CLAIMS

We claim:

1. A method of determining a desired pretorque level for a motor controlling motion in a counterbalancing system, the motor having a holding brake operatively connected to a drive shaft of the motor, the method comprising the steps of:

increasing a magnitude of current applied to the motor to generate torque in a first direction of rotation while the holding brake is set;

monitoring a position feedback signal corresponding to rotation of the motor while the torque is generated in the first direction;

removing the current applied to the motor to generate torque in the first direction of rotation while the holding brake is set;

increasing the magnitude of current applied to the motor to generate torque in a second direction of rotation while the holding brake is set;

monitoring the position feedback signal corresponding to rotation of the motor while the torque is generated in the second direction;

removing the current applied to the motor to generate torque in the second direction of rotation while the holding brake is set; and

determining the desired pretorque level as a function of the magnitude of current applied to the motor and a magnitude of rotation detected by the position feedback signal.

2. The method of claim 1 wherein the step of determining the desired pretorque level further comprises the steps of:

comparing a change in the position feedback signal to a first threshold; and

setting the desired pretorque level equal to the magnitude of current applied to the motor when the change in the position feedback signal reaches the first threshold.

3. The method of claim 1 wherein the step of:

removing the current applied to the motor to generate torque in the first direction of rotation further comprises the step of decreasing the magnitude of current applied to the motor to generate torque in the first direction of rotation while the holding brake is set;

removing the current applied to the motor to generate torque in the second direction of rotation further comprises the step of decreasing the magnitude of current applied to the motor to generate torque in the second direction of rotation while the holding brake is set; and

determining the desired pretorque level further comprises the steps of:

comparing a change in the position feedback signal to a first threshold;

when the change in the position feedback signal exceeds the first threshold, monitoring the position feedback signal until the change in the position feedback signal drops back below the first threshold; and

when the change in the position feedback signal drops back below the first threshold, setting the desired pretorque level equal to the magnitude of current applied to the motor when the change in the position feedback signal drops back below the first threshold.

4. The method of claim 1 further comprising the step of applying a magnitude of current to the motor to generate torque at the desired pretorque level prior to releasing the holding brake.

5. A system for determining a desired pretorque level for a motor controlling motion in a counterbalancing system, the motor having a holding brake operatively connected to a drive shaft of the motor, the system comprising:

a power converter operatively connected to the motor to supply a variable voltage and a variable current to the motor for controlling operation of the motor;

a position feedback device operatively connected to the motor and configured to generate a signal corresponding to an angular position of the motor; and

a controller including:

an input operative to receive the signal from the position feedback device;

a memory device operative to store a plurality of instructions; and

a processor operative to execute the plurality of instructions to:

control operation of the power converter to provide an increasing magnitude of current to the motor with a first polarity, wherein the current increases from a first level to a second level while the holding brake is set and generates a torque in the motor in a first direction of rotation,

monitor the signal from the position feedback device while the increasing magnitude of current with the first polarity is being provided to the motor,

control operation of the power converter to provide a decreasing magnitude of current with the first polarity to the motor, wherein the current decreases from the second level to the first level while the holding brake is set,

control operation of the power converter to provide an increasing magnitude of current to the motor with a second polarity, wherein the current increases from the first level to a third level while the holding brake is set, the second polarity is opposite the first polarity, and the current generates a torque in the motor in a second direction of rotation,

monitor the signal from the position feedback device while the increasing magnitude of current with the second polarity is being provided to the motor,

control operation of the power converter to provide a decreasing magnitude of current with the second polarity to the motor, wherein the current decreases from the third level to the first level while the holding brake is set, and

determine the desired pretorque level as a function of the magnitude of current applied to the motor and a magnitude of rotation detected by the position feedback signal.

6. The system of claim 5 further comprising a motor drive wherein the power converter is a power conversion section of the motor drive and the controller is a control section of the motor drive.

7. The system of claim 5 wherein the desired pretorque level is determined as a function of the magnitude of current applied to the motor as the current is increasing in magnitude.

8. The system of claim 7 wherein the processor is further operative to:

compare a change in the signal from the position feedback device to a first threshold, and

set the desired pretorque level equal to the magnitude of current applied to the motor when the change in the signal from the position feedback device reaches the first threshold.

9. The system of claim 5 wherein the desired pretorque level is determined as a function of the magnitude of current applied to the motor as the current is decreasing in magnitude.

10. The system of claim 9 wherein the processor is further operative to:

compare a change in the signal from the position feedback device to a first threshold,

when the change in the signal from the position feedback device exceeds the first threshold, monitor the signal from the position feedback device until the change in the signal drops back below the first threshold, and

when the change in the signal from the position feedback device drops back below the first threshold, set the desired pretorque level equal to the magnitude of current applied to the motor when the change in the signal from the position feedback device drops back below the first threshold.

11. The system of claim 5 wherein the processor is further operative to control operation of the power converter to provide

a magnitude of current to the motor to generate torque at the desired pretorque level prior to releasing the holding brake.

12. A method of reducing rollback for a motor controlling motion in a counterbalancing system, the motor having a holding brake operatively connected to a drive shaft of the motor, and the rollback occurring when the brake is opened, the method comprising the steps of:

while the holding brake is set:

activating the motor with a current increasing in magnitude and having a first polarity to apply a first torque to the drive shaft in a first direction;

monitoring a position feedback signal corresponding to rotation of the drive shaft while the first torque is being applied;

activating the motor with a current increasing in magnitude and having a second polarity, the second polarity opposite the first polarity, to apply a second torque to the drive shaft in a second direction;

monitoring the position feedback signal corresponding to rotation of the drive shaft while the second torque is being applied;

determining a magnitude and direction of a desired pretorque level as a function of the applied first and second torque and of the position feedback signal;

activating the motor to apply a torque at the desired pretorque level to the drive shaft; and

releasing the holding brake.

13. The method of claim 12 wherein a motor drive supplies a variable voltage and a variable current to the motor to apply each torque to the drive shaft and wherein the motor drive receives the position feedback signal and generates a control signal to release the holding brake.

14. The method of claim 12 wherein the step of activating the motor to apply the first torque further comprises the steps of:

incrementally changing a magnitude of current applied to the motor to generate the first torque from a first level to a second level; and

removing the current applied to the motor to generate the first torque.

15. The method of claim 14 wherein the desired pretorque level is determined as a function of the magnitude of current applied to the drive shaft.

16. The method of claim 15 wherein the step of determining the magnitude and direction of the desired pretorque level further comprises the steps of:

comparing a change in the position feedback signal to a first threshold; and

setting the desired pretorque level equal to a level of torque resulting from the magnitude of current being applied to the motor when the change in the position feedback signal reaches the first threshold.

17. The method of claim 15 wherein the step of:

removing the current applied to the motor to generate the first torque further comprises the step of decreasing the magnitude of current applied to the motor to generate the first torque in the first direction while the holding brake is set; and

determining the magnitude and direction of the desired pretorque level further comprises the steps of:

comparing a change in the position feedback signal to a first threshold;

when the change the position feedback signal exceeds the first threshold, monitor the position feedback signal until the change in the position feedback signal drops back below the first threshold; and

when the change in the position feedback signal drops back below the first threshold, set the desired pretorque level equal to a level of torque resulting from the magnitude of current being applied to the motor when the change in the position feedback signal drops back below the first threshold.

18. The method of claim 12 wherein the step of activating the motor to apply the second torque further comprises the steps of:

incrementally changing a magnitude of current applied to the motor to generate the second torque from a third level to a fourth level; and

removing the current applied to the motor to generate the second torque, wherein the desired pretorque level is determined as a function of the magnitude of current applied to the drive shaft.

19. The method of claim 18 wherein the step of determining the magnitude and direction of the desired pretorque level further comprises the steps of:

comparing a change in the position feedback signal to a first threshold; and

setting the desired pretorque level equal to a level of torque resulting from the magnitude of current being applied to the motor when the change in the position feedback signal reaches the first threshold.

20. The method of claim 18 wherein the step of:

removing the current applied to the motor to generate the second torque further comprises the step of decreasing the magnitude of current applied to the motor to generate the second torque in the second direction while the holding brake is set; and

determining the magnitude and direction of the desired pretorque level further comprises the steps of:

comparing a change in the position feedback signal to a first threshold;

when the change the position feedback signal exceeds the first threshold, monitor the position feedback signal until the change in the position feedback signal drops back below the first threshold; and

when the change in the position feedback signal drops back below the first threshold, set the desired pretorque level equal to a level of torque resulting from the magnitude of current being applied to the motor when the change in the position feedback signal drops back below the first threshold.