[0087] In the non-restrictive illustrative embodiment of FIG. **8**, transducer T**2** is a controllable source of speed **901** advantageously presenting a high intrinsic mechanical impedance Z_2 (see FIGS. **9-12**).

[0088] Since a high performance differential actuator is characterized by the expression:

$$(K+1)^2 Z_2 >> Z_1.$$

[0089] where Z_1 and Z_2 are equivalent mechanical impedances associated to transducers T**1** and T**2**, respectively, and K is the above mentioned amplification factor, the mechanical differential **801** acts as a speed reducer (speed reducer **802**) for transducer T**2** from a load point of view. Thus, if the intrinsic mechanical impedance of transducer **72** is low, a gear ratio and an intrinsic friction of the mechanical speed reducer **802** of the mechanical differential **801** will contribute to increase an equivalent impedance Z_{eq} of transducer **72** seen from the load **803**. It is not necessary to exert a precise control on the exact value of the mechanical impedance of transducer T**2**, since this does not affect the principle of operation of the differential actuation process. Taking into consideration the foregoing teaching of the specification in Section "*Real source of speed*", possible implementations of transducer T**2** comprise, for example:

[0090] A hydraulic transducer (T**2**) connected to a low gear ratio differential (K=1 implemented by the mechanical speed reducer **802**);

[0091] An ultrasonic actuator (T**2**) connected to a low gear ratio differential (K=1 implemented by the mechanical speed reducer **802**);

[0092] A direct drive electromechanical transducer (T**2**) connected to a high gear ratio differential (K>>1 implemented by the mechanical speed reducer **802**) and with a feedback speed controller (not shown; this type of controller is well known to those of ordinary skill in the art and for that reason will not be further described in the present specification); and

[0093] Any other actuator sub-system designed and suitable to act as a controllable source of speed.

[0094] Depending of the nature of transducer T**1** and taking into consideration the teaching of the above Section "Real source of force/torque", four categories of high performance differential actuators can be distinguished.

[0095] Category 1: Differential Actuator with Constant Impedance Dynamic Reaction

[0096] Transducer T**1** has a constant mechanical impedance Z**1**, as shown in FIG. **9**. The intrinsic mechanical impedance Z**1** of transducer T**1** is task dependant and is calculated during the phase of engineering of the actuator. The output force can be controlled within a limited amplitude and bandwidth depending on the mechanical impedance Z**1** and the speed bandwidth of transducer T**2**. Examples of possible physical implementations of transducer T**2** comprise, amongst others:

[0097] A passive mechanical spring;

[0098] A passive mechanical damper;

[0099] A passive mechanical inertia; and

[0100] A combination of passive mechanical elements such as springs, dampers and inertia elements.

Category 2: Force Controllable Differential Actuator

[0101] Transducer T**1** comprises an active source of force/torque **1001** with very low intrinsic impedance Z**1**, as shown in FIG. **10**. Possible physical implementations of transducer T**1** include, amongst others:

[0102] Force controlled direct drive electromechanical transducers;

[0103] Force controlled pneumatic transducers;

[0104] Any actuation sub-system acting as a controlled source of force/torque.

[0105] Category 3: Differential Actuator with Variable and Controllable Impedance Dynamic Reaction

[0106] Transducer T**1** has a variable and controllable impedance element, as shown in FIG. **11**. Possible physical implementations of variable and controllable impedance element include, amongst others:

[0107] A controlled magneto-rheological damper;

[0108] An controlled electro-rheological damper;

[0109] A controlled mechanism acting as a variable stiffness spring;

[0110] A direct drive electromechanical transducer controlled with a feedback of movement state variables of transducer T**1** (position, speed, acceleration) to implement virtual impedance;

[0111] A controlled magnetic particle brake;

[0112] A controlled magnetic brake based on the hysteresis effect;

[0113] A controlled stack of piezoelectric actuators acting on friction disks; and

[0114] Any mechanical component with variable and controllable mechanical impedance.

[0115] Category 4: Force Controllable Differential Actuator with Variable and Controllable Impedance Dynamic Reaction

[0116] As shown in FIG. **12**, transducer T**1** has a variable and controllable impedance element Z_1 connected with an active source of force/torque **1201** with very low intrinsic impedance. Possible physical implementations of transducer T**1** include, amongst others:

[0117] A direct drive electromechanical transducer with a <<2-portion based>> control scheme. One portion implements the <<source of force/torque>> contribution while the other portion implements the virtual impedance contribution. The two contributions are added inside a controller avoiding the physical implementation of two distinct transducers; and

[0118] Any actuation subsystem acting as a controlled source of force/torque (category 2) acting in parallel with any mechanical component with variable and controllable mechanical impedance (category 3).

[0119] Key Property of a Differential Actuator According to the Illustrative Embodiments of the Present Invention