System A Simulation Results Rev. B

Figure 1: Ideal simulation for the 4x4 Butler A System utilizing ideal components

Figure 2: Layout of the 4x4 Butler A System utilizing 90° Coupler and 45° Phase Shifter N-port data
The system is assembled using the N-port data from the 90° Coupler designed by Michael Pecararo in HFSS and 45° Phase Shifter designed by Mia Mujezinovic in HFSS.

Figure 3: Return Loss results for the 4x4 Butler A ideal system
The results show an increased return loss at 11GHz in the N-port system compared to the ideal system. At 10GHz and 12GHz, the return loss is similar between the N-port system and the ideal system. The increased return loss was seen in the 90° coupler designs. The minimum shifted from 11GHz to approximately 10GHz in the final HFSS designs. This can similarly be seen in the system results.
Figure 5: Isolation results for the 4x4 Butler A ideal system
There is an increased reflection in the N-port system compared to the ideal system. It remains below -16dB for the 10 to 12GHz range.

Figure 6: Isolation results for the 4x4 Butler A N-port system
Figure 7: Transmission results for the 4x4 Butler A ideal system
The ideal system transmission is centered around -6dB while the N-port system is centered closer to -6.4dB.
Figure 9: Phase progression for input 1 results for the 4x4 Butler ideal system
The ideal phase progression accurately shows 45° difference centered around the first output port. The N-port results show a 45° +/-0.7° difference centered around the first output port. (Graph to be updated to reflect this, Designer gives me problems when I remote desktop so this will be corrected later.)
Figure 11: Phase progression for input 2 results for the 4x4 Butler ideal system
The ideal phase progression accurately shows $135^\circ$ difference centered around the first output port. The N-port results show a $135^\circ +/-0.2^\circ$ difference centered around the first output port.
Figure 13: Phase progression for input 3 results for the 4x4 Butler ideal system
The ideal phase progression accurately shows 135° difference centered around the first output port. The N-port results show a 135° +/-0.4° difference centered around the first output port.
Figure 15: Phase progression for input 4 results for the 4x4 Butler ideal system

Figure 16: Phase progression for input 4 results for the 4x4 Butler N-port system
The ideal phase progression accurately shows 45° difference centered around the first output port. The N-port results show a 45° +/-0.5° difference centered around the first output port.

![Figure 17: Magnitude of the transmission for all input ports of the ideal system](image1)

![Figure 18: Magnitude of the transmission for all input ports of the N-port system](image2)

The ideal system shows a 0.5 amplitude at 11GHz and 0.5 +/-0.2 at 10 and 12GHz. The N-port system has a lower amplitude throughout the frequency range with a greater difference.