

# Altium Designer

## Advanced Course

Module: Using Signal Harnesses

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# Table of Contents

<b>Using Signal Harnesses</b>	<b>3</b>
<b>1.1 Purpose</b>	<b>3</b>
<b>1.2 Shortcuts</b>	<b>3</b>
<b>1.3 Overview</b>	<b>3</b>
1.3.1 Working on the Top Sheet .....	3
1.3.2 Schematic Navigation .....	4
<b>1.4 Creating a Signal Harness</b>	<b>5</b>
1.4.1 Starting a Signal Harness from Scratch .....	5
1.4.1.1 Harness Connector .....	5
1.4.1.2 Adding Harness Entries to the Harness Connector .....	6
1.4.1.3 Adding a Signal Harness & Port .....	7
1.4.1.4 Creating the matching Harness for UART7_MB .....	9
1.4.2 Using Predefined Harness information .....	9
1.4.3 Smart Paste for Harness .....	11
1.4.4 Nested Harness information .....	12
1.4.5 Making the Harness connection on Top Sheet .....	14
1.4.5.1 Creating the matching UART7_MB Harness on the Top Sheet .....	14
1.4.5.2 Synchronizing all remaining Sheet Entries and Signal Harnesses .....	17

# Using Signal Harnesses

## 1.1 Purpose

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A Signal Harness is an electrical design primitive. It is an abstract connection that enables the logical grouping of different signals including buses, wires and other signal harnesses, for increased flexibility and streamlined design. They are more complex to create and manage, but the reward is that they can greatly simplify the presentation of a schematic and enhance its readability.

## 1.2 Shortcuts

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**F1:** Help – Shortcut Key List

**P » H » H:** Place a Signal Harness

**P » H » C:** Place a Harness Connector

**P » H » E:** Place a Harness Entry

**P » H » P:** Open the Predefined Harness Connector Dialog

**D » P:** Synchronize Sheet Entries and Ports

## 1.3 Preparation

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1. **Close all existing projects and documents.**
2. Open the `Using Signal Harnesses.PrjPCB` project found in its respective folder of the Advanced Training.

## 1.4 Overview

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### 1.4.1 Working on the Top Sheet

3. Open the `0_TOP_Sheet.SchDoc` from the *Projects* panel.
4. In this exercise, we will finish the design by adding the missing harness information so that the final result will look similar to Figure 1.

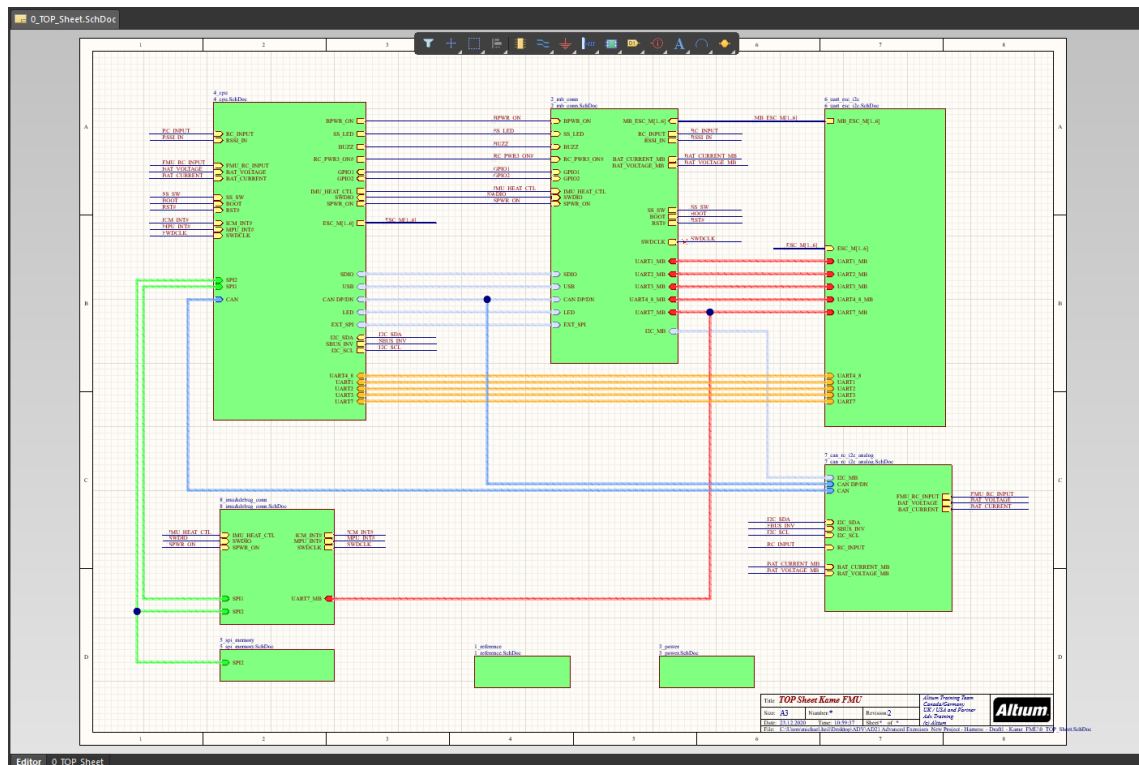


Figure 1. Final TOP Sheet

## 1.4.2 Schematic Navigation

- In the schematic, hover over the existing SPI2 harness connection to see the individual signals that are included in the harness. You will see the SPI2 nets as shown in Figure 2.



The design insight settings for hovering can be configured in the *Preferences* under the *System* section, in the *Design Insight* page.

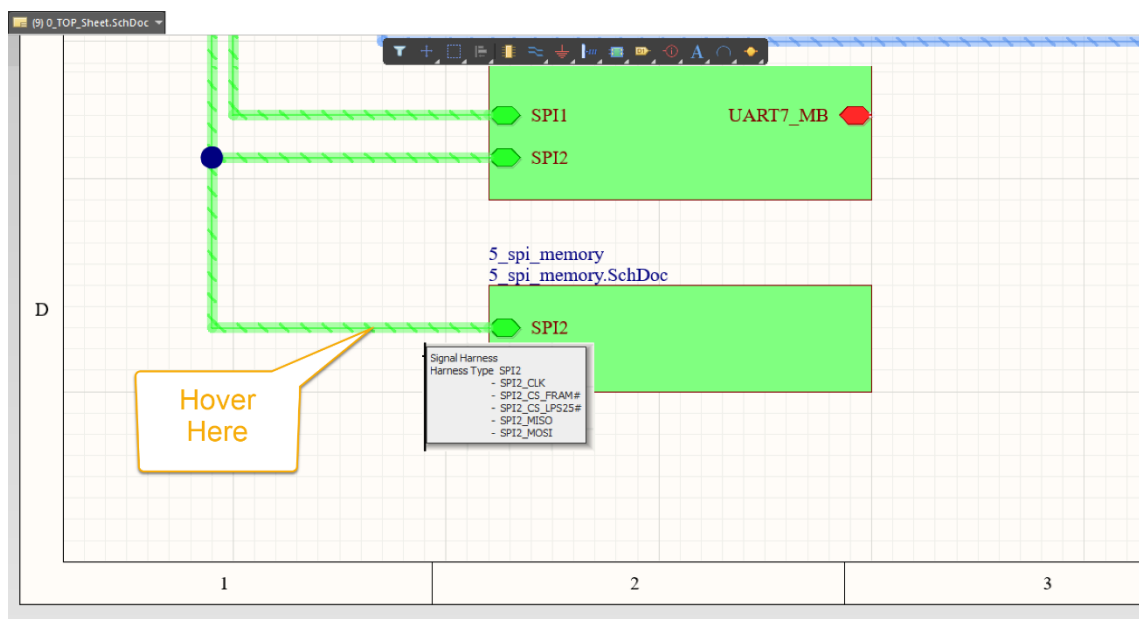


Figure 2. Signal Details inside of the Signal Harness

- To jump to the signals in the SPI2 harness, press and hold the **CTRL** key and double click on the sheet entry as shown in Figure 3.

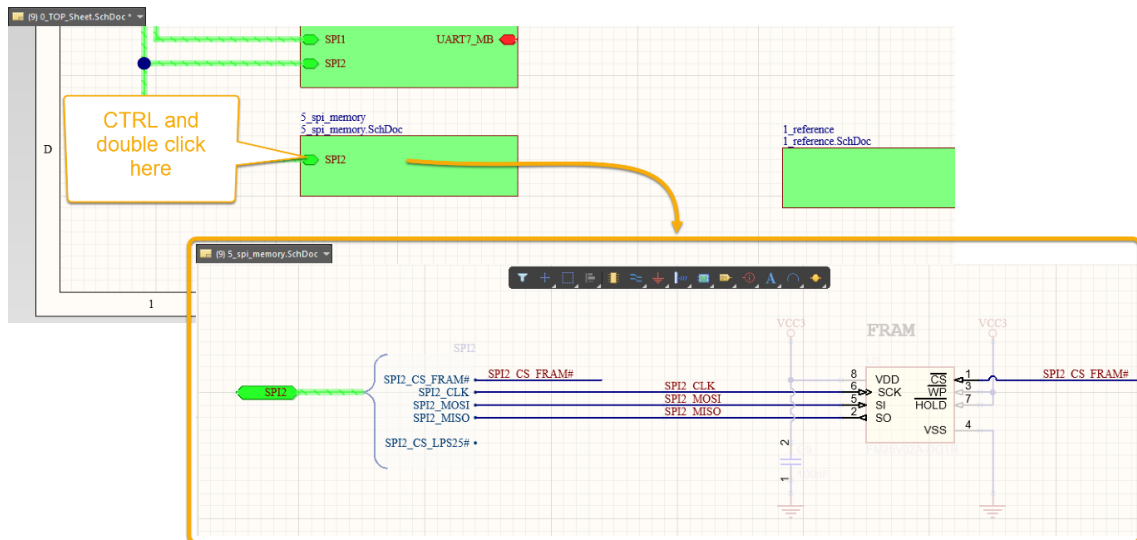


Figure 3. Navigating net connectivity between schematics

## 1.5 Creating a Signal Harness

### 1.5.1 Starting a Signal Harness from Scratch

A Signal Harness is created using multiple electrical primitives such as a harness connector, signal harness, harness entries and ports. If there's a signal harness existing in the design, we can reuse this predefined harness information, which we will see later in this exercise.

#### 1.5.1.1 Harness Connector

7. Open the `6_uart_esc_i2c` schematic document.
8. Navigate to the upper right corner of the schematic sheet, to the right-hand side of component RN1.
9. From the **Place** menu, select **Harness**, then **Harness Connector**. This command can also be accessed by right-clicking on the icon from the *ActiveBar* as shown in Figure 4.

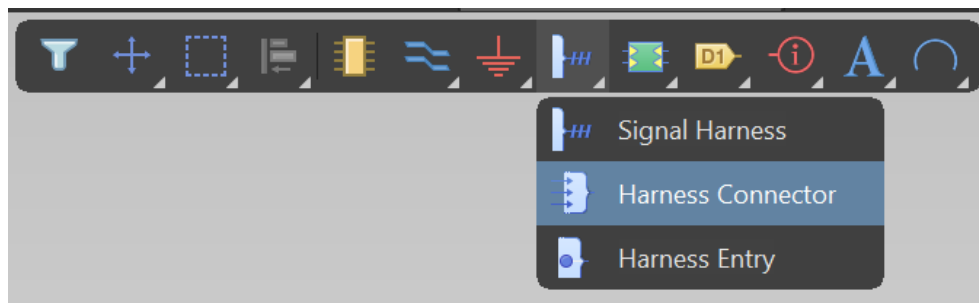


Figure 4. Placing a Harness Connector

10. The Harness Connector needs to be placed in a few steps:
  - a) Left-click once to anchor to the left-side of the connector.
  - b) Moving the mouse to the right will determine the width of the connector. Moving your cursor up or down will determine the overall height of the harness connector.
  - c) Once you're satisfied with the size of the Harness Connector, left-click again to accept the size.
  - d) Right-click to end the command once satisfied. The Harness Connector should look similar to Figure 5 below. The size can always be adjusted on the fly after it has been placed.



If needed, you can flip the harness connector with the shortcut key X after you placed it.

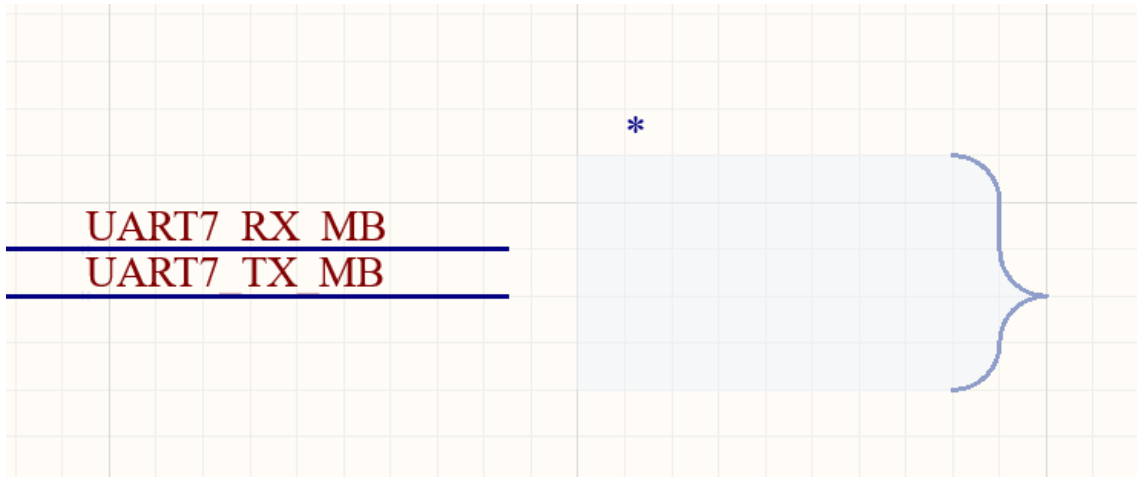


Figure 5. Place Harness Connector

11. Double-click the Harness Connector to open the *Properties* panel.
12. In the *Harness Type* field, add the name of UART7\_MB and hit **Enter** as shown in Figure 6.

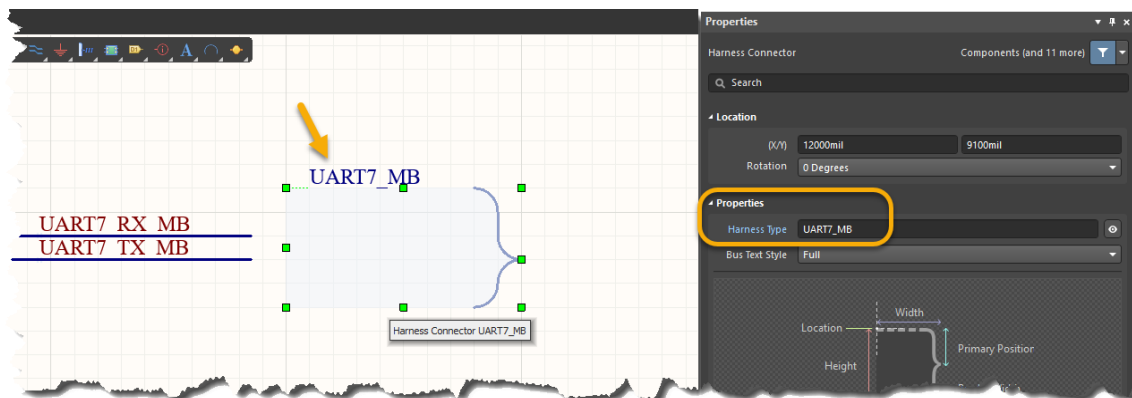


Figure 6. Harness Connector UART7\_MB

### 1.5.1.2 Adding Harness Entries to the Harness Connector

Next we will add the Harness Entries to the Harness Connector. These entries are going to be the nets that will be grouped inside of the harness.

13. From the **Place** menu, select **Harness**, then **Harness Entry**. It can also be accessed from the *ActiveBar*.
14. With the **Harness Entry** on your cursor:
  - a) Move your cursor to the inside of the Harness Connector as shown in Figure 7.

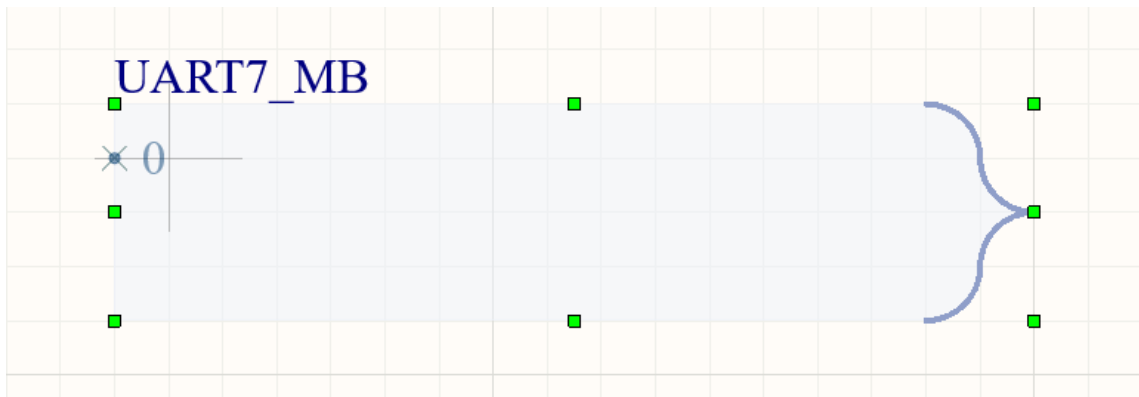



Figure 7. Place Harness Entry inside Harness Connector

- b) Before placing the entry, press the **TAB** key to open the *Properties* panel.
  - c) In the *Harness Name* field, enter the name `UART7_RX_MB`.
  - d) Hit **Enter**, or the **Pause** icon  to continue the placement of the entry.
  - e) Left-click to place the Harness Entry inside the Harness Connector in the same spot as Figure 7.
  - f) With the Harness Entry command still active, place a second Harness Entry with the name of `UART7_TX_MB` and place it below of the first entry.
  - g) Right-click to end the placement command.
  - h) If needed change the position and / or size of the Harness Connector by selecting and moving the vertices.
15. Left-click and drag the Harness Connector so that the Harness Entries are connected and aligned to their respective wires as shown in Figure 8.

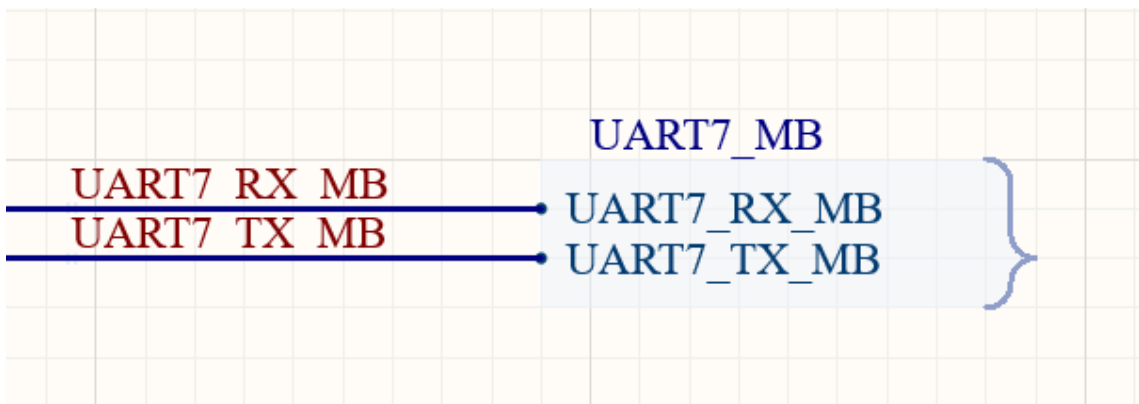


Figure 8. UART7\_MB Harness Connector with two Entries

### 1.5.1.3 Adding a Signal Harness & Port

Next we will add the Signal Harness and Port that allows us to transfer the group of signals to another schematic sheet. This is the most common use of harnesses in a hierarchical design.

16. From the **Place** menu, select **Harness**, then **Signal Harness**. It can also be accessed from the *ActiveBar*.
  - a) Left-click on the electrical hotspot of the Harness Connector to anchor the Signal Harness as shown in Figure 9.



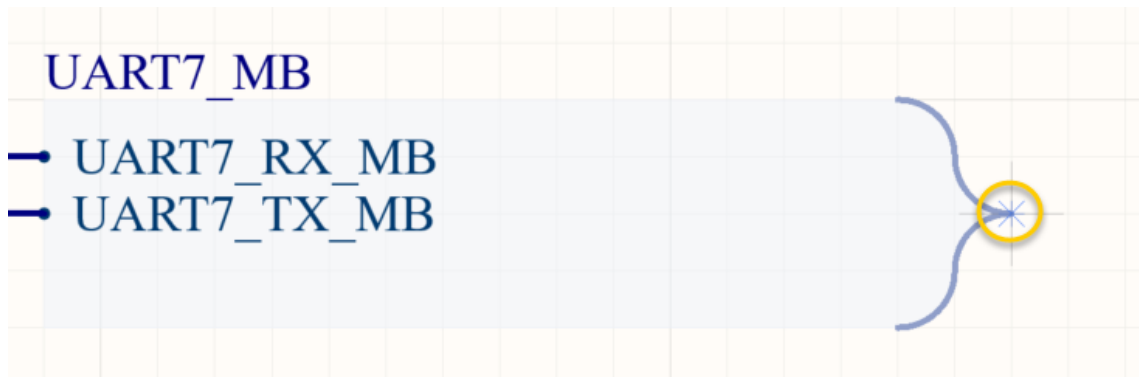


Figure 9. Place Signal Harness on Harness Connector

- b) Move your cursor to the right to expand the length of the Signal Harness.
- c) Left-click again to set the overall width of the Signal Harness.
- d) Right-click twice to exit the command. Your Signal Harness should look similar to what is shown in Figure 10.

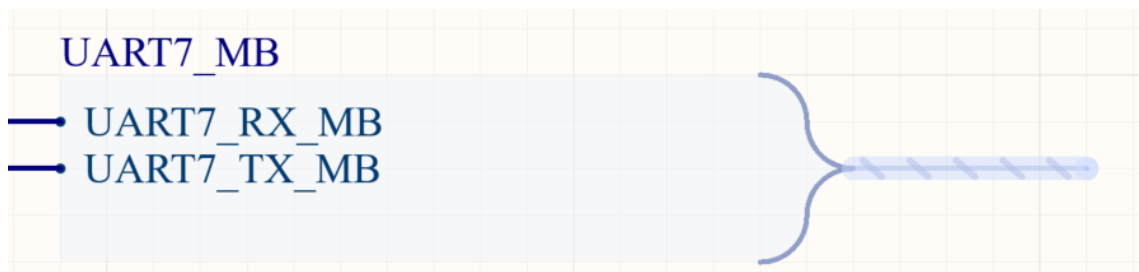


Figure 10. Signal Harness attached to the Harness Connector

17. From the **Place** menu, select **Port**. It can also be accessed from the *ActiveBar*.
18. Now that a Port is attached to your cursor, press the **TAB** key to open the *Properties* panel.
  - a) Change the *Name* to `UART7_MB`.
  - b) Leave the *I/O Type* as *Unspecified*.
  - c) Leave the *Harness Type* empty as this will be automatically updated when we place the Port.
  - d) Click the **Pause** icon (II) to continue placing the Port.
  - e) Left-click at the end of the Signal Harness to set the left side of the Port.
  - f) Move your cursor to the right and left-click a second to define the length of the Port.
  - g) Press the **ESC** key to cancel the placement command.
  - h) Now that the Port is placed and attached to a Signal Harness, it will be automatically be updated with the graphical information for the Harness and the correct Harness Type Information. Your result should be similar to Figure 11.

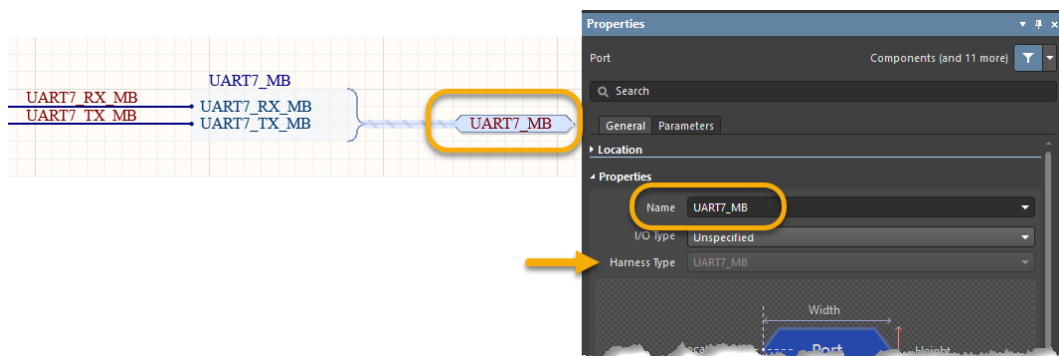


Figure 11. UART7\_MB Harness structure (Connector, Entry, Signal and Port).

#### 1.5.1.4 Creating the matching Harness for UART7\_MB

Similar to Net Labels and Ports, Signal Harnesses also need to have a matching partner for proper electrical connectivity to be established. Next, we will define the other end of the Harness that we just created.

19. Select the entire group of the Harness Connector, Signal Harness and Port you just created, and hit **CTRL+C** to copy the selection.



Instead of using Copy and Paste you can also place Predefined Harness Connectors. We will look at this shortly.

20. Open the `2_mb_conn` schematic document and navigate to the bottom-left of the sheet, near Zone 2-D in the title block.
21. Paste the copied harness using **CTRL+V**.
22. Before placing it, we will flip the orientation by hitting the **X** key.
23. Align the Harness Entries with the associated wires as shown in Figure 12.
24. Left-click to place the harness so that it makes an electrical connection to the UART7 wires.

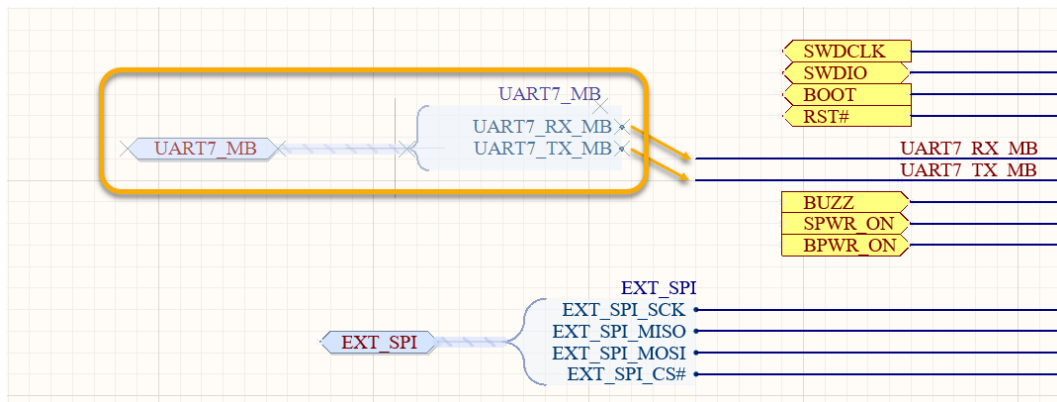


Figure 12. Matching UART7\_MB Harness on Sheet 2\_mb\_conn.SchDoc

#### 1.5.2 Using Predefined Harness information

Next we will place harnesses for the UART4 and the UART8 Signals. The matching Harness already exists in the design.



Whenever a Harness Connector is created in a Project, the information is stored in a configuration file and can be reused later. You will find on the hard disk the `[SheetName].Harness` files. These files are linked in the Projects panel under the Settings folder.

25. Return to the `6_uart_esc_i2c` schematic document.
26. From the **Place** menu, select **Harness**, then place a **Predefined Harness Connector**. The *Predefined Harness Connector* interface will appear.
27. The list on the left side shows several Harness Connectors, such as the UART7\_MB that we just created.
  - a) Scroll down the list and select the predefined Harness Connector named UART4\_8\_MB.
  - b) As we want to transfer the signal to another schematic sheet, its recommended to use the **Add Port** option. So we will enable this option as shown in Figure 13.
  - c) Enable the **Auto** option next to the port *Width*. This will set the size for us.
  - d) Ensure that the **Add Signal Harness** option is enabled.
  - e) Confirm that the option **Sort Harness Entries** is disabled.
  - f) Click **OK** to start placement for the Predefined Harness Connector.

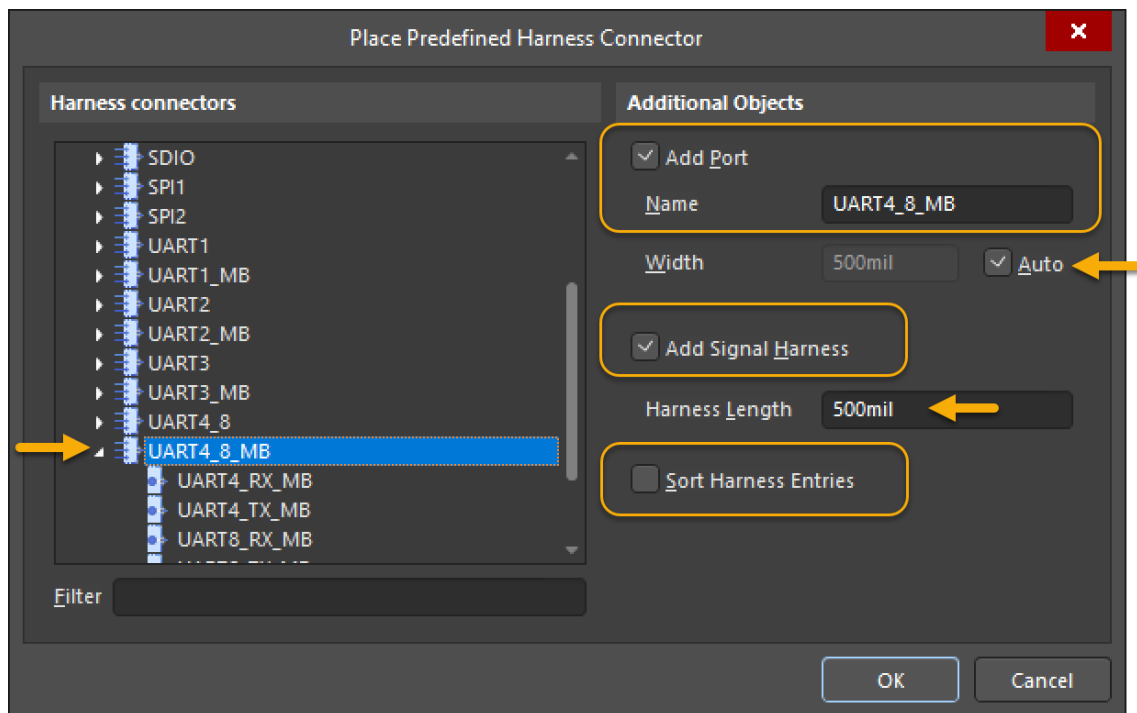


Figure 13. Select and Configure the Predefined UART4\_8\_MB

28. Place the predefined Harness Connector UART4\_8\_MB on the wires on the right-side of component RN3 as shown in Figure 14.

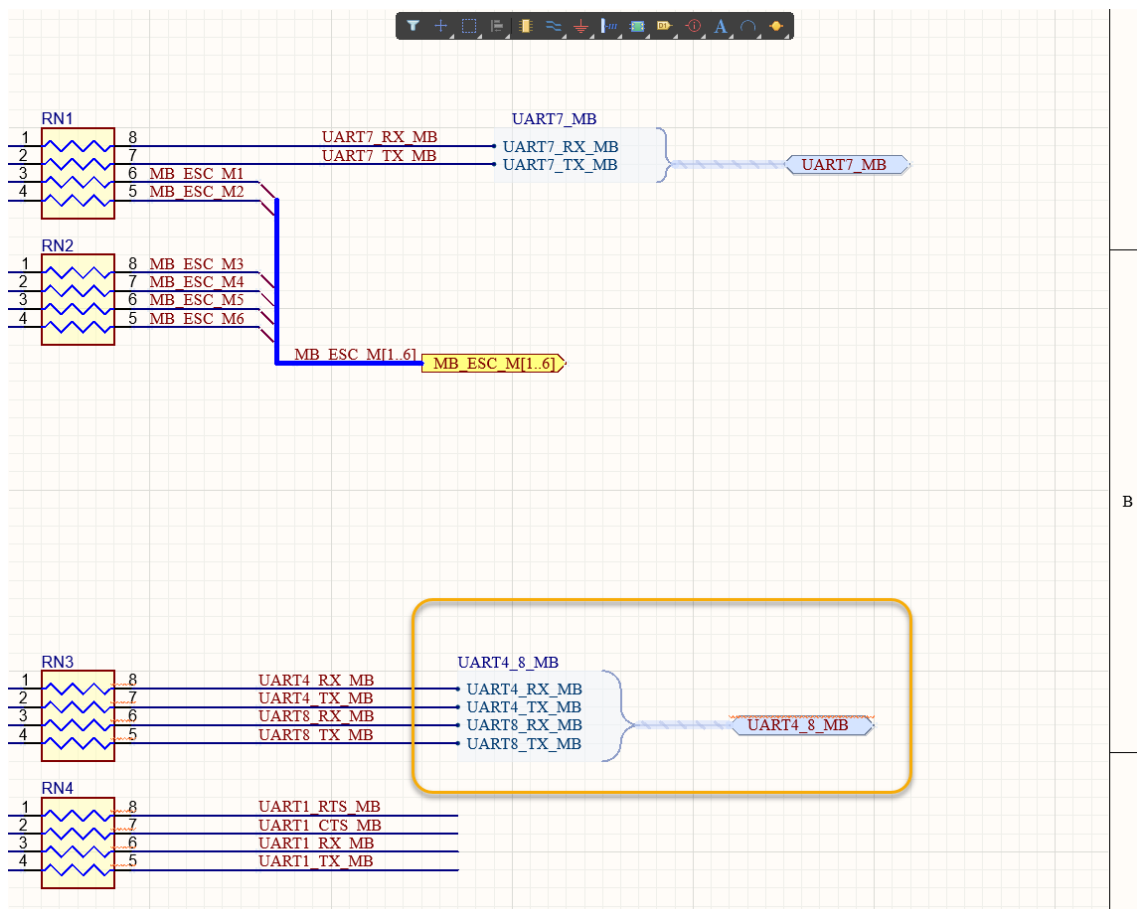


Figure 14. Place Predefined Harness connector UART4\_8\_MB

### 1.5.3 Smart Paste for Harness

Next we will create the Harness `UART1_MB` using the **Smart Paste** function. This is an alternative for creating the harness from scratch if Net Labels are available in the design.

29. Using Figure 15 on the following page as a reference, select the following `UART1` Net Labels below component `RN3`:

- a) `UART1_RTS_MB`
- b) `UART1_CTS_MB`
- c) `UART1_RX_MB`
- d) `UART_TX_MB`

30. Copy the Net Labels using **CTRL+C**.

31. From the **Edit** menu, select **Smart Paste**....

32. Using Figure 15 as a reference again, change the following settings in the *Smart Paste* dialog:

- a) *Paste As*: **Harness Connector and Port**
- b) *Sort Order*: **By Location**
- c) *Signal Names*: **Keep**
- d) *Harness Type*: `UART1_MB`
- e) *Harness Wire Length*: `500mil`
- f) *Port Name*: `UART1_MB`

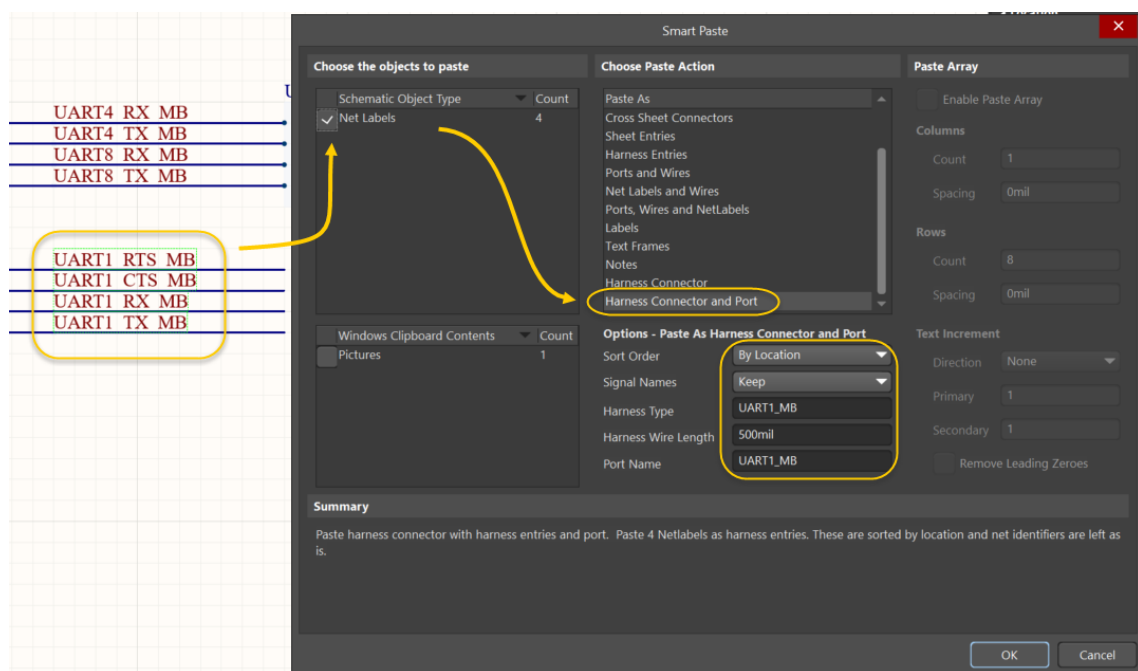


Figure 15. Harness creation based on netlabel

33. Click **OK** and you'll notice the Harness on your cursor.

34. Left-click to place it onto the `UART1` wires as shown in Figure 16.

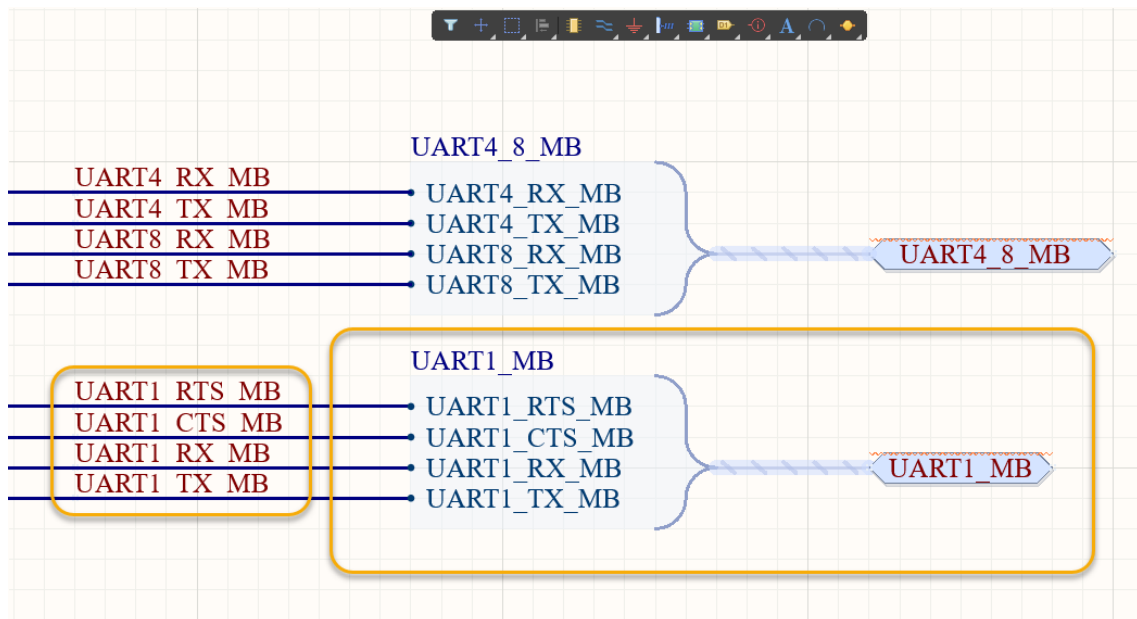


Figure 16. UART1\_MB at 6\_uart\_esc\_i2c.SchDoc

### 1.5.4 Nested Harness information

It's possible to define a high level harness that contains signals or other Harness definitions. Using a nested harness on lower level schematics would minimize the amount of harnesses on the top level sheet. In this example, we will create a general CAN Harness that is built out of the CAN1 and CAN2 Harnesses.

35. Open the 7\_can\_rc\_i2c\_analog schematic document.
36. Navigate to the *CAN driver* circuit on the left-hand side of component U9.
37. From the **Place** menu, select **Harness**, then **Predefined Harness Connector**.
38. When the *Predefined Harness Connector* window appears, use the information below, along with Figure 17 to assign the following settings.
  - a) Select CAN1 as the Harness Connector definition.
  - b) Disable the **Add Port** option.
  - c) Disable the **Add Signal Harness** option.
  - d) Disable the **Sort Harness Entries** option.
  - e) Click **OK** to continue.
39. With the Harness Connector your cursor, hit the **X** key to flip the harness.
40. Place it onto the respective CAN1 wires as shown in Figure 17.
41. Repeat the process above to place the CAN2 Harness Connector onto the CAN2 wires below.

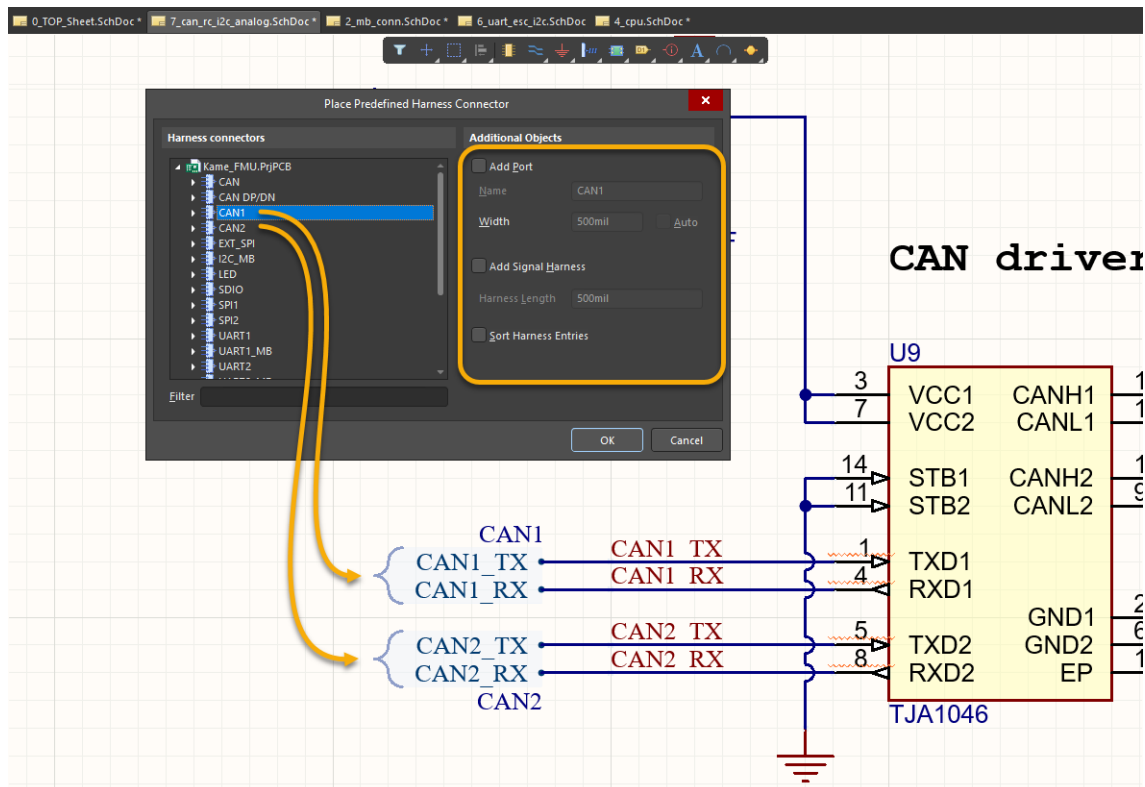


Figure 17. Page 7\_can\_rc\_i2c\_analog.SchDoc with two CAN harness

Creating a Nested Harness is the process of combining multiple signal harnesses into 1 main harness. So we will need to place another Harness Connector to complete this.

42. From the **Place** menu, select **Harness**, then **Predefined Harness Connector**. Then, follow the information for the settings using Figure 18 as a reference.
  - a) Select **CAN** from the list of Harness Connectors.
  - b) Enable the option to **Add Port**.
  - c) Enable the option to **Add Signal Harness**.
  - d) Click **OK** to create the Harness Connector.
  - e) With the Harness Connector on your cursor, hit the **X** key to flip it.
  - f) Left-click to place it to the left of the **CAN1** and **CAN2** Signal Harnesses as shown in Figure 18.

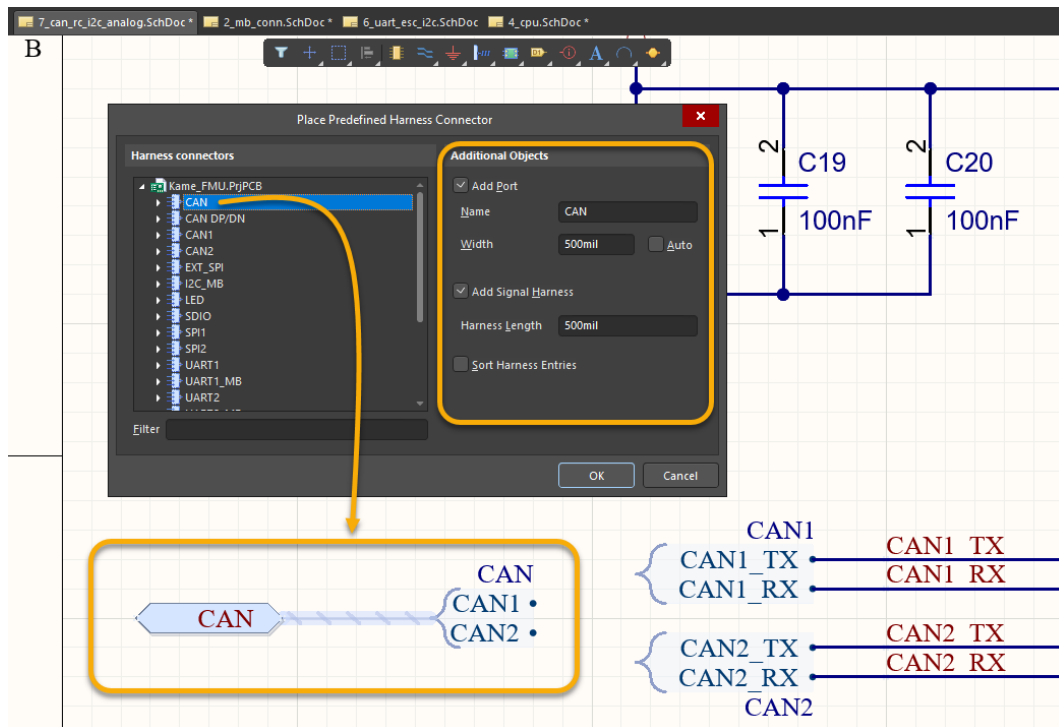


Figure 18. Page 7\_can\_rc\_i2c\_analog.SchDoc with three CAN harness

43. From the **Place** menu, or from the *ActiveBar*, place a **Signal Harness** to connect the new CAN1 Harness Entry to the CAN1 Signal Harness as show in Figure 19. Feel free to change the size of the Harness Connector CAN if needed.
44. Repeat the process above to connect the CAN2 Harness Entry to the CAN2 Signal Harness. Your end result should look similar to Figure 19.

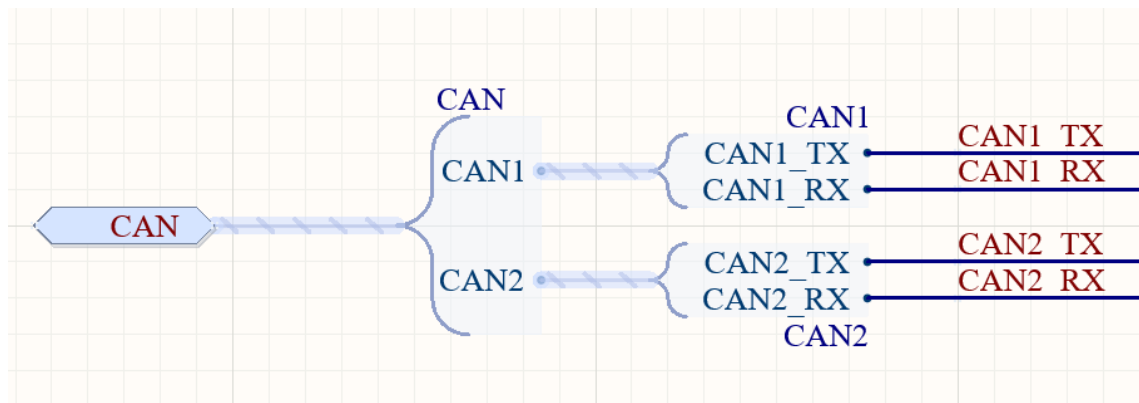


Figure 19. Page 7\_can\_rc\_i2c\_analog.SchDoc with nested CAN harness

## 1.5.5 Making the Harness connection on Top Sheet

### 1.5.5.1 Creating the matching UART7\_MB Harness on the Top Sheet

Next, we will create the connection between the sheet symbols on the Top Sheet for the 6\_uart\_esc\_i2c, 2\_mb\_conn and 8\_imu&debug\_conn schematics.

45. Change the focus back to the 0\_Top\_Sheet schematic sheet.
46. Open the *Preferences*. Navigate to the *Schematic* section and open the *Graphical Editing* page.
47. Confirm that the option to **Place Sheet Entries automatically** is enabled as shown in Figure 20. This will automatically create the sheet entry after the Harness connection is created on the Top Level sheet.
48. Close **OK** to close the *Preferences* when finished.

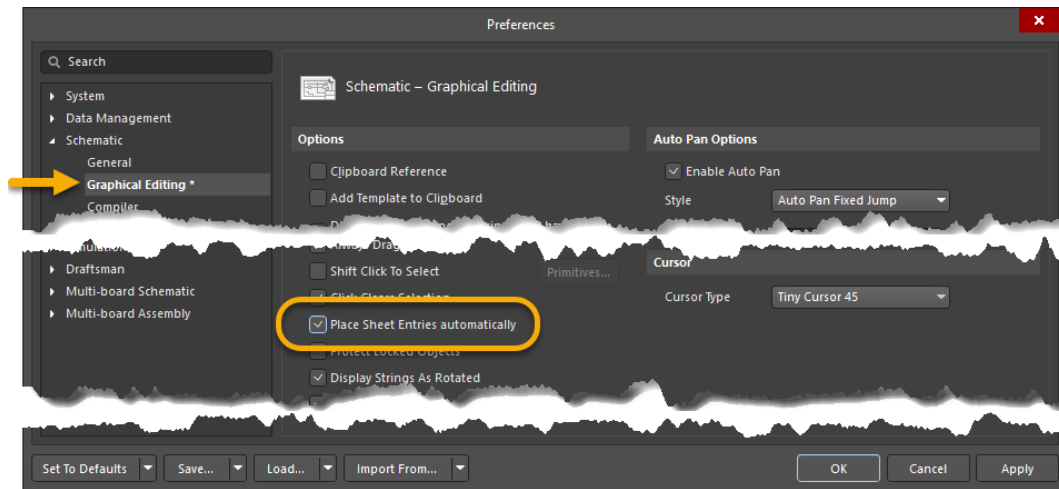


Figure 20. Option to Place Entries

49. From the **Place** menu, select **Harness**, then **Signal Harness**. This can also be accessed from the *ActiveBar*.

- Start drawing the Signal Harness at the existing Sheet Entry `UART7_MB` from Sheet Symbol `8_imu&debug_conn.SchDoc` as shown in Figure 21.
- Draw the Signal Harness to sheet symbol `6_uart_esc_i2c` following the arrow, similar to what is shown in Figure 21.
- When you click on the edge of the Sheet Symbol `6_uart_esc_i2c` to complete the connection, the sheet entry for `UART7_MB` will automatically generate.

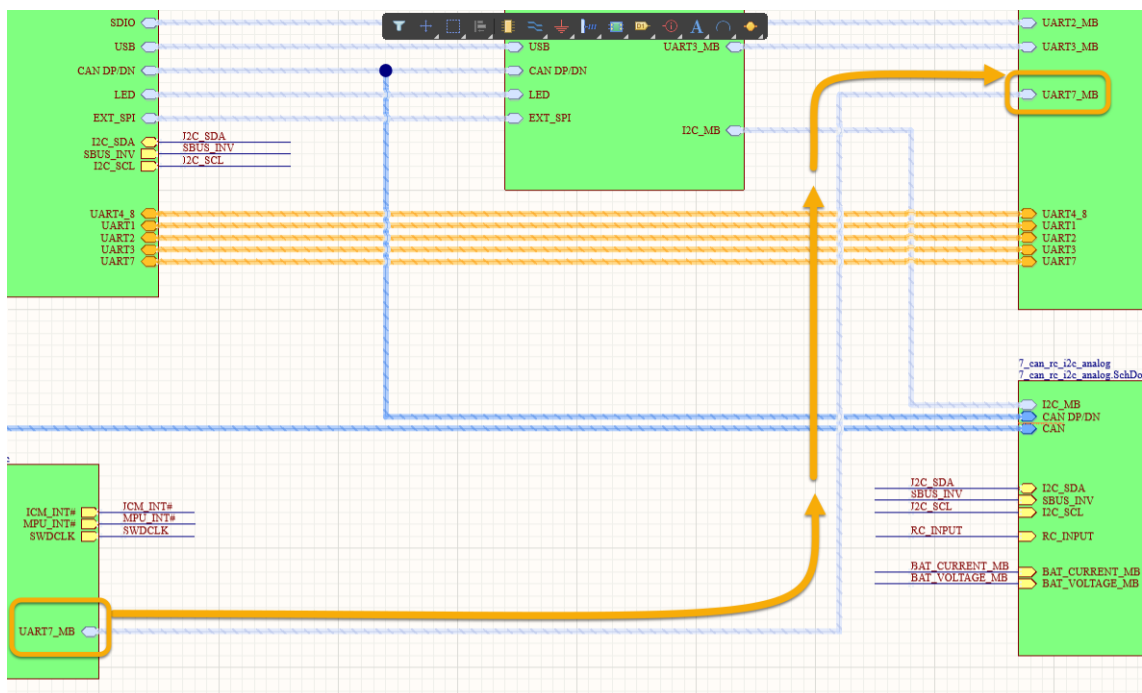


Figure 21. First part of Signal Harness

50. Similar to the previous step, we will make another Signal Harness connection between the `2_mb_conn.SchDoc` and `6_uart_esc_i2c.SchDoc` sheet symbols as seen in Figure 22.

- With the Signal Harness command still on your cursor, left-click on the corner of the `UART7_MB` Signal Harness you just created as shown in Figure 22.
- Complete the connection to the edge of the `2_mb_conn.SchDoc` Sheet Symbol and the `UART7_MB` Sheet Entry will automatically generate as shown in Figure 22.
- Press **ESC** or right-click to exit the Signal Harness command when finished.



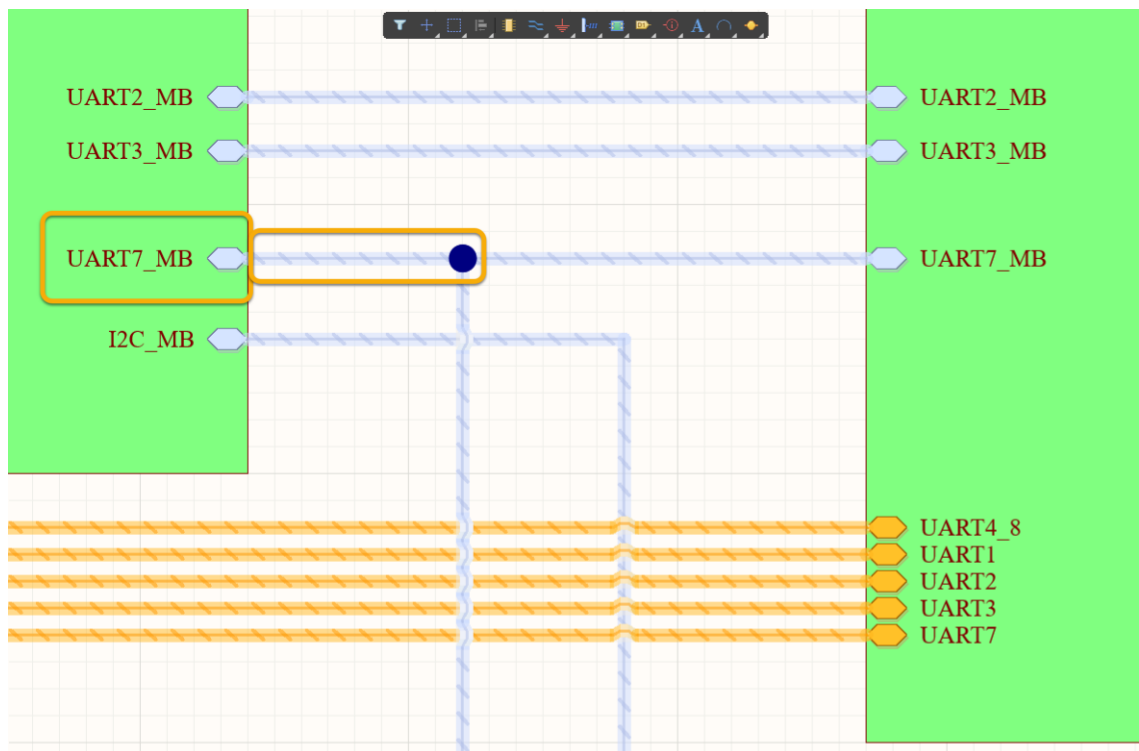


Figure 22. Final definition for Harness UART7\_MB Top Sheet

51. Right now, the new Sheet Entries have a name but no Harness Type information. Select one of the new UART7\_MB Sheet Entries.
52. From the *Properties* panel, select UART7\_MB from the *Harness Type* drop-down as shown in Figure 23.
53. Repeat the step above to make the change to the other UART7\_MB Sheet Entry as well.

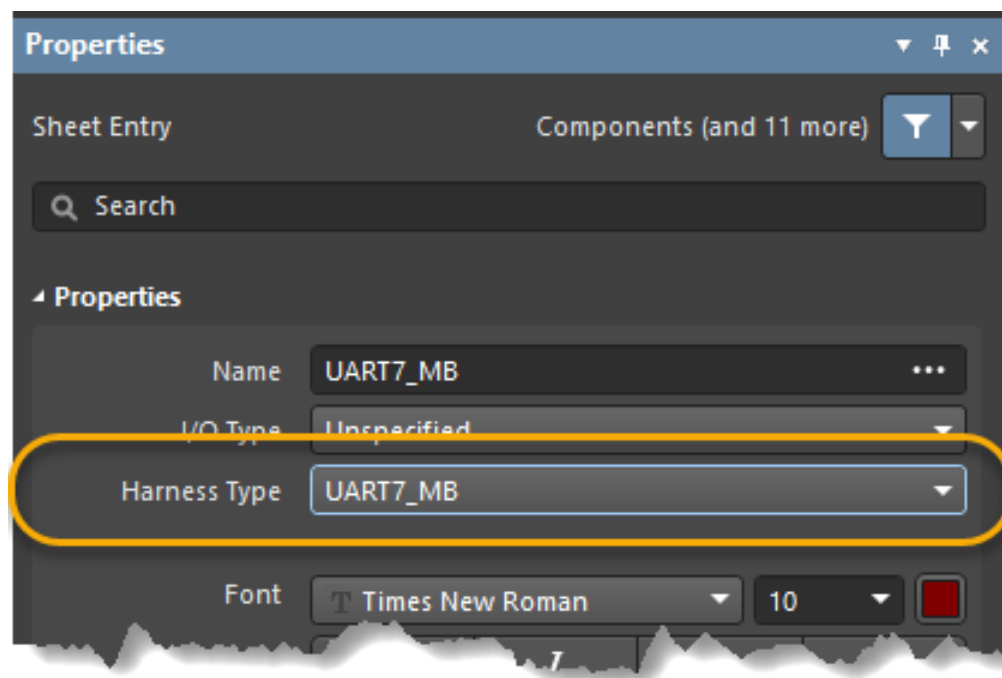


Figure 23. Sheet Entry Harness Type

54. To easily identify an important Signal Harness, we can change its color from the Properties panel. Select the Signal Harness that's connected between our UART7\_MB Sheet Entries.
55. Change the color to red as shown in Figure 24.

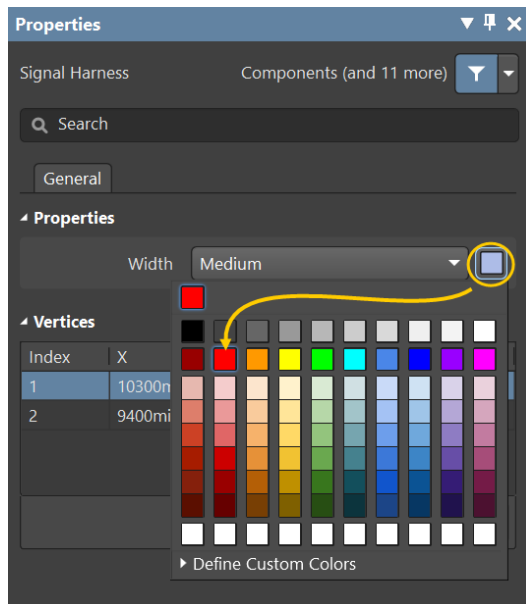


Figure 24. New Harness Color

56. The connected Sheet Entry and Harness will automatically be updated with the new color similar to Figure 25.
57. Only one of the connections will change. You will also need to select the 2<sup>nd</sup> UART7\_MB Harness connection and change it to red as well.

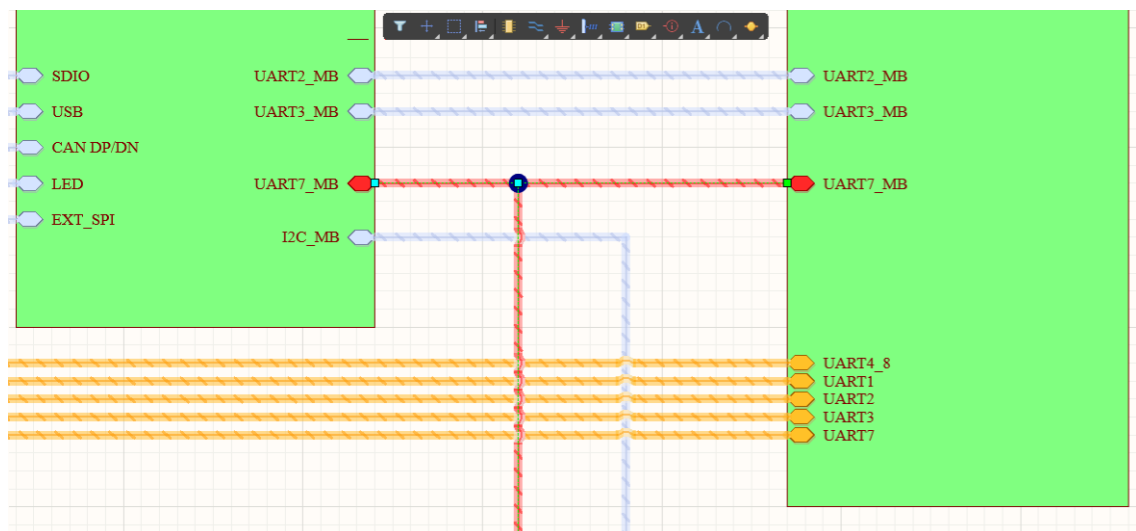


Figure 25. UART7\_MB drawn in red

### 1.5.5.2 Synchronizing all remaining Sheet Entries and Signal Harnesses

On the Top Level Sheet, we still need to create two connections for the other Harnesses we created. Instead of creating the Sheet Entries by drawing a Signal Harness to the edge of the Sheet symbol, we will synchronize the Lower-Level sheets with the Top Sheet. Altium Designer has a dedicated interface to help us properly synchronize our design.

58. We will open all of the schematic sheets in our design by right-clicking on the *Source Documents* folder of our project and select **Open All Schematic Documents** as shown in Figure 26.

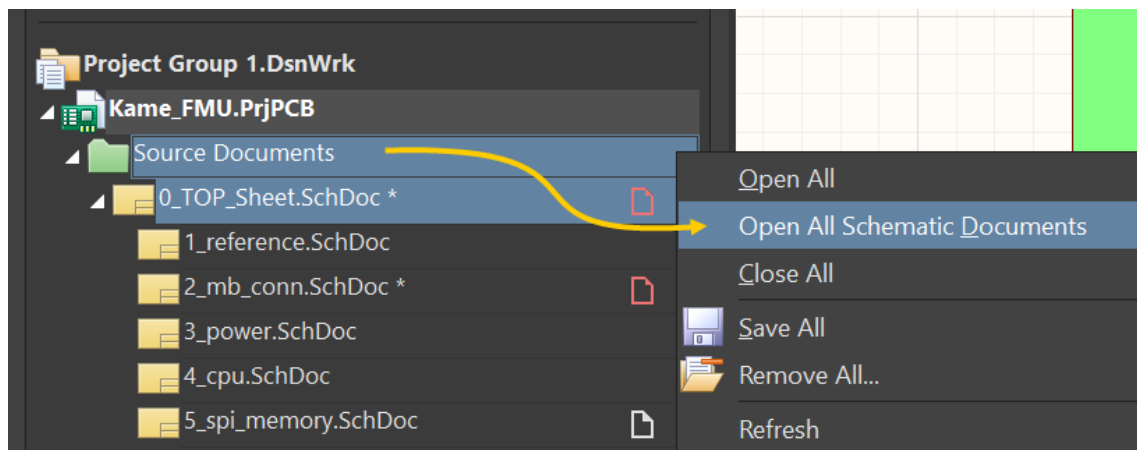


Figure 26. Unhide all schematic documents

59. Ensure that the 0\_TOP\_Sheet.SchDoc is the focused schematic.
60. From the **Design** menu, select **Synchronize Sheet Entries and Ports**. We will use the instructions below, as well as Figure 27 for reference.
  - a) Near the top-left of the *Synchronize* window, select the 6\_uart\_esc\_i2c tab as shown in Figure 27.
  - b) From the 6\_uart\_esc\_i2c.SchDoc section, select the unmatched port UART4\_8\_MB.
  - c) Select the command **Add Sheet Entries**. The focus will change to the schematic with a Sheet Entry on your cursor.
  - d) Place the new Sheet Entry below the existing UART3\_MB Sheet Entry on the 6\_uart\_esc\_i2c sheet symbol as shown in Figure 27. Feel free to change your grid using the **G** key to place it.
61. Repeat the steps above to place the UART1\_MB sheet entry above the UART2\_MB sheet entry.

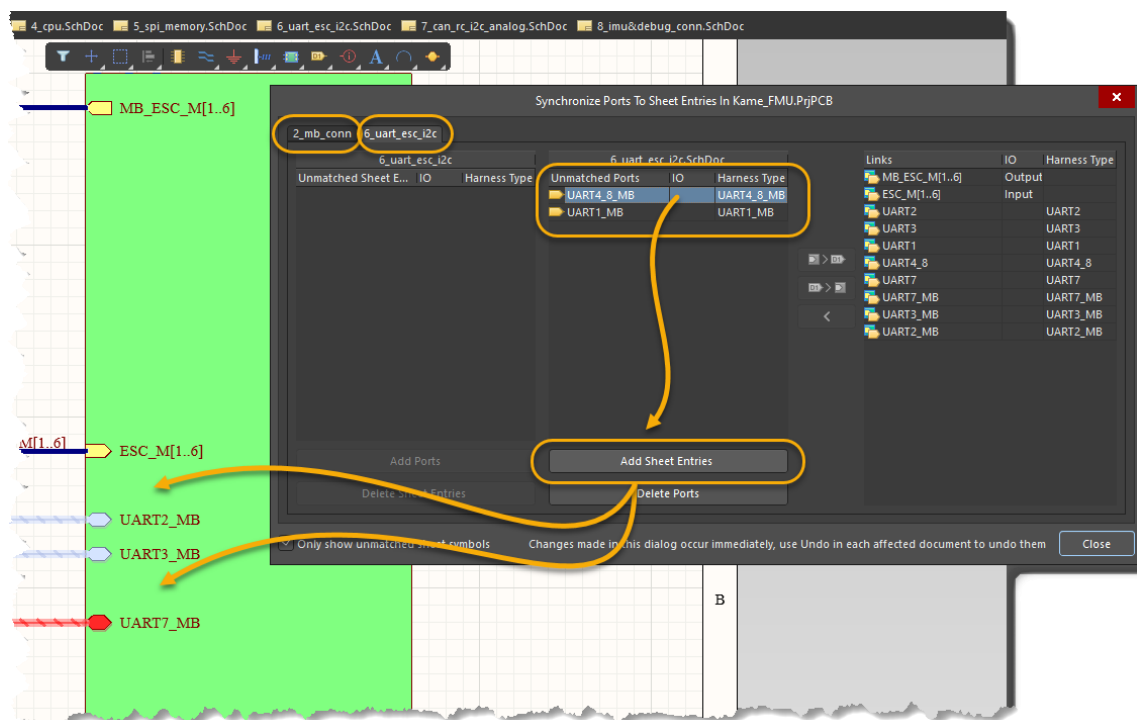


Figure 27. Synchronization for Hierarchical Designs

62. Select the 2\_mb\_conn tab as shown in Figure 28.

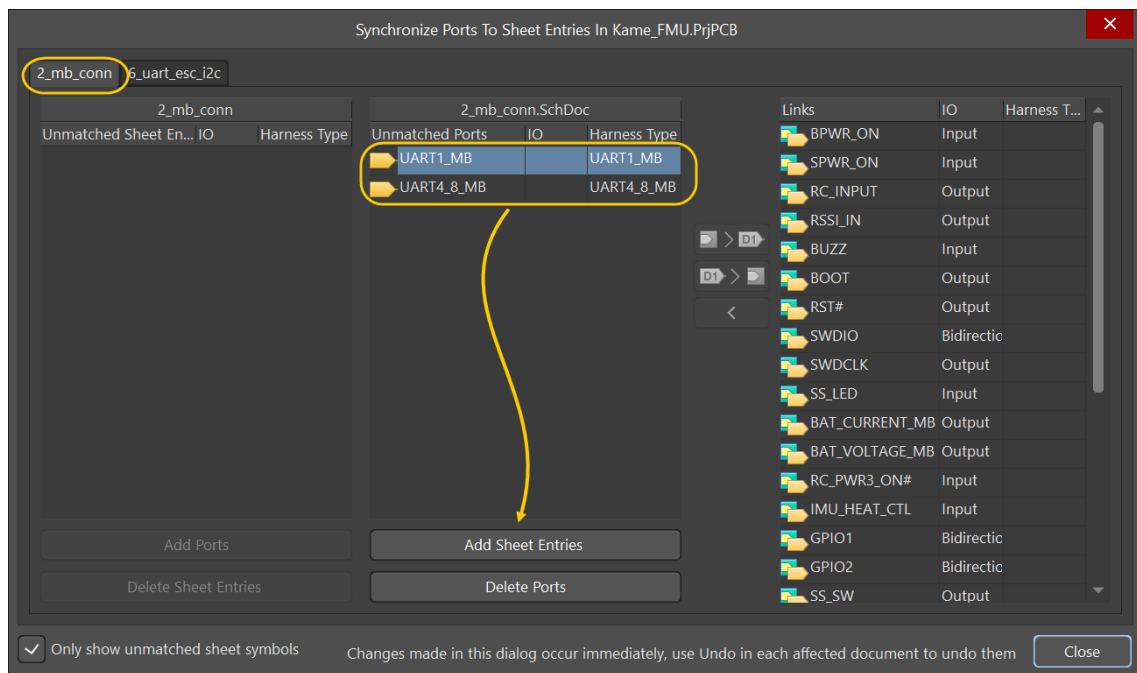


Figure 28. Placing Sheet Entries for 2\_mb\_conn

63. Repeat the process to **Add Sheet Entries** for both of the unmatched Ports onto the 2\_mb\_conn sheet symbol. Your final result should look similar to Figure 29 below.

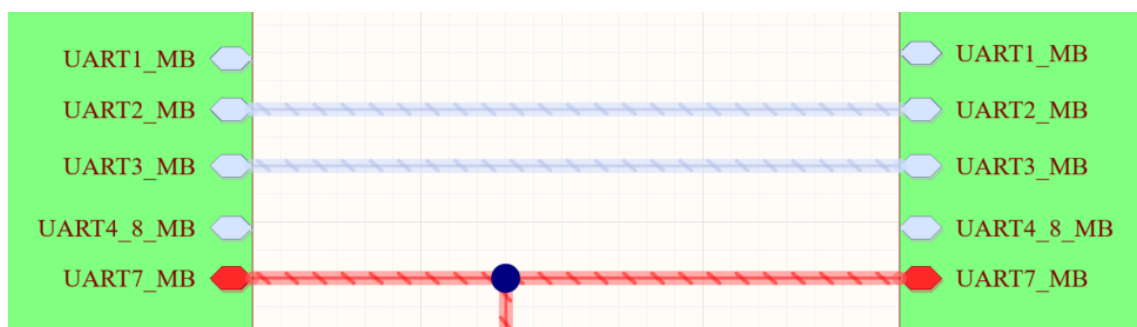


Figure 29. Synchronized sheet entries between sheet symbols

64. Close the *Synchronize Ports* interface.
65. Create the connection between the two Sheet Symbols by placing Signal Harnesses to their respective Sheet Entries. Your final result should look similar to Figure 30.

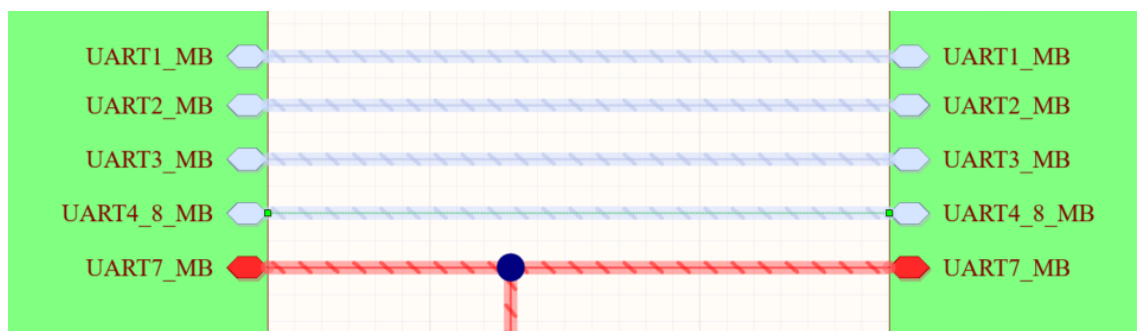


Figure 30. Signal Harnesses for the UART[number]\_MB

66. Right-click to end the Signal Harness command.
67. Feel free to save your modifications.
68. **Close the project and any open documents.**

**Congratulations on completing module**

Using Signal Harnesses

**from the**

**Altium Designer Advanced Course**

**Thank you for choosing Altium Designer**