White Paper

Pinout Selection and PCB Breakout Strategies for CABLINE®-CX II, UX II, and UA II Connectors

January 2025

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Introduction

This white paper discusses the CABLINE® series connectors, specifically the dual-row connectors CABLINE®-CX II, CABLINE®-UX II and CABLINE®-UA II. It focuses on the different pin-out selection and PCB breakouts to overcome some of the challenges that are presented with dual-row connectors.

Dual-row connectors can present various signal integrity complexities, especially as data rates increase and designs become more compact. These complexities are further exacerbated when dealing with connectors with a pitch of 0.25mm and 0.35mm, such as the CABLINE®-CX II and CABLINE®-UA II respectively.

These connectors require careful consideration of crosstalk, impedance control, return loss, insertion loss, skew, EMI, parasitic effects, channel modeling, material properties, and thermal and mechanical factors to ensure signal integrity in high-speed applications.

Connector Information

CABLINE®-CX II

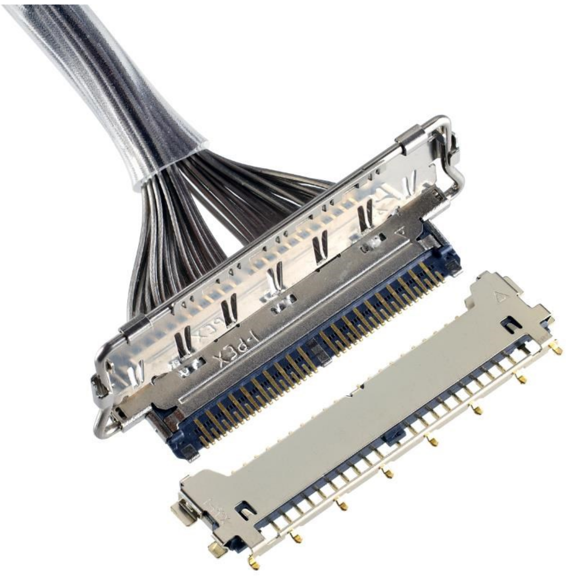

Figure 1: CABLINE®-CX II With Cover

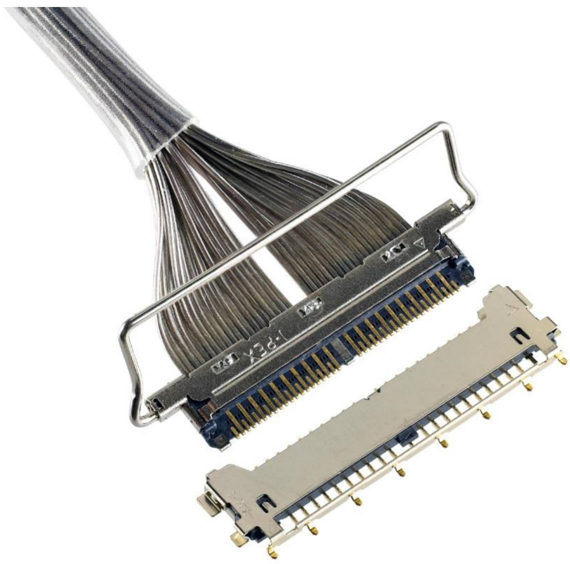

Figure 2: CABLINE®-CX II Without Cover

The CABLINE®-CX II connector is a high-performance micro-coaxial, horizontal mating type, wire-to-board connector designed for small and low-height applications, with a maximum height of 0.78 mm. It features an EMI shield cover option and includes a mechanical lock for secure connections.

With a horizontal mating type and a 0.25 mm wire pitch, it supports a board pitch of 0.5 mm and is available in a 40-pin count. Its mated size varies, with dimensions of 0.73 mm height without the cover and 1.0 mm with the cover, and a depth of 5.21 mm or 5.60 mm depending on the cover.

The CABLINE®-CX II connector receptacle has two rows of contacts with a pitch of 0.5mm between each contact within the same row. However, on the plug end of the connector, the contacts are in-line with a pitch of 0.25mm between the contacts.

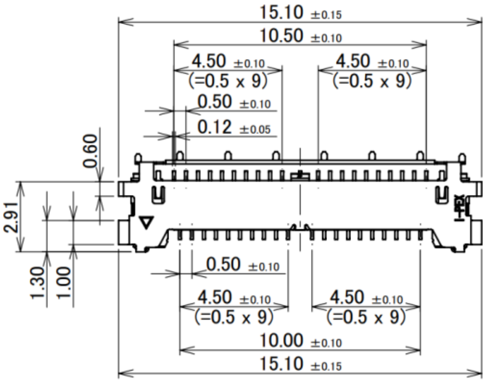

Figure 3: CABLINE®-CX II Receptacle

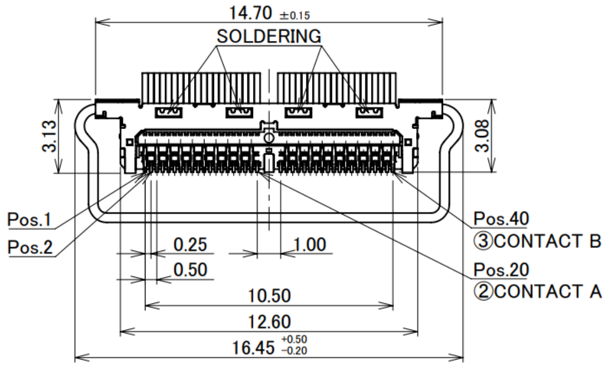

Figure 4: CABLINE®-CX II Plug

The CABLINE®-CX II accommodates 45 ohm (#44 or smaller) and 50 ohm (#46 or smaller) micro-coaxial cables. It supports high-speed data transfer standards such as USB 3.2 Gen 1 (5 Gbps), V-By-One HS 1.4 (4 Gbps), and HDMI 1.3 (3.4 Gbps), making it suitable for advanced electronic devices requiring compact, reliable connections.

CABLINE®-UX II

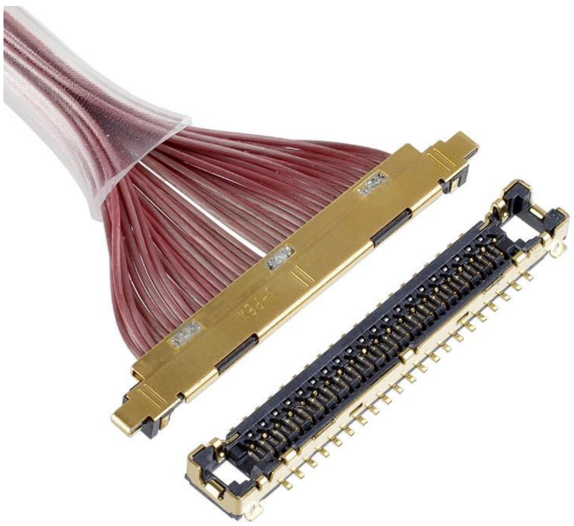

Figure 5: CABLINE®-UX II

The CABLINE®-UX II connector is a high-performance micro-coaxial connector designed for applications requiring high-speed data transfer and a compact form factor. With a 0.25 mm pitch, it supports a right-angle vertical mating type, making it suitable for space-constrained environments.

The connector is available in pin counts ranging from 30 to 50. It features a mated height of 1.04 mm ± 0.06, ensuring a low-profile connection.

The CABLINE®-UX II connector receptacle has two rows of contacts with a pitch of 0.5 mm between each contact within the same row, like the CABLINE®-UX II as shown below in Figure 6. On the plug end of the connector, the contacts are in-line with a pitch of 0.25 mm between the contacts.

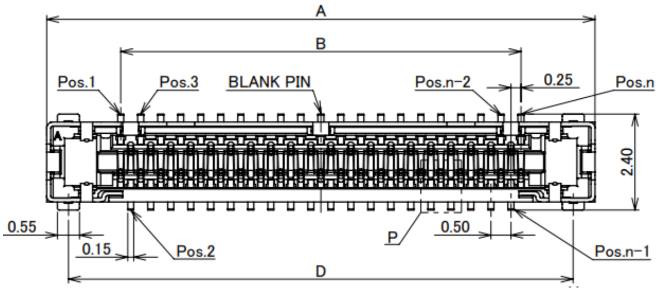

Figure 6: Staggered Rows of CABLINE®-UX II

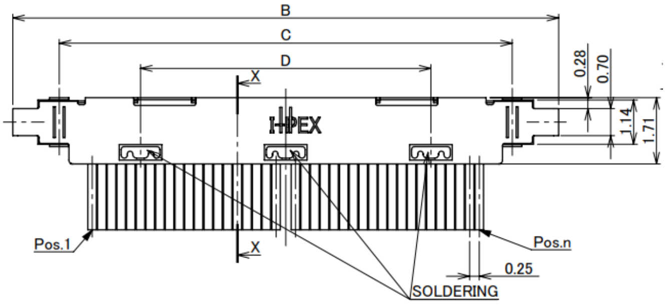

Figure 7: CABLINE®-UX II, Plug

The CABLINE®-UX II is compatible with a variety of signal cables, including 45 ohm micro-coaxial cables (#44 or smaller) and 50 ohm micro-coaxial cables (#46 or smaller). It is designed to work with such as USB 3.2 Gen 1 (5 Gbps), HDMI 1.3 (3.4 Gbps), and V-By-One HS 1.4 (4 Gbps) interfaces, providing versatility for different high-speed data applications.

The connector's slim plug design and small connector size make it an ideal choice for modern electronic devices where space and performance are critical.

CABLINE®-UA II

Figure 8: CABLINE®-UA II

The CABLINE®-UA II connector is a high-performance micro-coaxial connector featuring a 0.3 mm pitch and designed for right angle vertical mating. It supports pin counts ranging from 26 to 50, catering to a variety of high-density electronic applications.

The CABLINE®-UA II connector receptacle has two rows of contacts with a pitch of 0.6mm between each contact within the same row. However, like the CABLINE®-UX II, the two rows of the signal contacts are staggered as shown below in Figure 9. On the plug end of the connector, the contacts are in-line with a pitch of 0.3mm between the contacts.

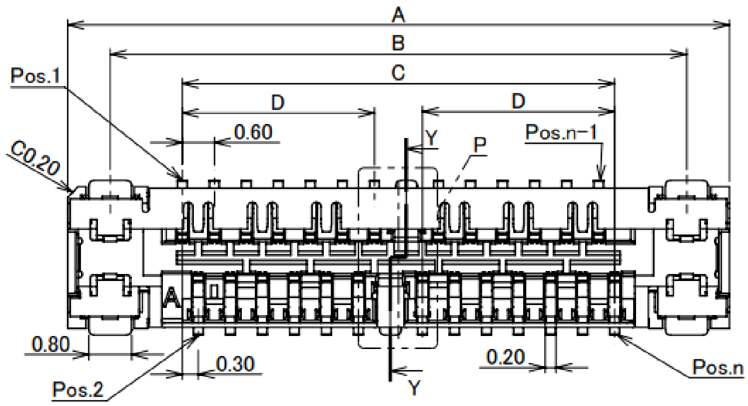

Figure 9: CABLINE®-UA II Receptacle

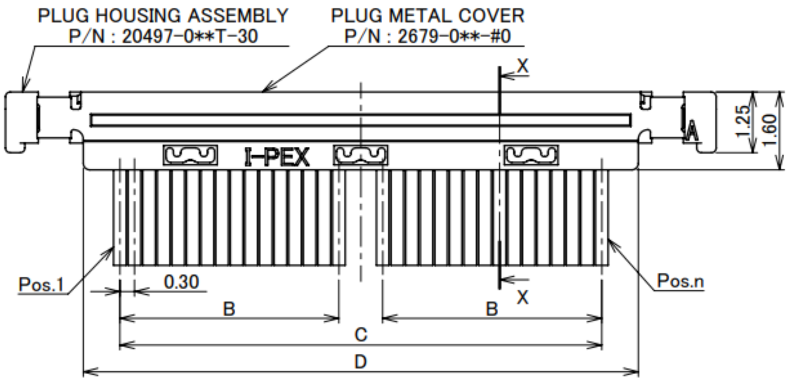

Figure 10: CABLINE®-UA II Plug

With a slim plug and small connector profile, it achieves a mated height of 1.27 ± 0.1 mm, making it suitable for devices where space is at a premium. The connector supports a range of micro-coaxial cables, including 45 ohm (#42 or smaller) and 50 ohm (#44 or smaller), ensuring compatibility with various high-speed data transfer requirements.

The CABLINE®-UA II is optimized for use with such as USB 3.2 Gen 1 (5 Gbps) interfaces, as well as HDMI 1.3 (3.4 Gbps) and V-By-One HS 1.4 (4 Gbps), providing versatility for modern electronic devices that require reliable and efficient connectivity. Its design ensures a secure connection and high retention force, making it an excellent choice for applications in consumer electronics, computing, and other high-speed data communication devices.

Pinout & Breakout Recommendations

This section focuses on the recommendations for the pinout selections as well as routing directions for the CABLINE®-UA II, UX II and CX II connectors, and uses simulation data to justify the pinout and breakout recommendations. Since most of the high-speed applications use differential signaling, the recommendations are also provided for differential signals. The simulations consider basic micro-strip routing techniques and do not consider advanced routing techniques such as the use of via-in-pads, as these are generally a cost-adder in PCB manufacturing.

I. Sequential GSSG Pinout with Ground Pins

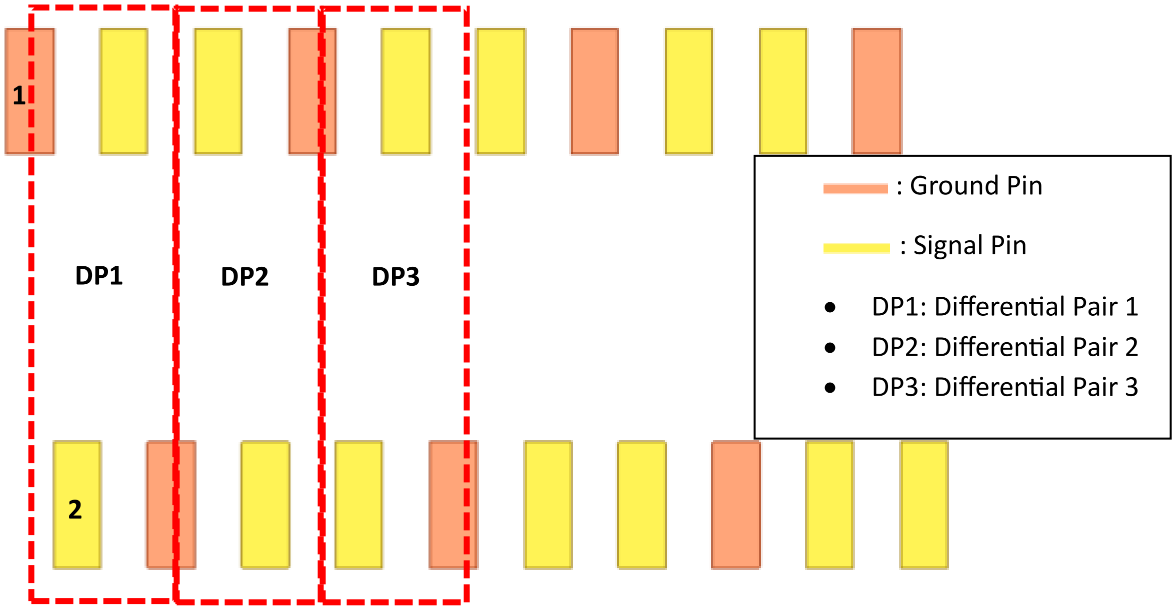

Figure 11 : Sequential Differential Pair Pinout

As previously mentioned, the CABLINE®-CX II, UA II and UX II have staggered signal contacts on the receptacle side. The sequential GSSG pinout refers to the pin assignment shown in Figure 11, that shows the ground pads and the Signal pads within the differential pair occupying both sets of rows. The positive signal of the differential pair is in one row while the negative signal of the differential pair is in the other row. In the above case, DP1 has DP1+ as Pin 2 and DP1- as Pin 3. Similarly, DP2+ is Pin 5 while DP2- is Pin 6. Pin 1, Pin 4 and Pin 7 are ground signals.

The benefit of this will be seen on the plug side of the connector. Since the plug end of the connector has a single row of contacts as shown below on Figure 12, the contacts on the plug side will have a GSSG configuration as indicated at the exits of the micro-coaxial cables. This pinout allows each differential pair signals to be separated from other differential pair signals by ground signals on either side. This is indicated in Figure 12, where the plug side is a single row with Pin 1 on the left and in a sequence to the right.

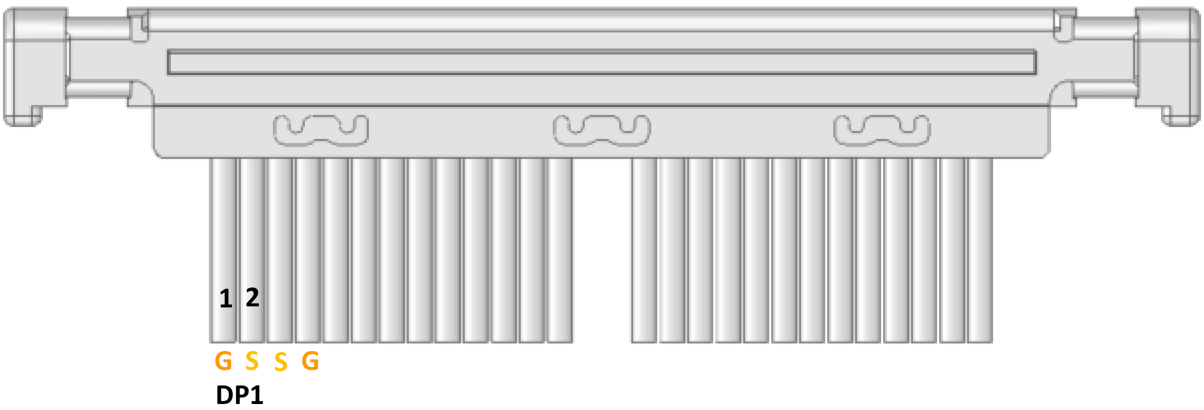

Figure 12: CABLINE®-UA II Plug

This approach will provide a bit of a challenge especially in terms of breaking out of the PCB pads and routing the PCB traces differentially, because of the asymmetry of the two rows of pads and the signal pins assigned across two rows. The DP+ is located in one row while DP- is located in the other row, so this asymmetry can result in skew and mode-conversion.

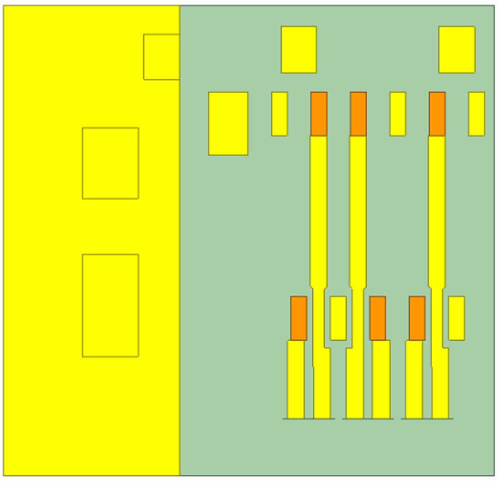

Figure 13: CABLINE®-CX II Simulation

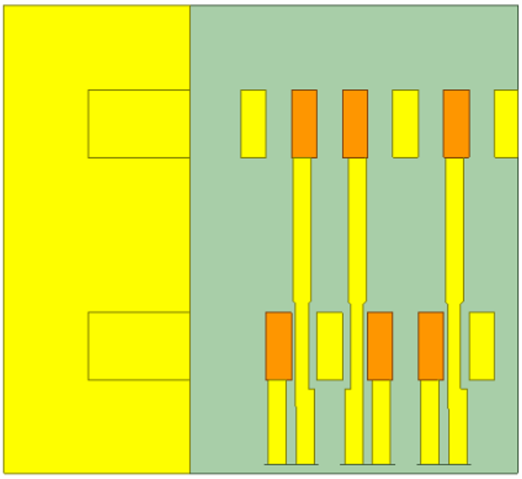

Figure 14: CABLINE®-UX II Simulation

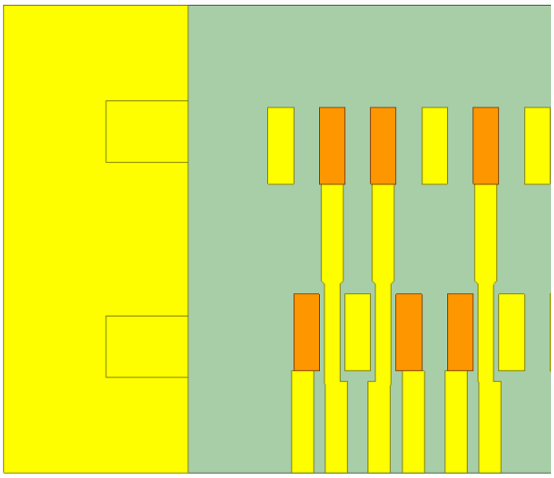

Figure 15: CABLINE®-UA II Simulation

Figure 13, Figure 14 and Figure 15 show the simulation setup for the CABLINE®-CX II, UX II and UA II respectively, and they follow the sequential pinout as discussed earlier. The Figures also show the trace exits for the differential pairs as they exit in the direction cable exiting from the plug. Most typical systems have the differential pairs going to a common destination, so this simulation was performed with the traces exiting in one direction.

The simulation results for this condition are shown in Figure 16 with the simulations focusing on the critical parameters – insertion loss, return loss, near-end crosstalk (NEXT) and far-end (crosstalk). The simulation results highlight the performance of the 3 different connectors in this configuration.

The connectors are all rated to 5Gbps, (Nyquist: 2.5GHz for NRZ signaling), however the simulation data below is shown up to 10 GHz.

The simulations for these connectors and pinouts were performed using ANSYS® HFSS Electronics Desktop™ and the port impedance used for these simulations is 100 Ohm differential.

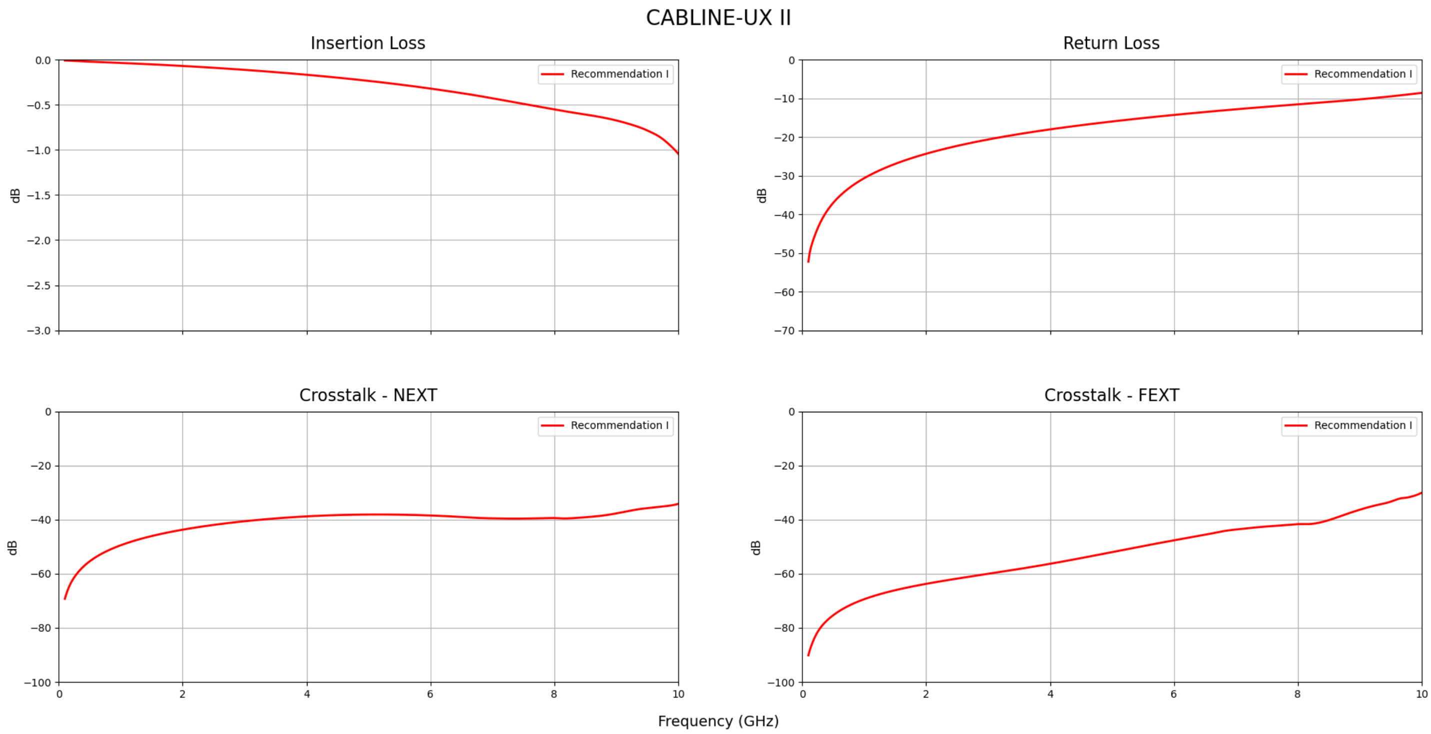

Figure 16: Sequential GSSG Pinout with Ground Pins - CABLINE®-UX II

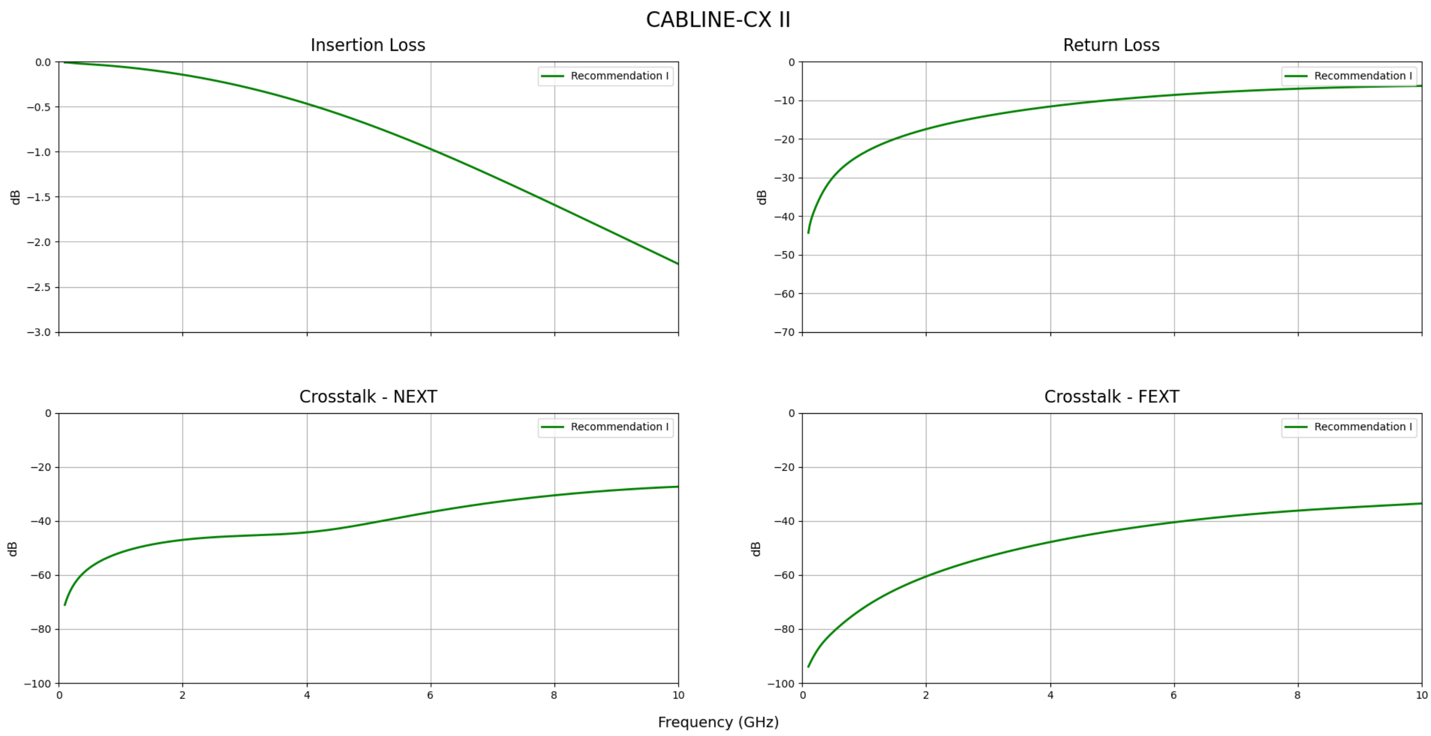

Figure 17: Sequential GSSG Pinout with Ground Pins – CABLINE®-CX II

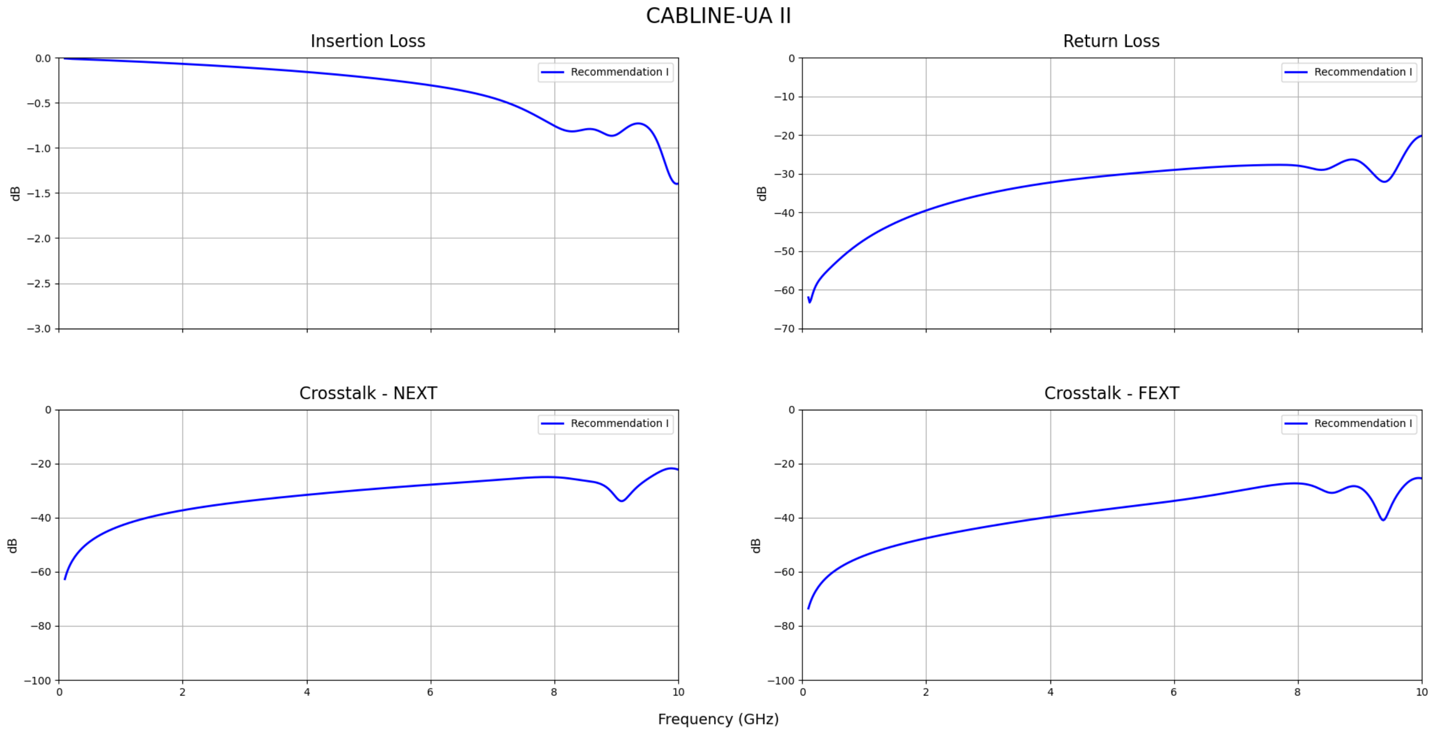

Figure 18: Sequential GSSG Pinout with Ground Pins – CABLINE®-UA II

Figure 16, Figure 17 and Figure 18 show the signal integrity performance of the CABLINE®-UX II, CABLINE®-CX II and CABLINE®-UA II connectors, specifically the insertion loss, return loss and crosstalk. The waveforms show that the performance of the connectors with this pinout is stable in terms of insertion loss and return loss performance. The CABLINE®-CX II has slightly higher insertion loss compared to its other counterparts, but this is inherent to the design of the connector.

The return loss for the CABLINE®-UX II and the CABLINE®-UA II is well below -10dB until 10 GHz, with the UA II connector showing excellent return loss up to 10 GHz. This is as a result of the of the CABLINE®-UA II being a 0.35mm pitch connector, that results in better return loss compared to the other two connectors. The crosstalk performance here refers to the signals on DP1 coupling to DP2 both on the near side as well as the far side. The more critical parameter here for the connector is the near-end crosstalk (NEXT) since this is primarily simulating the performance of the mated connector.

The general rule of thumb is the crosstalk performance needs to be less than -40 dB for the frequency of operation. Based on this and with this particular, the CABLINE®-UX II can be used for a maximum data-rate of 6 Gbps, the CABLINE®-CX II can be for operating at a maximum data-rate of 10 Gbps, while the CABLINE®-UA II can be used for a maximum data-rate of 2 Gbps.

II. Sequential SSSS Pinout with No Ground Pins

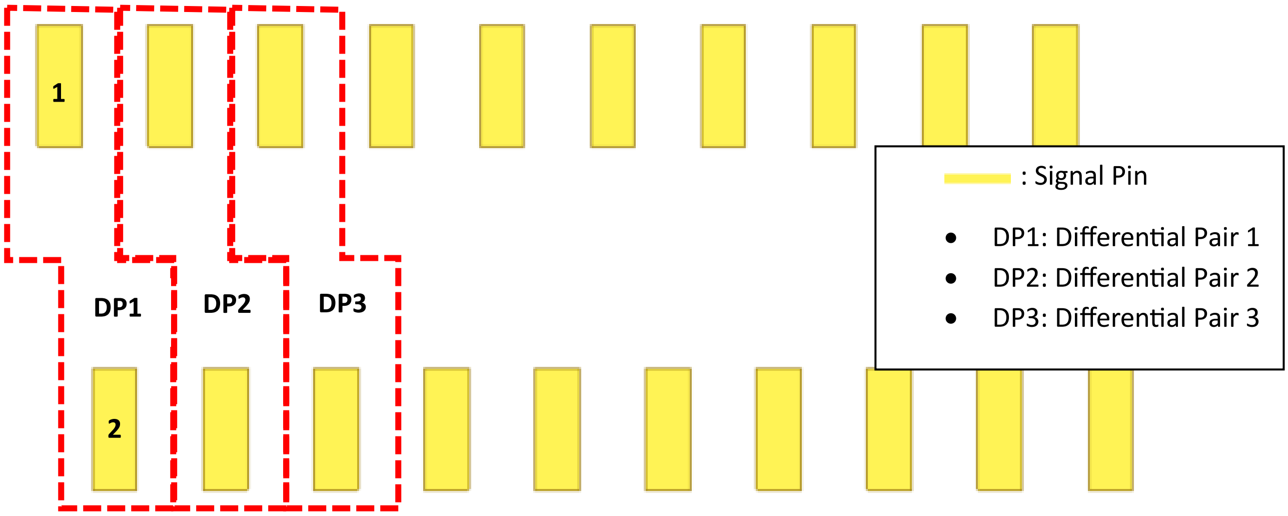

Figure 19: SSSS Differential Pair Pinout

In this pinout configuration, the differential signals are not separated by any ground signals on the receptacle side, as shown above in Figure 19. The differential pair pins are also grouped as shown in Figure 19 . This pin selection can be used in applications where pin density is a concern, however there will be performance trade-offs as the signal integrity performance with this approach will be worse than the earlier configuration.

As shown in Figure 20, the differential pair DP1 will have DP1+ as Pin 1 and DP1- as Pin 2. Similarly, DP2+ will be Pin 3 and DP2- will be Pin 4. The plug side, as previously mentioned are a single row of contacts starting with Pin 1 from the left to the right in a sequence.

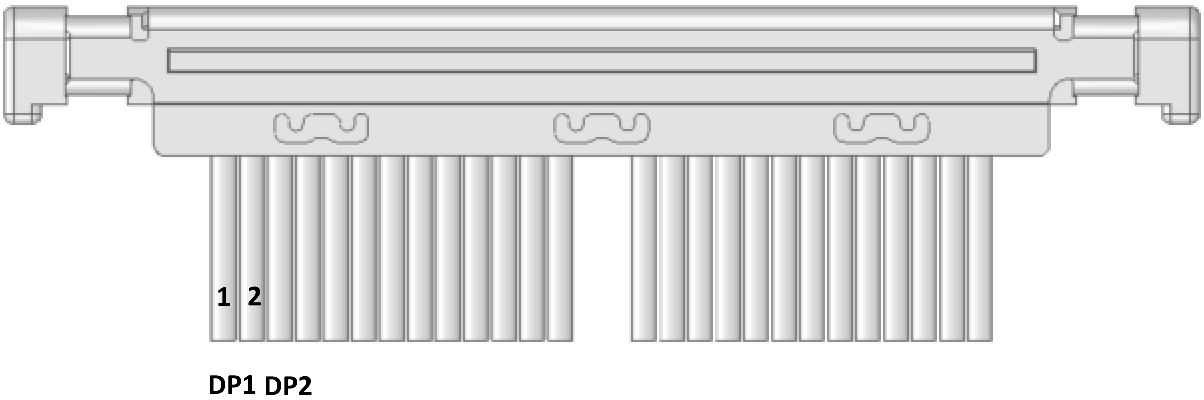

Figure 20: CABLINE®-UA II Plug

This approach is similar to the first approach will exit out as micro-strip traces towards the direction of the cable exit. As in the earlier case, the traces will need to be length matched as one of the traces from within the differential pair will be longer than the other one. Since there are no ground pins separating the differential pairs, this will result in higher crosstalk between the differential pairs.

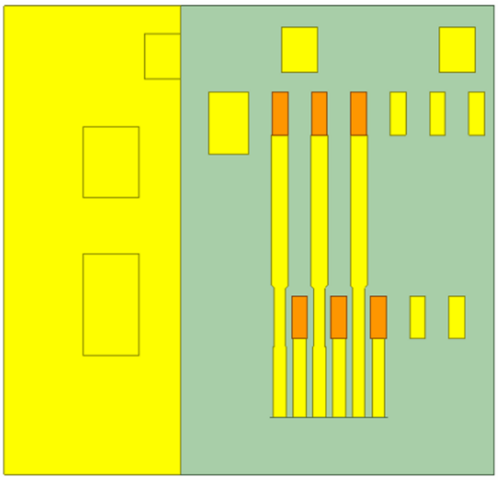

Figure 21: CABLINE®-CX II Simulation

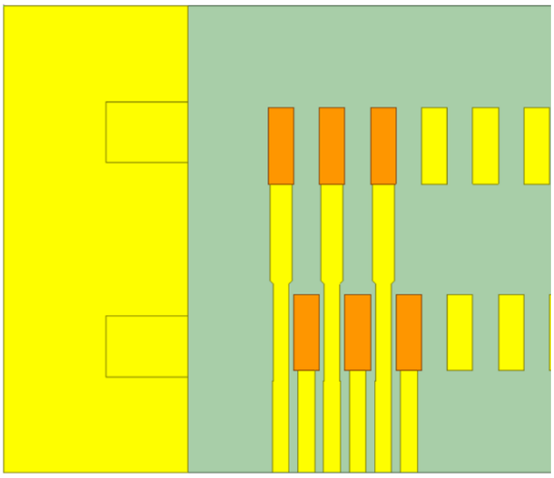

Figure 22: CABLINE®-UX II Simulation

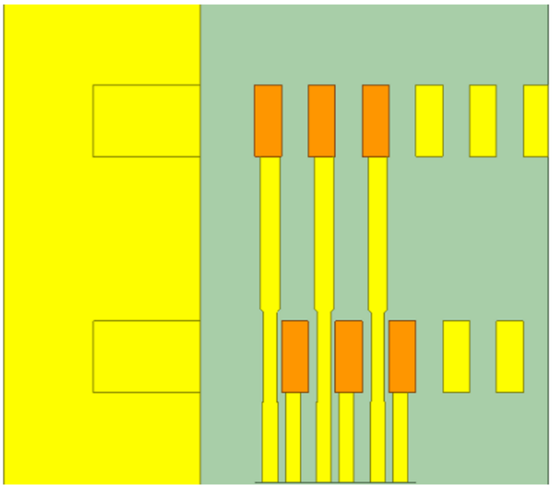

Figure 23: CABLINE®-UA II Simulation

The trace exits for the 3 different connectors are shown above in Figure 21, Figure 22 and Figure 23 and show the simulation setup for the CABLINE®-CX II, UX II and UA II respectively, and the SSSS sequential pinout. The Figures also show the trace exits for the differential pairs as they exit in the direction cable exiting from the plug.

The simulation results for this condition are shown below with the simulations focusing on the critical parameters – insertion loss, return loss, near-end crosstalk (NEXT) and far-end (crosstalk). The simulation results highlight the performance of the 3 different connectors in this configuration.

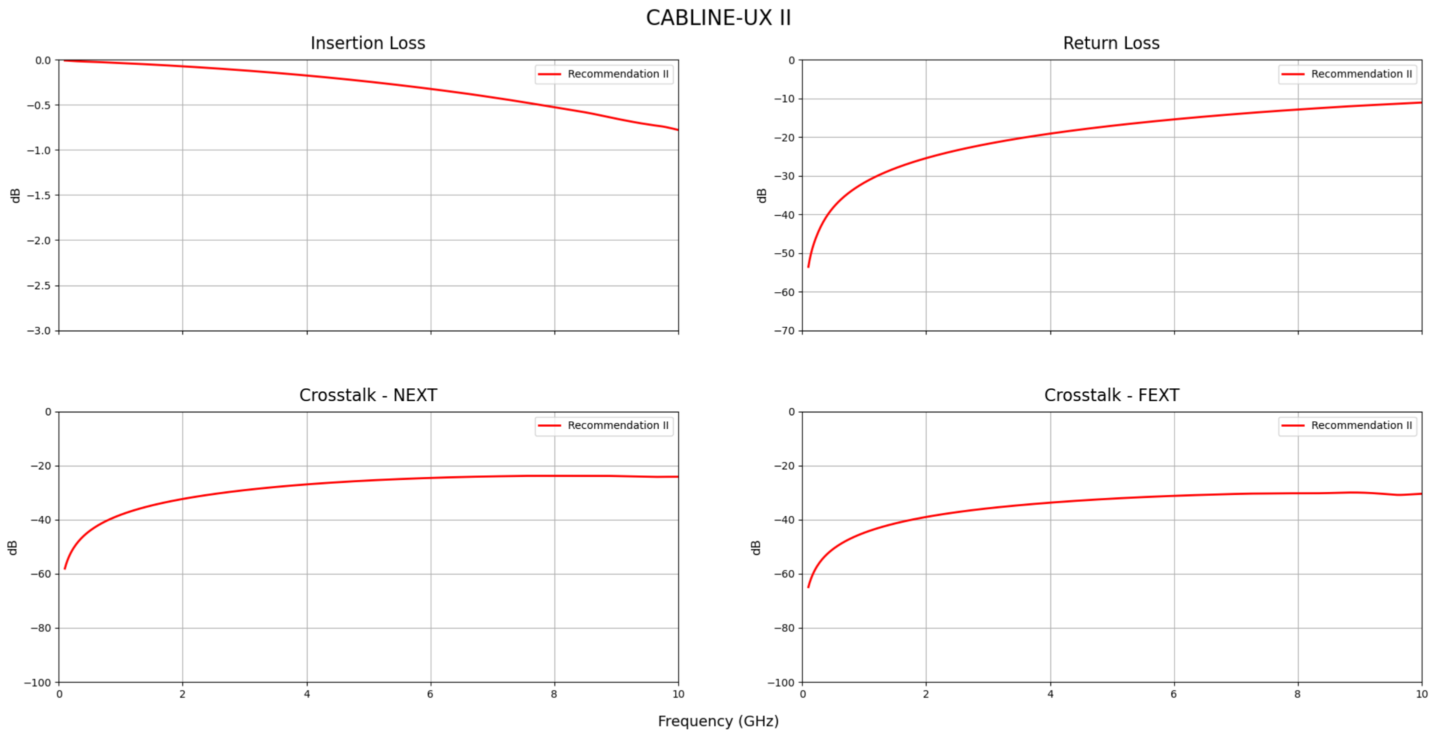

Figure 24: Sequential SSSS Pinout with No Ground Pins - CABLINE®-UX II

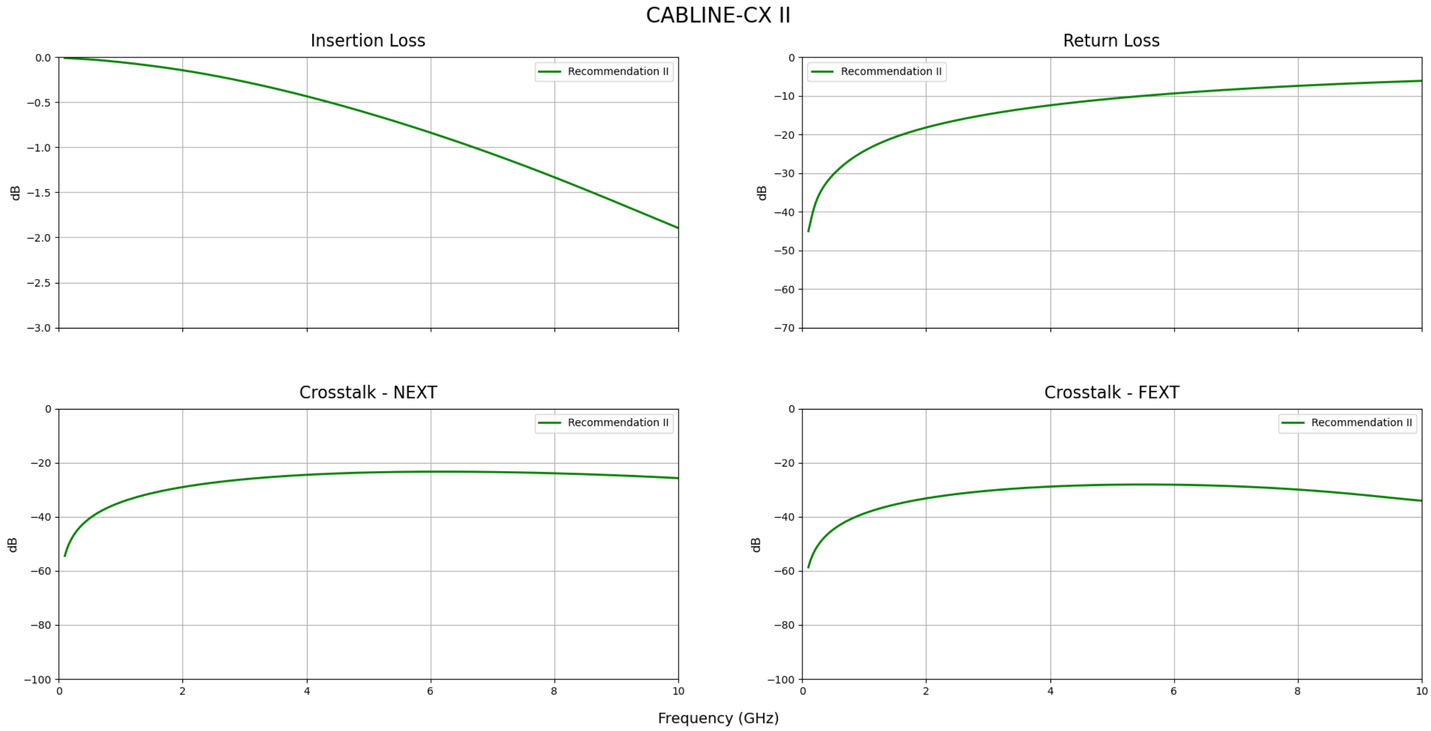

Figure 25 : Sequential SSSS Pinout with No Ground Pins - CABLINE®-CX II

Figure 24, Figure 25 and Figure 26 show the signal integrity performance of the CABLINE®-UX II, CABLINE®-CX II and CABLINE®-UA II connectors, specifically the insertion loss , return loss and crosstalk. The waveforms show that the performance of the CABLINE®-UX II and CABLINE®-UA II, with this pinout has a maximum insertion loss of -1 dB at a maximum frequency of 10 GHz while the CABLINE®-CX II has a maximum insertion loss of less than -2 dB below 10 GHz.

The return loss for the CABLINE®-UX II and the CABLINE®-UA II is below -10 dB until 10 GHz, with the UA II connector showing excellent return loss up to 10 GHz, similar to the earlier pinout. The CABLINE®-CX II has a slightly higher return loss compared to the other two connectors with -10 dB of loss at a frequency of 5 GHz.

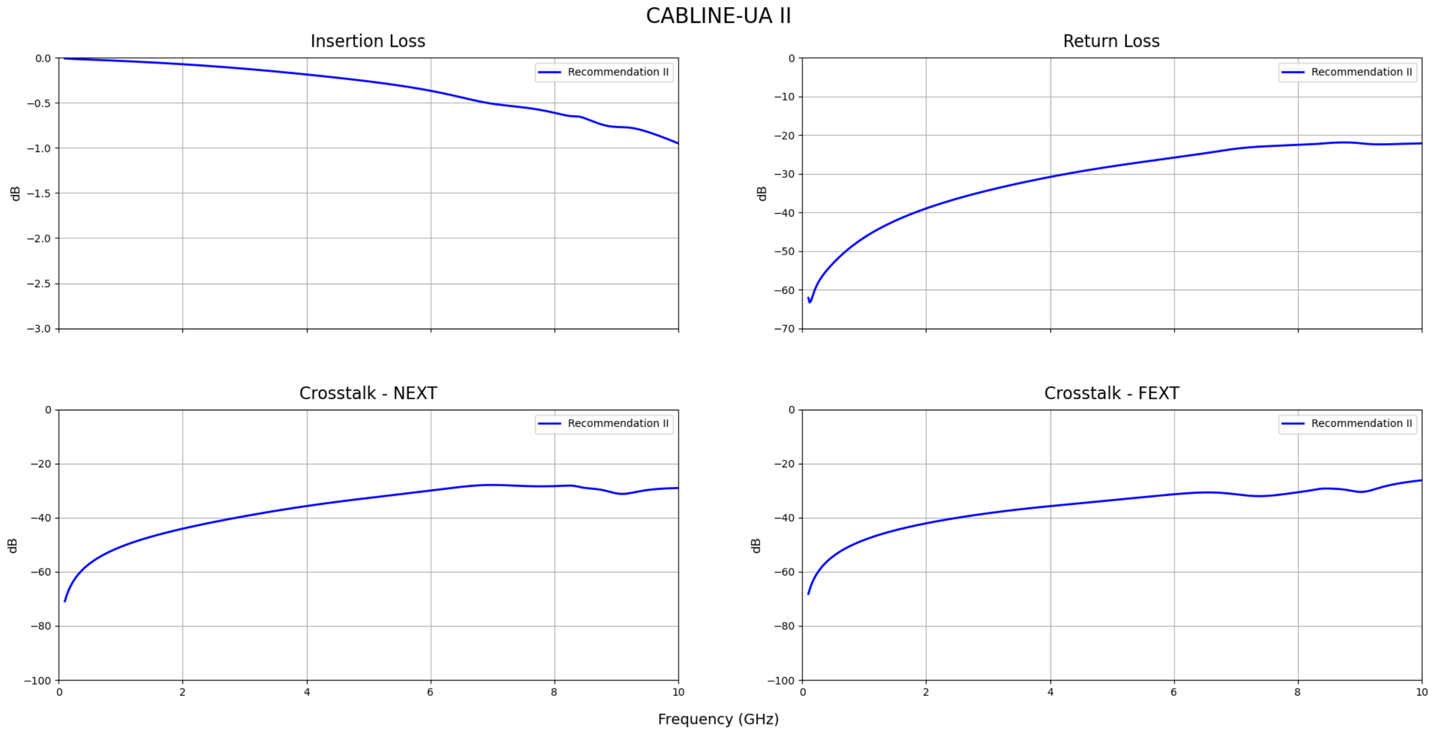

Figure 26: Sequential SSSS Pinout with No Ground Pins – CABLINE®-UA II

The crosstalk performance here refers to the signals on DP1 coupling to DP2 both on the near side as well as the far side.

As mentioned previously, this pinout without the ground signals separating the signal pins results in higher crosstalk between the differential pairs. The NEXT is higher than -40 dB at around 1 GHz for the CABLINE®-UX II and CABLINE®-CX II, while the CABLINE®-UA II shows -40 dB of loss at slightly more than 2 GHz.

This particular pinout, therefore should only be used for applications where the data-rate does not exceed 2 Gbps for the CABLINE®-UX II and the CABLINE®-CX II, while the data-rate does not exceed 5 Gbps for the CABLINE®-UA II.

III. GSSG Pinout in a Single Row, Breakout in Both Directions

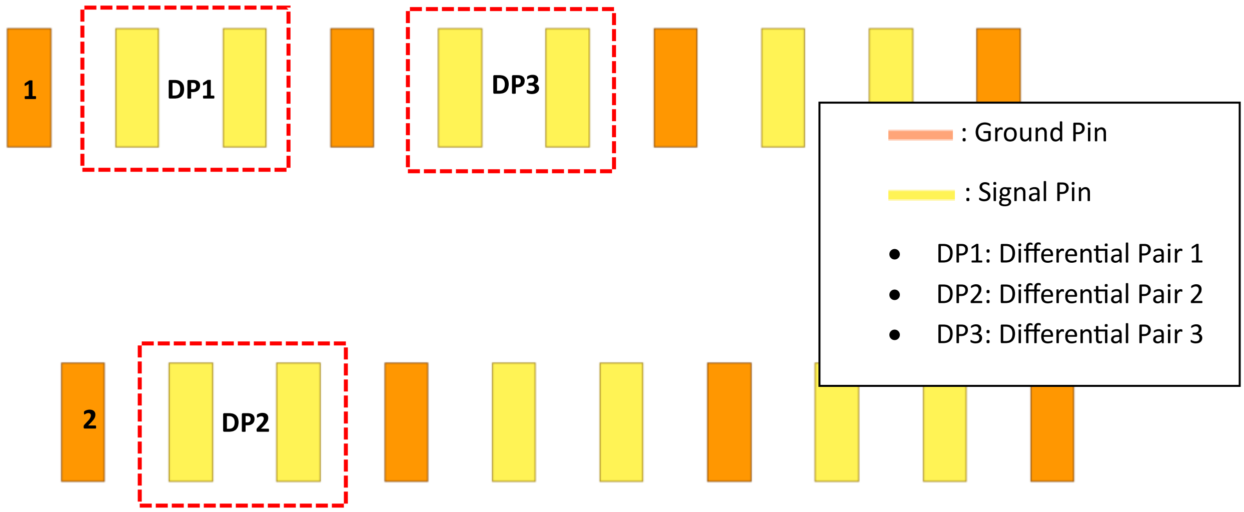

Figure 27: GSSG Differential Pair Pinout in a Single Row

In this particular pinout configuration, the differential signals are assigned pins as shown above in Figure 27. As opposed to the previous pinouts, where the positive and negative signals of a differential pair were in two rows, this approach has both the positive and negative signal pins adjacent to each other within the same row.

As shown above in Figure 27, the DP1 pair will have the Pin 3 for DP1+ and Pin 5 for DP1-, while the DP2 differential pair will have Pin 4 for DP2+ and Pin 6 for DP2-. Pins 1, 2, 7, 8 will be the ground pins.

While this pinout configuration seems ideal on the receptacle side in terms of symmetry and ensuring an elegant trace breakout, it does affect the pinout configuration on the plug side. Since the plug side is a single row of contacts with Pin 1 on the left side with the contacts being in sequence, it can mean that the cable configuration will look as shown in Figure 28

Since Pin 3 is DP1+ and Pin 4 is DP2+, this will mean that the differential signals for DP1 and DP2 will be interleaved with each other, so it will have some signal integrity implications.

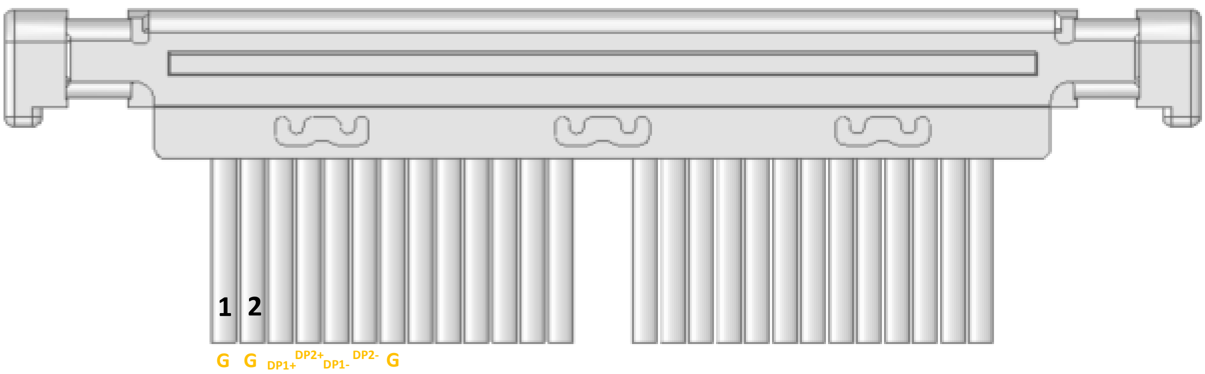

Figure 28: CABLINE®-UA II Plug

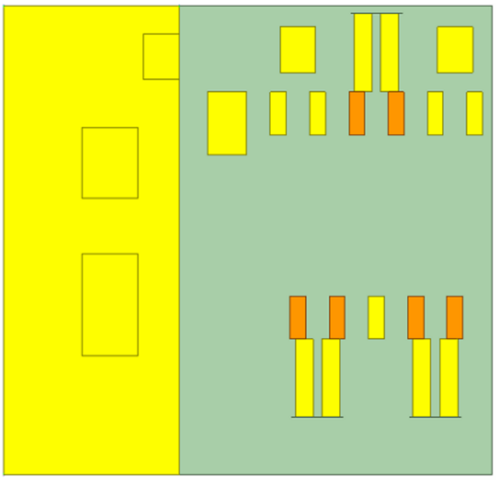

Figure 29: CABLINE®-CX II Simulation

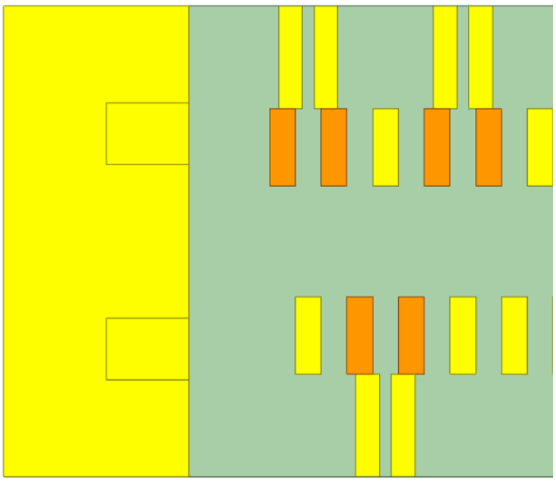

Figure 30: CABLINE®-UX II Simulation

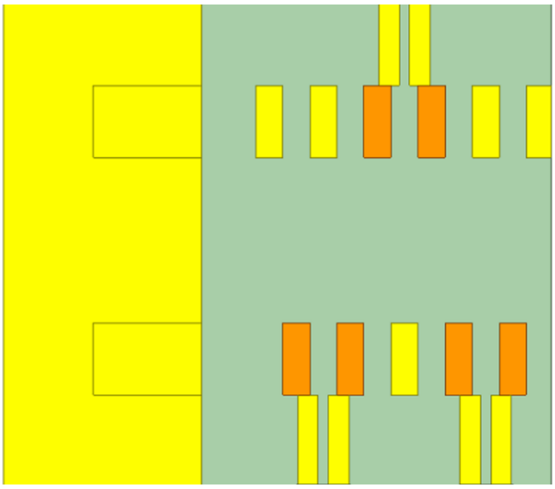

Figure 31: CABLINE®-UA II Simulation

The trace exits for the 3 different connectors are shown above in Figure 29, Figure 30 and Figure 31. They show the simulation setup for the CABLINE®-CX II, UX II and UA II respectively, and the GSSG pinout in a single row. The Figures also show the trace exits for the differential pairs as they exit in the opposite directions, in both directions. This is the most elegant method to break the traces out and ensure it is a symmetric exit.

The simulation results for this condition are shown below with the simulations focusing on the critical parameters – insertion loss, return loss, Near-End crosstalk (NEXT) and Far-End (crosstalk). The simulation results highlight the performance of the 3 different connectors in this configuration.

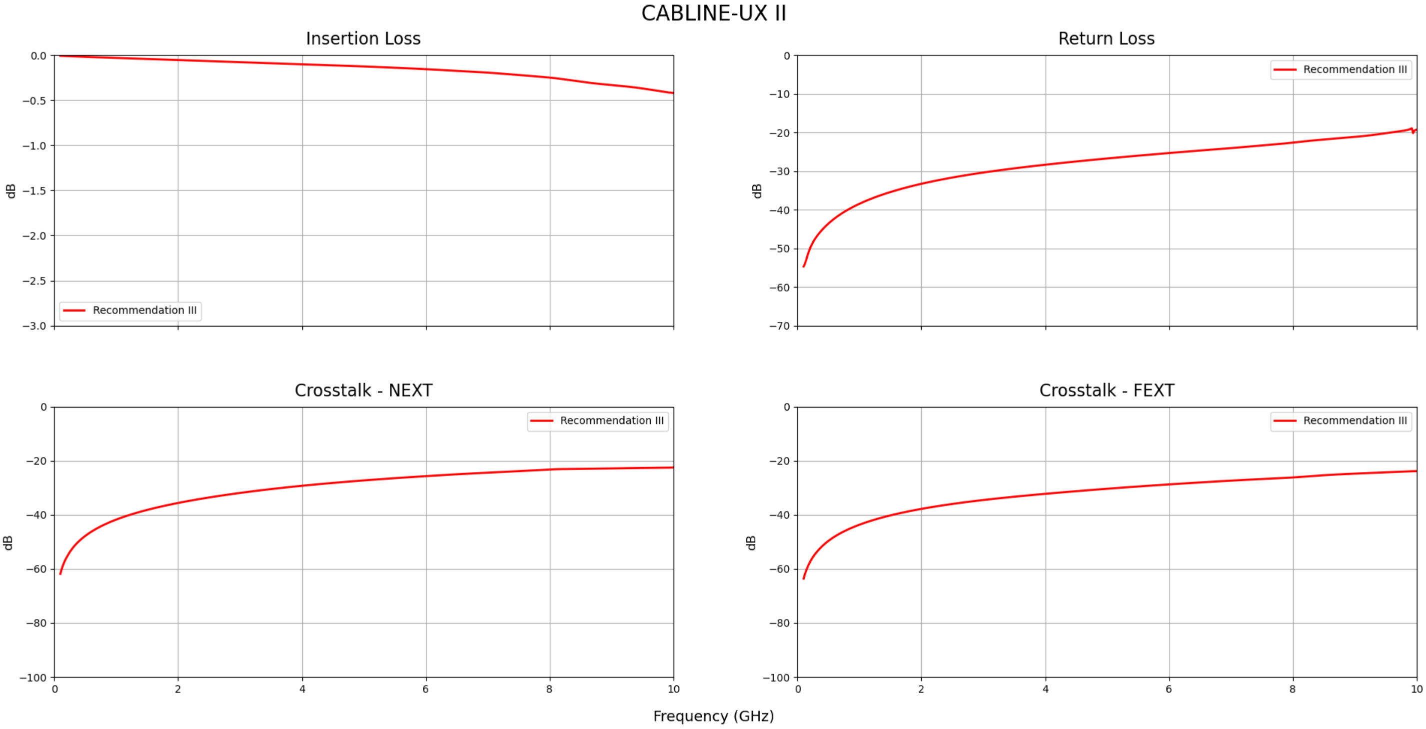

Figure 32: GSSG Pinout in a Single Row, Breakout in Both Directions – CABLINE®-UX II

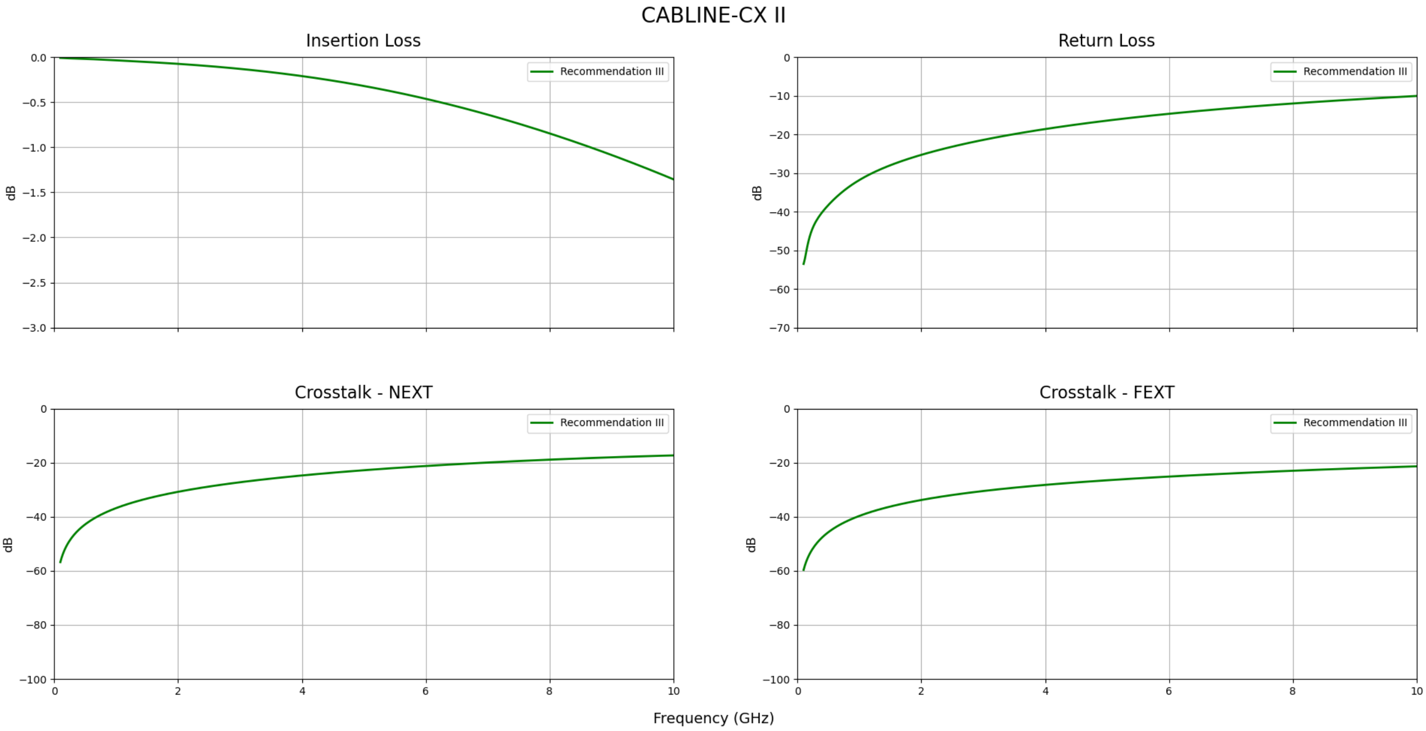

Figure 33: GSSG Pinout in a Single Row, Breakout in Both Directions – CABLINE®-CX II

Figure 32, Figure 33 and Figure 34 show the signal integrity performance of the CABLINE®-UX II, CABLINE®-CX II and CABLINE®-UA II connectors, specifically the insertion loss, return loss and crosstalk for this pinout. The waveforms show that the performance of the CABLINE®-UX II and CABLINE®-UA II, with this pinout has a maximum insertion loss of -0.75 dB at a maximum frequency of 10 GHz while the CABLINE®-CX II has a maximum insertion loss of less than -1.5 dB below 10 GHz.

The return loss for the CABLINE®-UX II, CABLINE®-CX II and the CABLINE®-UA II is below -10dB until 10 GHz, with the UA II connector showing excellent return loss up to 10 GHz.

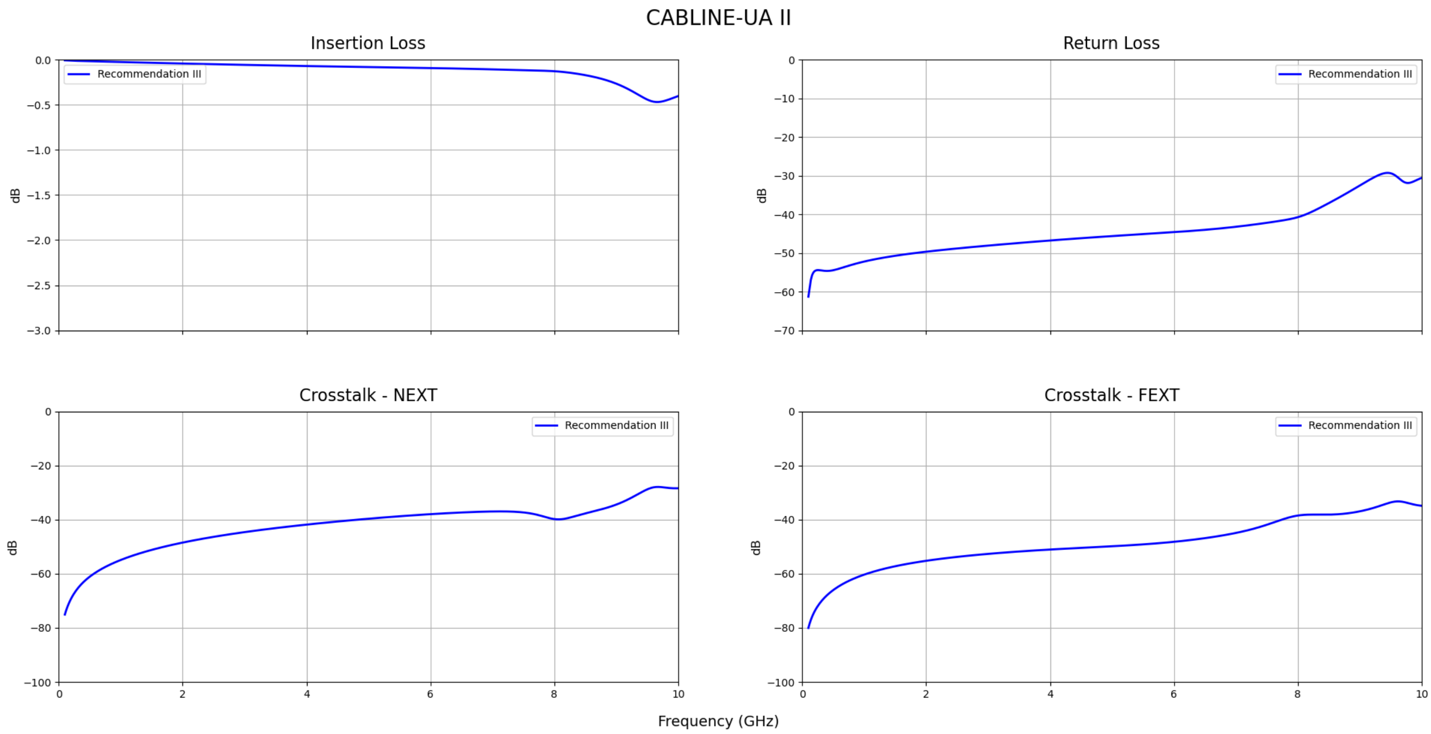

Figure 34: GSSG Pinout in a Single Row, Breakout in Both Directions – CABLINE®-UA II

The crosstalk performance here refers to the signals on DP1 coupling to DP2 both on the near side as well as the far side.

In this particular pinout configuration, the CABLINE®-UX II and the CABLINE®-CX II have less than -40 dB of crosstalk only below 1 GHz, while the CABLINE®-UA II shows excellent crosstalk performance up to 5 GHz. The higher crosstalk seen on the UX II and the CX II is as a result of the micro-coaxial cables being interleaved on the plug side resulting in higher crosstalk.

This particular pinout, therefore should only be used for applications where the data-rate does not exceed 2 Gbps for the CABLINE®-UX II and the CABLINE®-CX II, while the CABLINE®- UA II can be comfortably used up to 10 Gbps.

Comparison Between the Pinout & Routing Recommendations

This section demonstrates the comparison of the performance of each connector for the 3 recommended pinouts and routing schemes discussed earlier.

CABLINE®-UX II

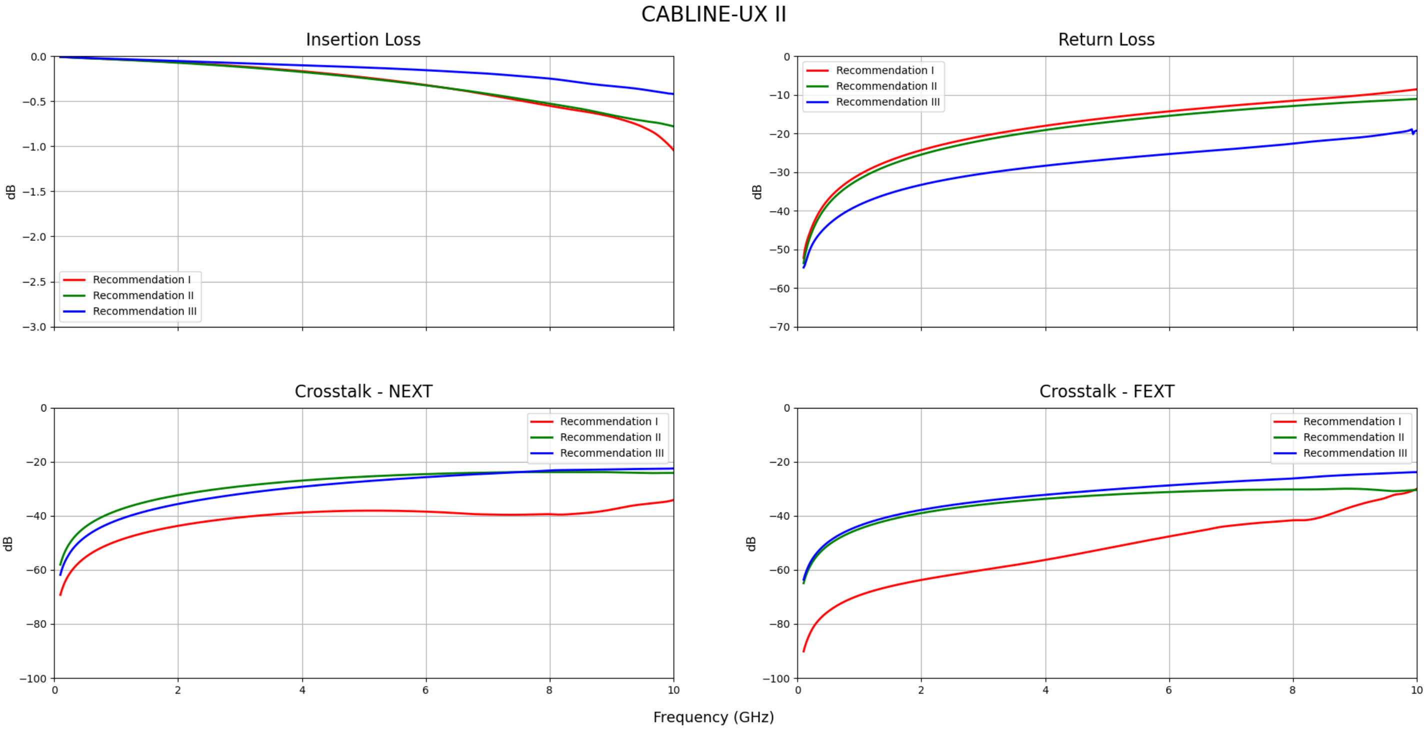

Figure 35: CABLINE®-UX II Comparison

The Figure 35 shows a comparison of the insertion loss, return loss and the crosstalk performance of the CABLINE®-UX II for the different pinouts and routing schemes discussed earlier in the previous section.

The Recommendation I show the best overall performance in terms of all the parameters even though the insertion loss and return loss is slightly higher than Recommendation III. However, in terms of crosstalk, Recommendation I is significantly better than the other pinout and routing schemes.

Recommendation II shows similar performance to Recommendation I in terms of insertion loss and return loss, but due to the lack of ground pins between the differential pairs, the crosstalk performance is similar to Recommendation III.

Recommendation III shows the best performance in terms of insertion loss and return loss, however due the micro-coaxial cables being interleaved on the plug side, it shows higher crosstalk than Recommendation I.

CABLINE®-CX II

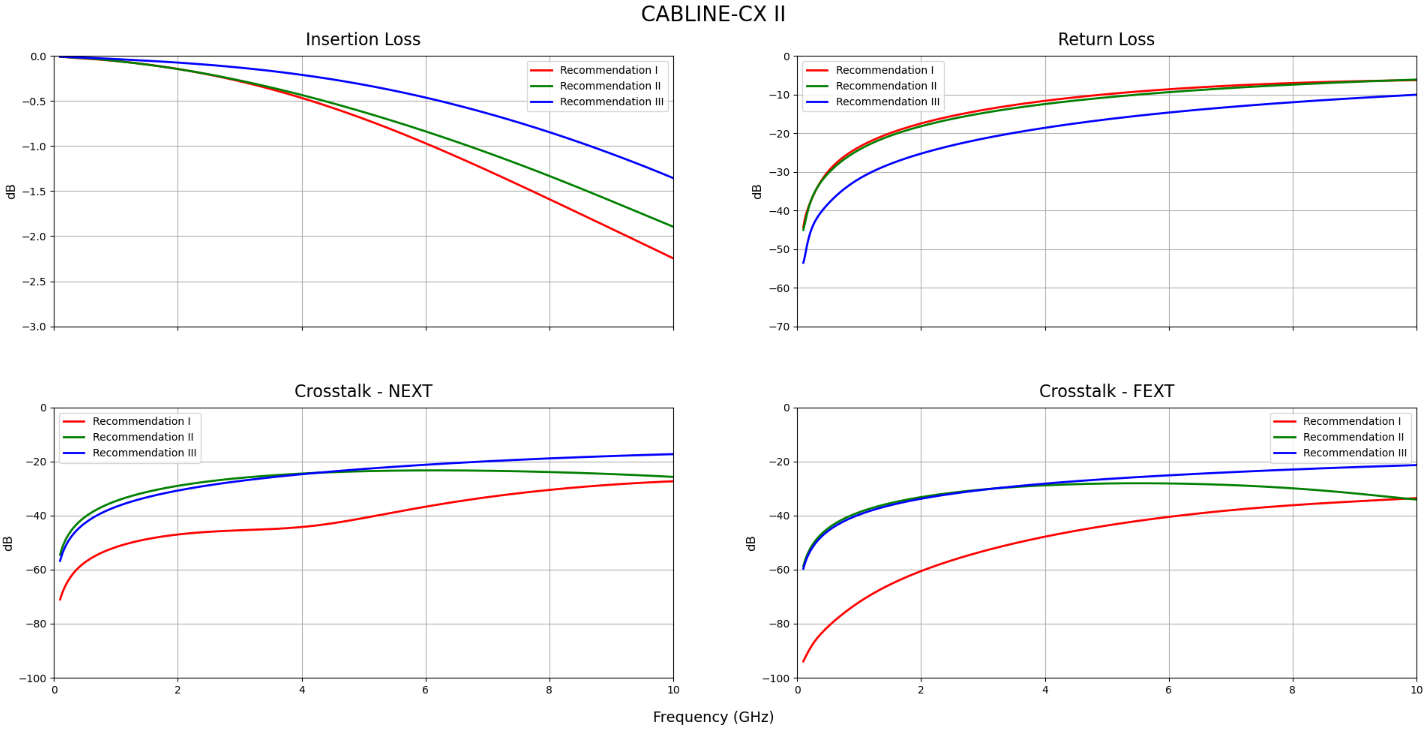

Figure 36: CABLINE®-CX II Comparison

The Figure 36 shows a comparison of the insertion loss, return loss and the crosstalk performance of the CABLINE®-CX II for the different pinouts and routing schemes discussed earlier in the previous section.

Recommendation I show the best overall performance in terms of all the parameters even though the insertion loss and return loss is slightly higher than Recommendation III, but the higher insertion loss and return loss is not critical. The critical factor would be crosstalk where Recommendation I is significantly better than the other pinout and routing schemes.

Recommendation II shows similar performance to Recommendation I in terms of insertion loss and return loss, but due to the lack of ground pins between the differential pairs, the crosstalk performance is similar to Recommendation III as seen previously with CABLINE®-UX II as well.

Recommendation III shows the best performance in terms of insertion loss and return loss, however due the micro-coaxial cables being interleaved on the plug side, it shows higher crosstalk than Recommendation I.

CABLINE®-UA II

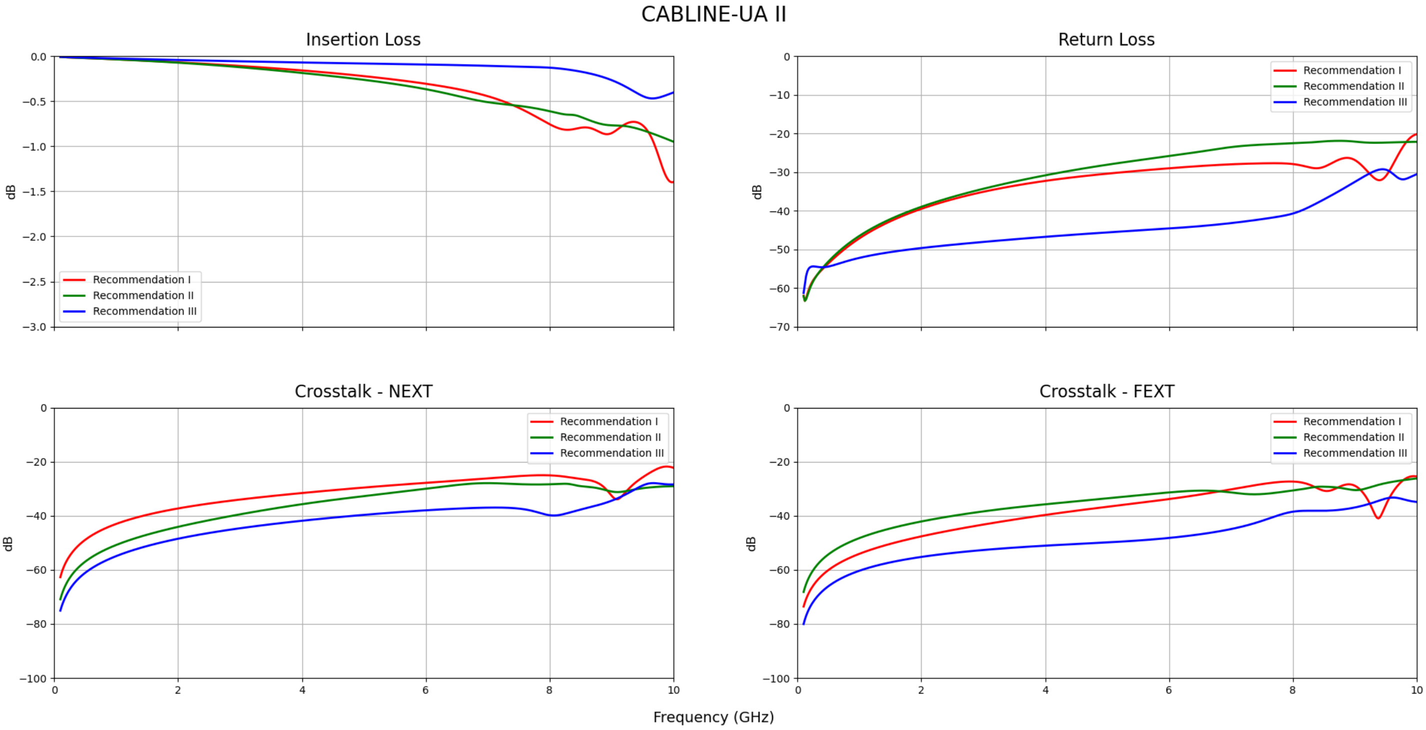

Figure 37: CABLINE®-UA II Comparison

The Figure 37 shows a comparison of the insertion loss, return loss and the crosstalk performance of the CABLINE®-UA II for the different pinouts and routing schemes discussed earlier in the previous section.

The Recommendation III shows the best overall performance in terms of all the parameters with the insertion loss, return loss and crosstalk showing significantly better performance over Recommendation I and II

Recommendation I and Recommendation II shows similar performance in terms of insertion loss and return loss as well as crosstalk. The wider pitch of the CABLINE®-UA II makes Recommendation III the better approach to Recommendation I and Recommendation II, as opposed to Recommendation I being the better approach as seen with CABLINE®-UX II and CABLINE®-CX II.

Conclusion

To summarize the paper, this paper discussed the CABLINE® series of connectors that use a dual-row of contacts, with 0.25mm and 0.35mm pitch, specifically the CABLINE®-UX II, CABLINE®-CX II and CABLINE®-UA II series of connectors.

The paper further discussed the challenges of pinout selection and routing for these connectors, with a focus on differential signaling. It proposed 3 different approaches keeping in mind signal integrity performance as well as pin density, to maximize the benefit of using the dual-row connectors.

It presented simulation data for the different approaches used so it helps determine the routing and pinout selection based on the application and the data-rate of the application.

The tables below give a concise summary of the simulation data where the application data-rate determines the type of routing and pinout selection as well as a dimensional comparison for pin-density considerations.

Table 1: Data-rate Comparison

	Recommendation I	Recommendation II	Recommendation III
CABLINE®-UX II	<=6 Gbps	<=2 Gbps	<=2 Gbps
CABLINE®-CX II	<=10 Gbps	<=2 Gbps	<=2 Gbps
CABLINE®-UA II	<=2 Gbps	<=5 Gbps	<=10 Gbps

Table 2: Mechanical Comparison for a 40-pin Connector

	Mated Height	Width	Depth
CABLINE®-UX II	1.04 mm	14.10 mm	2.40 mm
CABLINE®-CX II*	0.73 mm	16.45 mm	5.21 mm
CABLINE®-UA II	1.27 mm	17.00 mm	2.90 mm

*CABLINE®-CX II dimensions are for the unshielded version of the connector

However, the signaling and routing schemes are not limited to the recommendations provided in this paper. There are other routing and pinout selection that may provide better performance with other trade-offs.

I-PEX can support and provide simulation data if the application requires a different pinout or routing scheme.

For more information on our CABLINE®-UX II connector, including drawings, 3D models, PCB footprints, test reports and product specifications, please refer to the product page. https://www.i-pex.com/product/cabline-ux-II

For more information on our CABLINE®-CX II connector, including drawings, 3D models, PCB footprints, test reports and product specifications, please refer to the product page. https://www.i-pex.com/product/cabline-cx-II-with-cover

For more information on our CABLINE®-UA II connector, including drawings, 3D models, PCB footprints, test reports and product specifications, please refer to the product page. https://www.i-pex.com/product/cabline-ua-II

For a complete overview of the I-PEX micro-coaxial/twinax cable solutions, the product offerings can be reviewed on this matrix.