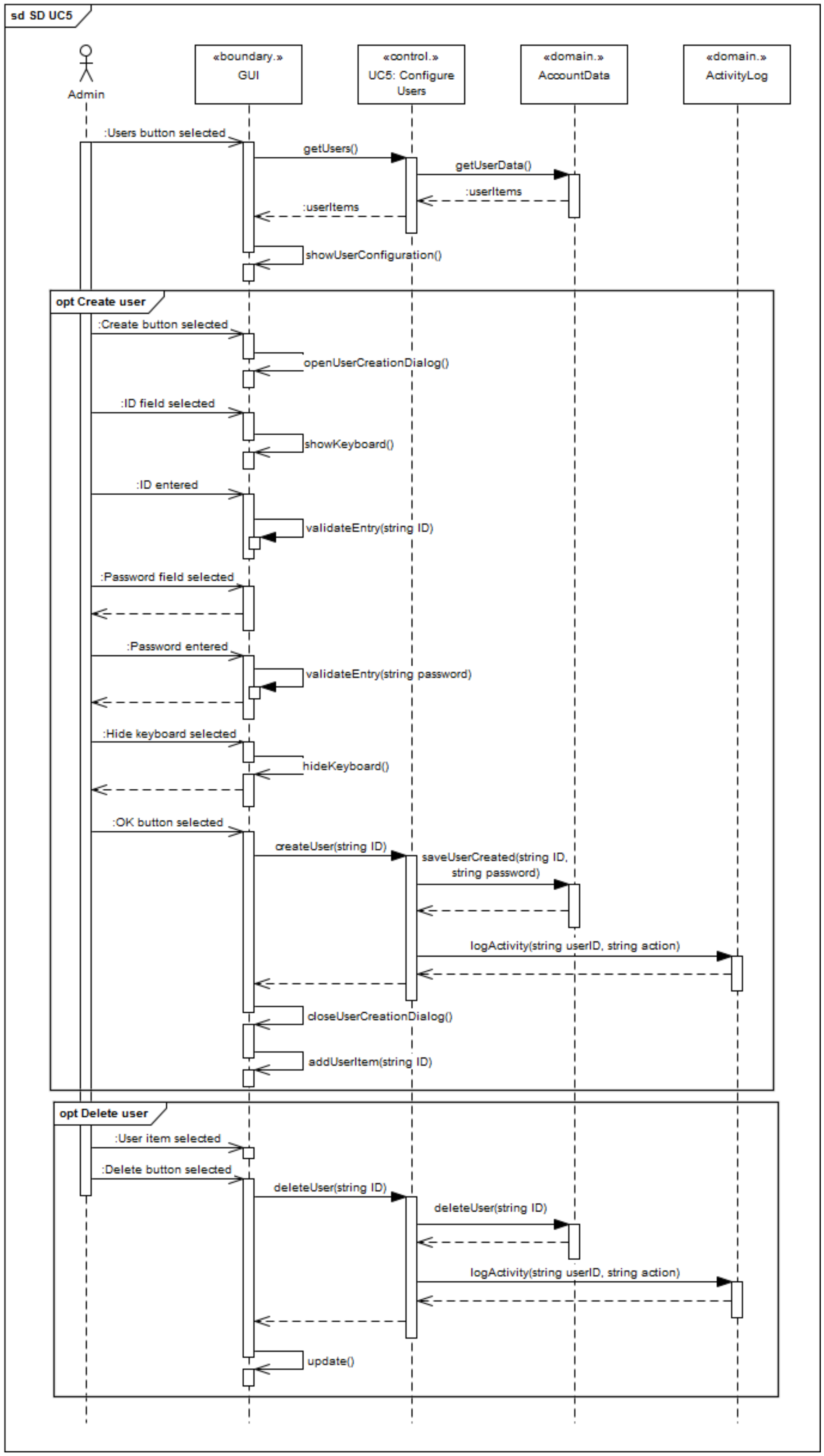

Figure 1.15: Sequence diagram of Usecase 5.

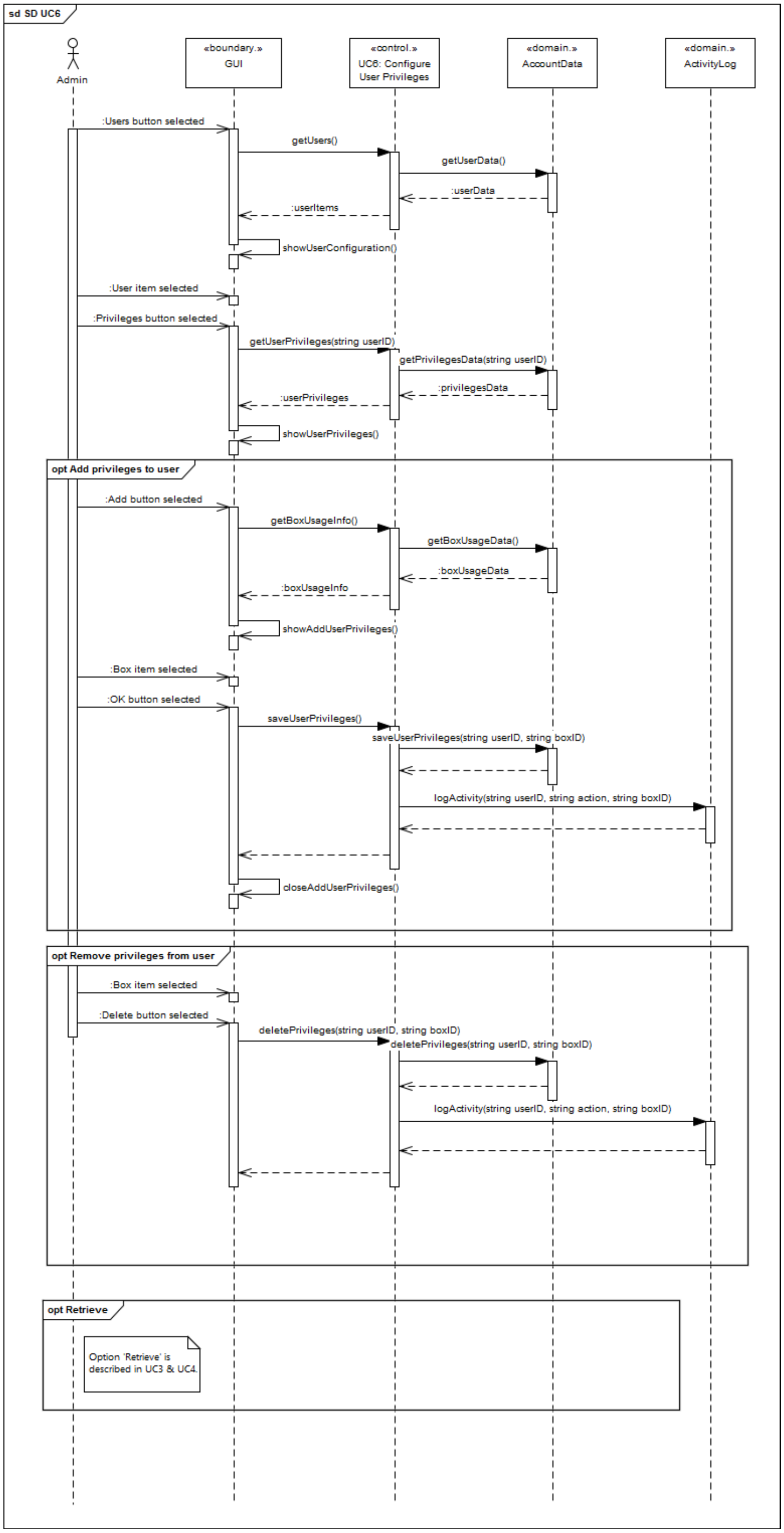

Figure 1.16: Sequence diagram of Usecase 6.

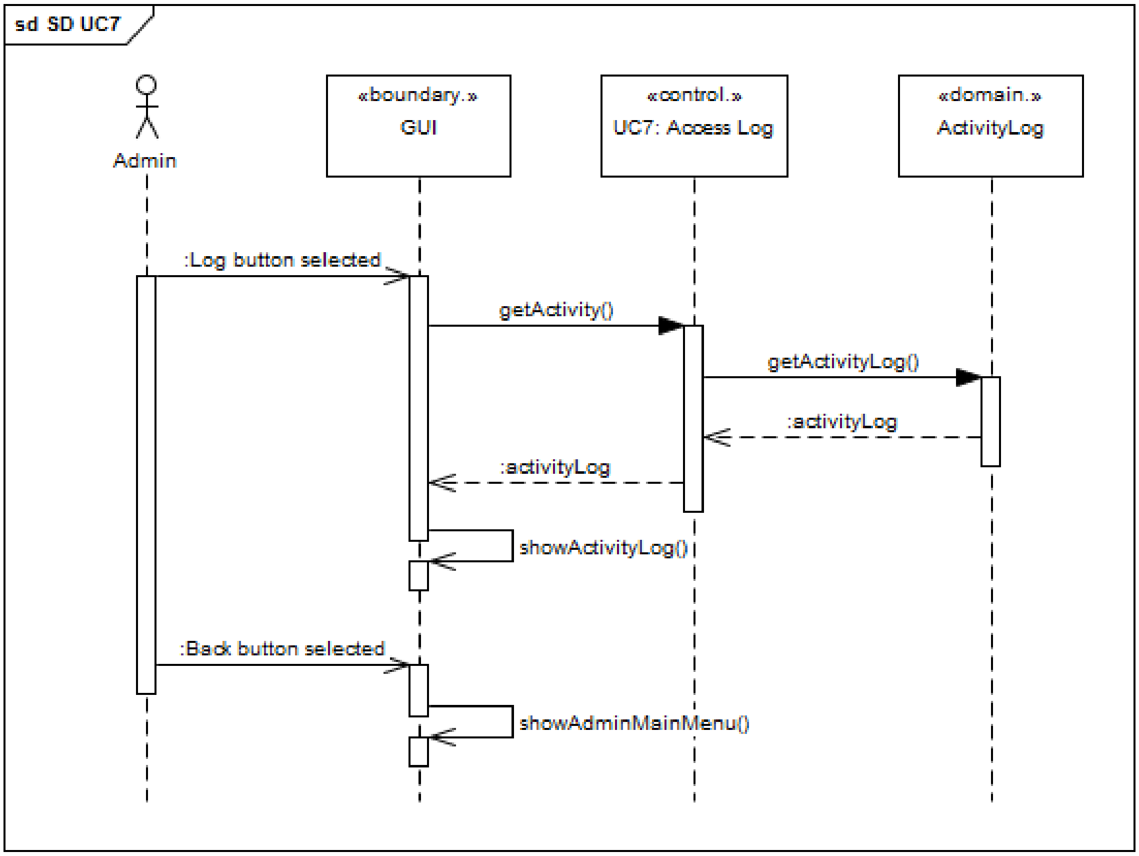

Figure 1.17: Sequence diagram of Usecase 7.

Class Diagram

The class diagram is made up from the functions identified in the sequence diagrams for the System Controller. The system control class has been made up from each use case control class and their corresponding functions.

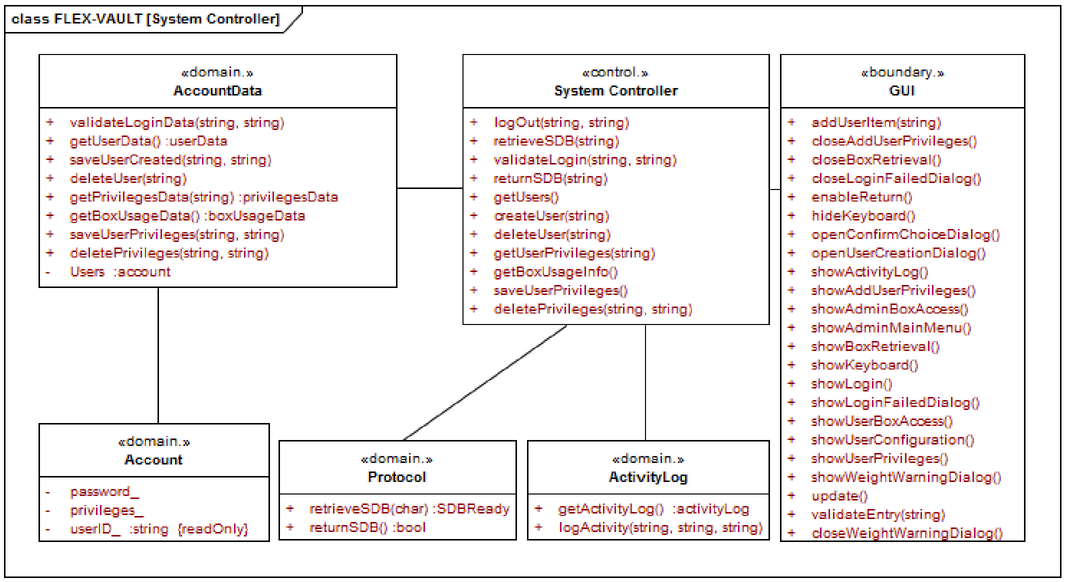

Figure 1.18: Class Diagram of System Controller SW.

Communication PSoC, Auxiliary Unit, Head Control Unit

Use Case 3 and 4 are identical in the communication layer between System Control, Communication PSoC, Auxiliary Control and Head Control so it is combined in one sequence diagram in Figure 1.19.

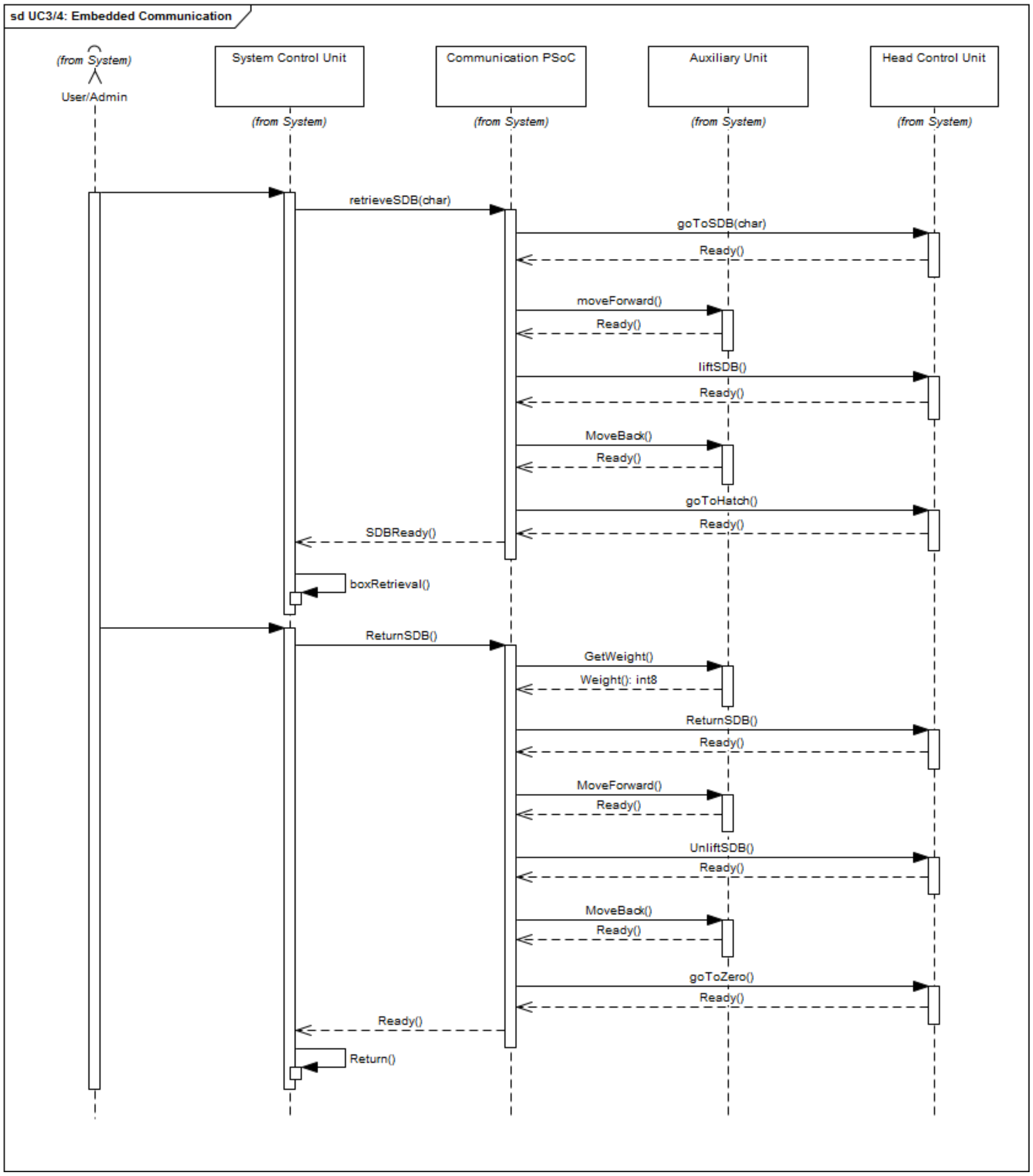

Figure 1.19: Sequence Diagram for Embedded Communication in UC 3/UC 4