

Title: Drive unit, drive system and offshore structure

The invention relates to a drive unit for driving at least two drive shafts simultaneously.

Units for driving two drive shafts simultaneously, for example for adjusting two components at the same time with the same rate, are known. An application of such a system can be found for example in a jack-up offshore installation of which the platform can be moved up and down along the legs or for example on an offshore platform on which a drilling cantilever can be moved outwardly of the platform.

For example for a jack-up offshore structure, the legs are typically provided with at least two racks, and in each rack at least one pinion is engaged. By driving drive shafts that are coupled to the pinions such that the pinions engage over their respective rack, the platform can be adjusted along the legs. In such an application it is important that the pinions are driven simultaneously via their respective drive shaft.

Known in the art is to drive each drive shaft with a single electric motor and gear box containing at least one sequential planetary gear system comprising at least two sequentially linked planetary gear sets. When the output axis of one planetary gear set provides for the input axis of the subsequent planetary gear set, the planetary gear sets are called to be sequentially linked.

When driving each drive shaft with a single electric motor and gear box, numerous components may be required. In particular for an offshore structure, where high reduction ratios, up to 1:8000, may be required, the weight of an individual gear box can become relatively high. For example, for a jack-up offshore structure having a jackable platform and a jacking system comprising gear boxes, the jacking system may take up to 8% of the total

empty weight of the platform. In addition, multiple components may increase maintenance costs and may lead to shorter maintenance intervals.

It is also known to drive two pinions with a single electric motor using a device with a single planetary gear set, as disclosed in US

5 2008/0116427. A drawback of this device is however that, in order to obtain the high reduction ratio, a lot of additional gear steps are still required. In addition, assembly of the device on site can be relatively complex.

French patent publication FR 2 753 466 relates to a jacking system for platforms comprising two pinions driven by a motor over a rack. Between
10 the motor and the pinions there is a first reduction part and a second reduction part. The second reduction part comprises a planetary gear set with a first output from the carrier to the pinion and a second output from the ring via a gear or a chain belt to the pinion. The configuration of FR 2 753 466 has a similar setup as the setup disclosed in publication US 2008/0116427
15 mentioned above.

There is a need for an improved drive unit for driving two drive shafts simultaneously. An object of the invention is to provide for an improved drive unit obviating at least one of the above mentioned drawbacks. In particular, a drive unit that achieves weight reduction and/or component
20 reduction may be aimed for.

Thereeto, the invention provides for a drive unit for driving at least two drive shafts, wherein the drive unit comprises a motor unit and a gear train coupled to the motor unit, wherein the gear train comprises a compound differential planetary gear system having at least one input shaft coupled to
25 the motor unit and at least two output shafts of which each output shaft is arranged for driving a drive shaft, wherein the compound differential planetary gear system comprises at least two planetary gear sets with different form factors that are coupled to each other to create a compound planetary gear setup, of which each planetary gear set is provided with an

output shaft for driving a drive shaft to create the compound differential planetary gear setup.

By providing a compound differential planetary gear system, in an efficient way a high reduction ratio can be obtained as well as it is enabled
5 that two drive shafts can be driven simultaneously at mutually varying speed. By providing a compound differential planetary gear system, a higher reduction ratio can be obtained with the same number of components compared to using a series of sequentially linked planetary gear sets, making the compound planetary gear system a highly compact transmission system.
10 Since fewer components may be required, a weight reduction can be obtained. A weight reduction may reduce production costs and may allow for taking up more payload, in particular in case of jack-up offshore structures, thereby reducing the operational costs of the offshore structure.

Compound planetary gear systems are known in various
15 embodiments, for example with meshed planets, stepped planets or with two or more planetary gear sets. According to the invention, the compound planetary gear system comprises at least two single planetary gear sets that are coupled to each other via two gear shafts. A planetary gear set comprises four gear shafts, i.e. a sun gear, one or more planet gears, a carrier and a ring gear.
20 Each planetary gear set has an input and an output. For example, the sun gear can be the input and the carrier or the ring can be the output.

When linking two planetary gear sets, the output of one planetary gear set can provide for the input of the subsequent planetary gear set. In that case, the planetary gear sets are linked sequentially to provide for a sequential
25 planetary gear system. Contrary to the sequential planetary gear system, in a compound planetary gear system two gear shafts are coupled to each other. For example, two planetary gear sets can be coupled to each other to create a compound planetary gear set-up by coupling the shafts of their sun gears and the shafts of their ring gears to obtain a compound planetary gear system. Or,
30 in another example, two planetary gear sets can be coupled to each other to

create a compound planetary gear set-up by coupling the shafts of their sun gears and the shafts of their carriers to obtain a compound planetary gear system. In general, planetary gear sets can be coupled to each other to create a compound planetary gear set-up by coupling two of four gear shafts.

5 In addition to the compound planetary gear set-up, the compound planetary gear system can be provided in a differential mode by using two of the remaining non-coupled gear shafts as output shafts. By providing the compound planetary gear system with two output shafts, a compound differential planetary gear system is obtained with one common input shaft.

10 The compound planetary gear system can be used as a differential planetary gear system, which can be obtained by using those shafts that are not coupled as output shafts. For example, when the shafts of the carriers and the shafts of the sun gears are coupled, the ring gears can be used as output shafts of the compound differential planetary gear system. For example, when
15 the rings and sun gears are coupled, the carriers are used as output shafts to obtain the differential function of the gear system.

 Many variants are possible for a compound planetary gear system. For example, the shafts of the planet gears of the at least two planetary gear sets can be coupled and the shafts of the sun gears can be coupled, while as
20 output shafts the ring gears can be used. Or, for example, the shafts of the carriers can be coupled and the shafts of the sun gears can be coupled, while the ring gears can be used as output shafts.

 By providing a differential functionality in the drive unit, the drive unit is able to compensate for variations in torque and/or rotational speed
25 between the at least two drive shafts, such that two drive shafts can be driven simultaneously at mutually varying speed. For example, in case the drive shafts are coupled to pinions that engage a rack respectively, the torque between the pinions can vary. For instance, due to wear and tear of the pinion and/or the rack, the contact profile between each pinion and the rack may

change. Therefore, the drive system needs to be able to alter the individual output speed of each pinion according to the reaction torque.

Typically, a planetary gear set has one input axis, e.g. the sun gear, and two output axes, e.g. the ring gear and the carrier, of which usually one is fixed and one is free. In a sequential planetary gear system each planetary gear set has one input, e.g. the sun gear, and one output, e.g. the carrier. The rings of each planetary gear set are fixed. The sequential planetary gear system is created by linking the output of each planetary gear set to the input of the subsequent planetary gear set.

By providing a compound differential planetary gear system for driving two drive shafts simultaneously, it can be enabled that the drive shafts counter-rotate with respect to each other, thereby compensating each others reaction torque. A sequentially linked planetary gear system driving one output shaft requires reaction-torque compensation, normally in the form of a heavy connection with the surrounding structure. By providing a common housing for the two counter-rotating output shafts the necessity for this heavy connection is obviated.

Advantageously, the coupled planetary gear sets of the compound differential planetary gear system are different such that a high reduction ratio can be obtained. Different planetary gear sets can be obtained by a difference between the ratios of the number of sun gear teeth over the number of planet gear teeth of the respective planetary gear sets, the ratio of the number of sun gear teeth versus the number of planet gear teeth is known by the person skilled in the art as the form factor.

As an example, the number of teeth on the planet gears of the first planetary gear set might be 27 and the number of teeth on the sun gear of the first planetary gear set might be 25 resulting in a first planetary gear set form factor of 0.926 ($=25/27$) and a transmission ratio of 1:4.16 when the ring gear would be fixed, the sun gear used as input shaft and the carrier as output shaft. In another example, the number of teeth on the planet gears of the

second planetary gear set might be 30 and the number of teeth on the sun gear of the second planetary gear set might be 22 resulting in a second planetary gear set form factor of 0.733 ($=22/30$) and a transmission ratio of 1:4.73 when the ring gear would be fixed, the sun gear used as input shaft and the carrier
5 as output. When the previously mentioned planetary gear sets would be coupled in a sequential set-up the overall ratio would be 1:19.7. When the previously mentioned planetary gear sets would be coupled in a compound differential set-up the overall transmission ratio would be 1:53.7. These examples are only given by way of elaboration on the higher transmission ratio
10 due to a difference in form factor between the planetary gear sets. The examples are by no means limiting or restricting the scope of the claims.

According to the invention, the form factors of the planetary gear sets are different. Preferably, the form factors have a difference between 0.1% and 300%, more preferably the difference is between 1% and 200%,
15 advantageously, the difference is between 1.5% and 50%.

Typically, as output shafts of the compound differential planetary gear system, the ring gears or the carriers of the planets can be used. The respective output shafts can then be coupled further to the drive shafts.

Between each output shaft and drive shaft a final gear set can be
20 arranged that are coupled to each other to provide for a reaction-torque free gear train. The final gear set can for example comprise two final planetary gear sets, of which each final planetary gear set is coupled to an output shaft as input and to a drive shaft as output. Both the ring gears of the final planetary gear sets can be coupled to each other to provide for a reaction-
25 torque free arrangement. By providing such a reaction-torque free arrangement, reaction forces do not need to be compensated in heavy structures and/or heavy housings so the drive unit may be constructed lighter.

Advantageously, the motor unit and/or an output shaft of the motor unit can be positioned approximately centrally in the drive unit. For example,
30 the motor unit can be positioned between the two drive shafts and/or an output

shaft of the motor unit can be aside or in line to the input shaft of the compound differential planetary gear system. By positioning the motor unit approximately centrally with respect to the drive unit, the drive unit can be relatively compact and/or a weight reduction may be achieved. Alternatively, 5 the motor unit can be positioned eccentrically with respect to the drive unit, e.g. asides the drive unit and/or outside of a gear train housing.

Advantageously, an output shaft of the motor unit can be positioned aside the input shaft of the compound differential planetary gear system, e.g. besides, above or beneath said input shaft, preferably substantially parallel to said 10 input shaft. Additionally, said shafts may be coupled by means of one or more gear sets, gears and/or other means such as a chain or a belt.

Alternatively or additionally, the motor unit can be placed in line with the at least one input shaft of the compound differential planetary gear system. Preferably, the motor unit can have an output shaft that is in line with 15 said at least one input shaft of the compound differential planetary gear system. The output shaft of the motor unit and the input shaft of the compound differential planetary gear system, which can be placed concentric with respect to each other, may be coupled in order to act as one shaft or said two shafts may be integrated in order to form a single shaft or act as a single 20 shaft, at least in one rotational direction thereof.

Additionally or alternatively, the motor unit may be placed at least partly, preferably substantially completely, between the at least two output shafts of the compound differential planetary gear system and/or at least partly, preferably substantially completely, between the two drive shafts, 25 especially two drive shafts coupled to two pinions engaging two opposing racks. Advantageously, the motor unit may be placed at least partly, preferably substantially completely, between two pinions coupled to the two drive shafts and/or at least partly, preferably substantially completely, between two racks arranged alongside each other and engaged by said two pinions.

By providing the motor unit in such a central position the drive unit can be relatively compact and/or the weight of the drive unit may be relatively low.

Furthermore, it is noted that the motor unit may be provided with a cooling unit. However, the cooling unit may alternatively be omitted or may be relatively small, for instance because the drive unit and its motor unit will normally be used only sporadically in case said drive unit is used for an offshore jack-up structure. In case the cooling unit is omitted or is relatively small, the motor unit can be relatively small, which may facilitate a central placement thereof.

Moreover, the motor unit of a drive unit according to the invention may be placed between two final planetary gear sets as mentioned above.

Further, it is noted that an output shaft of the motor unit and/or an input shaft of the compound differential planetary gear system may extend at least partly through a coupling which couples the ring gears of the final planetary gear sets.

Further, the drive unit may comprise a coupling unit arranged for coupling the output shaft of the motor unit to at least one input shaft of the compound differential planetary gear system.

Advantageously, the gear train is arranged in an enclosed housing. By arranging the gear train in an enclosed housing, the gear train can be manufactured and assembled off site, e.g. in a factory, and can then be transported to the construction yard to be installed onto the final structure, e.g. an offshore jack-up structure. By providing a housing for the relatively compact gear train, it may become possible to handle the gear train as a plug-and-play component of which it may also be possible to have such a component as a spare part onboard. Providing the gear train in a housing and arranging it as a plug-and-play component, may reduce installation time, but also may reduce maintenance costs and may further reduce operational costs of e.g. the offshore structure on which it is mounted. Since the drive shafts

advantageously counter-rotate with respect to each other, torque compensation may be obviated and the housing can be arranged to be torque-free, such that the housing may become lighter, thereby obtaining a further weight reduction.

Advantageously, the housing is provided with first connecting
5 elements for connection to a motor unit and with second connecting elements for connection to the drive shafts such that the plug-and-play functionality of the housing can be optimally used.

Preferably, the gear train is symmetrically arranged between the
centrelines of the drive shafts, to make optimal use of the counter-rotation of
10 the drive shafts for obtaining optimal weight reduction.

Further advantageous embodiments are represented in the
subclaims.

The invention further relates to a drive system, a gear box and to an
offshore structure.

15 The invention will further be elucidated on the basis of exemplary
embodiments which are represented in the drawings. The exemplary
embodiments are given by way of non-limitative illustration of the invention.

In the drawings:

Fig. 1a shows a schematic view of a first embodiment of a drive
20 system according to the invention;

Fig. 1b shows a schematic view of a second embodiment of a drive
system according to the invention;

Fig. 2a shows a schematic view of a third embodiment of a drive
system according to the invention;

25 Fig. 2b shows a schematic view of a fourth embodiment of a drive
system according to the invention;

Fig. 3 shows a schematic view of a fifth embodiment of a drive
system according to the invention;

Fig. 4 shows a schematic view of a sixth embodiment of a drive
30 system according to the invention;

Fig. 5 shows a schematic view of a seventh embodiment of a drive system according to the invention;

Fig. 6 shows a perspective view of a drive system as schematically represented in Fig. 2a;

5 Fig. 7a shows a schematic top view of a jack-up offshore structure comprising drive systems according to the invention; and

Fig. 7b shows a schematic side view of the jack-up offshore structure of Fig. 7a.

It is noted that the figures are only schematic representations of
10 embodiments of the invention that are given by way of non-limiting example. In the figures, the same or corresponding parts are designated with the same reference numerals.

Fig. 1a shows a drive system 1 according to the invention. The drive system 1 is arranged for driving multiple drive shafts simultaneously.

15 The drive system 1 comprises multiple drive units 4, in this figure, for simplicity's sake, only one drive unit 4 is shown. The drive unit 4 is arranged for driving at least two drive shafts. In this embodiment, there are two drive shafts, a first drive shaft 2 and a second drive shaft 3. The drive unit 4 comprises a motor unit 5 which drives a gear train 6.

20 The gear train 6 comprises a compound differential planetary gear system 7. The compound differential planetary gear system 7 has a single input shaft 8 that is connected to the motor unit 5. An output shaft 28 of the motor unit 5 is coupled to the input shaft 8.

The compound differential planetary gear system 7 has at least two
25 output shafts of which each output shaft is arranged for driving one of the drive shafts 2, 3. Typically, as many output shafts are provided as there are drive shafts. In this embodiment, there is a first output shaft 9 arranged for coupling with the first drive shaft 2. There is a second output shaft 10 arranged for coupling with the second drive shaft 3.

According to the invention, the compound differential planetary gear system 7 comprises at least two planetary gear sets with different form factors. The difference between the form factors of the planetary gear sets can be between 0.1% and 300%, preferably between 1% and 200%, more preferably
5 between 1.5% and 50%. In this embodiment, the compound differential planetary gear system 7 comprises two planetary gear sets 11 and 12. Each planetary gear set has a sun S, planet gears P, a ring R and a carrier C. The first planetary gear set 11 comprises a first sun S1, first planet gears P1a, P1b and a first ring R1. The second planetary gear set 12 comprises a second sun
10 S2, second planet gears P2a, P2b and a second ring R2. The ratio between the sizes of the planet gears P1a/P1b and sun gear S1 is different from the ratio between the sizes of planet gears P2a/P2b and sun gear S2.

The planet gears P1a, P1b, P2a and P2b share in the embodiment of Fig. 1a a single carrier C. The first planet P1a and the second planet P2a share
15 the same rotation axis Xa, but may individually rotate around the rotation axis Xa. The first planet P1b and the second planet P2b share the same rotation axis Xb, but can individually rotate around the rotation axis Xb.

The shafts of the sun gears S1, S2 are coupled to each other as well via a common input shaft 8.

20 By coupling the planetary gear sets 11 and 12 together, in Fig. 1a via coupled shafts of the planet gears P1a and P1b and coupled shafts of the sun gears S1 and S2, a compound planetary gear system 7 is obtained, resulting in a compact gear train with a relatively high transmission ratio. Other shafts of the planetary gear sets can be coupled as well, such as the
25 rings.

Various embodiments of a compound differential planetary gear system are possible. With a compound planetary gear system 7, a larger reduction ratio can be achieved than by linking the planetary gear sets sequentially. The result is that the compound planetary gear system may

require fewer components and may therefore reduce weight and costs, such as manufacturing, installation or maintenance costs.

By providing a compound differential planetary gear system 7, the drive system 1 is able to alter the individual output speed of each drive shaft 2, 3 according to the reaction torque, such that variations in torque between the drive shafts 2, 3 can be compensated. The compound planetary gear system 7 has a differential functionality because there are two output shafts 9, 10 used, contrary to a non-differential compound planetary gear system in which one output shaft is free and one output shaft is fixed. By providing this differential functionality it may become possible to drive two drive shafts simultaneously at mutually varying speed, for instance when each of the drive shafts 2, 3 connects to a respective pinion engaging a respective rack. When the racks are mounted on the same object, it is important to provide for the differential functionality for driving the pinions over their respective racks, because altering the output speed of one of the drive shafts 2, 3 enables load distribution between the pinions in case geometric alterations, for example due to wear, occur on the rack.

The embodiment shown in Fig. 1b is similar to the embodiment of Fig. 1a. In Fig. 1b, the motor unit 5 is placed in line with the input shaft 8 of the compound differential planetary gear system 7. The output shaft 28 of the motor unit 5 is in line with and coupled to the input shaft 8 of the compound differential planetary gear system 7. Actually, the output shaft 28 of the motor unit 5 and the input shaft 8 of the compound differential planetary gear system 7 are placed concentric with respect to each other and are coupled in order to act as one shaft 8, 28. Alternatively, said two shafts 8, 28 may be integrated in order to form a single shaft. Alternatively, a coupling unit can be positioned between the output shaft 28 and the input shaft 8 to couple the shafts to each other.

Here, the motor unit 5 is placed between the two drive shafts 2, 3. Said two drive shafts 2, 3 may be coupled to two pinions engaging two racks.

Alternatively or additionally, the motor unit 5 may be placed between the at least two output shafts 9, 10 of the compound differential planetary gear system 7. Advantageously, the motor unit 5 may be placed between two pinions coupled to the two drive shafts and/or between two racks arranged
5 alongside each other and engaged by said two pinions.

In the embodiment shown in Fig. 2a, a final gear set 13, 14 is positioned between the output shafts 9, 10 and the drive shafts 2, 3 respectively. The final gear set 13, 14 comprises in this embodiment a traverse gear 15, 16 and a final planetary gear set 17, 18 respectively. The first output
10 shaft 9 is coupled to the first drive shaft 2 via a first traverse gear 15 and a final planetary gear set 17. The second output shaft 10 is coupled to the second drive shaft 3 via a second traverse gear 16 and a second final planetary gear set 18. The final gear sets 13, 14 are coupled together, here by coupling the ring gears of the final planetary gear sets 17 and 18, to create a reaction-
15 torque free gear train.

The embodiment shown in Fig. 2b is similar to the embodiment of Fig. 2a. In Fig. 2b, the motor unit 5 is placed between the two drive shafts 2, 3.

In embodiments, the motor unit 5 of a drive unit 4 according to the invention can be placed between the final planetary gear sets 17 and 18. It is
20 noted that an output shaft 28 of the motor unit 5 and/or an input shaft 8 of the compound differential planetary gear system 7 may extend at least partly through a coupling unit which couples the ring gears of said final planetary gear sets 17 and 18, as can be seen in Fig. 2b. In the embodiment of Fig. 3, the output shafts 9, 10 are connected to the drive shafts 2, 3 via final gear sets 13,
25 14 comprising traverse gears 15, 16 and final planetary gears sets 17, 18 in a similar way as shown in Fig. 1a. The embodiment of Fig. 3 shows a different configuration of the compound differential planetary gear system 7 than the embodiments of Fig. 1a and Fig. 2a. Like in Fig. 2a, in the embodiment of Fig. 3, the suns S1, S2 are connected to each other via the input shaft 8. However,
30 instead of using an integrated carrier C as in the embodiment of Fig. 2a, the

first and second planetary gear sets 11, 12 of the embodiment of Fig. 3 both have their own carrier C1 and C2. Further, instead of using the rings R1, R2 as an output as in the embodiment of Fig. 2a, the carriers C1 and C2 are in this embodiment arranged as the first and second output shafts 9, 10
5 respectively. The rings R1 and R2 are in this embodiment coupled to each other to form one ring gear R. In this embodiment, the compound differential planetary gear system 7 is obtained by coupling the sun gears S1 and S2 and by coupling the ring gears R1 and R2. The differential functionality is provided by using the two carriers C1, C2 as output shafts 9, 10. Similar to the
10 embodiments of Fig. 1b or Fig. 2b, the motor unit 5 can be positioned centrally between the drive shafts 2, 3.

In a sixth embodiment, shown in Fig. 4, a different configuration of the compound differential planetary gear system 7 is shown. In this embodiment, the two planetary gear sets 11, 12 are arranged beside each
15 other, whereas in the embodiments of Fig. 2a and Fig. 3, the planetary gear sets 11, 12 are arranged in line with each other, i.e. behind each other. The compound differential planetary gear system 7 shown in Fig. 4 has an input shaft 8 that drives two suns S1 and S2, via input gears 19, 20. Both suns S1 and S2 have thus a common, albeit divided, input shaft 8. Here, the carriers
20 C1 and C2 of the planets P1a, P1b, P2a, P2b are arranged as output shafts 9, 10 of the compound differential planetary gear system 7 that drive the drive shafts 2, 3, via the final planetary gear sets 17, 18. The final gear sets 13, 14 in this embodiment comprise the final planetary gear sets 17, 18 for coupling between the output shafts 9, 10 and the drive shafts 2, 3. The final gear sets
25 13, 14 are coupled to each other to create a reaction-torque free gear train 6. The rings R1 and R2 are coupled to each other via an intermediate gear 21, to create the compound differential planetary gear setup. Similar to the embodiments of Fig. 1b or Fig. 2b, the motor unit 5 can be positioned centrally between the drive shafts 2, 3.

The embodiment shown in Fig. 5 shows a configuration similar to the configuration in Fig. 4. In this embodiment the two planetary gear sets 11 and 12 are also arranged beside each other but the embodiment of Fig. 5 shows a different configuration of the compound differential planetary gear system 7.

5 In the embodiment of Fig. 5 the compound differential planetary gear setup is created by coupling the carriers C1 and C2 of planetary gear sets 11 and 12 via an intermediate gear 21 and using the ring gears R1 and R2 as output shaft 9, 10. Similar to the embodiments of Fig. 1b or Fig. 2b, the motor unit 5 can be positioned centrally between the drive shafts 2, 3.

10 Fig. 6 shows a perspective view of a drive unit 4 incorporating the configuration shown in Fig. 2a providing a compact configuration of the drive unit 4. In Fig. 6 it can be seen that the motor unit 5 is positioned aside the gear train 6 encompassing the compound differential planetary gear system 7 in a relatively central position with respect to the drive unit 4. By positioning
15 the motor unit 5 in axial direction aside the gear train 6, e.g. besides, above or beneath the gear train 6, a relative compact configuration may be provided. The output shaft 28 of the motor unit 5 may be positioned aside e.g. besides, above or beneath the input shaft 8 of the compound differential planetary gear system, preferably substantially parallel to said input shaft 8. For instance,
20 said shafts 8, 28 can be coupled by a coupling unit comprising e.g. one or more gear sets, gears and/or other means such as a chain or a belt. Adjacent the gear train 6, the final gear set 13 comprising the traverse gear 15 and the final planetary gear set 17 connecting to drive shaft 2 and the final gear set 14 comprising the traverse gear 16 and the final planetary gear set 18 connecting
25 to drive shaft 3 are arranged. The gear train 6 is arranged in a housing 22 such that it can be relatively easily installed, maintained and/or replaced, thereby reducing costs. The motor unit 5 typically comprises an electric motor, but may also comprise a hydraulic motor or a combination of different motor types. Also, the motor unit 5 may comprise gear sets to direct the output of the
30 motor to the input shaft 8 of the gear train 6. Advantageously, the housing 22

has first connecting elements to connect with the motor unit 5, which is in this embodiment positioned approximately centrally with respect to the housing 22, and second connecting elements for connection with the drive shafts 2, 3. As can be seen in Fig. 6, the motor unit 5 can be placed at least partly between the final planetary gear sets 17 and 18. Alternatively, the motor unit 5 can be positioned eccentrically with respect to the drive unit, e.g. asides of the drive unit and/or eccentrically outside of the gear train housing.

Fig. 7a and Fig. 7b schematically show a top and side view of a jack-up offshore structure 23. The offshore structure 23 comprises a platform 24 and legs 25. In this embodiment, there are three legs 25. For the sake of example, there is one cylindrical leg 25' shown and two triangular legs 25". It is clear that the legs of a single offshore structure usually all have the same cross-sectional shape. The platform 24 is adjustable along the legs 25. Typically, the platform 24 may be a floating pontoon and the platform 24 may be adjustable between a floating position, an installation position and a working position. In the floating position, the legs 25 extend substantially above the platform 24 and the offshore structure can be towed towards its offshore location. In the installation position, the platform 24 typically floats on the water surface while the legs 23 are being adjusted to install the legs 25 to the sea bottom. In the installation position, the legs 25 extend substantially below the platform 24 and the platform 22 is above water level. Thereafter, the platform 24 is adjusted towards the working position in which the platform 24 extends above the water level.

For adjusting the platform 24 with respect to the legs 25, the legs are usually provided with racks 26 in which pinions 27 engage. The pinions 27 are connected to the drive shafts 2, 3 of a drive unit 4 comprising a compound differential planetary gear system 7 for driving the two pinions 27 simultaneously. By providing the drive unit 4 with a differential functionality, variations in torque of the pinions 27 can be compensated.

By providing the gear train 6 in a housing 22, the drive system 1 can be relatively simply connected to the pinions 27. Also, in case of maintenance or damage, the respective drive unit 4 can be removed relatively easily and a spare drive unit 4 can be put in place relatively easily, thereby reducing
5 downtime, maintenance costs and/or repair costs. It is noted that on the offshore structure 23, it may be possible to carry a spare part drive unit 4.

In case of the triangular leg 25", each corner can be provided with a rack-and-pinion adjustment system comprising the drive system 1. Here, each corner has two racks 26, wherein in each rack 26 a pinion 27 is engaged.
10 Typically, multiple pinions are engaged per rack 26. By driving two pinions 27 with a single motor unit a significant weight reduction can be achieved compared to the state of the art situation in which a single motor unit per pinion is used. The two pinions 27 that are driven simultaneously by a single motor unit can be arranged on the same rack above each other, or can be
15 arranged on different racks at approximately the same level with respect to each other, they are so-called horizontally arranged.

In the embodiment shown in Fig. 7a and 7b the racks 26 are in a standing position along which the pinions 27 can move up and down. In another embodiment, the racks 26 can be oriented in a lying position along
20 which the pinions 27 can be moved forward and backward, for instance when moving a cantilever outwardly and inwardly with respect to an offshore platform.

Many variants will be apparent to the person skilled in the art. The invention is explained by means of embodiments in which a drive shaft is
25 connected to a pinion engaging a rack, typically on a jack-up offshore structure. To the person skilled in the art it is clear that the invention is not limited thereto. Also other applications may be possible, for instance applications that require simultaneous adjustment of two, or more, objects. All variants are understood to be comprised within the scope of the invention
30 defined in the following claims.

	1	Drive system	S ₁	sun gear 1
	2	Drive shaft 1	S ₂	sun gear 2
	3	Drive shaft 2	C	coupled carrier
5	4	Drive unit	C ₁	carrier 1
	5	Motor unit	C ₂	carrier 2
	6	Gear train	P _{1a}	planet gear 1a
	7	Compound differential planetary gear system	P _{1b}	planet gear 1b
10	8	Input shaft	P _{2a}	planet gear 2a
	9	Output shaft 1	P _{2b}	planet gear 2b
	10	Output shaft 2	R	coupled ring gear
	11	Compound planetary gear set 1	R ₁	ring gear 1
	12	Compound planetary gear set 2	R ₂	ring gear 2
15	13	Final gear set 1	X _A	planet axle A
	14	Final gear set 2	X _B	planet axle B
	15	Traverse gear 1		
	16	Traverse gear 2		
	17	Final planetary gear set 1		
20	18	Final planetary gear set 2		
	19	Input gear 1		
	20	Input gear 2		
	21	Intermediate gear		
	22	Housing		
25	23	Jack-up offshore structure		
	24	Platform		
	25	Legs		
	26	Rack		
	27	Pinion		
30	28	Output shaft of the motor unit		

Claims

1. Drive unit for driving at least two drive shafts,
wherein the drive unit comprises a motor unit and a gear train coupled to the
motor unit, wherein the gear train comprises a compound differential
planetary gear system having at least one input shaft coupled to the motor
5 unit and at least two output shafts of which each output shaft is arranged for
driving a drive shaft, wherein the compound differential planetary gear system
comprises at least two planetary gear sets with different form factors that are
coupled to each other to create a compound planetary gear setup, of which each
planetary gear set is provided with an output shaft for driving a drive shaft to
10 create the compound differential planetary gear setup.
2. Drive unit according to claim 1, wherein a shaft of sun gears of the
respective planetary gear sets are coupled to each other via the input shaft.
3. Drive unit according to claim 1 or 2, wherein either one of a carrier
or a ring gear of the planetary gear system is provided as an output shaft for
15 driving the drive shaft.
4. Drive unit according to any one of the preceding claims, wherein a
final gear set is arranged between each output shaft and each drive shaft that
are coupled to each other to provide a reaction-torque free gear train.
5. Drive unit according to any one of the preceding claims, wherein the
20 gear train is arranged in a housing.
6. Drive unit according to claim 5, wherein the housing comprises first
connecting elements for connection with the motor unit and second connecting
elements for connection with the drive shafts.
7. Drive unit according to any one of the preceding claims, wherein the
25 drive shaft is a pinion that is arranged for engaging a rack.

8. Drive unit according to any one of the preceding claims, wherein the motor unit has an output shaft being in line with the at least one input shaft of the compound differential planetary gear system and/or integrated therewith.
9. Drive unit according to any one of the preceding claims, wherein the
5 motor unit is placed at least partly, preferably substantially completely, between the at least two output shafts of the compound differential planetary gear system.
10. Gear box comprising a gear train for use in a drive unit according to any one of the claims 1 – 9.
- 10 11. Gear box according to claim 10, wherein the gear train is arranged in a housing.
12. Drive system for driving multiple drive shafts simultaneously, comprising a number of drive units according to any one of the claims 1 – 9.
13. Drive system according to claim 12, wherein the drive shaft
15 comprises a pinion that is arranged for engagement with a rack.
14. Drive system according to claim 13, wherein pinions driven by a drive unit are arranged on the same rack.
15. Drive system according to claim 13, wherein pinions driven by a drive unit are arranged on different racks alongside each other.
- 20 16. Drive system according to any one of the claims 12 – 15, wherein the racks are positioned in a standing position for driving the pinions up or down along the racks.
17. Drive system according to any one of the claims 12 – 15, wherein the racks are positioned in a lying position for driving the pinions forwards or
25 backwards along the racks.
18. Offshore structure comprising a drive system according to any one of claims 12 – 17.