particular, electrical tensioners have a more rapid response time and greater precision of control than hydro-pneumatic tensioners. The quick response time may be advantageously employed to perform anti-recoil functions. This anti-recoil control design for a riser hybrid tensioning system provides increased precision and flexibility in control, as well as additional possibilities for test scenarios, thus enhancing reliability and safety.

[0012a] According to a first aspect of the present invention, there is provided an apparatus, comprising: a vessel; a drilling riser; a plurality of wires coupled to the drilling riser; a first and second electrical tensioner coupled to the drilling riser via a first and second wire of the plurality of wires; a first data logging system coupled to the vessel, configured to generate first data regarding the properties of the vessel; a second data logging system coupled to the drilling riser, configured to generate second data regarding the properties of the riser; and a controller coupled to the first and the second electrical tensioners and coupled to the first and the second data logging systems and configured to perform steps comprising: receiving the first data from the first data logging system; receiving the second data from the second data logging system; comparing the first data with the second data; determining a tension for the first and the second electrical tensioners based, at least in part, on the comparison of the first data with the second data to control a position of the drilling riser with respect to a reference point; retracting, when in a testing mode, a lower marine riser package from a blowout preventer to a distance less than that present in a full retraction; and controlling the first and the second electrical tensioners to apply the determined tension to the first and the second wires.

[0012b] According to a second aspect of the present invention, there is provided a method, comprising: receiving first data regarding the properties of a vessel; receiving second data regarding the properties of a drilling riser; comparing the first data with the second data; determining a tension for a plurality of electrical tensioners based, at least in part, on the comparison of the first data with the second data to control a position of the drilling riser with respect to a reference point; dynamically adjusting the tensions of the plurality of electrical tensioners, based, at least in part, on a real time comparison of the first data with the second data, to retract a lower marine riser package from a blowout preventer to a lesser degree than that occurring in a full disconnect; and controlling a plurality of electrical tensioners to apply the determined tension to a plurality of wires.

[0012c] According to the third aspect of the present invention, there is provided an apparatus comprising: a controller configured to perform steps comprising: receiving first data

from the first data logging system; receiving second data from the second data logging system; comparing the first data with the second data; determining a tension for a first and a second electrical tensioner based, at least in part, on the comparison of the first data with the second data to control a position of the drilling riser with respect to a reference point; retracting, when in a testing mode, a lower marine riser package from a blowout preventer to a distance less than that present in a full retraction; and controlling the first and the second electrical tensioners to apply the determined tension to a first and a second wire.

[0013] The system may include a drilling riser, a vessel, a first data logging system coupled to a vessel, a second data logging system coupled to the top of the drilling riser, an array of electrical tensioners coupled to the drilling riser via an array of wires, one or more hydro-pneumatic tensioners coupled to the drilling riser via one or more wires, and a controller, coupled to and controlling the tensioners and receiving data from the first and second data logging systems. The first data logging system sends data to the controller regarding the acceleration, velocity, and position of the vessel itself. The second data logging system sends data to the controller regarding the acceleration, velocity, and position of the top of the drilling riser. The controller then estimates the properties of the entire drilling riser based on the data regarding the top of the drilling riser and data as to the properties of the drilling riser that are constant. A vessel as referred to throughout this document may refer to a ship, a platform, or any other sea capable structure or vehicle.

[0014] When the drilling riser disconnects from a blowout preventer, the first goal of the anti-recoil system is to create as much distance between the lower marine riser package, or the bottom of the drilling riser, and the blowout preventer as possible. To that effect, when the data as to the acceleration, velocity, and positon of the drilling riser relative to the position of the blowout preventer indicates that a disconnect has occurred, the controller is configured to cause the electrical tensioners to apply a maximum tension to the wires to which they are coupled in order to create a maximum distance between the drilling riser and the blowout preventer as fast as possible. The goal is to prevent a collision between the lower marine riser package and the blowout preventer.

CLAIMS

What is claimed is:

1. An apparatus, comprising:

a vessel;

a drilling riser;

a plurality of wires coupled to the drilling riser;

a first and second electrical tensioners coupled to the drilling riser via a first and second wires of the plurality of wires;

a first data logging system coupled to the vessel, configured to generate first data regarding the properties of the vessel;

a second data logging system coupled to the drilling riser, configured to generate second data regarding the properties of the riser; and

a controller coupled to the first and the second electrical tensioners and coupled to the first and the second data logging systems and configured to perform steps comprising:

receiving the first data from the first data logging system;

receiving the second data from the second data logging system;

comparing the first data with the second data;

determining a tension for the first and the second electrical tensioners based, at least in part, on the comparison of the first data with the

second data to control a position of the drilling riser with respect to a reference point;

retracting, when in a testing mode, a lower marine riser package from a blowout preventer to a distance less than that present in a full retraction; and

controlling the first and the second electrical tensioners to apply the determined tension to the first and the second wires.

2. The apparatus of claim 1, further comprising:

a hydro-pneumatic tensioner coupled to the drilling riser via a third wire of the plurality of wires,

in which the controller is further configured to control the hydro-pneumatic tensioner to adjust a tension of the third wire.

3. The apparatus of claim 2, in which the hydro-pneumatic tensioner comprises an anti-recoil valve.

4. The apparatus of claim 3, in which the controller is configured to control the anti-recoil valve of the hydro-pneumatic tensioner to be kept open during a riser recoil process to enhance predictability of the riser system.

5. The apparatus of claim 3, in which the controller is further configured to close the anti-recoil valve of the hydro-pneumatic tensioner to supplement anti-recoil capabilities of the first and the second electrical tensioners.

6. The apparatus of claim 1, in which the second data comprises at least one of:

an acceleration of the top of the drilling riser;

a velocity of the top of the drilling riser;

a position of the top of the drilling riser; and

11. The apparatus of claim 10, in which the first data comprises an acceleration of a vessel and the second data comprises an acceleration of a top of the drilling riser, and in which the controller is further configured to compare the acceleration of the vessel with the acceleration of the top of the drilling riser in order to detect a possible collision.

12. The apparatus of claim 11, in which the controller is further configured to reduce the tension applied to the first and the second wires if the difference between the acceleration of the top of the drilling riser and the acceleration of the vessel exceeds a threshold.

13. The apparatus of claim 1, in which the controller is further configured to increase the tension applied to the first and the second wires for a time period based, at least in part, on a desired drilling riser position and the second data in order to move the drilling riser into the desired drilling riser position.

14. The apparatus of claim 1, in which the controller is further configured to adjust the degree of retraction of the lower marine riser package based, at least in part, on an adjustable control parameter.

15. The apparatus of claim 1, in which the controller is further configured to control the first and the second electrical tensioners to dynamically adjust an upward pulling force on the drilling riser in an anti-recoil mode based, at least in part, on a real time comparison of the first data with the second data.

16. The apparatus of claim 1, in which the controller is further configured to control the tensions of the first and the second wires by applying an optimization control technique.

17. The apparatus of claim 1, wherein the reference point comprises at least one of the drilling vessel, a node along the drilling riser, another separate vessel, and a seabed.

18. The apparatus of claim 1, wherein the controller is configured to control the position of the drilling riser according to at least one of a PID control loop, a Linear Quadratic Gaussian control loop, an H-infinity control loop, and a non-linear control loop.

19. A method, comprising:

receiving first data regarding the properties of a vessel;

receiving second data regarding the properties of a drilling riser;

comparing the first data with the second data;

determining a tension for a plurality of electrical tensioners based, at least in part, on the comparison of the first data with the second data to control a position of the drilling riser with respect to a reference point;

dynamically adjusting the tensions of the plurality of electrical tensioners, based, at least in part, on a real time comparison of the first data with the second data, to retract a lower marine riser package from a blowout preventer to a lesser degree than that occurring in a full disconnect; and

controlling a plurality of electrical tensioners to apply the determined tension to a plurality of wires.

20. The method of claim 19, in which the first data comprises at least one of:

an acceleration of the vessel;
a velocity of the vessel; and
a position of the vessel.

21. The method of claim 19, in which the second data comprises at least one of:

an acceleration of the drilling riser;

a velocity of the drilling riser; and

a position of the drilling riser.

22. The method of claim 19, in which the step of controlling the plurality of electrical tensioners comprises compensating the position for a disconnect between a lower marine riser package and a blowout preventer.

23. The method of claim 19, further comprising dynamically adjusting the tensions of the plurality of electrical tensioners, based, at least in part, on a real time comparison of the first data with the second data and with a position of a blowout preventer, to control the distance between a lower marine riser package and a blowout preventer in the event of a disconnect between the lower marine riser package and the blowout preventer.

24. The method of claim 19, further comprising dynamically adjusting the tensions of the plurality of electrical tensioners, based, at least in part, on a real time comparison of the first data with the second data, to control the distance between the drilling riser and a floor of the vessel.

25. The method of claim 19, further comprising adjusting the distance of retraction of the lower marine riser package from the blowout preventer based, at least in part, on an adjustable control parameter.

26. The method of claim 19, wherein the reference point comprises at least one of the drilling vessel, a node along the drilling riser , another separate vessel, another separate vessel and a seabed.

27. The method of claim 19, wherein the controller is configured to control the position of the drilling riser according to at least one of a PID control loop, a Linear Quadratic Gaussian control loop, an H-infinity control loop and a non-linear control loop.

28. An apparatus comprising:

a controller configured to perform steps comprising:

receiving first data from the first data logging system;

receiving second data from the second data logging system;

comparing the first data with the second data;

determining a tension for a first and a second electrical tensioner based, at least in part, on the comparison of the first data with the second data to control a position of the drilling riser with respect to a reference point;

retracting, when in a testing mode, a lower marine riser package from a blowout preventer to a distance less than that present in a full retraction; and

controlling the first and the second electrical tensioners to apply the determined tension to a first and a second wire.

29. The apparatus of claim 28, in which the controller is further configured to perform a step of controlling a hydro-pneumatic tensioner to adjust a tension of a third wire of the plurality of wires.

30. The apparatus of claim 29, in which the controller is further configured to perform a step of controlling an anti-recoil valve of the hydro-pneumatic tensioner to be kept open during a riser recoil process to enhance predictability of a riser system.

31. The apparatus of claim 29, in which the controller is further configured to perform a step of closing an anti-recoil valve of the hydro-pneumatic tensioner to supplement anti-recoil capabilities of the first and the second electrical tensioners.

32. The apparatus of claim 28, in which the controller is further configured to perform a step of adjusting the tensions of the first and the second electrical tensioners to control a distance between a lower marine riser package and a blowout preventer in the case of a disconnect between a lower marine riser package and a blowout preventer in the case of a disconnect between the lower marine riser package and the blowout preventer.

33. The apparatus of claim 28, in which the controller is further configured to perform the step of adjusting the tensions of the first and the second electrical tensioners to control a distance between a drilling riser and a floor of a vessel in the event of a disconnect between a lower marine riser package and a blowout preventer.

34. The apparatus of claim 28, in which the controller is further configured to perform the step of distributing a maximum tension to the first and the second wires upon detection of a disconnect between a lower marine riser package and a blowout preventer for a period of time calculated based, at least in part, on a position of the blowout preventer and the second data, comprising a position of a drilling riser, a velocity of a drilling riser, and an acceleration of a drilling riser.

35. The apparatus of claim 28, in which the controller is further configured to perform the step of reducing the tension applied to the first and the second wires based, at least

in part, on the first data and the second data in order to keep a drilling riser from impacting a floor of a vessel.

36. The apparatus of claim 35, in which the controller is further configured to perform the step of comparing the first data, comprising an acceleration of a vessel, with a second data, comprising an acceleration of a top of a drilling riser, in order to detect a forthcoming collision.

37. The apparatus of claim 36, in which the controller is further configured to perform the step of reducing the tension applied to the first and the second wires if the difference between the acceleration of the top of the drilling riser and the acceleration of the vessel exceeds a threshold.

38. The apparatus of claim 28, in which the controller is further configured to perform the step of increasing the tension applied to the first and the second wires for a time period based, at least in part, on a desired drilling riser position, and the second data, in order to move a drilling riser into the desired drilling riser position.

39. The apparatus of claim 28, in which the controller is further configured to perform the step of adjusting the degree of attraction of the lower marine riser package based, at least in part, on an adjustable control parameter.

40. The apparatus of claim 28, in which the controller is further configured to perform the step of controlling the first and the second electrical tensioners to dynamically adjust an upward pulling force on a drilling riser in an anti-recoil mode, based, at least in part, on a real-time comparison of the first data with the second data.

41. The apparatus of claim 28, in which the controller is further configured to perform the step of controlling the tensions of the first and the second wires by applying a Linear-Quadratic Gaussian equation.

42. The apparatus of claim 28, wherein the reference point comprises at least one of the drilling vessel, a node along the drilling riser, another separate vessel, another separate vessel, and a seabed.

43. The apparatus of claim 28, wherein the controller is configured to control the position of the drilling riser according to at least one of a PID control loop, a Linear Quadratic Gaussian control loop, an H-infinity control loop, and a non-linear control loop.