

ST4000+ Autopilots Service Manual

For use on

Z326, Wheel Autopilot

Z327, Tiller Autopilot

Z332, Tiller GP Autopilot

Warning

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Chapter 1. ST4000+ Control Head

1.1 PCB Changes

When a PCB is changed, it may be necessary to set the new PCB to the required pilot type, ST4000+ Wheel, ST4000+ Tiller or ST4000+ Tiller GP

1. If the instrument is disassembled, fit the reflector, diffuser, elastomers, LCD and surround to the PCB
2. Apply 12V power to the instrument/PCB assembly
3. Press and hold STDBY for 14 seconds until CAL ? is displayed
4. Momentarily press +1 and -1 together to gain access to extended calibration (dealer set - up)
5. Advance from the CAL LOCK page to the pilot type page by pressing DISP
6. Use the +1 and -1 buttons to set the pilot type as required, 4000 WHL (wheel) or 4000 TILL (tiller)
7. Press STDBY to exit extended calibration
8. Switch off the power supply. Do not disconnect
9. When the pilot is fully powered down, switch the power on again
10. Check that the required pilot type is momentarily displayed before STANDBY is entered. If not, repeat the set - up procedure. In the case of a second failure, change the PCB.

1.2 Disassembly/Assembly

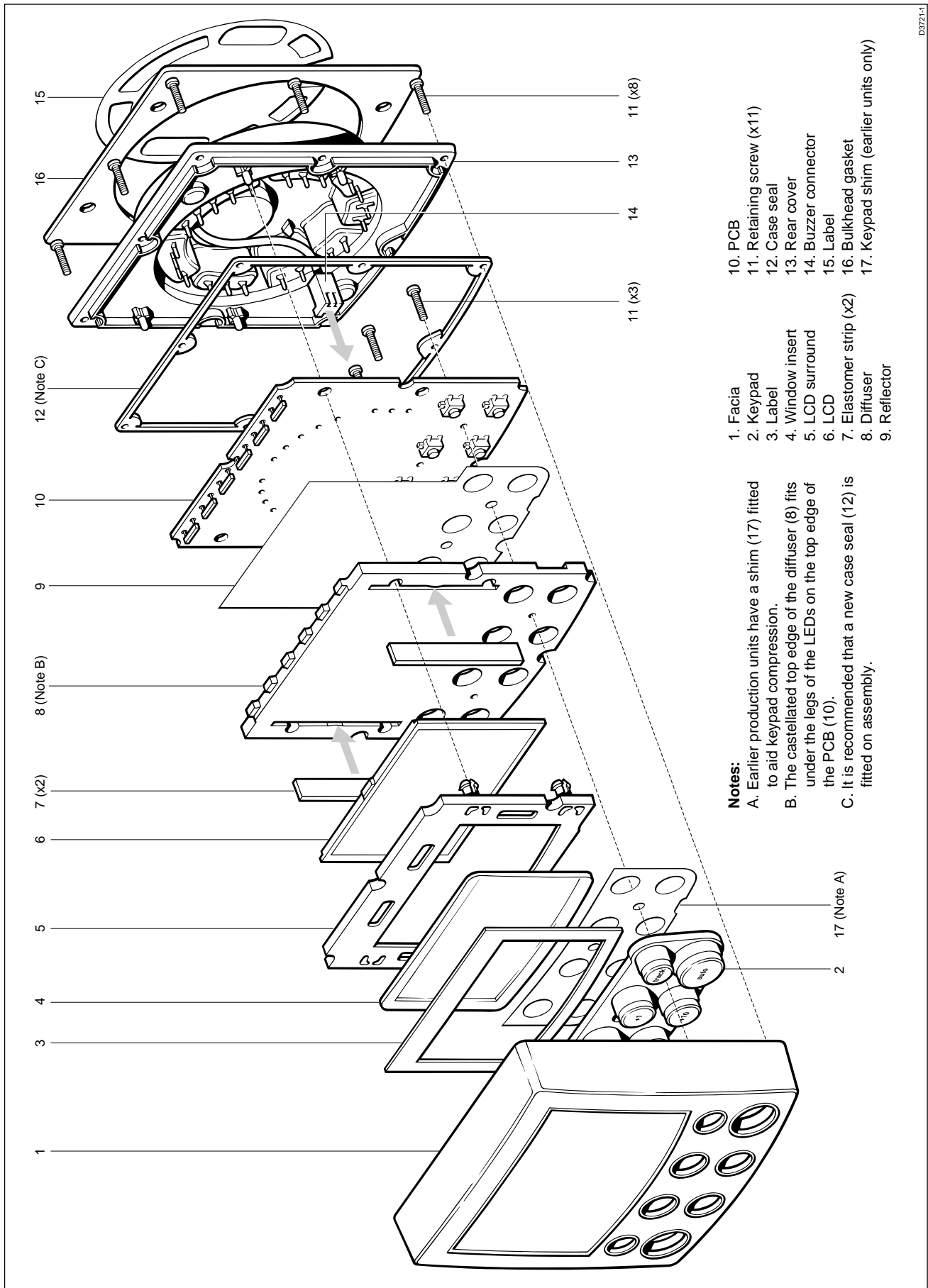


Figure 1: ST4000+ Control Head exploded view

ST4000+ Control Head spare parts list

The **item** numbers refer to Figure 1: ST4000+ Control Head exploded view

Item	Spare Description	Part No.	Comments
1	Facia	W115	
2	Keypad	Q219	
3	Display kit, <i>including</i> Label (selection)	Q220	Fit ST4000+ label
4	Window insert		
5	LCD surround		
6	LCD		
7	Elastomer (x2)		
8	Diffuser kit, <i>including</i> Diffuser	W117	
9	Reflector		
10	PCB	Q221	ST4000+/ST5000+ PCB
11	Fixing kit, <i>including</i> Screw (x11)	W120	
12	Case seal	W118	
13	Back cover assembly, <i>including</i> Back cover	W119	<i>Comes fitted with, Gortex filter, Sleeving, Buzzer and Buzzer connector</i>
14			
15	Label (selection)		Fit ST4000+ label
16	Bulkhead gasket	W125	
	Sun cover	D340	Not illustrated

1.3 PCB Details

Input/Output Signals (refer to Figure 2. Circuit Diagram)

Pin No.	Signal	Description
PL1/1	+12V	Nominal 12V dc
PL1/2	0V in	0V
PL1/3	SeaTalk	Intermittent streams of (nominal) 12V pulses
PL2/1	+12V	Nominal 12V dc
PL2/2	0V in	0V
PL2/3	SeaTalk	Intermittent streams of (nominal) 12V pulses
P1	+12V	Nominal 12V dc
P2	0V in	0V
P3	SCRN	0V
P4	Bias	Nominal 2.5V dc (VRESET)
P5	F/GA	+2.5V dc
P6	F/GB	+2.5V dc
P7	Coil drive	AC signal, 17 cycles at 7.9kHz, driven twice every 1/16 second
P8	Rudder reference supply	Nominal 5V supply to rudder reference
P9	Rudder reference	0 to 5V dc (nominal) rudder reference output
P10	Rudder reference 0V	0V
P11	SCRN	0V
C+	Clutch	+12V if Autopilot engaged; otherwise 0V
C-	Clutch 0V	0V
MD1	MD1	When Autopilot engaged and depending on direction of drive, intermittent variable length pulses, nominal 12V; otherwise 0V
MD2	MD2	When Autopilot engaged and depending on direction of drive, intermittent variable length pulses, nominal 12V; otherwise 0V
NMEA in+	NMEA+	Intermittent streams of (nominal) 12V pulses
NMEA in-	NMEA-	0V

Circuit Diagram

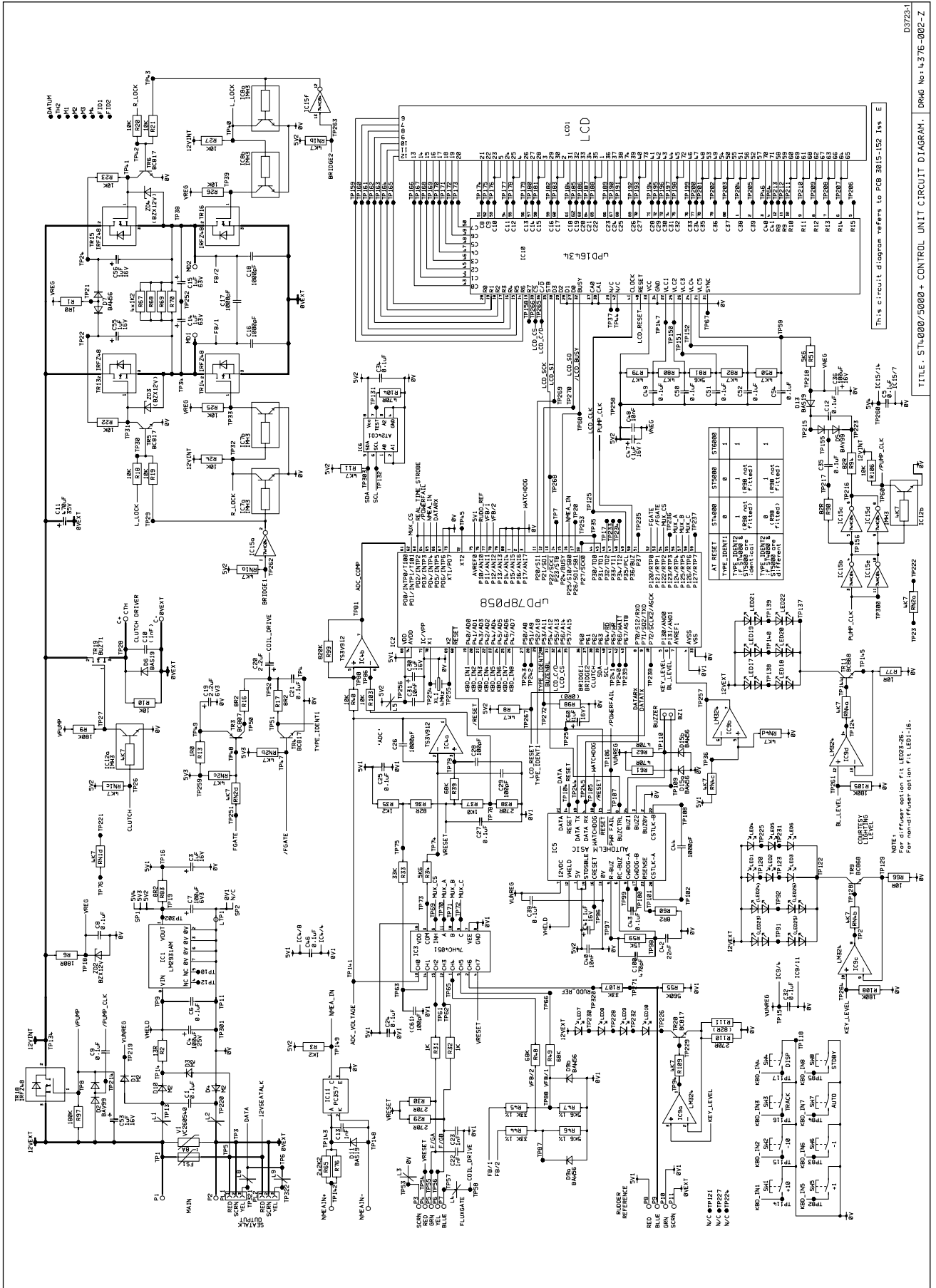


Figure 2: Circuit Diagram

PCB Layout

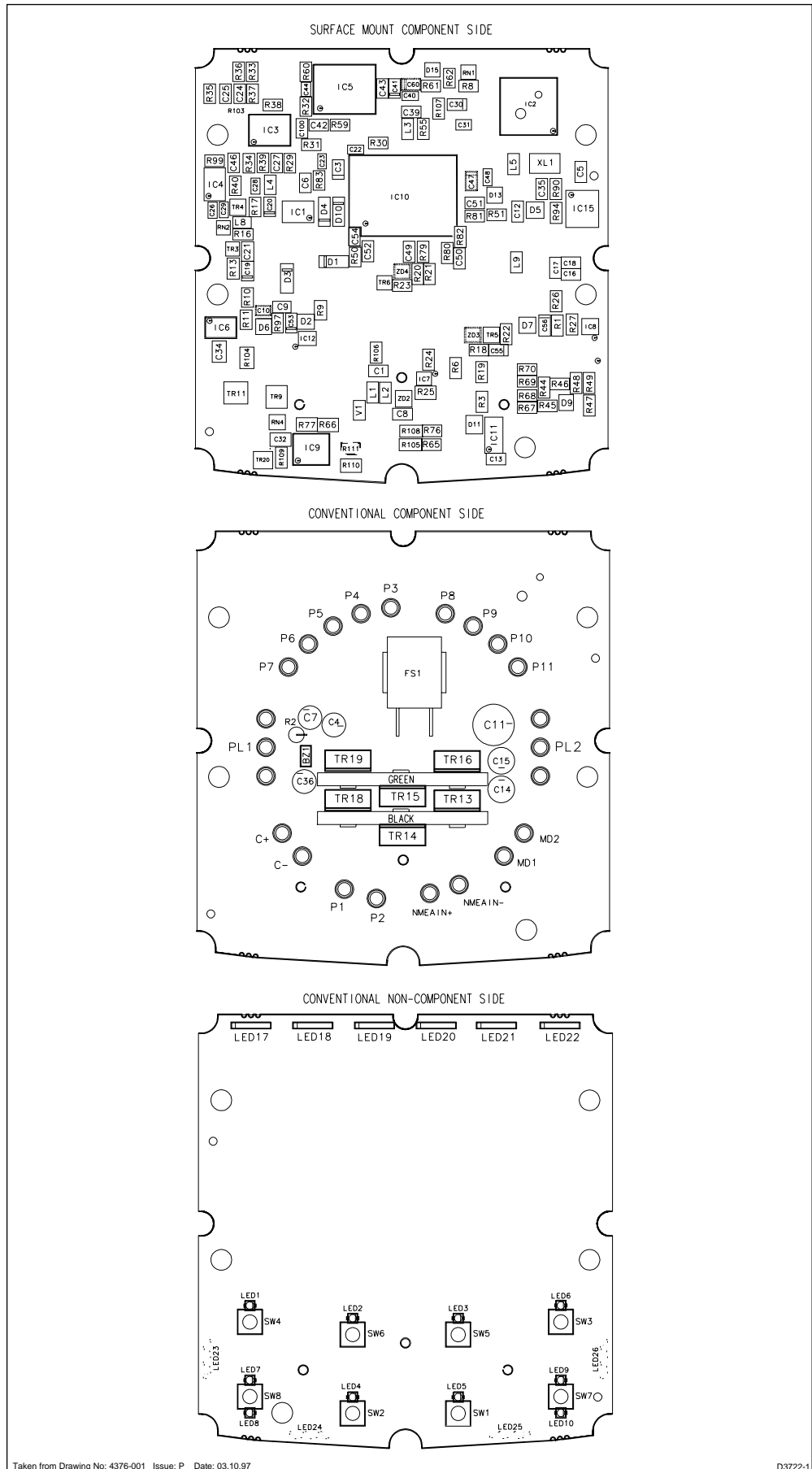


Figure 3: PCB Component Layout

PCB Component list

SURFACE MOUNT COMPONENT SIDE

9103270R	RESISTOR WCR 1206 270R 1% 0.125W	R110
9600L1	SOLID CHIP INDUCTOR	L1-5,8,9
9600RES4M0	RESONATOR 4MHz	XL1
9108VC260540	VARIABLE CAPACITOR VC260540	V1
940074HC04	IC HEX INVERTING BUFFER 74HC04	IC15
9400PC317	IC OPTO ISOLATOR PC357 S016	IC11
940016434	IC LCD DRIVER uPD16434	IC10
9400LM324	IC QUAD OPAMP LM324	IC9
95001MH3	TRANSISTOR ARRAY 1MH3AT110 SOT36	IC7,8,12
940024C01A	IC CMOS EEPROM AT24C01	IC6
9401RLA80	IC RAYTHEON ASIC	IC5
9400TS3V912	IC TS3V912	IC4
940074HC4051	IC 74HC4051	IC3
940078P058	IC MICROPROCESSOR uPD78P058 80PIN QFP	IC2
9400LM2931AM	IC REGULATOR LM2931AM 5V S08	IC1
9501BC868	TRANSISTOR SOT89 BC868 NPN	TR9,11
9500BC807	TRANSISTOR SOT23 BC807 PNP	TR3
9500BC817	TRANSISTOR SOT23 BC817 NPN	TR4,6,20
930522N	CAPACITOR X7R 22nF 5% 50V 1206	C42
9302100P	CAPACITOR COG 100pF 10% 50V 0805	C28,29
93102U2	CAPACITOR TANT 2.2uF 20% 6V3 TANTA	C19,20
93041000P	CAPACITOR X7R 1000pF 10% 50V 0805	(C10),13,16-18,22,23,44
93091U	CAPACITOR TANT 1uF 10% 16V TANTA	C3,30,41,(47),53,55,56,(60)
93040U01	CAPACITOR X7R 0.01uF 10% 50V 0805	C31,40,48
93001000P	CAPACITOR COG 1000pF 10% 50V 0805	C26
93070U1	CAPACITOR X7R 0.1uF 20% 50V 1206	C1,5,6,8,9,12,21,24,25,27,32,34,35,39,43,46,49-52,54
9317470P	CAPACITOR COG 470pF 20% 50V 1206	C100
9203B2X12V	DIODE ZENER BZX84C12V SOT23	ZD2,(3,4)
9200BAS19	DIODE BAS19 SOT23	D6,11,13
9200BAW56	DIODE BAW56 SOT23	D7,9,15
9200M2SYM	DIODE M2-SYM 10A 100V	D1,3,4,10
9200BAV99	DIODE BAV99 SOT23	D2,5
91124K7	RESISTOR NETWORK 4K7	RN1,2,4
9103180K	RESISTOR WCR 1206 180K 1% 0.125W	R9,97,105,108
9106820K	RESISTOR WCR 1206 820K 5% 0.125W	R99
910310R	RESISTOR WCR 1206 10R 1% 0.125W	R66,77
9106470R	RESISTOR WCR 1206 470R 5% 0.125W	R61,62,104
910315K	RESISTOR WCR 1206 15K 1% 0.125W	R59
9103560K	RESISTOR WCR 1206 560K 1% 0.125W	R55
910368K	RESISTOR WCR 1206 68K 1% 0.125W	R39,48,49
910382R	RESISTOR WCR 1206 82R 1% 0.125W	R36,90,94,(111)
91031K2	RESISTOR WCR 1206 1K2 1% 0.125W	R3,35,67-70
91035K6	RESISTOR WCR 1206 5K6 1% 0.125W	R34,46,47,51,81
910333K	RESISTOR WCR 1206 33K 1% 0.125W	R33,44,45,107
91031K0	RESISTOR WCR 1206 1K0 1% 0.125W	R31,32,37
9103270R	RESISTOR WCR 1206 270R 1% 0.125W	R29,30,38
91064K7	RESISTOR WCR 1206 4K7 5% 0.125W	R8,11,50,79,80,82,109
9106180R	RESISTOR WCR 1206 180R 5% 0.125W	R6
91062K2	RESISTOR WCR 1206 2K2 5% 0.125W	R65,76
91061R0	RESISTOR WCR 1206 1R 5% 0.125W	R1,13
91068R2	RESISTOR WCR 1206 8R2 5% 0.125W	R16,17,60,83
910610K	RESISTOR WCR 1206 10K 5% 0.125W	R10,18-27,40,103,106
3015-152	PCB ST60 ST4/5/6000 CONTROL UNIT AND AUTOPILOT	

CONVENTIONAL COMPONENT SIDE

3036-141	HEATSINK	
15277	INSULATOR KOOL PAD	
15014	INSULATING BUSH	
26008	RIVSCREW	
15047	PAD DOUBLE SIDED ADHESIVE	
3030-035-B	SOLDER BUCKETS	PL1,2,P1-11,MD1,2,C+,C-,JMEAIN+,JMEAIN-
15289	FUSE 8A POLY	FS1
07266	HEADER MOLEX 2WAY	B21
03074	CAPACITOR ELEC 100uF 16V +/-20%	C36
03062	CAPACITOR ELEC 100uF 6V3 20%	C7
03050	CAPACITOR ELEC 1uF 63V 20%	C14,15
03069	CAPACITOR ELEC 470uF 35V 20%	C11
03100	CAPACITOR ELEC LOW IMP 100uF 25V 20%	C4
05040	TRANSISTOR FET IRFZ48N 60V TO220	TR13-16,18
05048	TRANSISTOR BUZ71	TR19
01183	RESISTOR 13R 5% 0.4W SFR25	R2

CONVENTIONAL NON-COMPONENT SIDE

15165	LED 202	LED17-22,(23-26)
02050	LED HLMP6505	LED1-6
02076	LED HLMPQ102	LED7-10
06030	SWITCHES ALPMIN	SW1-8

Taken from Drawing No: 4376-001 Issue: P Date: 03.10.97

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Chapter 2. Fluxgate Compass Transducer

2.1 Functional test

Disconnect the Fluxgate from the Autopilot and check continuity as follows:

Cable colour	Connector pin number	Resistance
Screen to blue	2/4	< 10 ohms
Red to green	3/5	< 5 ohms
Red to yellow	3/6	< 5 ohms
Red to screen	3/2	Open circuit

2.2 Magnetic deviation

The Fluxgate Compass requires careful siting if optimum Autopilot performance is to be achieved. The SeaTalk electronics is able to correct the compass for most deviating magnetic fields present when the linearisation procedure is carried out. Any further deviation, introduced after linearisation, will introduce an error between the Fluxgate and the ship's compass. This can be removed by carrying out the linearisation again. If the displayed deviation is greater than ± 15 degrees the Fluxgate should be resited.

Note: The linearisation procedure should always be carried out if the Fluxgate has been exchanged, removed or moved from its original mounting position.

2.3 Disassembly/assembly

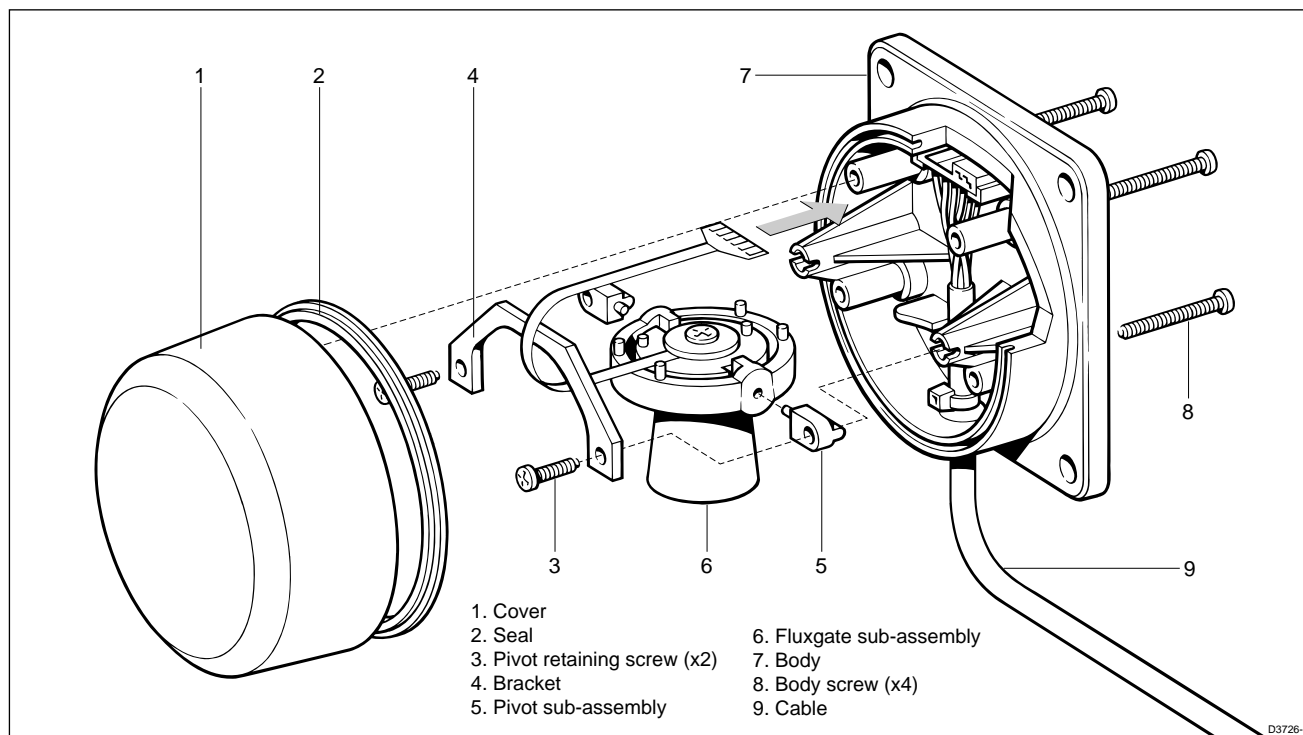


Figure 4. Fluxgate Compass exploded view

Fluxgate Compass spare parts list

The **item** numbers refer to Figure 4: Fluxgate Compass exploded view

Item	Spare Description	Part No.	Comments
3	Compass base kit, <i>including</i> Pivot retaining screw (x2)	M096	
4	Bracket		
5	Fluxgate sub-assembly, <i>including</i> Pivot sub-assembly (x2)	M022	
6	Fluxgate sub-assembly		

Chapter 3. Wheel Drive Actuator

3.1 Wheel Drive Actuator test

Carry out the passive and active tests detailed in Figure 6.

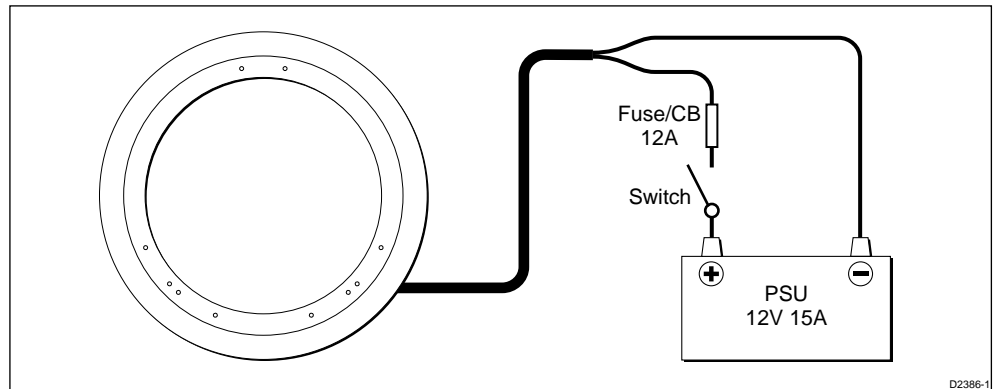


Figure 5. Wheel Drive Actuator test connections

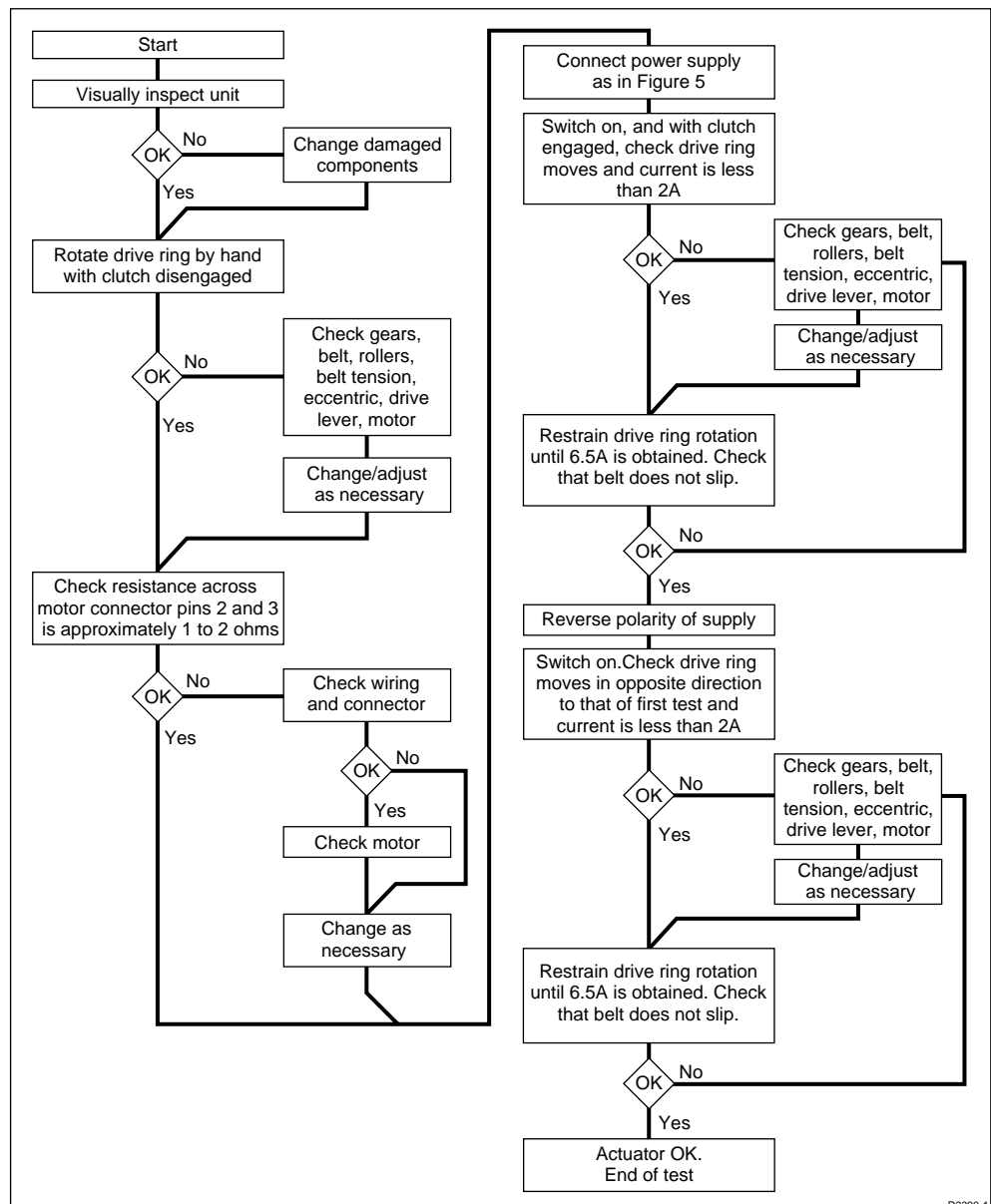


Figure 6. Wheel Drive Actuator test flowchart

3.2 Disassembly/assembly

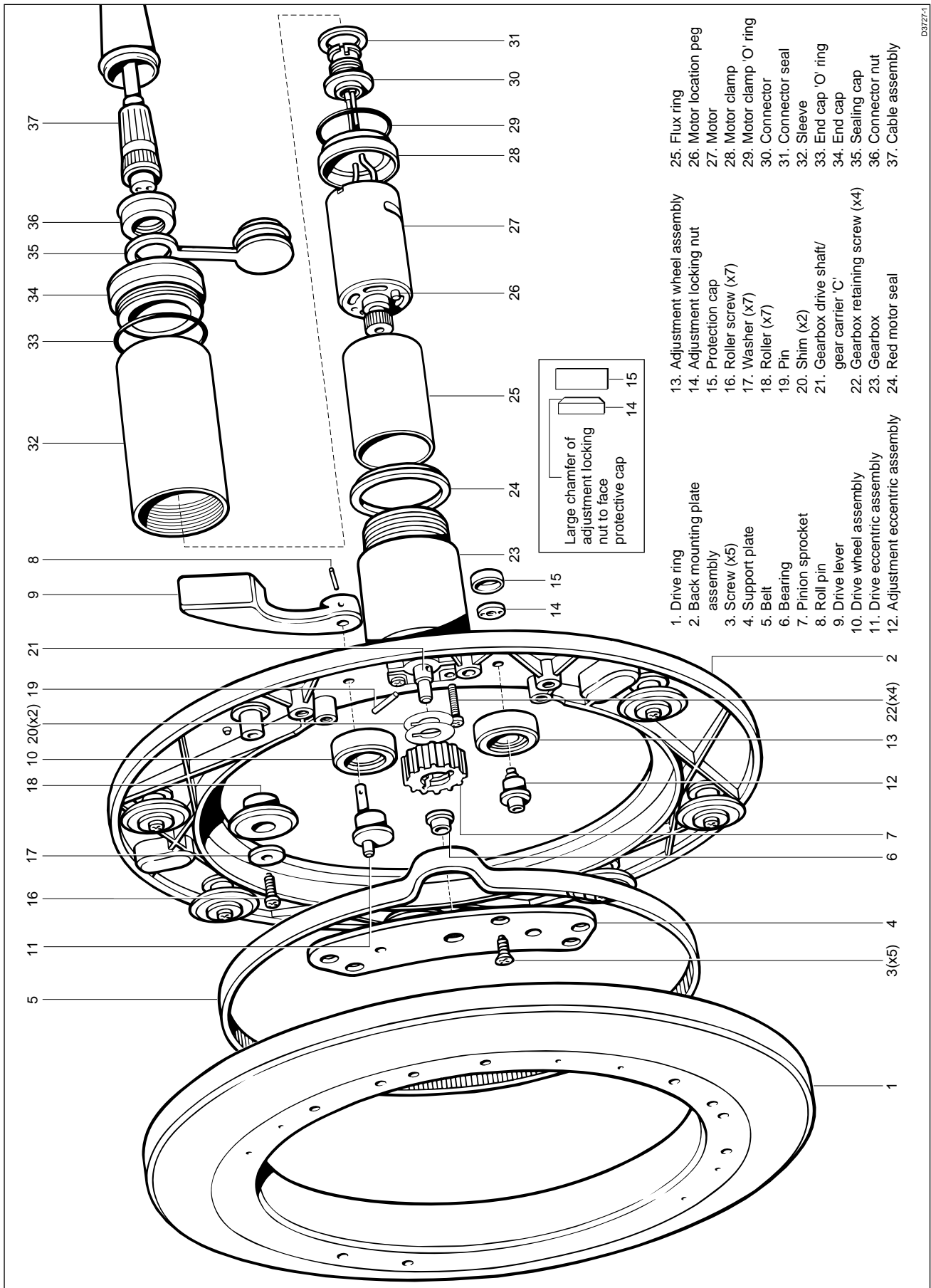


Figure 7. Wheel Drive Actuator exploded view

Wheel Drive Actuator spare parts list

The **item** numbers refer to Figure 7: Wheel Drive Actuator exploded view

Item	Spare Description	Part No.	Comments
1	Drive ring	N031	
2	Back mounting plate assembly	N013	<i>Comes fitted with, pre-assembled gearbox, item 23</i>
5	Belt	D169	
	Pinion kit, <i>including</i>	N014	
7	Pinion sprocket		
15	Protection cap		
19	Pin		
20	Shim (x2)		
	Drive lever kit, <i>including</i>	N011	
8	Roll pin		
9	Drive lever		
11	Drive eccentric assembly	N024	
	Gearbox drive shaft/gear carrier 'C' kit, <i>including</i>	N026	
21	Gearbox drive shaft/gear carrier 'C'		See Figure 8, item 3
–	Planet gear (x12)		See Figure 8, item 4
–	Shim		See Figure 8, item 2
–	'O' ring		See Figure 8, item 1
27	Motor	N012	
	Wiring kit, <i>including</i>	Q106	
28	Motor clamp		
29	Motor clamp 'O' ring		
30	Connector		
31	Connector seal		
33	End cap 'O' ring		
34	End cap		
35	Sealing cap		
36	Connector nut		
37	Cable assembly		

Disassembly

Belt removal

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Insert a wide flat, non-metallic blade into the gap between the drive ring (1) and the back mounting plate (2). Gently lever the blade to force the drive ring (1) off the rollers (18) of the back mounting plate (2). Repeat this action in three to four places around the drive ring (1) in order to remove.
2. Unscrew and remove the five screws (3). Detach the support plate (4) from the back mounting plate (2).
3. Remove the belt (5).

Pinion sprocket removal

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Perform actions as described in *Belt removal*.
2. Lift the pinion sprocket (7) off the gearbox drive shaft/gear carrier 'C' (21).

Drive lever and eccentric removal

Refer to Figure 7. Wheel drive actuator exploded view.

1. Perform actions as described in *Pinion sprocket removal*.
2. Place a block with a suitable clearance hole under the drive lever/shaft (9) to provide support and prevent the shaft bending when the roll pin is driven out.
3. Drive out the roll pin (8).
4. Pull the drive lever (9) off the drive eccentric shaft (11).
5. Lift the drive eccentric assembly (11) and drive wheel assembly (10) off the back mounting plate (2).

Motor removal

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Unscrew and remove the connector nut (36).
2. Remove the sealing cap (35).
3. Grip the gearbox (23), unscrew and remove the sleeve (32) ensuring the connector does not rotate.
4. Withdraw motor (27)/location peg (26) disengaging it from the gearbox (23). Slide off the flux ring (25).

Note: Although given separate item numbers, the gearbox (23) is an integral part of the back mounting plate assembly (2) and the location peg (26) is part of the motor (27).

5. Desolder connector wires from the motor tags.

Gearbox removal

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Perform actions as described in *Pinion sprocket removal*, and 1, 2, 3 and 4 in *Motor removal*.
2. Unscrew and remove the four gearbox retaining screws (22).
3. Separate the gearbox (23) from the back mounting plate assembly (2) leaving the gearbox drive shaft/gear carrier 'C' (21) in place.
4. Support the gearbox drive shaft/gear carrier 'C' (21) and drive out the pin (19).
5. Withdraw the gearbox drive shaft/gear carrier 'C' (21) from the back mounting plate assembly (2).

Gearbox disassembly

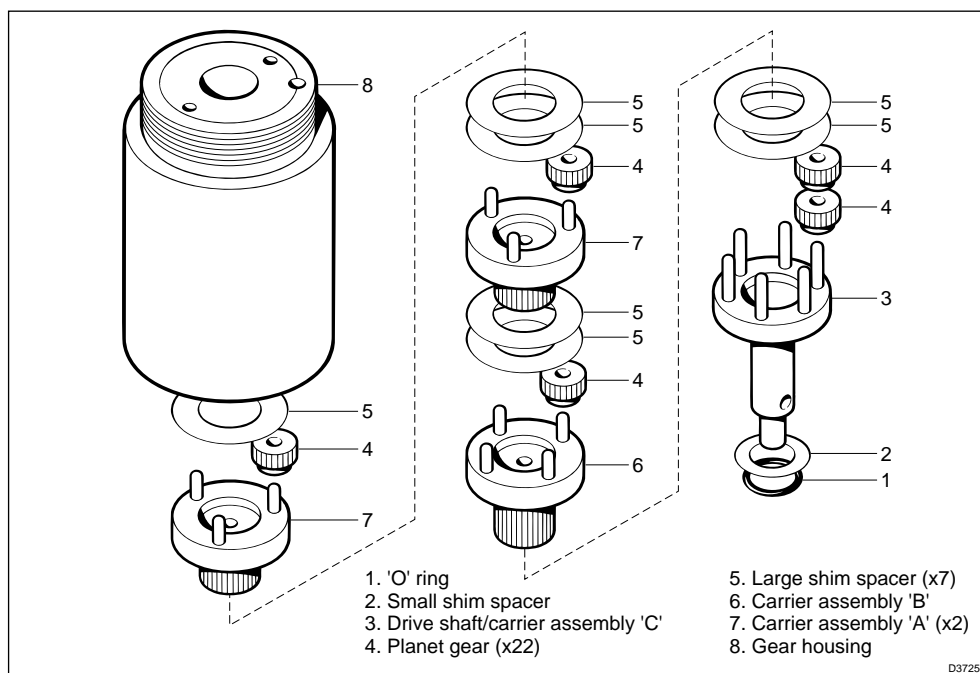


Figure 8. Gearbox exploded view

Assembly

In all cases, assembly is a straight reversal of the steps described in *Disassembly*.

Gearbox assembly

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Rebuild gearbox. Refer to Figure 8. Gearbox exploded view
2. Fix the gearbox (23) to the back mounting plate assembly (2) using the four gearbox retaining screws (22).
3. Slide the two shims (20) over the gearbox drive shaft/gear carrier 'C' (21) and hard up against the back mounting plate assembly (2).
4. Support the gearbox drive shaft/gear carrier 'C' (21) and refit the pin (19).

Note: If the original pin (19) is bent or damaged a replacement pin can be obtained from pinion kit, part no. N014.

Motor assembly

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Fit the red motor seal (24) over the threaded end of the gearbox (23).
2. Insert the connector wires through the motor clamp (28), and solder the connector wires to the motor tags – red lead to the tag with a red spot, black lead to the other motor tag.
3. Slide flux ring (25) on the motor (27) and fit onto the gearbox (23) ensuring that the motor drive gear is fully engaged with the gear train and the motor location peg (26) is engaged correctly into the gearbox (23).
4. Fit the 'O' ring (29) onto the motor clamp (28).
5. Place the connector seal (31) over the connector (30).
6. Screw the sleeve (32) with fitted 'O' ring (33) and end cap (34) onto the gearbox (23).
7. Place the sealing cap (35) over the connector (36) and secure with the connector nut (37).

Adjustment eccentric assembly

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Assemble the adjustment wheel assembly (13), adjustment eccentric assembly (12), adjustment lock nut (14) with its chamfered edge facing outwards, and protection cap (15) to the back mounting plate assembly (2).

Note: Ensure that the drive lever (9) is in the slack (declutched) position and the adjustment eccentric assembly (12) is in its lowest position, so that the belt (5) is at its slackest.

Drive lever and eccentric assembly

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Assemble the drive eccentric assembly (11) and drive wheel assembly (10) to the back mounting plate assembly (2).
2. Slide the drive lever (9) onto the drive eccentric assembly (11). Support the drive lever (9) and insert the roll pin (8).

Note: Always use a new roll pin (8) on refit.

Pinion sprocket and belt assembly

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Slot the pinion sprocket (7) over the gearbox drive shaft (21) and pin (19).
2. With the drive lever (9) in its slack (declutched) position and the adjustment eccentric assembly (12) is in its lowest position fit the belt (5) around the pinion sprocket (7), drive wheel assembly (10) and adjustment wheel assembly (13).
3. Position the support plate (4) with fitted bearing (6) onto the gearbox drive shaft (21), drive eccentric assembly (11), adjustment eccentric assembly (12) and over the screw pillars. Insert the five screws (3) and secure the support plate (4).

Note: Take care not to cut new threads in the screw pillars when securing the support plate (4).

Drive ring closure

Refer to Figure 7. Wheel Drive Actuator exploded view.

1. Rest the drive ring (1) over the rollers (18).
2. Locate the rollers (18) nearest the gearbox (23) into the groove of the drive ring (1). Push down and around the drive ring (1) to progressively snap the drive ring (1) over the remaining rollers (18).
3. Spin the drive ring (1) in both directions, two or three times, too ensure the assembly is fully seated and free running.

3.3 Setting Belt Tension

The purpose of the belt tensioning procedure is to ensure that:

1. The belt is sufficiently tight to transmit the normal maximum drive torques.
2. The belt is not over-tightened, as this will increase the backdrive load to a level where it can be felt on the vessel's wheel.

Tools required:

4000 Drive unit torque fixture

Service tool number - T033

4000 Drive unit torque adjuster

Service tool number - T032

Motor drive box and ammeter

Motor drive box

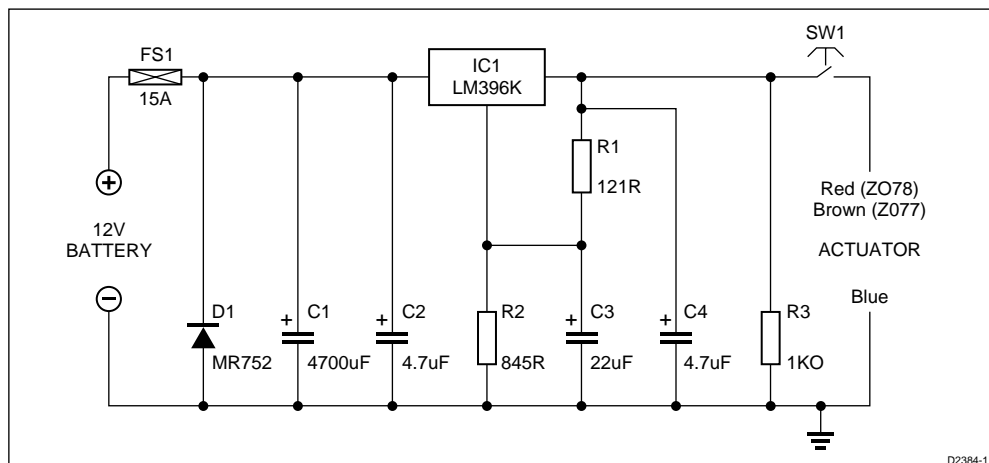


Figure 9. Motor drive box circuit diagram

Motor drive box parts

Component	Description	
R1	Resistor	121R 0.1% metal film
R2	Resistor	845R 0.1% metal film
R3	Resistor	1k0 0.5W
C1	Capacitor	4700uF 20% electrolytic 25V
C2	Capacitor	4.7uF 10% solid tantalum 35V
C3	Capacitor	22uF 10% solid tantalum 35V
C4	Capacitor	4.7uF 10% solid tantalum 35V
D1	Diode	MR 752
IC1	LM396K	High power 10A regulator
F1	Fuse Fuseholder	15A quick blow 1.1/4 inch
SW1	Switch TO3 Diecast box	Single pole single throw Insulating kit

Procedure

1. Screw the drive ring clamp to the front ring. Use the group of two holes on their own, not two holes in a group of four. Screw the torque restraint pin into the back mounting plate
2. Connect the motor to the motor drive box, using an in - line ammeter (0 - 10 amps) to measure current
3. Connect the motor drive box to a 12V battery. The drive box provides a regulated 10.5V supply to the motor
4. Engage the drive unit clutch
5. Use the eccentric adjuster to loosen (anti - clockwise) the locking nut and allow the eccentric to move to the minimum tension position
6. Switch on the drive to the motor and, using a 1.5mm Allen key, rotate the eccentric anticlockwise (as viewed from above) to increase belt tension until the belt just stops slipping (motor stalled)
7. Check that the motor current is approximately 6.5 amps
8. Tighten the locking nut, apply Loctite to retain the setting and switch off the motor drive.

Chapter 4. Tiller Drive Actuator

4.1 Tiller Drive Actuator test

Carry out the passive and active tests detailed in Figure 11. Tiller Drive Actuator test flowchart.

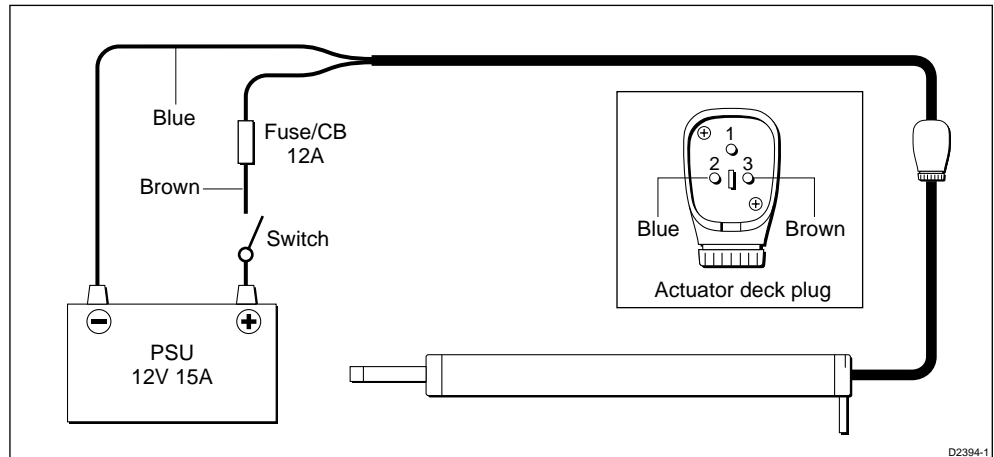


Figure 10. Tiller Drive Actuator test connections

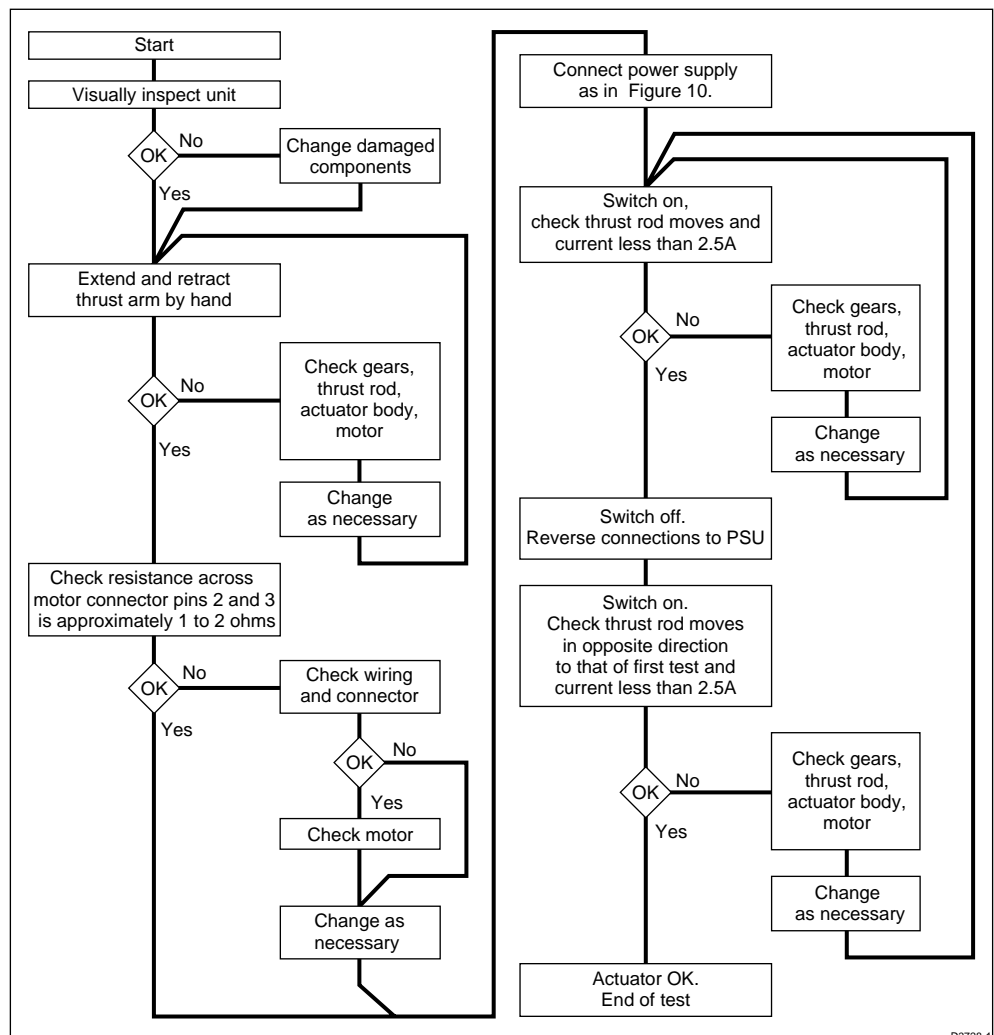


Figure 11. Tiller Drive Actuator test flowchart

4.2 Disassembly/assembly

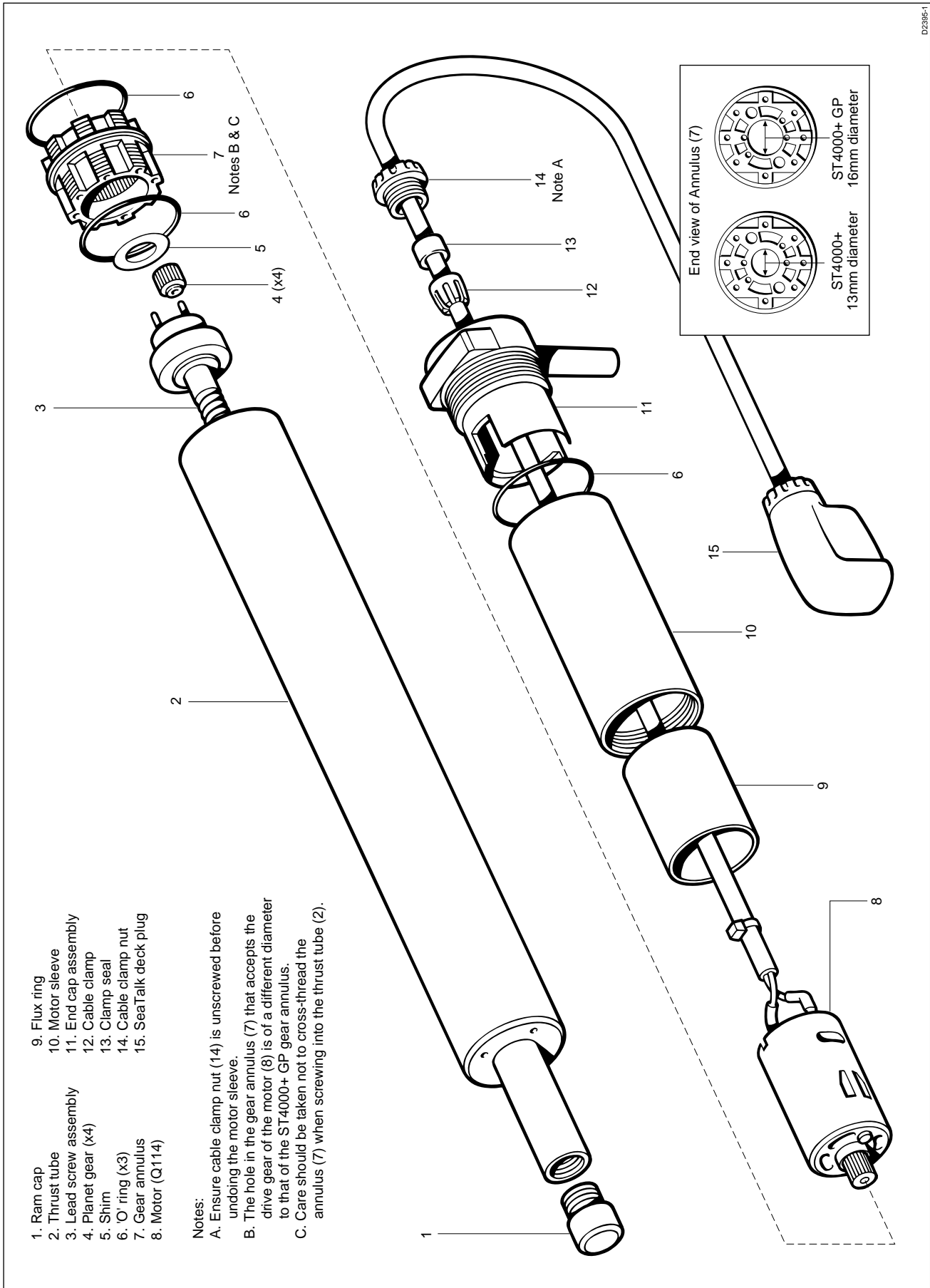


Figure 12. Tiller Drive Actuator exploded view

Tiller Drive Actuator spare parts list

The **item** numbers refer to Figure 12: Tiller Drive Actuator exploded view

Item	Spare Description	Part No.	Comments
	Drive module	Q047	Complete drive unit
8	Motor	Q114	
11	End cap assembly	W014	

Tiller Drive Actuator GP conversion kit (W003)

This GP conversion kit (W003) gives the option of converting the ST4000+ which has the power to helm boats of up to 6,500 kg (14,300 lbs) displacement, to the ST4000+ GP which would push the limit up to 9,000 kg (20,000 lbs) displacement.

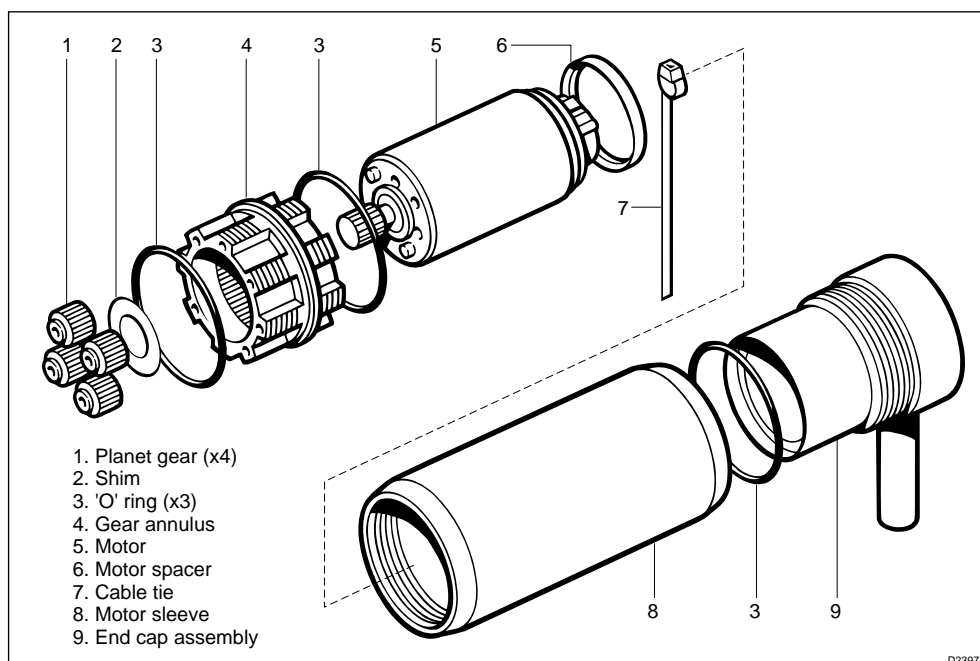


Figure 13. Tiller Drive Actuator GP conversion kit (W003)

Chapter 5. Tiller Drive Actuator GP

5.1 Tiller Drive Actuator GP test

Carry out the passive and active tests detailed in Figure 15. Tiller Drive Actuator GP test flowchart.

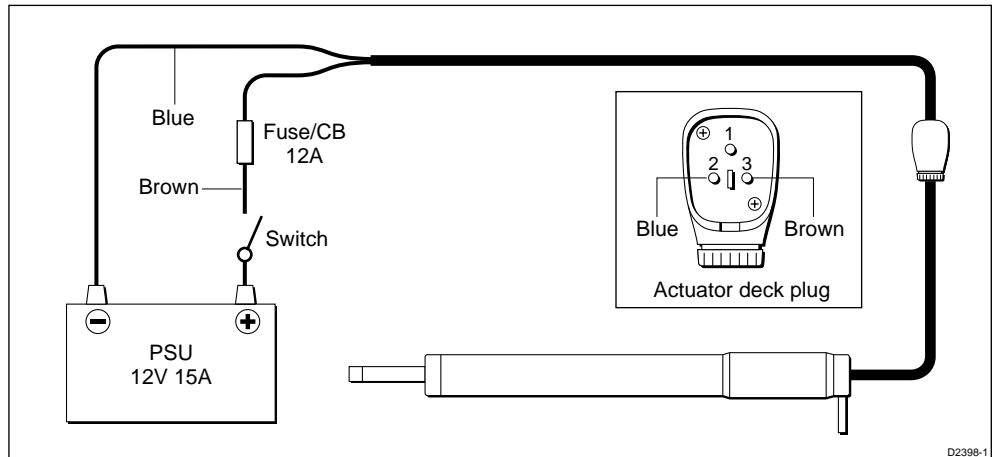


Figure 14. Tiller Drive Actuator GP test connections

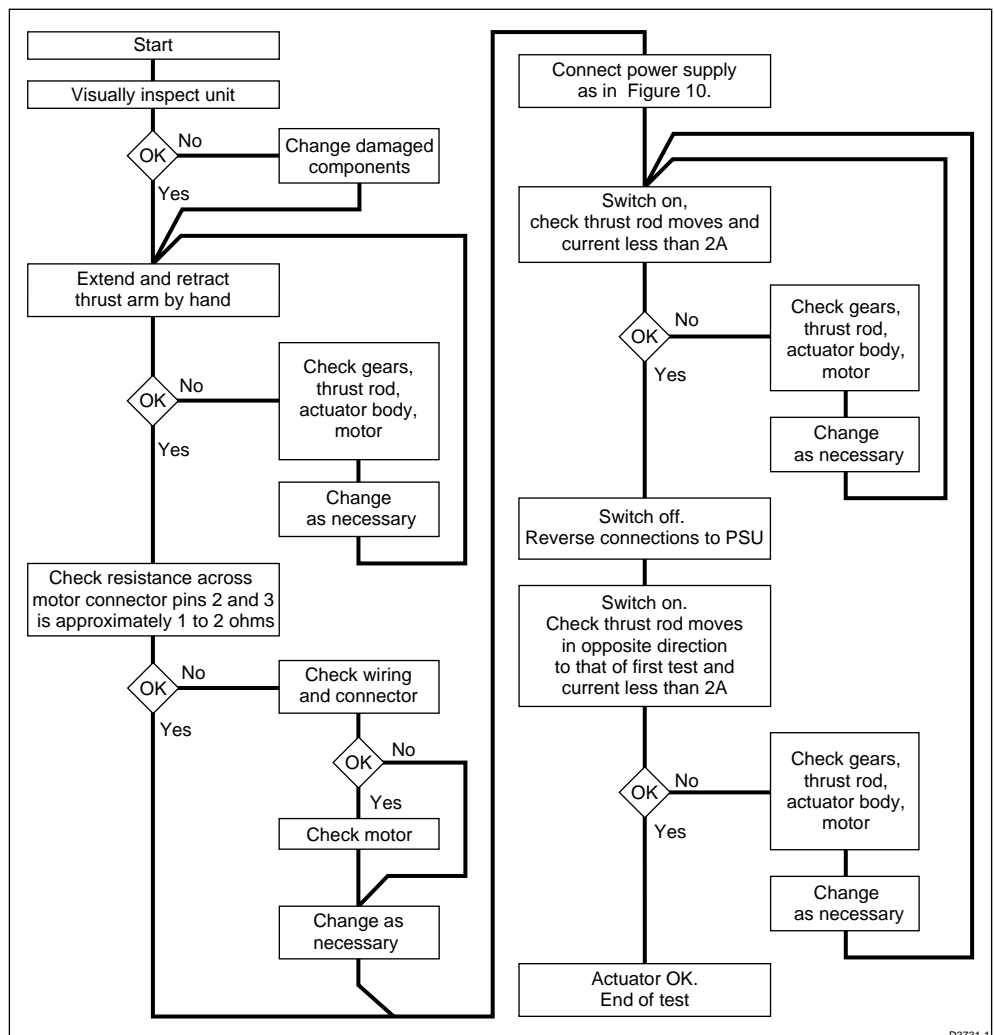


Figure 15. Tiller Drive Actuator GP test flowchart

5.2 Disassembly/assembly

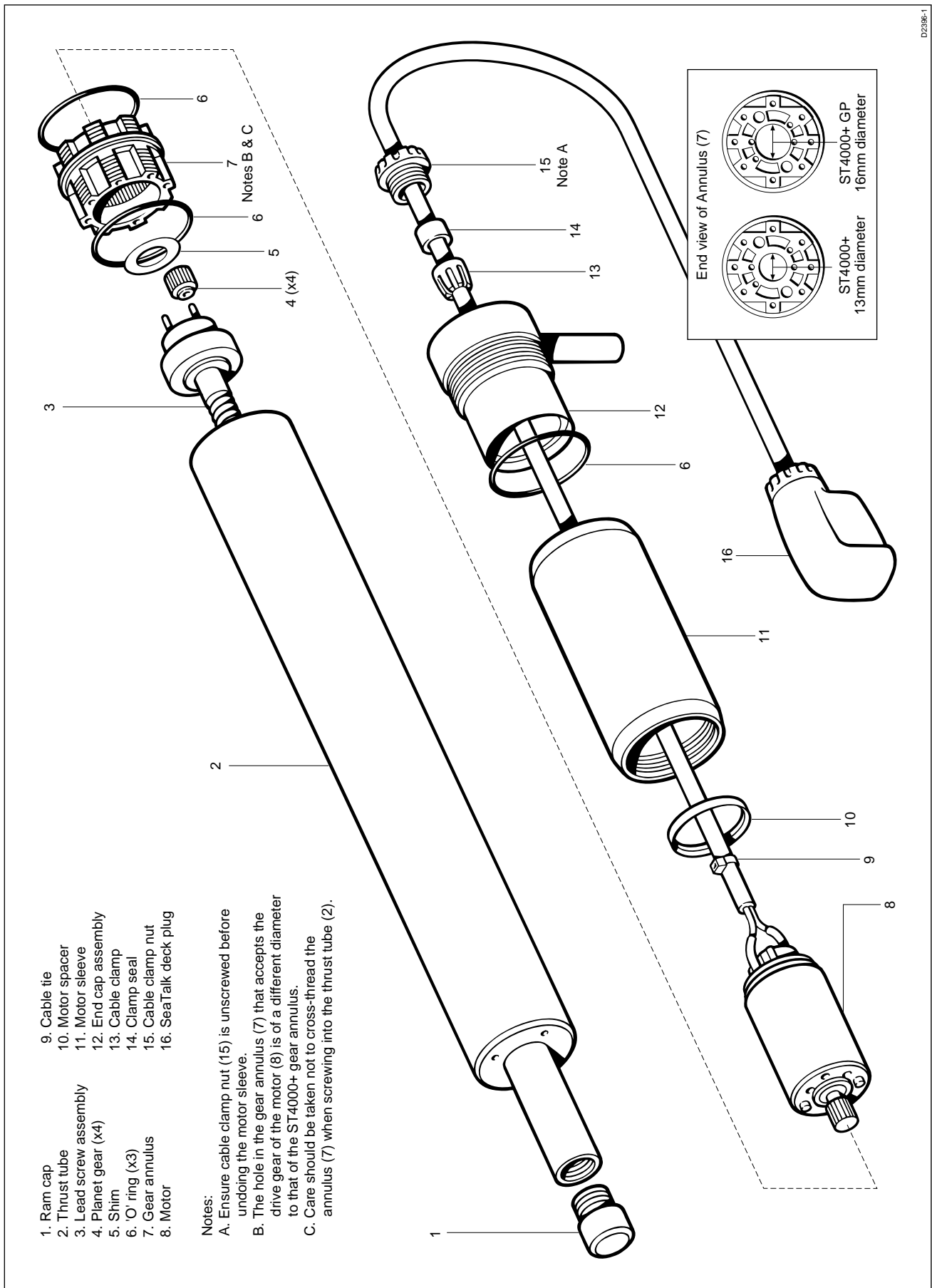


Figure 16. Tiller Drive Actuator GP exploded view

Tiller Drive Actuator GP spare parts list

The **item** numbers refer to Figure 16: Tiller drive actuator GP exploded view

Item	Spare Description	Part No.	Comments
	Drive module	Q086	Complete drive unit
	ST4000+ GP kit, <i>including</i>	W003	Serves as an upgrade conversion kit for the ST4000+ tiller drive actuator.
4	Planet gear (x4)		
5	Shim		
6	'O' ring (x3)		
7	Annulus		
8	Motor		
9	Cable tie		
10	Motor spacer		
11	Motor sleeve		
12	End cap assembly		

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