Claims

1. An actuator (10, 210) comprising:

a housing (14, 214) having a first end (15, 215) and an aperture (13, 213) positioned at the first end of the housing;

an actuator rod (12, 212) extending through the aperture along an axis (11, 211) of the actuator, the actuator rod operable to be driven with a bidirectional stroke, wherein the bidirectional stroke comprises an operational range and an end-of-stroke range; and

a snubber assembly (28, 228), wherein:

the snubber assembly is mounted at the first end of the housing;

the snubber assembly includes one or more energy absorbing devices (110, 2100, 314), and the snubber assembly is positioned on the housing such that an axis of each of the one or more energy absorbing devices is offset relative to the axis of the actuator; and

wherein the snubber assembly is configured such that the one or more energy absorbing devices provide bidirectional damping to the end-of-stroke range motion of the actuator rod;

wherein the snubber assembly includes a frame (30, 230) that is configured to receive the one or more energy absorbing devices, wherein the frame includes a first frame part (32, 232) and a second frame part (34, 234), and the one or more energy absorbing devices are positioned between the first frame part and the second frame part; and

wherein:

the first frame part is moveable relative to the second frame part along the axis of the actuator; and

the first frame part and the second frame part are moveable relative to the housing along the axis of the actuator.

2. An actuator according to claim 1, wherein the snubber assembly is configured such that:

the one or more energy devices compress to provide damping at the end of an extension stroke of the actuator rod;

the one or more energy devices compress to provide damping at the end of a retraction stroke of the actuator rod.

3. An actuator according to claim 1, wherein at least one of the one or more energy absorbing devices is selected from: a damper, a mechanical damper, a spring, a crush tube, a plastically deformable material.

4. An actuator according to claim 1 or claim 3, wherein;

the actuator rod has a first end (15, 215) and a second end distal (16, 216) to the first end;

the actuator rod comprises a first stop at the first end of the actuator rod and a second stop at the second end of the actuator rod;

the housing comprises a third stop at the first end of the housing;

the first frame part includes a fourth stop configured to engage with the first stop and a seventh stop configured to engage with the third stop; and

the second frame part includes fifth stop configured to engage with the second stop, and a sixth stop configured to engage with the third stop.

5. An actuator according to claim 4 wherein the third stop is positioned between the seventh stop and the sixth stop.

6. An actuator according to claim 4 or claim 5 wherein in use:

when the actuator rod is extended from the housing to a first predetermined extension distance:

the second stop is brought into abutting engagement with the fifth stop;

the seventh stop abuts the third stop thereby preventing motion of the first frame part in the direction of the extension of the actuator rod;

further extension of the actuator rod causes the second frame part to move in the direction of extension of the actuator rod, thereby compressing the one or more energy absorbing devices between the first frame part and the second frame part.

7. An actuator according to any of claims 4 to 6 wherein in use:

when the actuator rod is retracted into the housing to a second predetermined extension distance:

the first stop is brought into abutting engagement with the fourth stop;

the second stop abuts the third stop thereby preventing motion of the second frame part in the direction of the retraction of the actuator rod;

further retraction of the actuator rod causes the first frame part to move in the direction of retraction of the actuator rod, thereby compressing the one or more energy absorbing devices between the first frame part and the second frame part.

8. An actuator according to any of claims 4 to 6 wherein the first frame part comprises a rod linking the fourth stop and the seventh stop.

9. An actuator according to claim 8, wherein;

a first energy absorbing device of the one or more energy absorbing devices is a crush tube or spring surrounding a portion of the rod, wherein the first energy absorbing device is positioned between the first frame part and the second frame part.

10. An actuator according to claim 9, wherein the first energy absorbing device is positioned between the fourth stop and the sixth stop.

11. An actuator according to any of claims 4 to 6, wherein;

the second frame part includes an eighth stop configured to engage with the one or more energy absorbing devices.

12. An actuator according to claim 11 wherein in use:

when the actuator rod is extended from the housing to the first predetermined extension distance:

the eighth stop abuts the one or more energy absorbing devices;

the further extension of the actuator rod causes compression of the one or more energy absorbing devices between the first frame part and the eighth stop.

13. An actuator according to claim 11 or claim 12 wherein in use:

when the actuator rod is retracted into the housing to the second predetermined extension distance:

the eighth stop abuts the one or more energy absorbing devices;

the further retraction of the actuator rod causes compression of the one or more energy absorbing devices between the first frame part and the eighth stop.

14. An actuator according to any of claims 3 to 7, and claims 11 to 13, wherein the first frame part includes a mounting member.

15. An actuator according to claim 14, wherein the first frame part mounting member is configured to receive the energy absorbing device.

16. An actuator according to any of claims 3 to 7, and claims 11 to 13, wherein the second frame part includes a housing and a rod.

17. An actuator according to claim 16, wherein the rod extends between the eighth stop and the second frame member housing.

18. An actuator according to claim 16 or claim 17, wherein;

a first energy absorbing device of the one or more energy absorbing devices is a crush tube or spring surrounding a portion of the rod, wherein the first energy absorbing device is positioned between the eighth stop and the third stop.

19. An actuator according to any of claims 16 to 18, when dependent on claim 14 or 15, wherein the second frame member housing includes an opening that is configured to receive the first frame part mounting member.

20. An actuator according to claim 19, wherein the third stop is a ring member, wherein the ring member is positioned between the fourth stop and the eighth stop.

21. A simulator or test system including a base, a platform that is mounted for movement relative to the base, and an actuation mechanism that is operatively arranged between the base and the platform, wherein the actuation mechanism includes at least one actuator as defined by any of claims 1 to 20.