Supplementary Material

In this paper, three topology design rules are derived from maximum power transmission capability (MPTC) results of more than 80 typical IDBS-MPET topologies. Limited by the length of this paper, only a few typical IDBS-MPET topologies and their MPTC calculation results are presented in the main body. The other IDBS-MPET topologies and their MPTC calculation results are listed in this supplementary material.
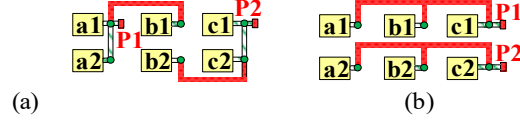

(a)   (b)

Fig. S1. IDBS-MPET of $N_{(2)}P_{(2)}$. (a) $N_{(2)}P_{(2)}$-$D_{(2)(2,1)}$. (b) $N_{(2)}P_{(2)}$-$T_{(2)(1,1,1)}$.

(a)   (b)
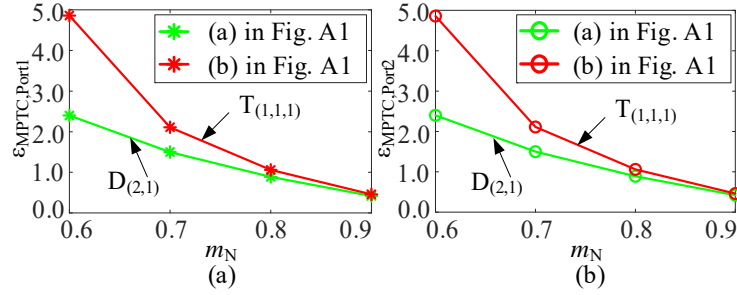
Fig. S2. MPTC of LVDC ports in MPETs shown in Fig. A1. (a) MPTC of Port1. (b) MPTC of Port2.
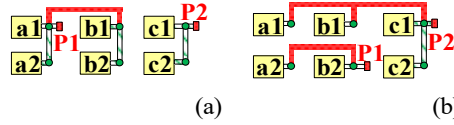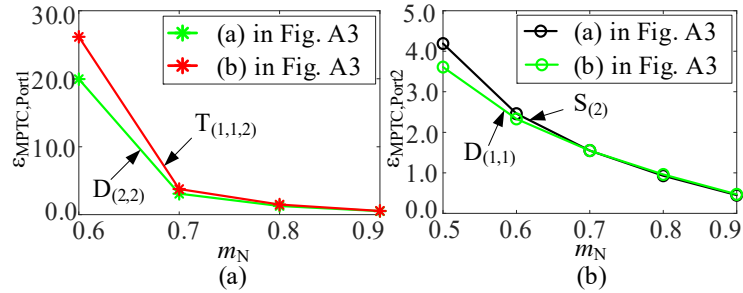

(a)   (b)

Fig. S3. IDBS-MPET of $N_{(2)}P_{(2)}$. (a) $N_{(2)}P_{(2)}$-$S_{(1)(1)}D_{(1)(2,2)}$. (b) $N_{(2)}P_{(2)}$-$D_{(1)(1,1)}T_{(1)(1,1,2)}$.

(a)   (b)

Fig. S4. MPTC of LVDC ports in MPETs shown in Fig. A3. (a) MPTC of Port1. (b) MPTC of Port2.

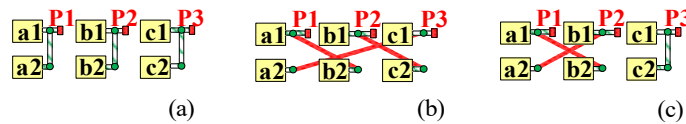(a)   (b)   (c)

Fig. S5. IDBS-MPET of $N_{(2)}P_{(3)}$. (a) $N_{(2)}P_{(3)}$-$S_{(3)(2)}$. (b) $N_{(2)}P_{(3)}$-$D_{(3)(1,1)}$. (c) $N_{(2)}P_{(3)}$-$S_{(1)(2)}D_{(2)(1,1)}$.
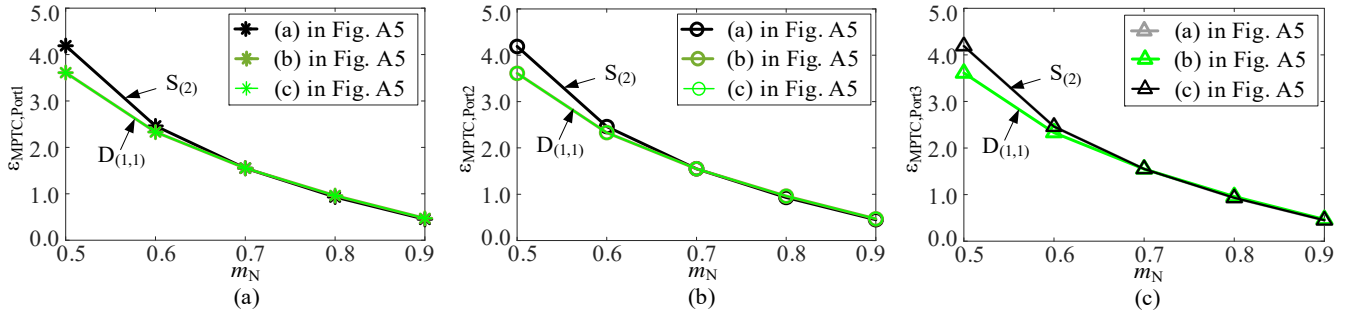
Fig. S6. MPTC of LVDC ports in MPETs shown in Fig. A5. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.
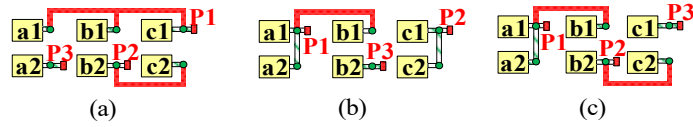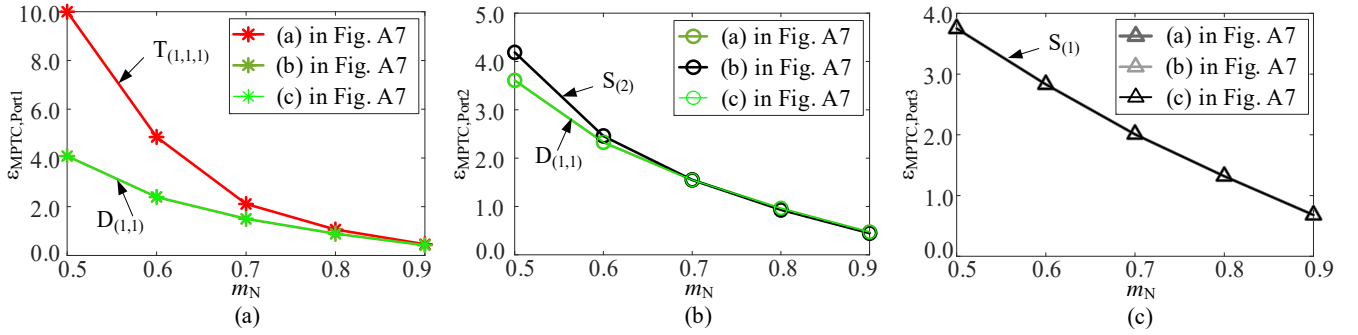

Fig. S7. IDBS-MPET of $N_{(2)}P_{(3)}$. (a) $N_{(2)}P_{(3)}$-$S_{(1)(1)}D_{(1)(1,1)}T_{(1)(1,1,1)}$. (b) $N_{(2)}P_{(3)}$-$S_{(1)(1)}S_{(1)(2)}D_{(1)(2,1)}$. (c) $N_{(2)}P_{(3)}$-$S_{(1)(1)}D_{(1)(1,1)}D_{(1)(2,1)}$.

Fig. S8. MPTC of LVDC ports in MPETs shown in Fig. A7. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.
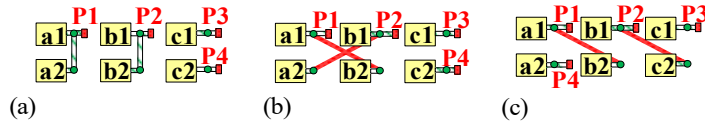

Fig. S9. IDBS-MPET of $N_{(2)}P_{(4)}$. (a) $N_{(2)}P_{(4)}$-$S_{(2)(2)}S_{(2)(1)}$. (b) $N_{(2)}P_{(4)}$-$S_{(2)(1)}D_{(2)(1,1)}$. (c) $N_{(2)}P_{(4)}$-$S_{(2)(1)}D_{(2)(1,1)}$.
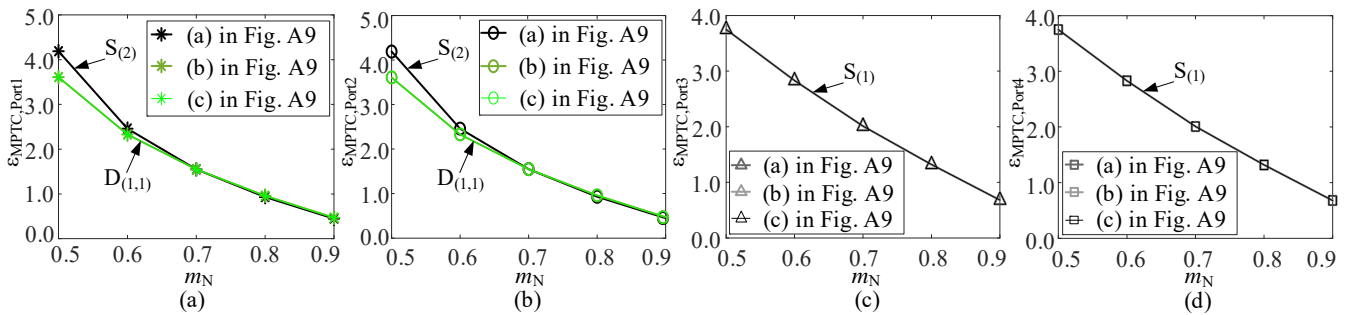

Fig. S10. MPTC of LVDC ports in MPETs shown in Fig. A9. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3. (d) MPTC of Port4.
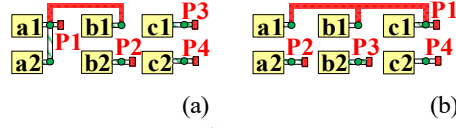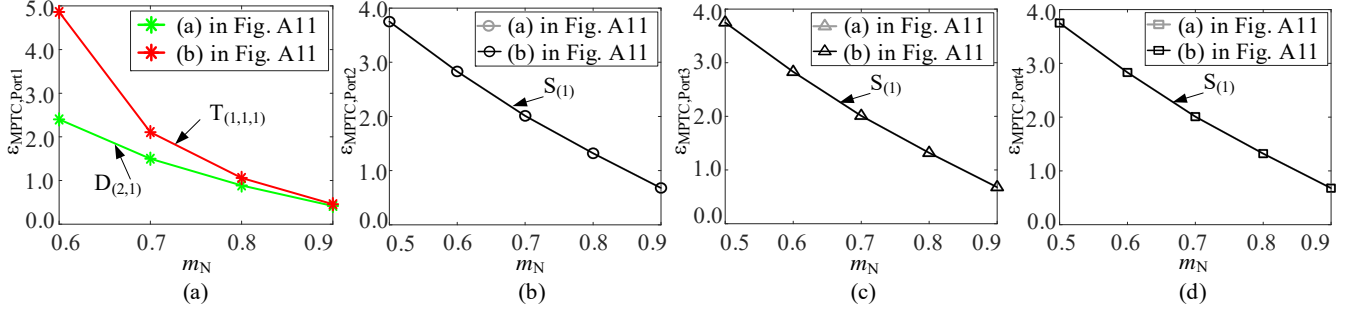
Fig. S11. IDBS-MPET of $N_{(2)}P_{(4)}$. (a) $N_{(2)}P_{(4)}$-$S_{(3)(1)}D_{(1)(2,1)}$. (b) $N_{(2)}P_{(4)}$-$S_{(3)(1)}T_{(1)(1,1,1)}$.

Fig. S12. MPTC of LVDC ports in MPETs shown in Fig. A11. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3. (d) MPTC of Port4.
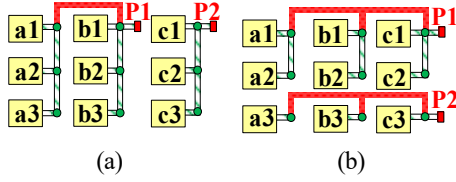

Fig. S13. IDBS-MPET of $N_{(3)}P_{(2)}$. (a) $N_{(3)}P_{(2)}$-$S_{(1)(3)}D_{(1)(3,3)}$. (b) $N_{(3)}P_{(2)}$-$T_{(1)(2,2,2)}T_{(1)(1,1,1)}$. (c) $N_{(3)}P_{(2)}$-$D_{(1)(3,2)}D_{(1)(3,1)}$. (d) $N_{(3)}P_{(2)}$-$T_{(1)(2,2,1)}T_{(1)(2,1,1)}$.
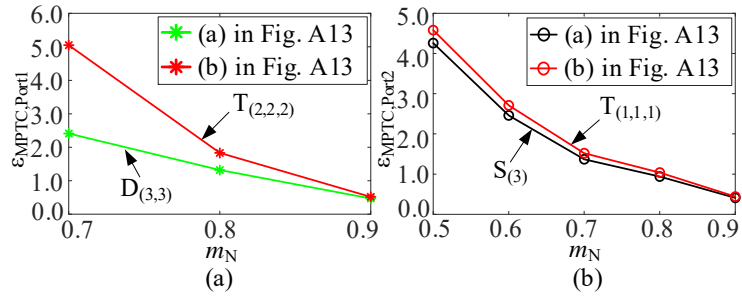

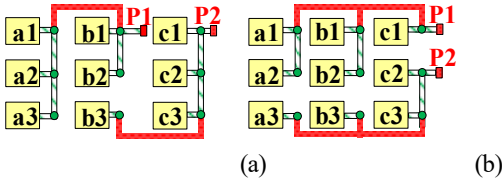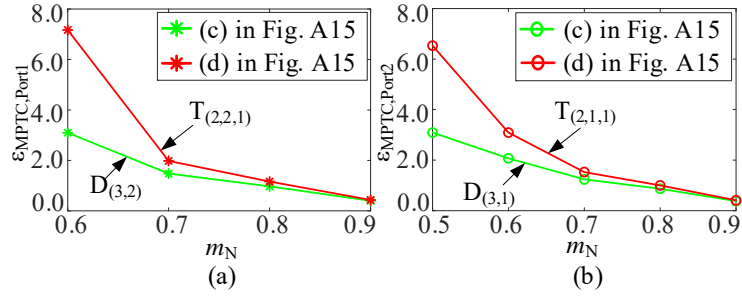Fig. S14. MPTC of LVDC ports in MPETs shown in Fig. A13. (a) MPTC of Port1. (b) MPTC of Port2.

Fig. S15. IDBS-MPET of $N_{(3)}P_{(2)}$. (a) $N_{(3)}P_{(2)}$-$D_{(1)(3,2)}D_{(1)(3,1)}$. (b) $N_{(3)}P_{(2)}$-$T_{(1)(2,2,1)}T_{(1)(2,1,1)}$.

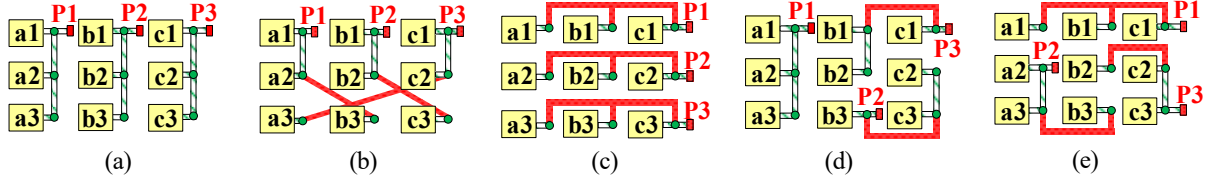Fig. S16. MPTC of LVDC ports in MPETs shown in Fig. A15. (a) MPTC of Port1. (b) MPTC of Port2.

Fig. S17. IDBS-MPET of $N_{(3)}P_{(3)}$. (a) $N_{(3)}P_{(3)}$-$S_{(3)(3)}$. (b) $N_{(3)}P_{(3)}$-$D_{(3)(2,1)}$. (c) $N_{(3)}P_{(3)}$-$T_{(3)(1,1,1)}$. (d) $N_{(3)}P_{(3)}$-$S_{(1)(3)}D_{(2)(2,1)}$. (e) $N_{(3)}P_{(3)}$-$D_{(2)(2,1)}T_{(1)(1,1,1)}$.
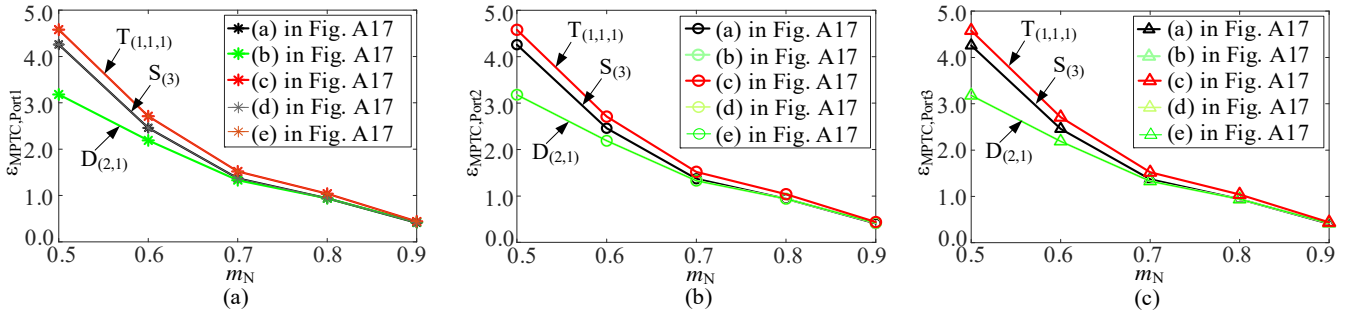

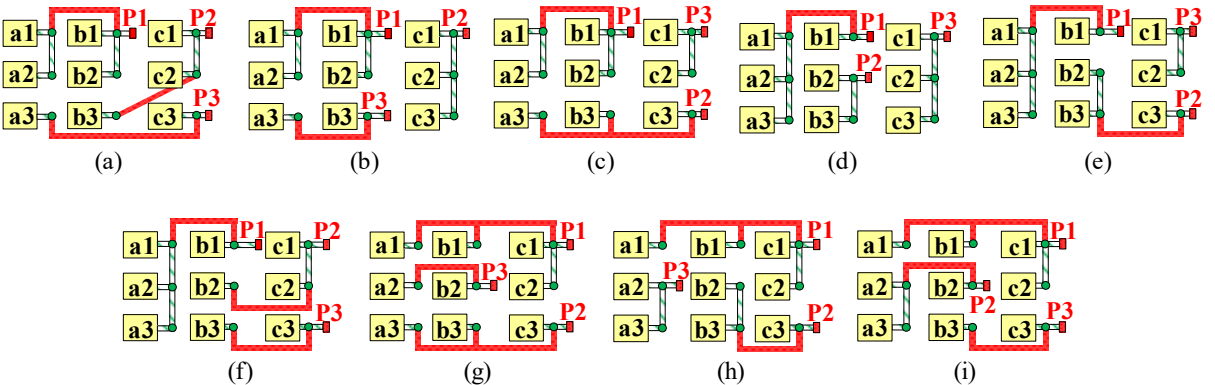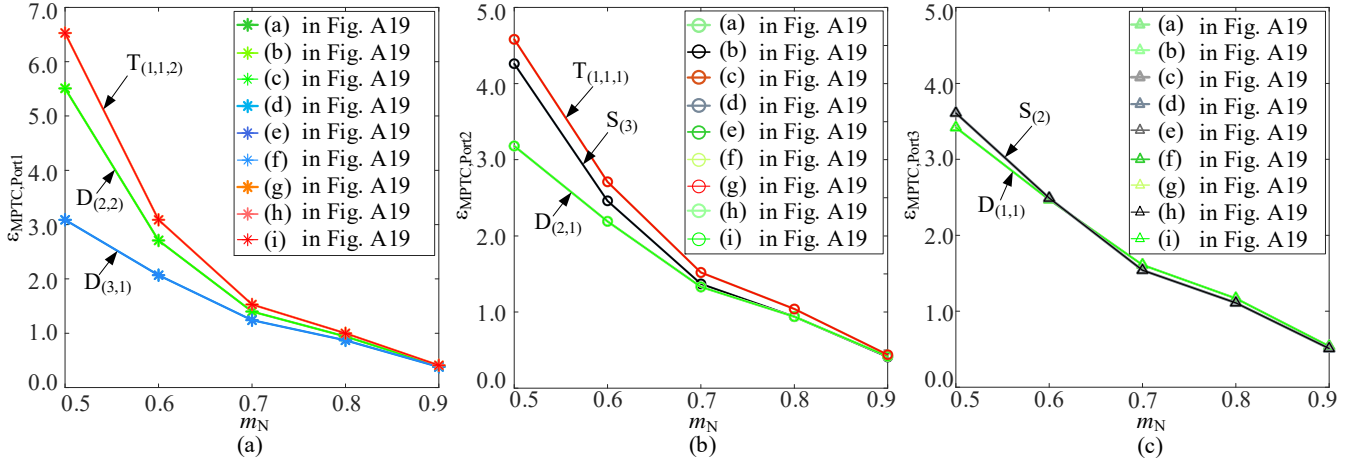Fig. S18. MPTC of LVDC ports in MPETs shown in Fig. A17. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.

Fig. S19. IDBS-MPET of $N_{(3)}P_{(3)}$. (a) $N_{(3)}P_{(3)}$-$D_{(1)(2,2)}D_{(1)(2,1)}D_{(1)(1,1)}$. (b) $N_{(3)}P_{(3)}$-$S_{(1)(3)}D_{(1)(2,2)}D_{(1)(1,1)}$. (c) $N_{(3)}P_{(3)}$-$S_{(1)(2)}D_{(1)(2,2)}T_{(1)(1,1,1)}$. (d) $N_{(3)}P_{(3)}$-$S_{(1)(3)}S_{(1)(2)}D_{(1)(3,1)}$. (e) $N_{(3)}P_{(3)}$-$S_{(1)(2)}D_{(1)(2,1)}D_{(1)(3,1)}$. (f) $N_{(3)}P_{(3)}$- $D_{(1)(3,1)}D_{(1)(2,1)}D_{(1)(1,1)}$. (g) $N_{(3)}P_{(3)}$-$D_{(1)(1,1)}T_{(1)(2,1,1)}T_{(1)(1,1,1)}$. (h) $N_{(3)}P_{(3)}$-$S_{(1)(2)}D_{(1)(2,1)}T_{(1)(2,1,1)}$. (i) $N_{(3)}P_{(3)}$- $D_{(1)(1,1)}D_{(1)(2,1)}T_{(1)(2,1,1)}$.

Fig. S20. MPTC of LVDC ports in MPETs shown in Fig. A19. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.
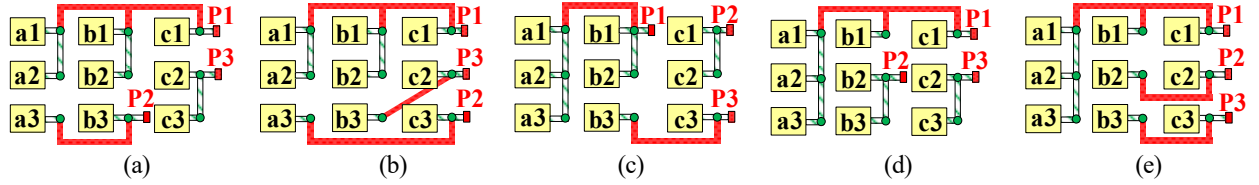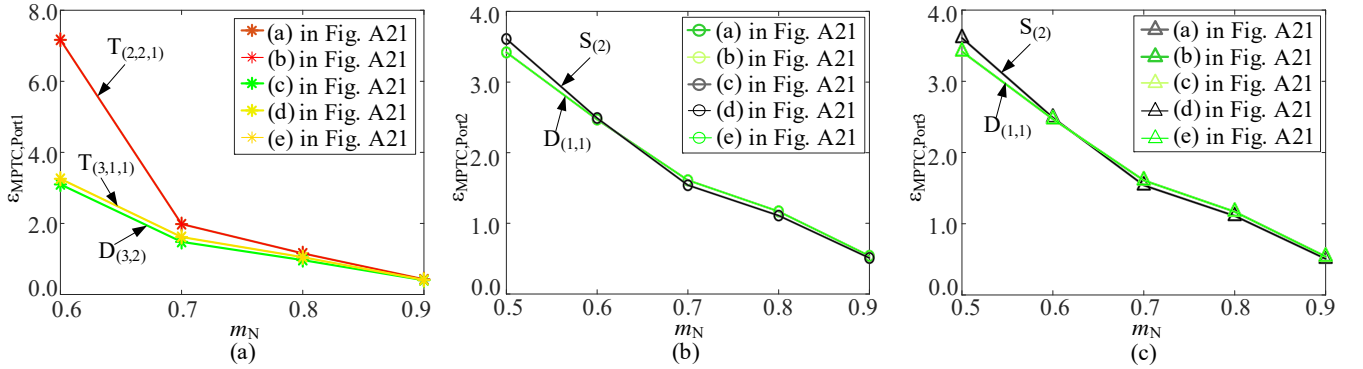

Fig. S21. IDBS-MPET of $N_{(3)}P_{(3)}$. (a) $N_{(3)}P_{(3)}$-$S_{(1)(2)}D_{(1)(1,1)}T_{(1)(2,2,1)}$. (b) $N_{(3)}P_{(3)}$-$D_{(2)(1,1)}T_{(1)(2,2,1)}$. (c) $N_{(3)}P_{(3)}$-$S_{(1)(2)}D_{(1)(3,2)}D_{(1)(1,1)}$. (d) $N_{(3)}P_{(3)}$-$S_{(2)(2)}T_{(1)(3,1,1)}$. (e) $N_{(3)}P_{(3)}$-$D_{(2)(1,1)}T_{(1)(3,1,1)}$.

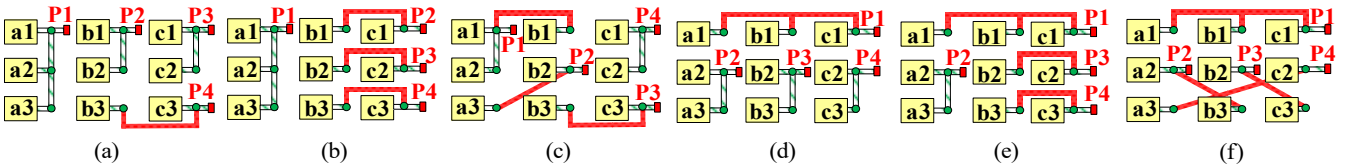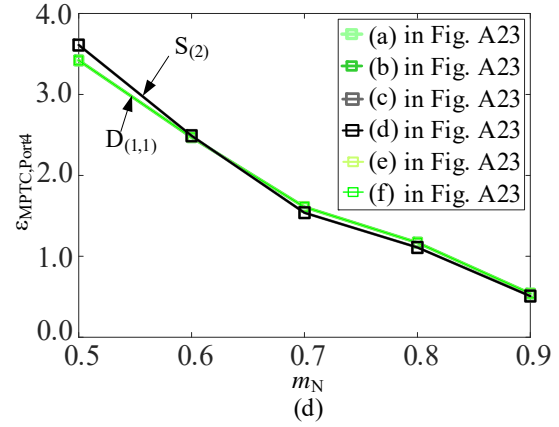Fig. S22. MPTC of LVDC ports in MPETs shown in Fig. A21. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.

Fig. S23. IDBS-MPET of $N_{(3)}P_{(4)}$. (a) $N_{(3)}P_{(4)}$-$S_{(1)(3)}S_{(2)(2)}D_{(1)(1,1)}$. (b) $N_{(3)}P_{(4)}$-$S_{(1)(3)}D_{(3)(1,1)}$. (c) $N_{(3)}P_{(4)}$-$S_{(1)(2)}D_{(1)(2,1)}D_{(2)(1,1)}$. (d) $N_{(3)}P_{(4)}$-$S_{(3)(2)}T_{(1)(1,1,1)}$. (e) $N_{(3)}P_{(4)}$-$S_{(1)(2)}D_{(2)(1,1)}T_{(1)(1,1,1)}$. (f) $N_{(3)}P_{(4)}$-$D_{(3)(1,1)}T_{(1)(1,1,1)}$.
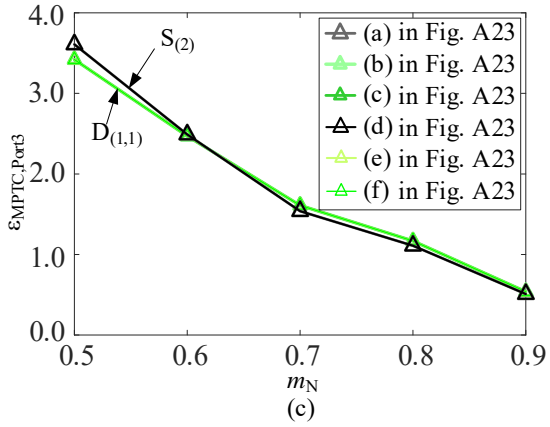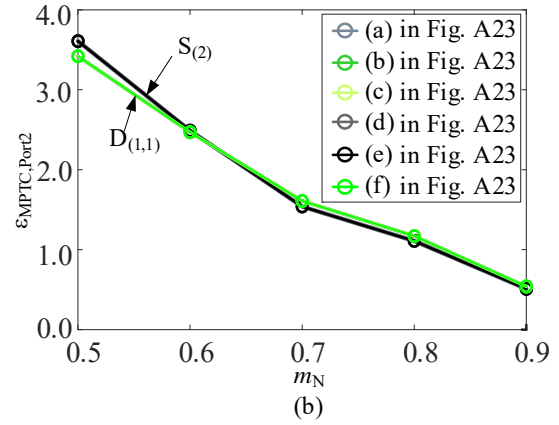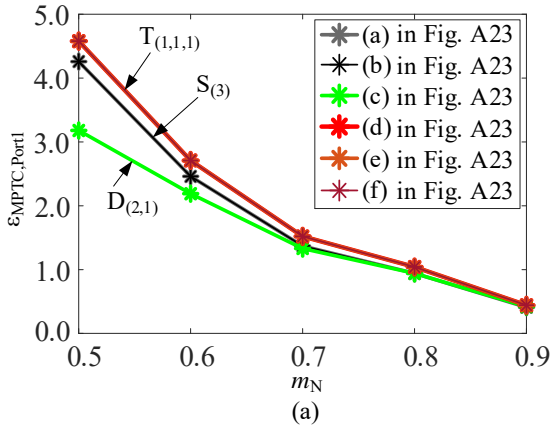
Fig. S24. MPTC of LVDC ports in MPETs shown in Fig. A23. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3. (d) MPTC of Port4.
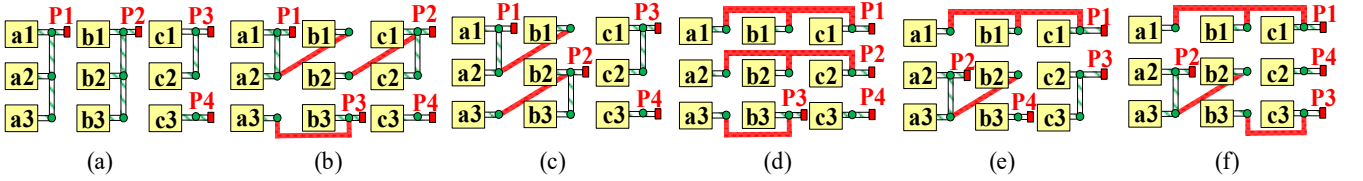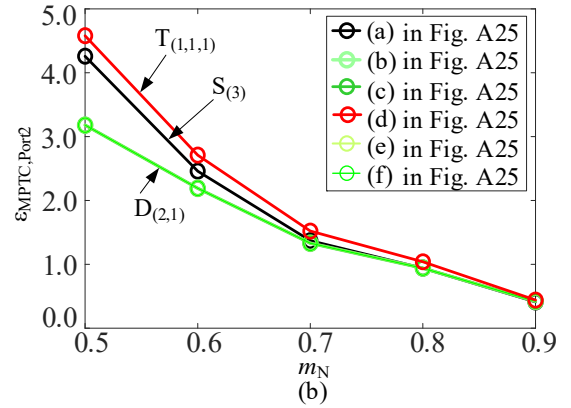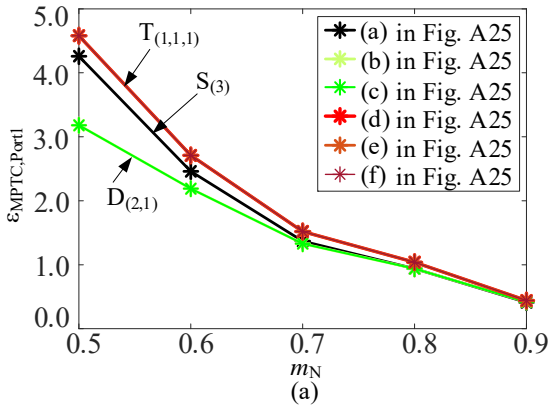

Fig. S25. IDBS-MPET of $N_{(3)}P_{(4)}$. (a) $N_{(3)}P_{(4)}$-$S_{(2)(3)}S_{(1)(2)}S_{(1)(1)}$. (b) $N_{(3)}P_{(4)}$-$S_{(1)(1)}D_{(2)(2,1)}D_{(1)(1,1)}$. (c) $N_{(3)}P_{(4)}$-$S_{(1)(2)}S_{(1)(1)}D_{(2)(2,1)}$. (d) $N_{(3)}P_{(4)}$-$S_{(1)(1)}D_{(1)(1,1)}T_{(2)(1,1,1)}$. (e) $N_{(3)}P_{(4)}$-$S_{(1)(1)}S_{(1)(2)}D_{(1)(2,1)}T_{(1)(1,1,1)}$. (f) $N_{(3)}P_{(4)}$-$S_{(1)(1)}D_{(1)(2,1)}D_{(1)(1,1)}T_{(1)(1,1,1)}$.
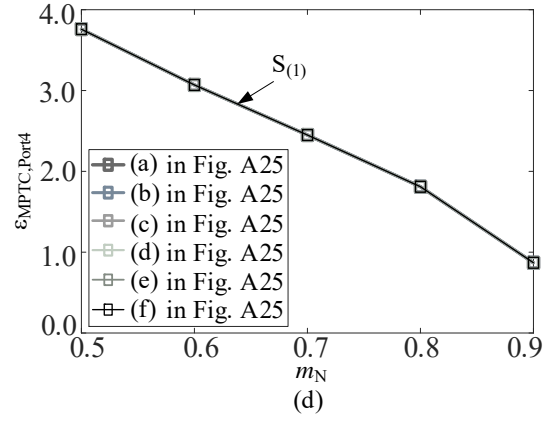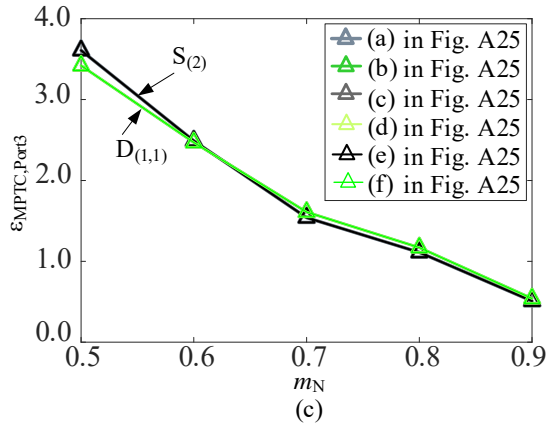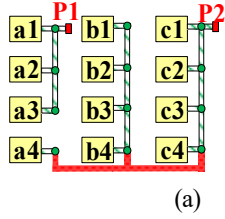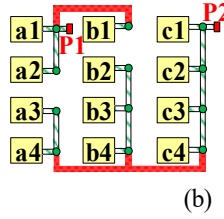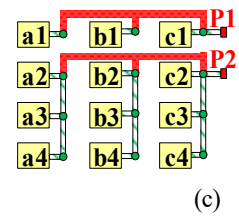
Fig. S26. MPTC of LVDC ports in MPETs shown in Fig. A25. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3. (d) MPTC of Port4.
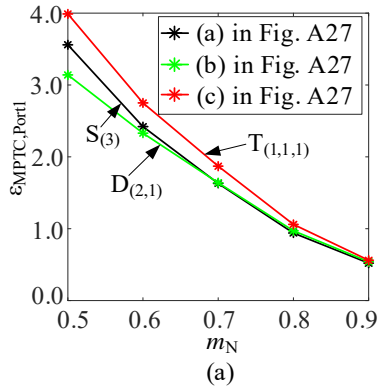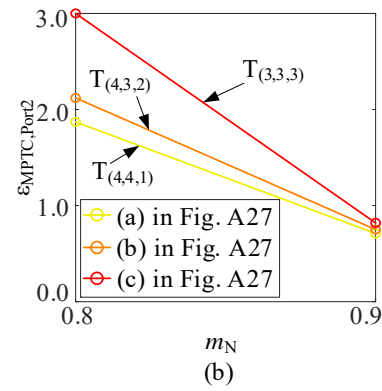

Fig. S27. IDBS-MPET of $N_{(4)}P_{(2)}$. (a) $N_{(4)}P_{(2)}$-$S_{(1)(3)}T_{(1)(4,4,1)}$. (b) $N_{(4)}P_{(2)}$-$D_{(1)(2,1)}T_{(1)(2,3,4)}$. (c) $N_{(4)}P_{(2)}$-$T_{(1)(1,1,1)}T_{(1)(3,3,3)}$.
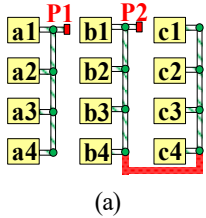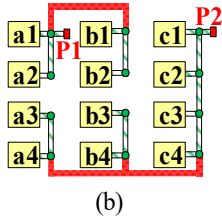

Fig. S28. MPTC of LVDC ports in MPETs shown in Fig. A27. (a) MPTC of Port1. (b) MPTC of Port2.

Fig. S29. IDBS-MPET of $N_{(4)}P_{(2)}$. (a) $N_{(4)}P_{(2)}$-$S_{(1)(4)}D_{(1)(4,4)}$. (b) $N_{(4)}P_{(3)}$-$D_{(1)(2,2)}T_{(1)(2,2,4)}$. (c) $N_{(4)}P_{(3)}$-$D_{(1)(3,1)}T_{(1)(1,3,4)}$. (d) $N_{(4)}P_{(3)}$-$T_{(1)(1,1,2)}T_{(1)(3,3,2)}$.
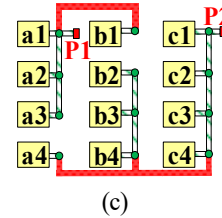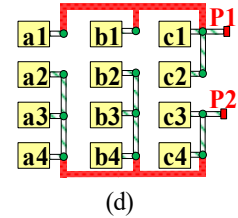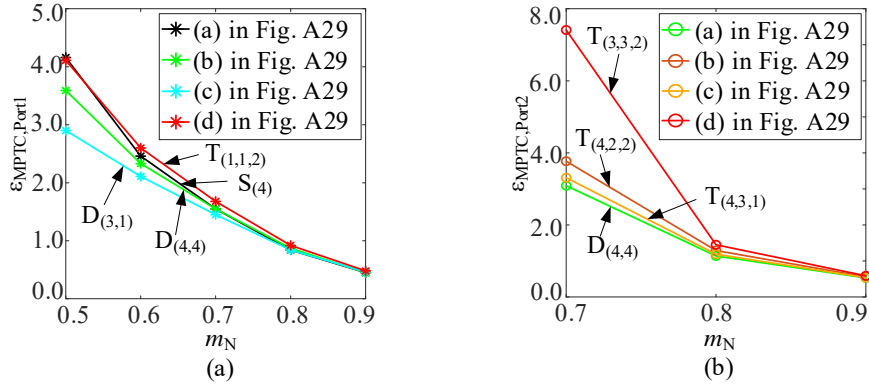
Fig. S30. MPTC of LVDC ports in MPETs shown in Fig. A29. (a) MPTC of Port1. (b) MPTC of Port2.
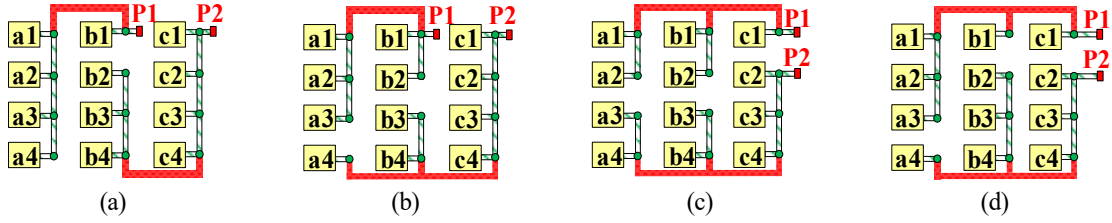

Fig. S31. IDBS-MPET of $N_{(4)}P_{(2)}$. (a) $N_{(4)}P_{(2)}$-$D_{(1)(4,1)}D_{(1)(4,3)}$. (b) $N_{(4)}P_{(2)}$-$D_{(1)(3,2)}T_{(1)(1,2,4)}$. (c) $N_{(4)}P_{(2)}$-$T_{(1)(2,2,1)}T_{(1)(2,2,3)}$. (d) $N_{(4)}P_{(2)}$-$T_{(1)(3,1,1)}T_{(1)(1,3,3)}$.

Fig. S32. MPTC of LVDC ports in MPETs shown in Fig. A31. (a) MPTC of Port1. (b) MPTC of Port2.

Fig. S33. IDBS-MPET of $N_{(4)}P_{(2)}$. (a) $N_{(4)}P_{(2)}$-$D_{(2)(4,2)}$. (b) $N_{(4)}P_{(2)}$-$T_{(2)(2,2,2)}$. (c) $N_{(4)}P_{(2)}$-$T_{(2)(3,2,1)}$. (d) $N_{(4)}P_{(2)}$-$D_{(1)(3,3)}T_{(1)(4,1,1)}$.
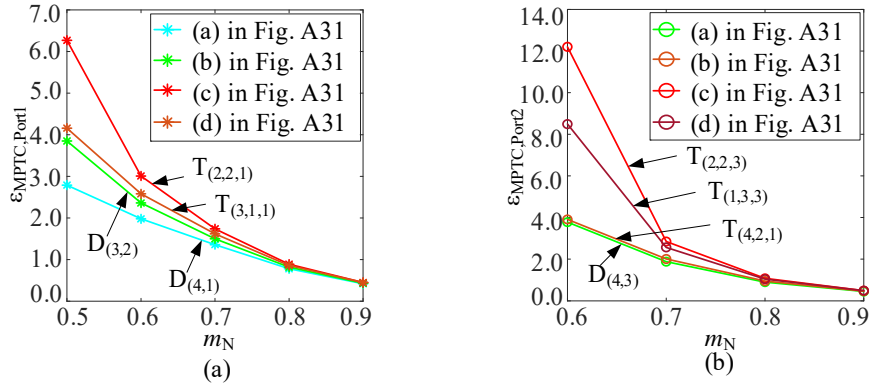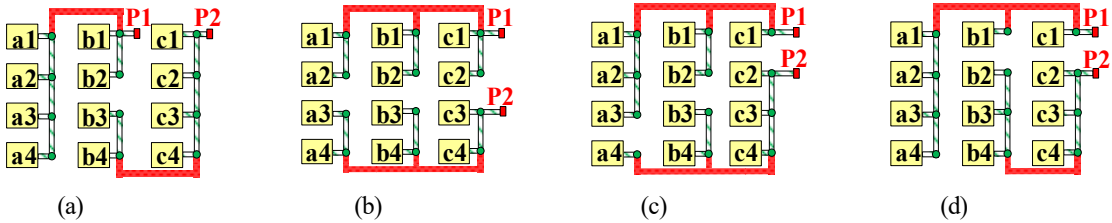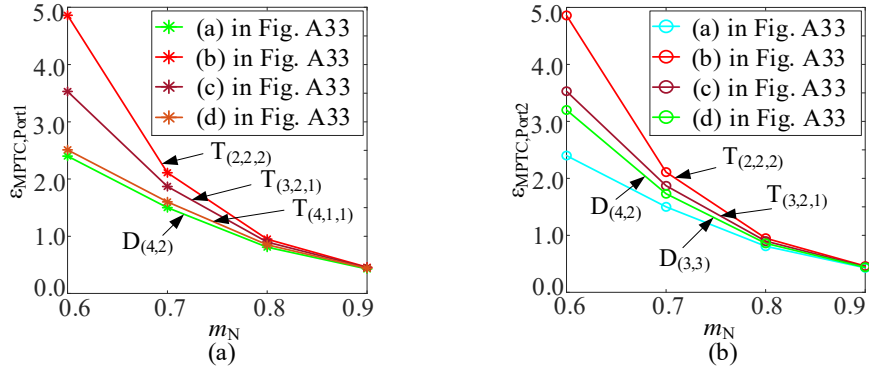
Fig. S34. MPTC of LVDC ports in MPETs shown in Fig. A33. (a) MPTC of Port1. (b) MPTC of Port2.

Fig. S35. IDBS-MPET of $N_{(4)}P_{(3)}$. (a) $N_{(4)}P_{(3)}$-$S_{(3)(4)}$. (b) $N_{(4)}P_{(3)}$-$S_{(1)(4)}D_{(2)(2,2)}$. (c) $N_{(4)}P_{(3)}$-$S_{(1)(4)}D_{(2)(3,1)}$. (d) $N_{(4)}P_{(3)}$-$D_{(3)(2,2)}$. (e) $N_{(4)}P_{(3)}$-$D_{(3)(3,1)}$. (f) $N_{(4)}P_{(3)}$-$T_{(3)(2,1,1)}$. (g) $N_{(4)}P_{(3)}$-$D_{(2)(3,1)}T_{(1)(2,1,1)}$.

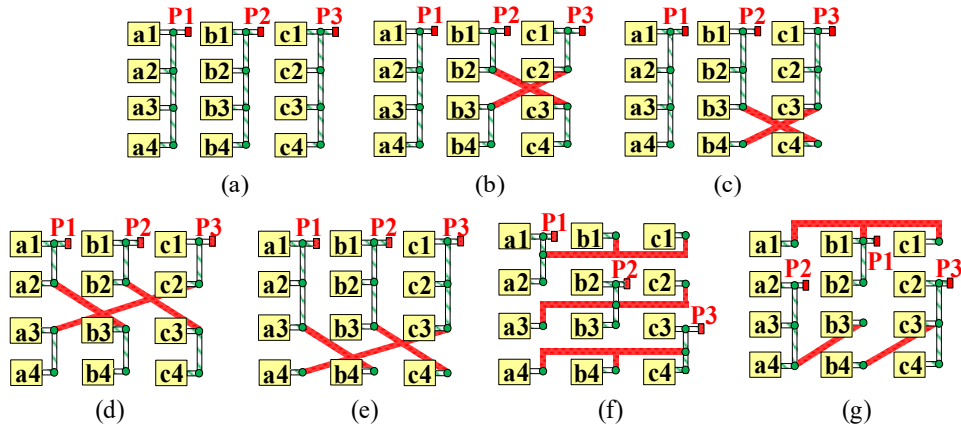Fig. S36. MPTC of LVDC ports in MPETs shown in Fig. A35. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.

Fig. S37. IDBS-MPET of $N_{(4)}P_{(3)}$. (a) $N_{(4)}P_{(3)}$-$S_{(1)(3)}S_{(1)(3)}D_{(1)(4,1)}$. (b) $N_{(4)}P_{(3)}$-$S_{(1)(3)}D_{(1)(4,1)}D_{(1)(3,1)}$. (c) $N_{(4)}P_{(3)}$-$D_{(1)(4,1)}D_{(1)(2,2)}D_{(1)(2,1)}$. (d) $N_{(4)}P_{(3)}$-$S_{(1)(4)}D_{(1)(3,2)}D_{(1)(2,1)}$. (e) $N_{(4)}P_{(3)}$-$D_{(1)(3,2)}D_{(1)(2,2)}D_{(1)(2,1)}$. (f) $N_{(4)}P_{(3)}$-$S_{(1)(3)}D_{(1)(3,2)}T_{(1)(2,1,1)}$. (g) $N_{(4)}P_{(3)}$-$T_{(1)(2,2,1)}T_{(1)(2,1,1)}T_{(1)(1,1,1)}$. (h) $N_{(4)}P_{(3)}$-$D_{(1)(2,1)}T_{(1)(2,2,1)}T_{(1)(2,1,1)}$. (i) $N_{(4)}P_{(3)}$-$S_{(1)(3)}D_{(1)(2,2)}T_{(1)(2,2,1)}$. (j) $N_{(4)}P_{(3)}$-$D_{(1)(2,1)}D_{(1)(2,2)}T_{(1)(2,1,1)}$.
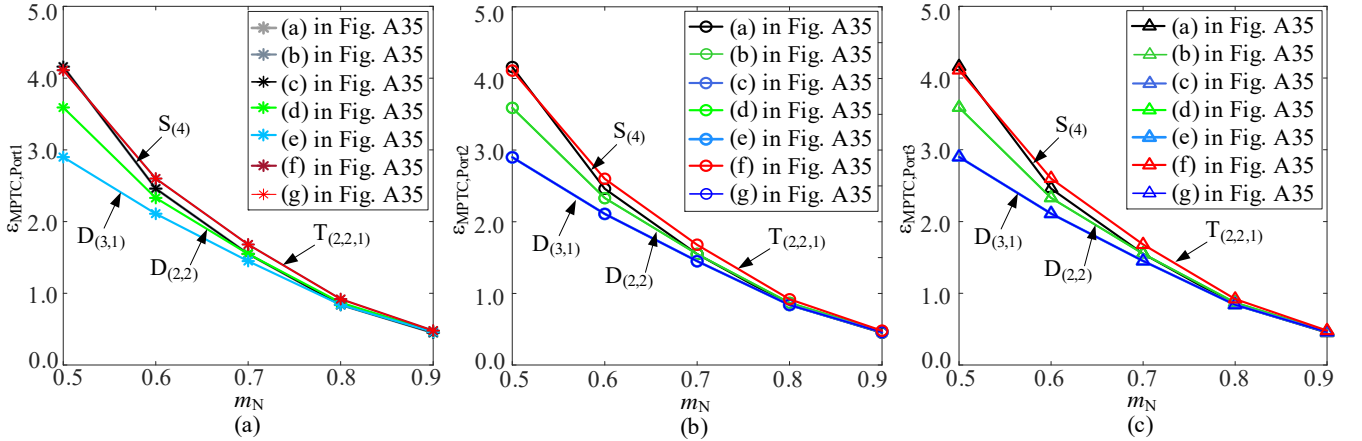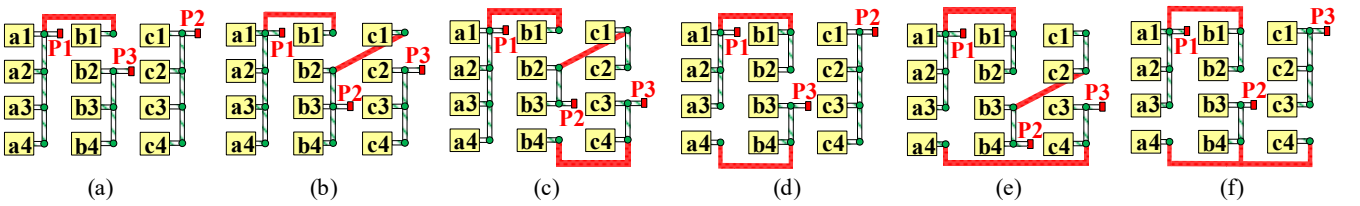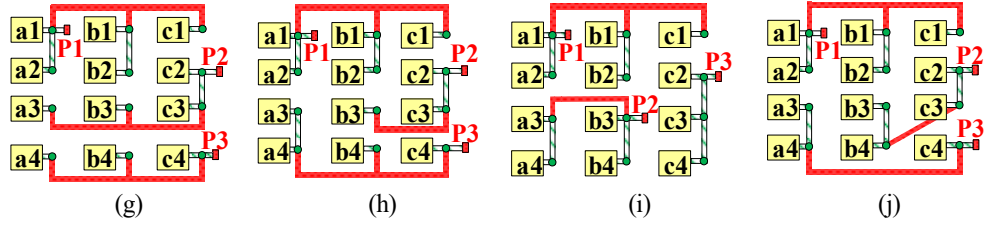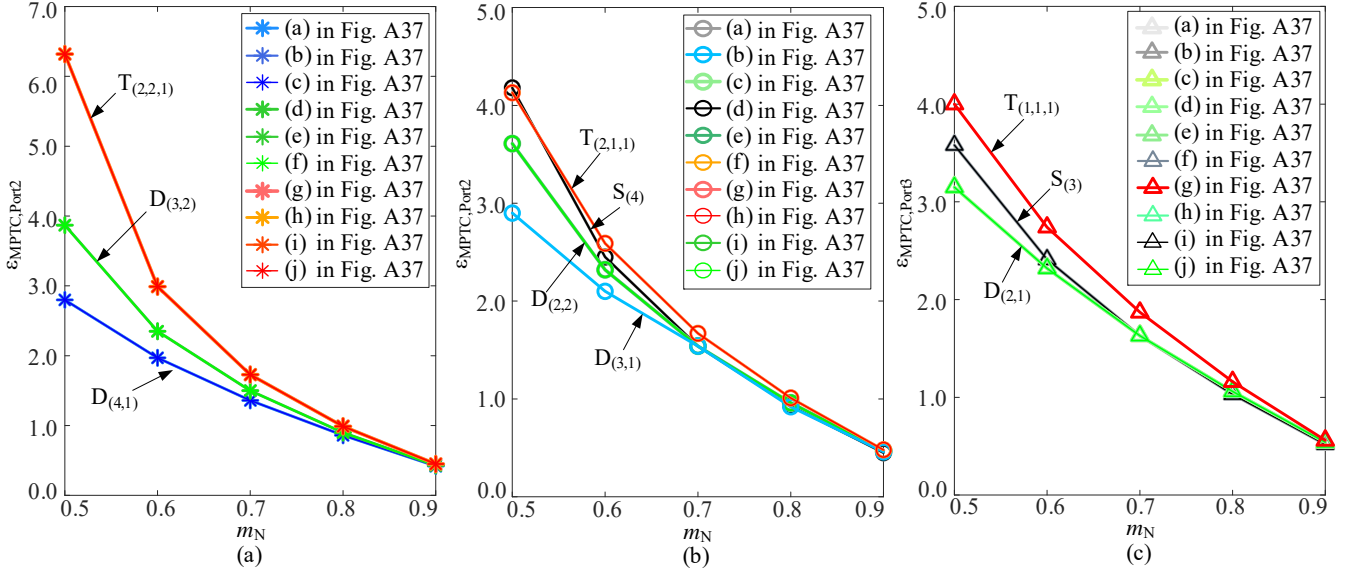

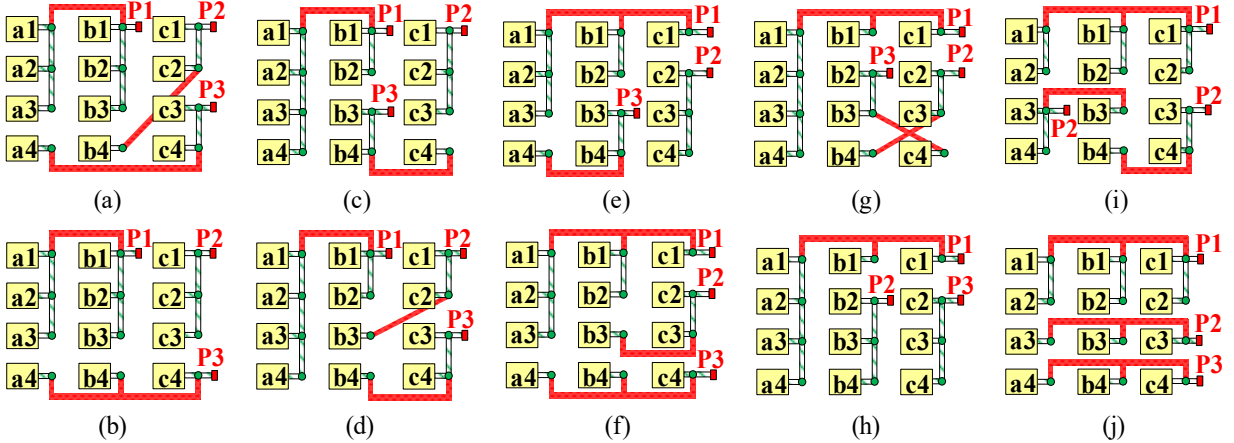Fig. S38. MPTC of LVDC ports in MPETs shown in Fig. A37. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.

Fig. S39. IDBS-MPET of $N_{(4)}P_{(3)}$. (a) $N_{(4)}P_{(3)}$-$D_{(1)(3,3)}D_{(1)(2,1)}$. (b) $N_{(4)}P_{(3)}$-$S_{(1)(3)}D_{(1)(3,3)}T_{(1)(1,1,1)}$. (c) $N_{(4)}P_{(3)}$-$S_{(1)(3)}D_{(1)(4,2)}D_{(1)(2,1)}$. (d) $N_{(4)}P_{(3)}$-$D_{(1)(4,2)}D_{(2)(2,1)}$. (e) $N_{(4)}P_{(3)}$-$S_{(1)(3)}D_{(1)(2,1)}T_{(1)(3,2,1)}$. (f) $N_{(4)}P_{(3)}$-$D_{(1)(2,1)}T_{(1)(3,2,1)}T_{(1)(1,1,1)}$. (g) $N_{(4)}P_{(3)}$-$D_{(2)(2,1)}T_{(1)(4,1,1)}$. (h) $N_{(4)}P_{(3)}$-$S_{(2)(3)}T_{(1)(4,1,1)}$. (i) $N_{(4)}P_{(3)}$-$D_{(2)(2,1)}T_{(1)(2,2,2)}$. (j) $N_{(4)}P_{(3)}$-$T_{(1)(2,2,2)}T_{(2)(1,1,1)}$.
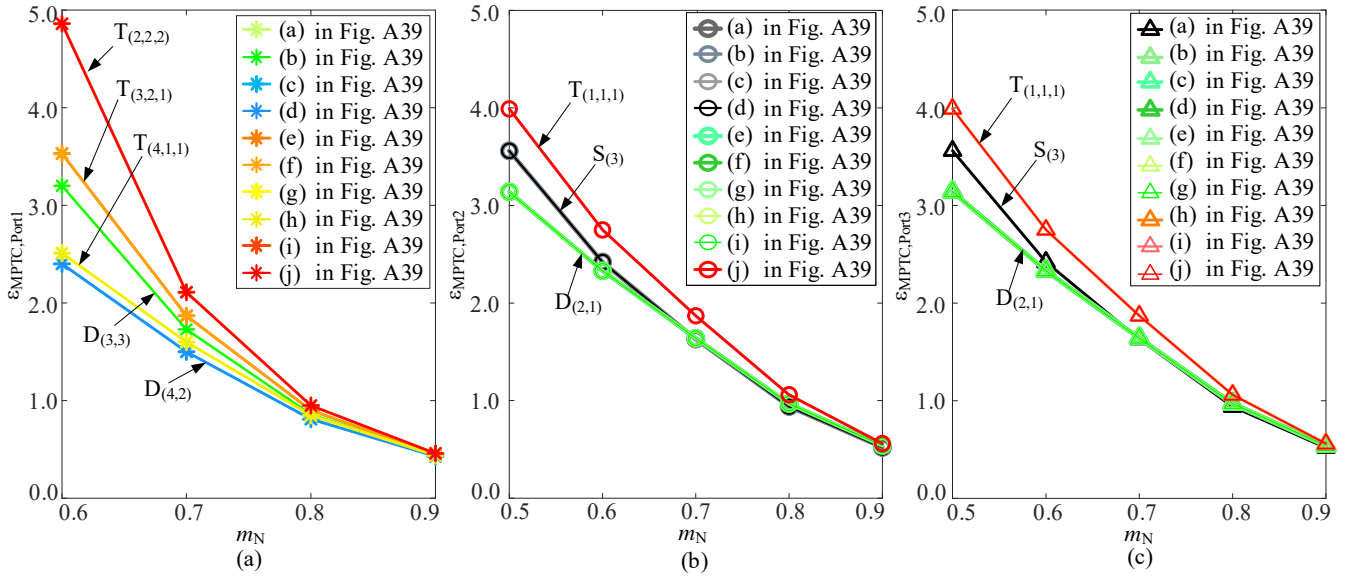
Fig. S40. MPTC of LVDC ports in MPETs shown in Fig. A39. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.
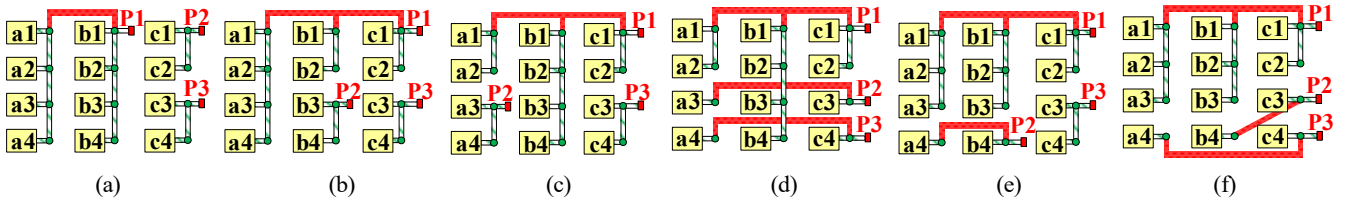

Fig. S41. IDBS-MPET of $N_{(4)}P_{(3)}$. (a) $N_{(4)}P_{(3)}$-$S_{(2)(2)}D_{(1)(4,4)}$. (b) $N_{(4)}P_{(3)}$-$S_{(2)(2)}T_{(1)(4,2,2)}$. (c) $N_{(4)}P_{(3)}$-$S_{(2)(2)}T_{(1)(4,2,2)}$. (d) $N_{(4)}P_{(3)}$-$T_{(1)(4,2,2)}D_{(1)(2,2)}$. (e) $N_{(4)}P_{(3)}$-$S_{(1)(2)}D_{(1)(1,1)}T_{(1)(3,3,2)}$. (f) $N_{(4)}P_{(3)}$-$D_{(2)(1,1)}T_{(1)(3,3,2)}$.
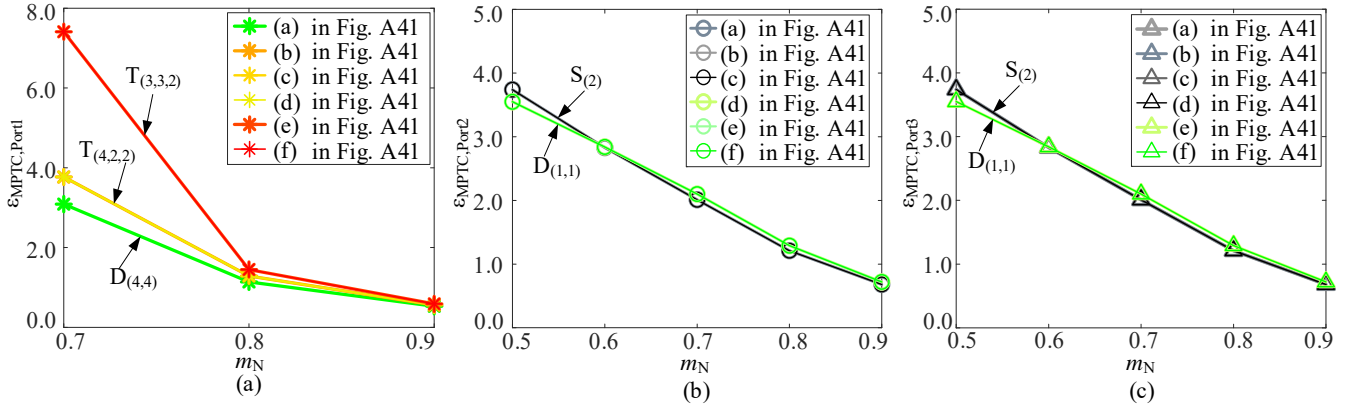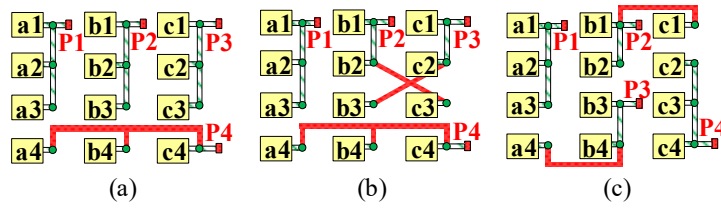

Fig. S42. MPTC of LVDC ports in MPETs shown in Fig. A41. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3.
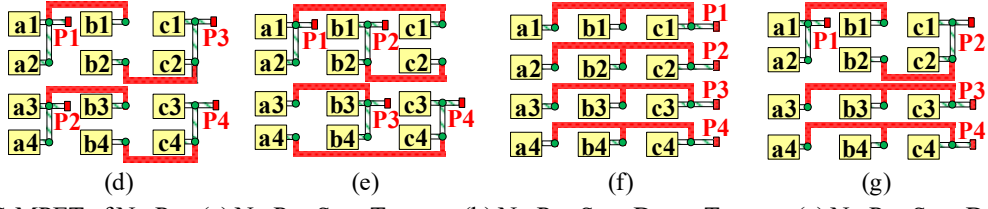

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Fig. S43. IDBS-MPET of $N_{(4)}P_{(4)}$. (a) $N_{(4)}P_{(4)}$-$S_{(3)(3)}T_{(3)(1,1,1)}$. (b) $N_{(4)}P_{(4)}$-$S_{(1)(3)}D_{(2)(2,1)}T_{(1)(1,1,1)}$. (c) $N_{(4)}P_{(4)}$-$S_{(2)(3)}D_{(2)(2,1)}$. (d) $N_{(4)}P_{(4)}$-$D_{(4)(2,1)}$. (e) $N_{(4)}P_{(4)}$-$D_{(4)(2,1)}$. (f) $N_{(4)}P_{(4)}$-$T_{(4)(1,1,1)}$. (g) $N_{(4)}P_{(4)}$-$D_{(2)(2,1)}T_{(2)(1,1,1)}$.
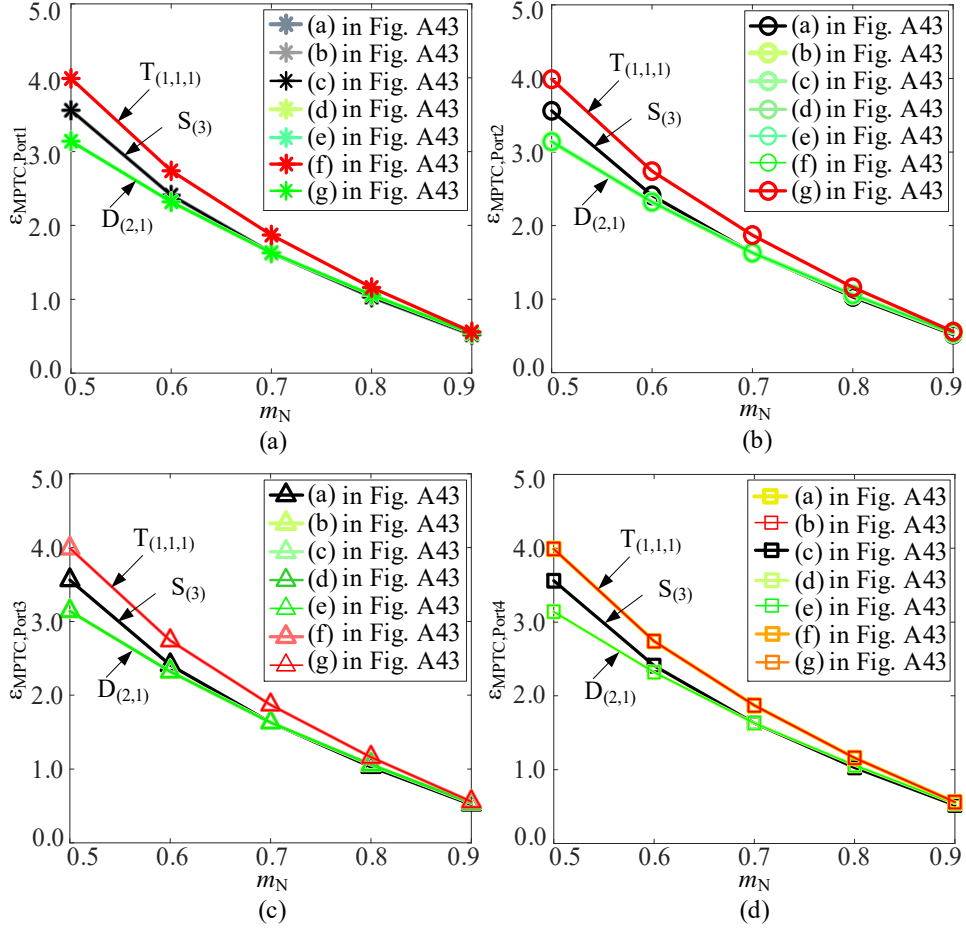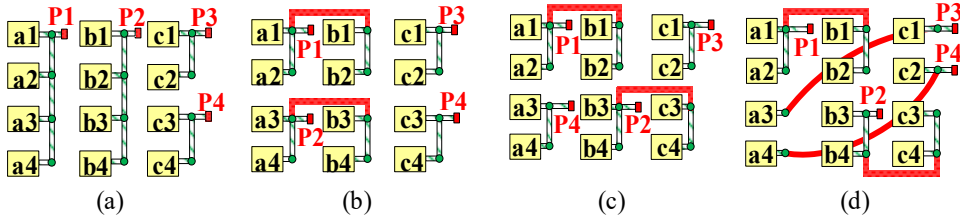

Fig. S44. MPTC of LVDC ports in MPETs shown in Fig. A43. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3. (d) MPTC of Port4.
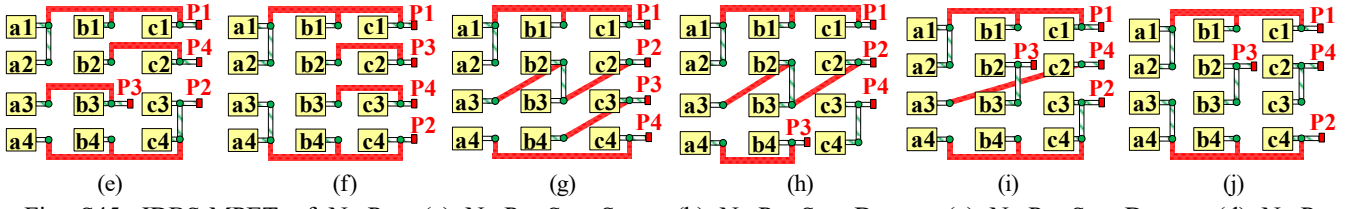
Fig. S45. IDBS-MPET of $N_{(4)}P_{(4)}$. (a) $N_{(4)}P_{(4)}$-$S_{(2)(2)}S_{(2)(4)}$. (b) $N_{(4)}P_{(4)}$-$S_{(2)(2)}D_{(2)(2,2)}$. (c) $N_{(4)}P_{(4)}$-$S_{(2)(2)}D_{(2)(2,2)}$. (d) $N_{(4)}P_{(4)}$-$D_{(2)(1,1)}D_{(2)(2,2)}$. (e) $N_{(4)}P_{(4)}$-$D_{(2)(1,1)}T_{(2)(2,1,1)}$. (f) $N_{(4)}P_{(4)}$-$D_{(2)(1,1)}T_{(2)(2,1,1)}$. (g) $N_{(4)}P_{(4)}$-$D_{(2)(1,1)}T_{(2)(2,1,1)}$. (h) $N_{(4)}P_{(4)}$-$S_{(1)(2)}D_{(1)(1,1)}T_{(2)(2,1,1)}$. (i) $N_{(4)}P_{(4)}$-$S_{(1)(2)}D_{(1)(1,1)}T_{(2)(2,1,1)}$. (j) $N_{(4)}P_{(4)}$-$S_{(2)(2)}T_{(2)(2,1,1)}$.
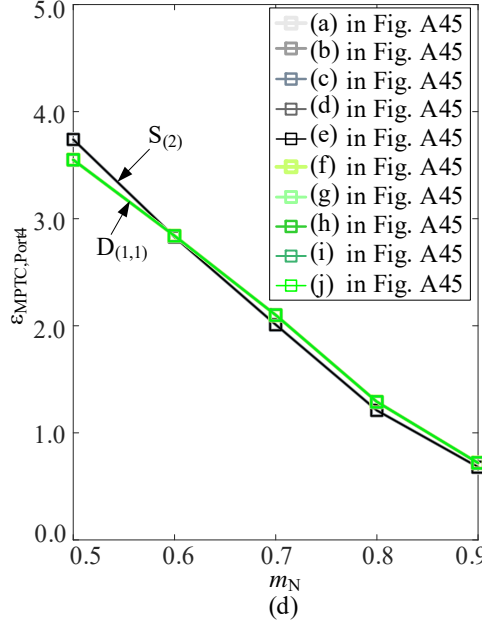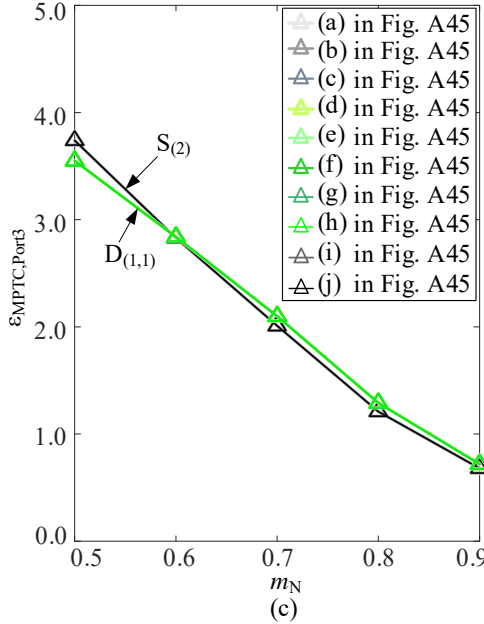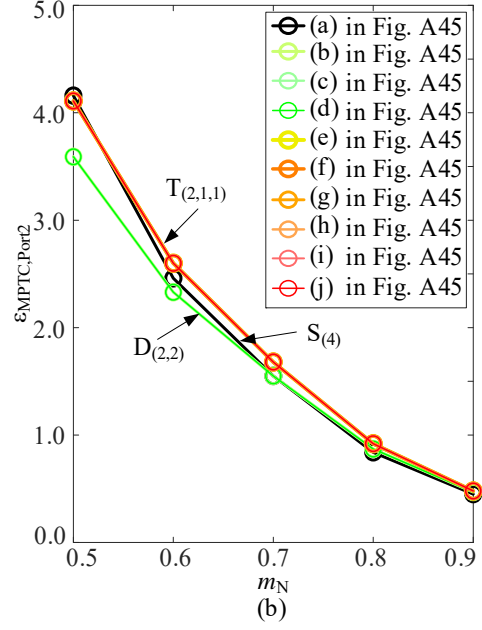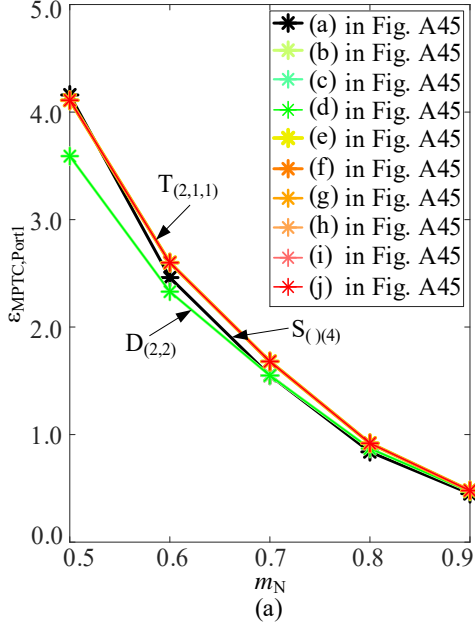

Fig. S46. MPTC of LVDC ports in MPETs shown in Fig. A45. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3. (d) MPTC of Port4.

Fig. S47. IDBS-MPET of $N_{(4)}P_{(4)}$. (a) $N_{(4)}P_{(4)}$-$S_{(2)(2)}D_{(1)(3,3)}D_{(1)(1,1)}$. (b) $N_{(4)}P_{(4)}$-$S_{(1)(2)}D_{(1)(3,3)}D_{(2)(1,1)}$. (c) $N_{(4)}P_{(4)}$-$S_{(3)(2)}D_{(1)(4,2)}$. (d) $N_{(4)}P_{(4)}$-$S_{(1)(2)}D_{(1)(4,2)}D_{(2)(1,1)}$. (e) $N_{(4)}P_{(4)}$-$S_{(3)(2)}T_{(1)(2,2,2)}$. (f) $N_{(4)}P_{(4)}$-$S_{(1)(2)}D_{(2)(1,1)}T_{(1)(2,2,2)}$. (g) $N_{(4)}P_{(4)}$-$D_{(3)(1,1)}T_{(1)(2,2,2)}$. (h) $N_{(4)}P_{(4)}$-$S_{(1)(2)}D_{(2)(1,1)}T_{(1)(3,2,1)}$. (i) $N_{(4)}P_{(4)}$-$S_{(2)(2)}D_{(1)(1,1)}T_{(1)(3,2,1)}$. (j) $N_{(4)}P_{(4)}$-$D_{(3)(1,1)}T_{(1)(4,1,1)}$. (k) $N_{(4)}P_{(4)}$-$S_{(2)(2)}D_{(1)(1,1)}T_{(1)(4,1,1)}$.

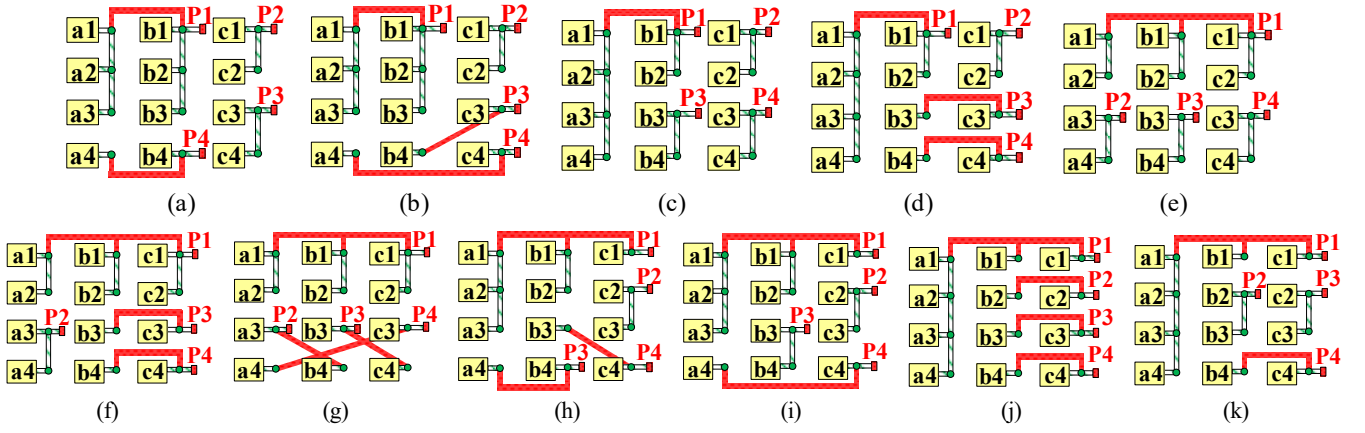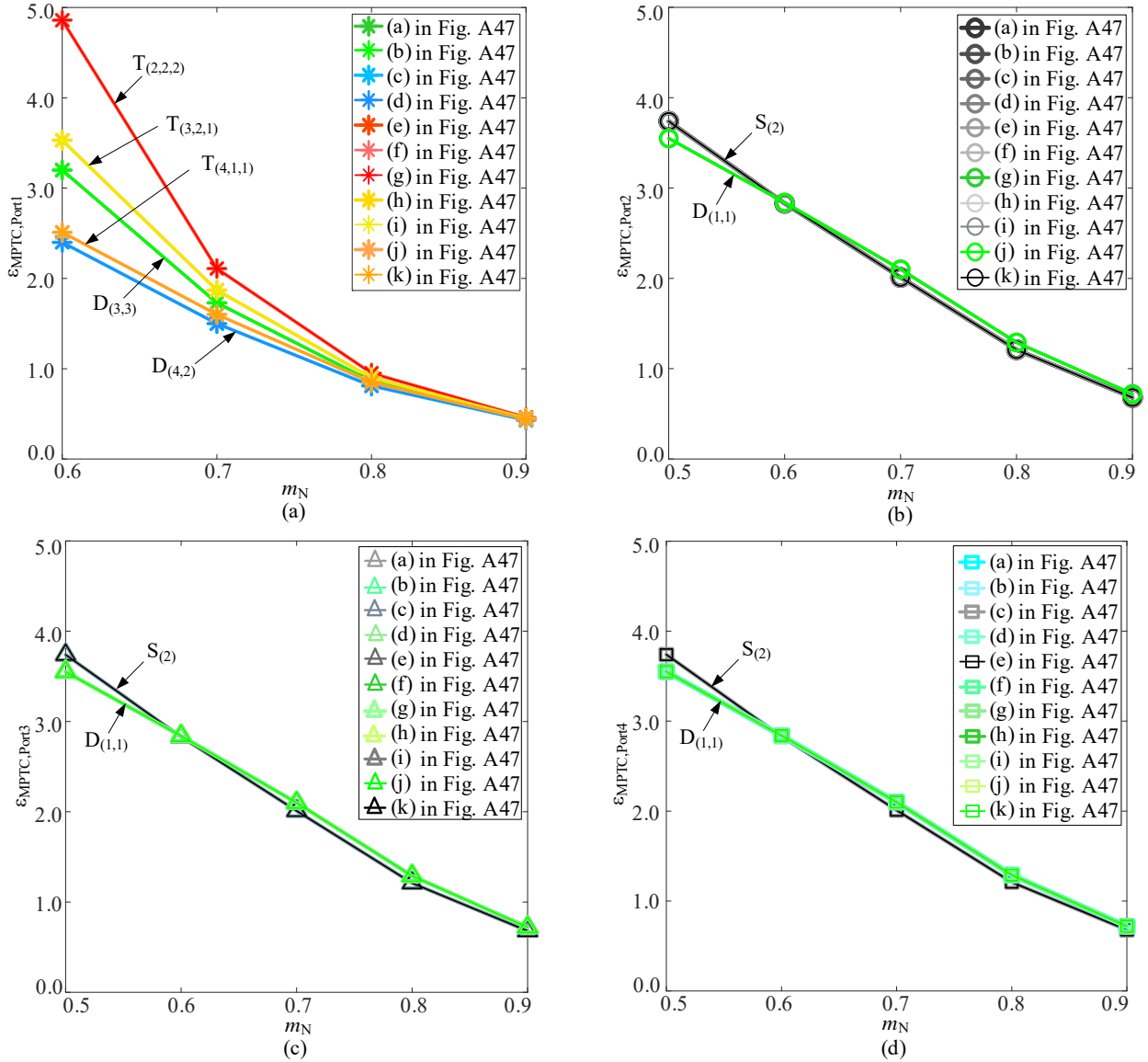Fig. S48. MPTC of LVDC ports in MPETs shown in Fig. A47. (a) MPTC of Port1. (b) MPTC of Port2. (c) MPTC of Port3. (d) MPTC of Port4.