What is claimed is:

1. A four channel gas delivery system comprising:

an inlet channel;

four outlet channels;

four control valves, each valve being arranged so as to control the flow from the inlet channel through a corresponding one of the outlet channels;

a flow ratio control system configured so as to control the flow from the inlet channel through the corresponding outlet channels so that the following flow ratios are controlled:

(a) a first ratio of flows between the outlet channels of a first pair;

(b) a second ratio of flows between the outlet channels of a second pair; and

(c) a third ratio of flows between the first pair of outlet channels relative to the second pair of outlet channels;

wherein the third ratio is controlled by generating at least one bias signal respectively applied to at least one pair of valves, the bias signal being a function of a predetermined set point of the third ratio and measured values of the third ratio.

2. The four channel gas delivery system of claim 1, further including four flow sensors arranged to the sense the flows through the corresponding four outlet channels, wherein the measured values of all three flow ratios are functions of the flows sensed through the flow sensors.

3. The four channel gas delivery system of claim 2, wherein the flow ratio control system includes antisymmetric feedback control arrangements configured to control the flows between the first pair of outlet channels relative to the second pair of outlet channels as a function of the third ratio set point.

4. The four channel gas delivery system of claim 1, wherein the flow ratio control system includes a dual antisymmetric optimal control module including a

feedback control arrangement for controlling the third ratio of flows between the first pair of outlet channels relative to the second pair of outlet channels so as to maintain the measured third ratio equal to the predetermined set point.

5. The four channel gas delivery system of claim 4, wherein the dual antisymmetric optimal control module is implemented in software.

6. The four channel gas delivery system of claim 1, wherein the set point of the third ratio is the summation of the flow ratio setpoints on the first pair flow channels.

7. The four channel gas delivery system of claim 1, wherein the set point of each of the first and second ratios are the relative ratio between the flow ratio setpoints in the paired flow channels.

8. The four channel gas delivery system of claim 1, further including four flow meters arranged to measure flow through the corresponding outlet channels and for providing a flow measurement signal representative of the measured flow through each outlet channel, wherein each valve is responsive to at least one of the flow measurement signals.

9. The four channel gas delivery system of claim 8, wherein measured values of all three ratios are determined as a function of the flow measurement signals associated with the four outlet channels.

10. The four channel gas delivery system of claim 1, wherein the flow ratio control system includes a controller configured to provide antisymmetric optimal control of the mass flow through the outlet channels so as to maintain the first, second and third ratios of flow through the outlet channels.

11. The four channel gas delivery system of claim 10, wherein the controller further includes three dual antisymmetric optimal (DAO) control modules for

generating a valve control signal for each of the valves, wherein each of the valves is responsive to a corresponding valve control signal.

12. The four channel gas delivery system of claim 11, wherein the bias signal is added to the valve control signals applied to the at least one pair of valves.

13. The four channel gas delivery system of claim 12, wherein a second bias signal is added to the valve control signals applied of the other pair of valves.

14. The four channel gas delivery system of claim 13, wherein one of the bias signals is the optimal bias for maintaining at least one of the valves in a maximum allowable opened position.

15. The four channel gas delivery system of claim 14, were the valves are normally opened valves and the one bias signal is minimum allowable valve current.

16. The four channel gas delivery system of claim 14, wherein the valves are normally closed valves and the one bias signal is the maximum allowable valve current required to keep the valve at the maximum allowable open position.

17. The four channel gas delivery system of claim 1, wherein the flow ratio control system includes two dual asymmetric optimal (DAO) control modules configured and arranged so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a virtual DAO control module configured and arranged so as to control the ratio of flow between the two DAO control modules.

18. The four channel gas delivery system of claim 17, wherein the virtual DAO control module is configured and arranged so to determine a bias current for each of the DAO control modules as a function of the ratio of flow between the two DAO control modules.

19. The four channel gas delivery system of claim 17, wherein the ratio set point of the virtual DAO control module is nominally set at 50%.

20. The four channel gas delivery system of claim 19, wherein the ratio set point of one of the DAO control modules is set for r1/(r1+r2), wherein r1 and r2 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

21. The four channel gas delivery system of claim 19, wherein the ratio set point of the other of the DAO control modules is set for r4/(r3+r4), wherein r3 and r4 are the ratio of flows through the corresponding outlet channels of the other DAO control module relative to the total flow.

22. The four channel gas delivery system of claim 17, wherein the ratio set point of the virtual DAO control module is set for r1+r4, wherein r1 and r4 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

23. The four channel gas delivery system of claim 22, wherein the ratio set point of one of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

24. The four channel gas delivery system of claim 22, wherein the ratio set point of the other of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

25. The four channel gas delivery system of claim 17, wherein the ratio set point of the virtual DAO control module is the summation of the flow ratio setpoints on the first pair flow channels.

26. The four channel gas delivery system of claim 25, wherein the ratio set point of one of the DAO control modules is the relative ratio between the flow ratio setpoints in the first paired flow channels.

27. The four channel gas delivery system of claim 25, wherein the ratio set point of the other of the DAO control modules is the relative ratio between the flow ratio setpoints in the second paired flow channels.

28. A four channel gas delivery system comprising:

an inlet channel;

four outlet channels;

four control valves, each valve being arranged so as to control the flow from the inlet channel through a corresponding one of the outlet channels;

a flow ratio control system including two dual asymmetric optimal (DAO) control modules configured and arranged so as to control the respective control valves so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a virtual DAO control module configured and arranged so as to control the ratio of flow between the two DAO control modules.

29. The four channel gas delivery system of claim 28, wherein the virtual DAO control module is configured and arranged so to determine a bias current for each of the DAO control modules as a function of the ratio of flow between the two DAO control modules.

30. The four channel gas delivery system of claim 28, wherein the virtual DAO control module provides a bias current to each of the DAO control modules as a function of the ratio of flow between the two DAO control modules, and each of the DAO control modules provides a pair of bias currents to two of the control valves used to control the flow rates through two corresponding outlet channels.

31. The four channel gas delivery system of claim 28, wherein the ratio set point of the virtual DAO control module is nominally set at 50%.

32. The four channel gas delivery system of claim 31, wherein the ratio set point of one of the DAO control modules is set for r1/(r1+r2), wherein r1 and r2 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

33. The four channel gas delivery system of claim 31, wherein the ratio set point of the other of the DAO control modules is set for r4/(r3+r4), wherein r3 and r4 are the ratio of flows through the corresponding outlet channels of the other DAO control module relative to the total flow.

34. The four channel gas delivery system of claim 28, wherein the ratio set point of the virtual DAO control module is set for r1+r4, wherein r1 and r4 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

35. The four channel gas delivery system of claim 34, wherein the ratio set point of one of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

36. The four channel gas delivery system of claim 34, wherein the ratio set point of the other of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the other DAO control module is nominally the same.

37. The four channel gas delivery system of claim 28, wherein the ratio set point of the virtual DAO control module is the summation of the flow ratio setpoints on the first pair flow channels.

38. The four channel gas delivery system of claim 37, wherein the ratio set point of one of the DAO control modules is the relative ratio between the flow ratio setpoints in the first paired flow channels.

39. The four channel gas delivery system of claim 37, wherein the ratio set point of the other of the DAO control modules is the relative ratio between the flow ratio setpoints in the second paired flow channels.

40. A multi-channel gas delivery system for controlling the flow from an inlet channel through four outlet channels, comprising:

a flow ratio control system including two dual asymmetric optimal (DAO) control modules configured and arranged so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a signal generator configured and arranged so as generate a control signal for each of the two DAO control modules as a function of the ratio of flow through the two DAO control modules.

41. The multi-channel gas delivery system of claim 40, wherein the control signal generator generates the control signal as a function of the ratio setpoint of the ratio of flows through the two outlet channels of the respective DAO control module, the measured ratio of flows through the two outlet channels of the respective DAO control module and an optimal bias current.

42. The multi-channel gas delivery system of claim 41, wherein the flow through each outlet channel is controlled by a control valve in response to a valve drive signal and the corresponding control signal is added to drive currents generated by each DAO control module.

43. The multi-channel gas delivery system of claim 40, wherein the ratio set point of the control signal generator module is nominally set at 50%.

44. The multi-channel gas delivery system of claim 43, wherein the ratio set point of one of the DAO control modules is set for r1/(r1+r2), wherein r1 and r2 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

45. The multi-channel gas delivery system of claim 43, wherein the ratio set point of the other of the DAO control modules is set for r4/(r3+r4), wherein r3 and r4 are the ratio of flows through the corresponding outlet channels of the other DAO control module relative to the total flow.

46. The multi-channel gas delivery system of claim 41, wherein the ratio set point of the control signal generator is set for r1+r4, wherein r1 and r4 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

47. The multi-channel gas delivery system of claim 46, wherein the ratio set point of one of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

48. The multi-channel gas delivery system of claim 46, wherein the ratio set point of the other of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

49. The four channel gas delivery system of claim 41, wherein the ratio set point of the control signal generator is the summation of the flow ratio setpoints on the first pair flow channels.

50. The four channel gas delivery system of claim 49, wherein the ratio set point of one of the DAO control modules is the relative ratio between the flow ratio setpoints in the first paired flow channels.

51. The four channel gas delivery system of claim 49, wherein the ratio set point of the other of the DAO control modules is the relative ratio between the flow ratio setpoints in the second paired flow channels.

52. A method of controlling four control valves so as to control the relative ratios of flow from an inlet channel through four outlet channels using two dual asymmetric optimal (DAO) control modules; the method comprising:

generating a bias control signal for each of the two DAO control modules as a function of the ratio of flow through the two DAO control modules.

Claims:

1. A four channel gas delivery system comprising:

an inlet channel;

four outlet channels;

four control valves, each valve being arranged so as to control a flow from the inlet channel through a corresponding one of the outlet channels;

a flow ratio control system configured so as to control the flow from the inlet channel through the corresponding outlet channels so that the following flow ratios are controlled:

(a) a first ratio of flows between the outlet channels of a first pair;

(b) a second ratio of flows between the outlet channels of a second pair; and

(c) a third ratio of flows between the first pair of outlet channels relative to the second pair of outlet channels;

wherein the third ratio is controlled by generating at least one bias signal respectively applied to at least one pair of valves, the bias signal being a function of a predetermined set point of the third ratio and measured values of the third ratio.

2. The four channel gas delivery system of claim 1, further including four flow sensors arranged to the sense the flows through the corresponding four outlet channels, wherein the measured values of all three flow ratios are functions of the flows sensed through the flow sensors.

3. The four channel gas delivery system of claim 2, wherein the flow ratio control system includes antisymmetric feedback control arrangements configured to control the flows between the first pair of outlet channels relative to the second pair of outlet channels as a function of the third ratio set point.

4. The four channel gas delivery system of claim 1, wherein the flow ratio control system includes a dual antisymmetric optimal control module including a feedback control arrangement for controlling the third ratio of flows between the first pair of outlet channels relative to the second pair of outlet channels so as to maintain the measured third ratio equal to a predetermined set point.

5. The four channel gas delivery system of claim 4, wherein the dual antisymmetric optimal control module is implemented in software.

6. The four channel gas delivery system of claim 1, wherein a set point of the third ratio is the summation of flow ratio setpoints on the first paired flow channels.

7. The four channel gas delivery system of claim 1, wherein the set point of each of the first and second ratios are the relative ratio between ~~the~~ flow ratio setpoints in the paired flow channels.

8. The four channel gas delivery system of claim 1, further including four flow meters arranged to measure flow through the corresponding outlet channels and for providing a flow measurement signal representative of the measured flow through each outlet channel, wherein each valve is responsive to at least one of the flow measurement signals.

9. The four channel gas delivery system of claim 8, wherein measured values of all three ratios are determined as a function of the flow measurement signals associated with the four outlet channels.

10. The four channel gas delivery system of claim 1, wherein the flow ratio control system includes a controller configured to provide antisymmetric optimal control of the mass flow through the outlet channels so as to maintain the first, second and third ratios of flow through the outlet channels.

11. The four channel gas delivery system of claim 10, wherein the controller further includes three dual antisymmetric optimal (DAO) control modules for generating a valve control signal for each of the valves, wherein each of the valves is responsive to a corresponding valve control signal.

12. The four channel gas delivery system of claim 11, wherein the bias signal is added to the valve control signals applied to the at least one pair of valves.

13. The four channel gas delivery system of claim 12, wherein a second bias signal is added to the valve control signals applied of the other pair of valves.

14. The four channel gas delivery system of claim 13, wherein one of the bias signals is the optimal bias for maintaining at least one of the valves in a maximum allowable opened position.

15. The four channel gas delivery system of claim 14, were the valves are normally opened valves and the one bias signal is minimum allowable valve current.

16. The four channel gas delivery system of claim 14, wherein the valves are normally closed valves and the one bias signal is the maximum allowable valve current required to keep the valve at the maximum allowable open position.

17. The four channel gas delivery system of claim 1, wherein the flow ratio control system includes two dual antisymmetric optimal (DAO) control modules configured and arranged so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a virtual DAO control module configured and arranged so as to control the ratio of flow between the two DAO control modules.

18. The four channel gas delivery system of claim 17, wherein the virtual DAO control module is configured and arranged so to determine a bias current for each of the DAO control modules as a function of the ratio of flow between the two DAO control modules.

19. The four channel gas delivery system of claim 17, wherein a ratio set point of the virtual DAO control module is nominally set at 50%.

20. The four channel gas delivery system of claim 19, wherein the ratio set point of one of the DAO control modules is set for r1/(r1+r2), wherein r1 and r2 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

21. The four channel gas delivery system of claim 19, wherein the ratio set point of the other of the DAO control modules is set for r4/(r3+r4), wherein r3 and r4 are the ratio of flows through the corresponding outlet channels of the other DAO control module relative to the total flow.

22. The four channel gas delivery system of claim 17, wherein a ratio set point of the virtual DAO control module is set for r1+r4, wherein r1 and r4 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

23. The four channel gas delivery system of claim 22, wherein the ratio set point of one of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

24. The four channel gas delivery system of claim 22, wherein the ratio set point of the other of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

25. The four channel gas delivery system of claim 17, wherein a ratio set point of the virtual DAO control module is the summation of flow ratio setpoints on first paired flow channels.

26. The four channel gas delivery system of claim 25, wherein the ratio set point of one of the DAO control modules is the relative ratio between the flow ratio setpoints in the first paired flow channels.

27. The four channel gas delivery system of claim 25, wherein the ratio set point of the other of the DAO control modules is the relative ratio between the flow ratio setpoints in the second paired flow channels.

28. A four channel gas delivery system comprising:

an inlet channel;

four outlet channels;

four control valves, each valve being arranged so as to control a flow from the inlet channel through a corresponding one of the outlet channels;

a flow ratio control system including two dual antisymmetric optimal (DAO) control modules configured and arranged so as to control the respective control valves so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a virtual DAO control module configured and arranged so as to control the ratio of flow between the two DAO control modules; wherein a ratio set point of the virtual DAO control module is nominally set at 50%; and

wherein the ratio set point of one of the DAO control modules is set for r1/(r1+r2), wherein r1 and r2 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

29. A four channel gas delivery system comprising:

an inlet channel;

four outlet channels;

four control valves, each valve being arranged so as to control a flow from the inlet channel through a corresponding one of the outlet channels;

a flow ratio control system including two dual antisymmetric optimal (DAO) control modules configured and arranged so as to control the respective control valves so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a virtual DAO control module configured and arranged so as to control the ratio of flow between the two DAO control modules; wherein a ratio set point of the virtual DAO control module is nominally set at 50%; and

wherein the ratio set point of the other of the DAO control modules is set for r4/(r3+r4), wherein r3 and r4 are the ratio of flows through the corresponding outlet channels of the other DAO control module relative to the total flow.

30. A four channel gas delivery system comprising:

an inlet channel;

four outlet channels;

four control valves, each valve being arranged so as to control a flow from the inlet channel through a corresponding one of the outlet channels;

a flow ratio control system including two dual antisymmetric optimal (DAO) control modules configured and arranged so as to control the respective control valves so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a virtual DAO control module configured and arranged so as to control the ratio of flow between the two DAO control modules; and

wherein a ratio set point of the virtual DAO control module is set for r1+r4, wherein r1 and r4 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

31. The four channel gas delivery system of claim 30, wherein the ratio set point of one of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

32. The four channel gas delivery system of claim 30, wherein the ratio set point of the other of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the other DAO control module is nominally the same.

33. The four channel gas delivery system of claim 30, wherein the ratio set point of the virtual DAO control module is the summation of the flow ratio setpoints on first paired flow channels.

34. The four channel gas delivery system of claim 33, wherein the ratio set point of one of the DAO control modules is the relative ratio between the flow ratio setpoints in the first paired flow channels.

35. The four channel gas delivery system of claim 33, wherein the ratio set point of the other of the DAO control modules is the relative ratio between the flow ratio setpoints in the second paired flow channels.

36. A multi-channel gas delivery system for controlling a flow from an inlet channel through four outlet channels, comprising:

a flow ratio control system including two dual antisymmetric optimal (DAO) control modules configured and arranged so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a signal generator configured and arranged so as generate a control signal for each of the two DAO control modules as a function of the ratio of flow through the two DAO control modules;

wherein a ratio set point of the control signal generator module is nominally set at 50%;

wherein the ratio set point of one of the DAO control modules is set for r1/(r1+r2), wherein r1 and r2 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

37. A multi-channel gas delivery system for controlling a flow from an inlet channel through four outlet channels, comprising:

a flow ratio control system including two dual antisymmetric optimal (DAO) control modules configured and arranged so as to control the relative ratios of flow from the inlet

channel through the four outlet channels, and a signal generator configured and arranged so as generate a control signal for each of the two DAO control modules as a function of the ratio of flow through the two DAO control modules;

wherein a ratio set point of the control signal generator module is nominally set at 50%; and

wherein the ratio set point of the other of the DAO control modules is set for r4/(r3+r4), wherein r3 and r4 are the ratio of flows through the corresponding outlet channels of the other DAO control module relative to the total flow.

38. A multi-channel gas delivery system for controlling the a flow from an inlet channel through four outlet channels, comprising:

a flow ratio control system including two dual antisymmetric optimal (DAO) control modules configured and arranged so as to control the relative ratios of flow from the inlet channel through the four outlet channels, and a signal generator configured and arranged so as generate a control signal for each of the two DAO control modules as a function of the ratio of flow through the two DAO control modules;

wherein the control signal generator generates the control signal as a function of the a ratio setpoint of the ratio of flows through the two outlet channels of the respective DAO control module, the measured ratio of flows through the two outlet channels of the respective DAO control module and an optimal bias current; and

wherein the ratio set point of the control signal generator is set for r1+r4, wherein r1 and r4 are the ratio of flows through the corresponding outlet channels of the one DAO control module relative to the total flow.

39. The multi-channel gas delivery system of claim 38, wherein the ratio set point of one of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

40. The multi-channel gas delivery system of claim 38, wherein the ratio set point of the other of the DAO control modules is set nominally for 50% so that the flow rates through the outlet channels of the one DAO control module is nominally the same.

41. The four channel gas delivery system of claim 38, wherein the ratio set point of the control signal generator is the summation of ~~the~~ flow ratio setpoints on first paired flow channels.

42. The four channel gas delivery system of claim 41, wherein the ratio set point of one of the DAO control modules is the relative ratio between the flow ratio setpoints in the first paired flow channels.

43. The four channel gas delivery system of claim 41, wherein the ratio set point of the other of the DAO control modules is the relative ratio between the flow ratio setpoints in the second paired flow channels.

44. The four channel gas delivery system of claim 28, wherein the virtual DAO control module is configured and arranged so to determine a bias current for each of the DAO control modules as a function of the ratio of flow between the two DAO control modules.

45. The four channel gas delivery system of claim 29, wherein the virtual DAO control module is configured and arranged so to determine a bias current for each of the DAO control modules as a function of the ratio of flow between the two DAO control modules.

46. The four channel gas delivery system of claim 30, wherein the virtual DAO control module is configured and arranged so to determine a bias current for each of the DAO control modules as a function of the ratio of flow between the two DAO control modules.

47. The four channel gas delivery system of claim 28, wherein the virtual DAO control module provides a bias current to each of the DAO control modules as a function of the ratio of flow between the two DAO control modules, and each of the DAO control modules provides a pair of bias currents to two of the control valves used to control the flow rates through two corresponding outlet channels.

48. The four channel gas delivery system of claim 29, wherein the virtual DAO control module provides a bias current to each of the DAO control modules as a function of the ratio of flow between the two DAO control modules, and each of the DAO control modules provides a

pair of bias currents to two of the control valves used to control the flow rates through two corresponding outlet channels.

49. The four channel gas delivery system of claim 30, wherein the virtual DAO control module provides a bias current to each of the DAO control modules as a function of the ratio of flow between the two DAO control modules, and each of the DAO control modules provides a pair of bias currents to two of the control valves used to control the flow rates through two corresponding outlet channels.

50. The multi-channel gas delivery system of claim 36, wherein the flow through each outlet channel is controlled by a control valve in response to a valve drive signal and the corresponding control signal is added to drive currents generated by each DAO control module.

51. The multi-channel gas delivery system of claim 37, wherein the flow through each outlet channel is controlled by a control valve in response to a valve drive signal and the corresponding control signal is added to drive currents generated by each DAO control module.

52. The multi-channel gas delivery system of claim 38, wherein the flow through each outlet channel is controlled by a control valve in response to a valve drive signal and the corresponding control signal is added to drive currents generated by each DAO control module.