

1. Выбор кинематической схемы манипулятора

На рисунках 1 – 6 представлены три кинематические схемы манипуляторов с графиками рабочих зон.

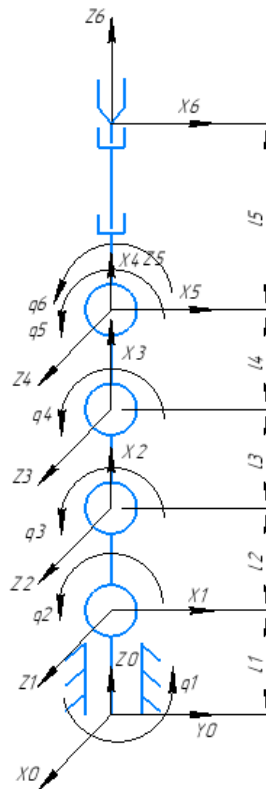


Рисунок 1 — Кинематическая схема манипулятора №1

$$q1 = (-180 \text{ — } 180)^\circ$$

$$l1 = 0.20 \text{ м}$$

$$q2 = (-90 \text{ — } 90)^\circ$$

$$l2 = 0.40 \text{ м}$$

$$q3 = (-90 \text{ — } 90)^\circ$$

$$l3 = 0.25 \text{ м}$$

$$q4 = (-90 \text{ — } 90)^\circ$$

$$l4 = 0.20 \text{ м}$$

$$q5 = (-90 \text{ — } 90)^\circ$$

$$l5 = 0.15 \text{ м}$$

$$q6 = (-180 \text{ — } 180)^\circ$$

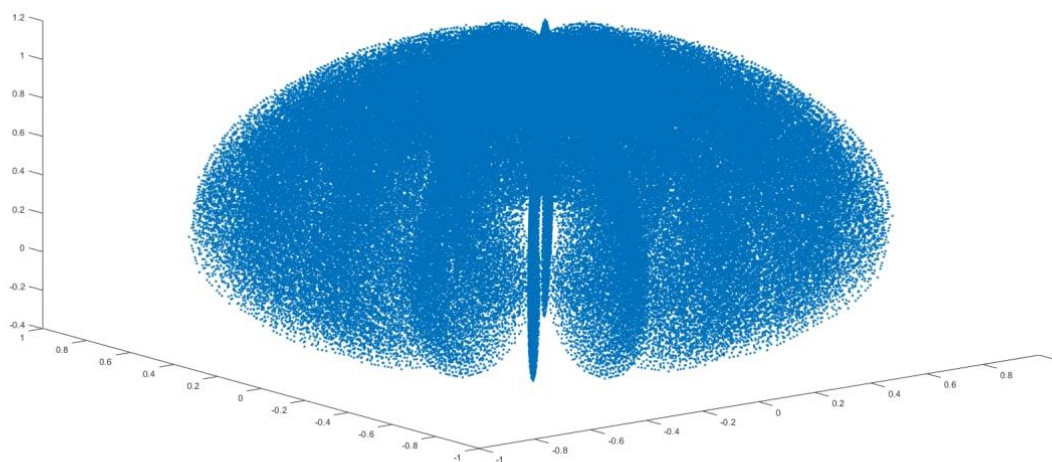


Рисунок 2 — Рабочая зона манипулятора №1

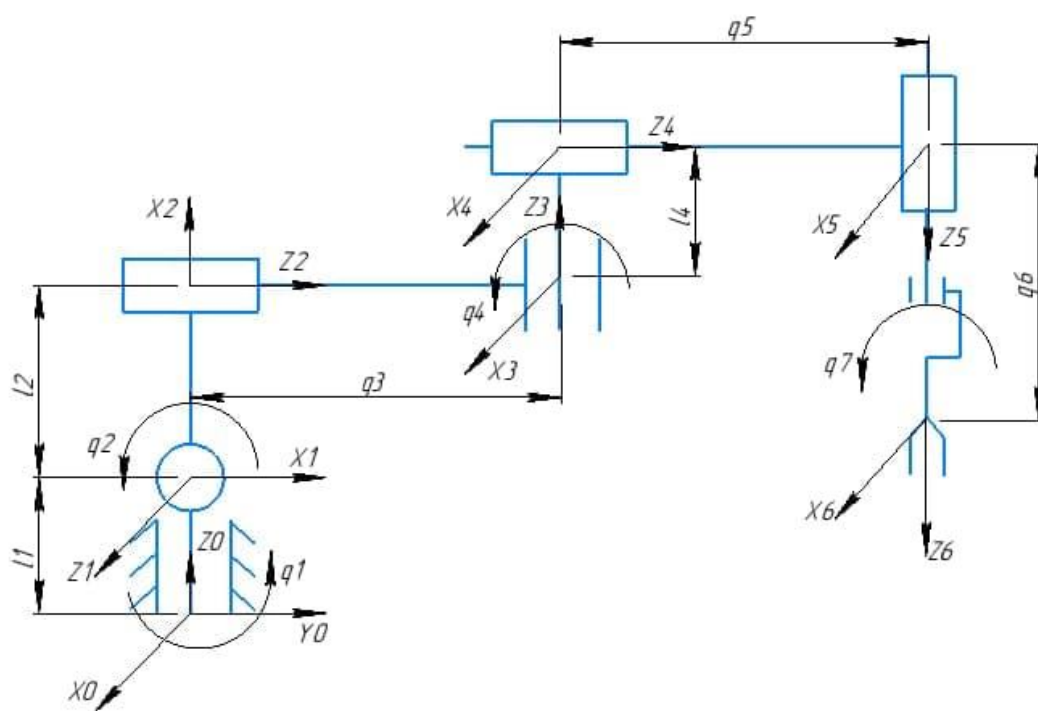


Рисунок 3 — Кинематическая схема манипулятора №2

$$q1 = (-180 \text{ — } 180)^\circ$$

$$q6 = (0.1 \text{ — } 0.6) \text{ м}$$

$$q2 = (-30 \text{ — } 90)^\circ$$

$$q3 = (0.15 \text{ — } 0.6) \text{ м}$$

$$l1 = 0.1 \text{ м}$$

$$q4 = (-150 \text{ — } 150)^\circ$$

$$l2 = 0.2 \text{ м}$$

$$q5 = (0.15 \text{ — } 0.4) \text{ м}$$

$$l4 = 0.15 \text{ м}$$

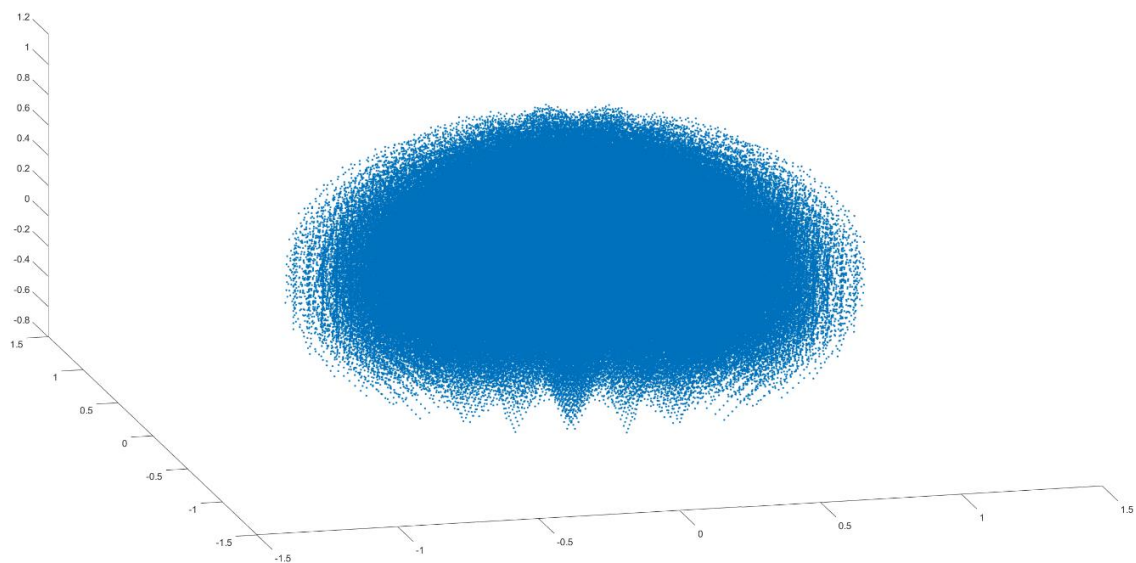


Рисунок 4 — Рабочая зона манипулятора №2

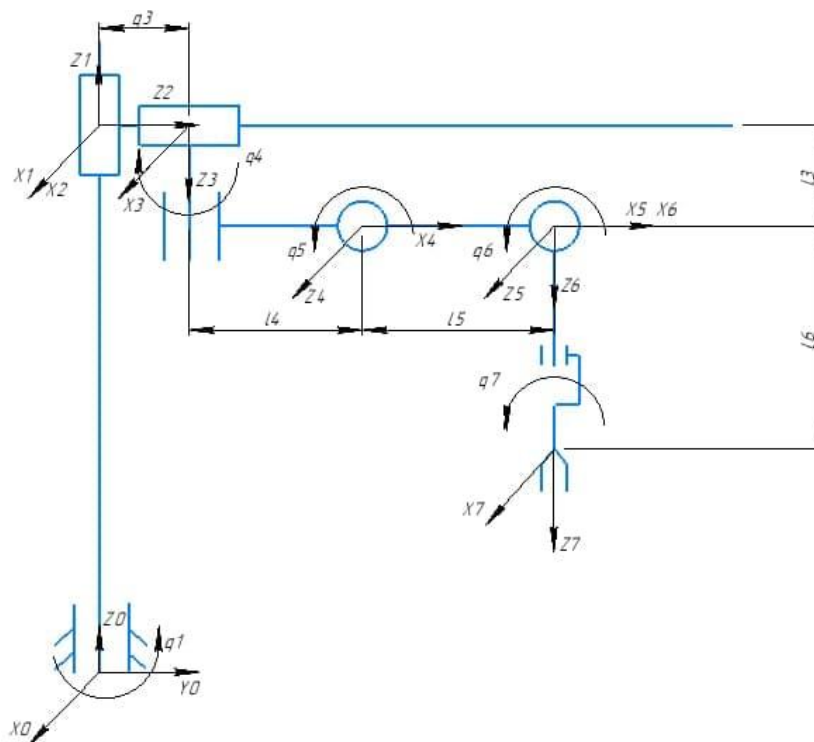


Рисунок 5 — Кинематическая схема манипулятора №3

$$q1 = (-180 \text{ — } 180)^\circ$$

$$q7 = (-180 \text{ — } 180)^\circ$$

$$q2 = (0.2 \text{ — } 1.0) \text{ м}$$

$$l3 = 0.1 \text{ м}$$

$$q3 = (0.15 \text{ — } 0.5) \text{ м}$$

$$l4 = 0.2 \text{ м}$$

$$q4 = (-170 \text{ — } 170)^\circ$$

$$l5 = 0.2 \text{ м}$$

$$q5 = (-150 \text{ — } 120)^\circ$$

$$l6 = 0.2 \text{ м}$$

$$q6 = (-160 \text{ — } 160)^\circ$$

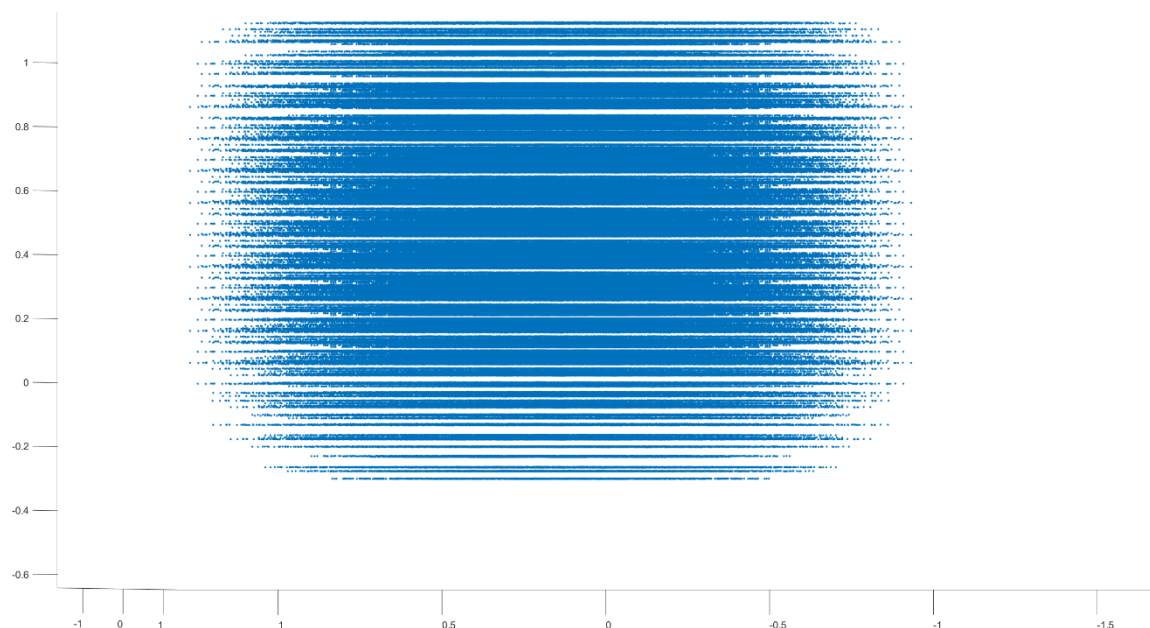


Рисунок 6 — Рабочая зона манипулятора №3

Код для решения ПЗК представлен в файлах Manipulator1, Manipulator2 и Manipulator3. В файлах Manipulator1_workspace, Manipulator2_workspace и Manipulator3_workspace представлен код многократного решения ПЗК синтезированных манипуляторов для построения рабочей зоны.

На рисунках 7 – 12 представлены схемы нагружения исполнительного манипулятора и силовой расчет исполнительного манипулятора по схеме нагружения без учета инерционной составляющей.

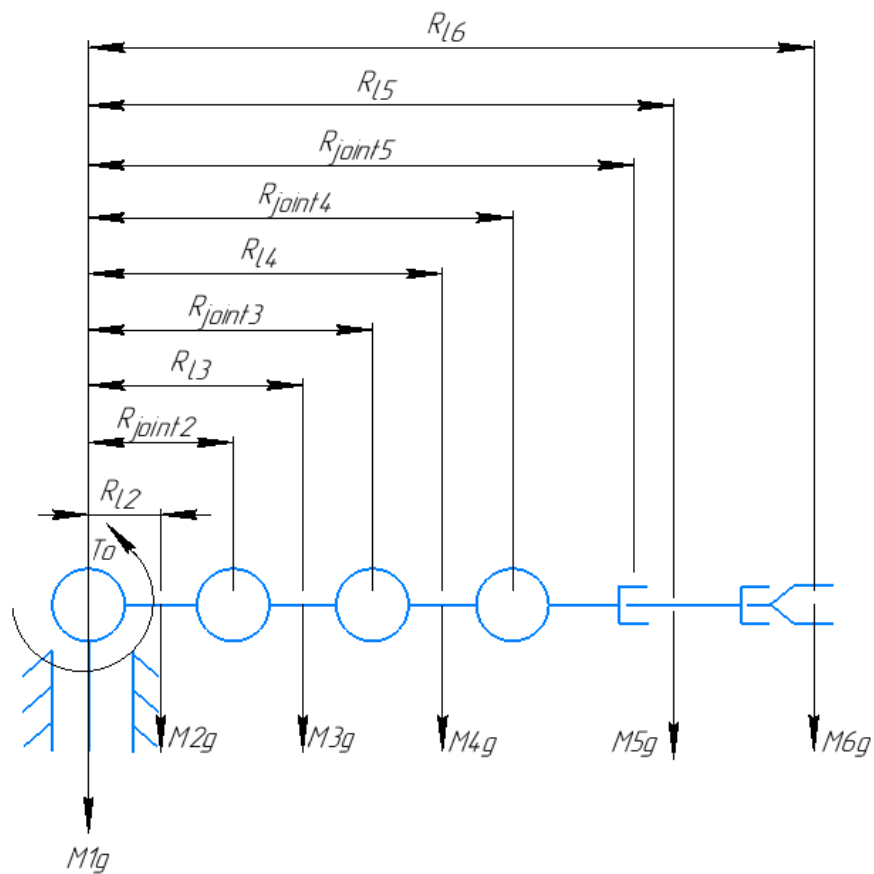


Рисунок 7 — Манипулятор №1 с изображением приложенных сил

$$\begin{aligned}
 L1 &:= 0.20 & k1 &:= 1 & M1 &:= k1 \cdot L1 = 0.2 & g &= 9.807 \frac{\text{m}}{\text{s}^2} \\
 L2 &:= 0.40 & k2 &:= 1 & M2 &:= k2 \cdot L2 = 0.4 \\
 L3 &:= 0.25 & k3 &:= 1 & M3 &:= k3 \cdot L3 = 0.25 \\
 L4 &:= 0.20 & k4 &:= 1 & M4 &:= k4 \cdot L4 = 0.2 \\
 L5 &:= 0.15 & k5 &:= 1 & M5 &:= k5 \cdot L5 = 0.15 \\
 & & & & M6 &:= 5 \\
 R2 &:= 0.5 \cdot L2 = 0.2 \\
 R3 &:= R2 + 0.5 \cdot L2 + 0.5 \cdot L3 = 0.525 \\
 R4 &:= R3 + 0.5 \cdot L3 + 0.5 \cdot L4 = 0.75 \\
 R5 &:= R4 + 0.5 \cdot L4 + 0.5 \cdot L5 = 0.925 \\
 R6 &:= R5 + 0.5 \cdot L5 = 1 \\
 To1 &:= M1 \cdot g + M2 \cdot g \cdot R2 + M3 \cdot g \cdot R3 + M4 \cdot g \cdot R4 + M5 \cdot g \cdot R5 + M6 \cdot g \cdot R6 = 55.898 \frac{\text{m}}{\text{s}^2}
 \end{aligned}$$

Рисунок 8 — Фрагмент листа MathCAD с расчётом момента, противодействующего опрокидыванию для манипулятора №1

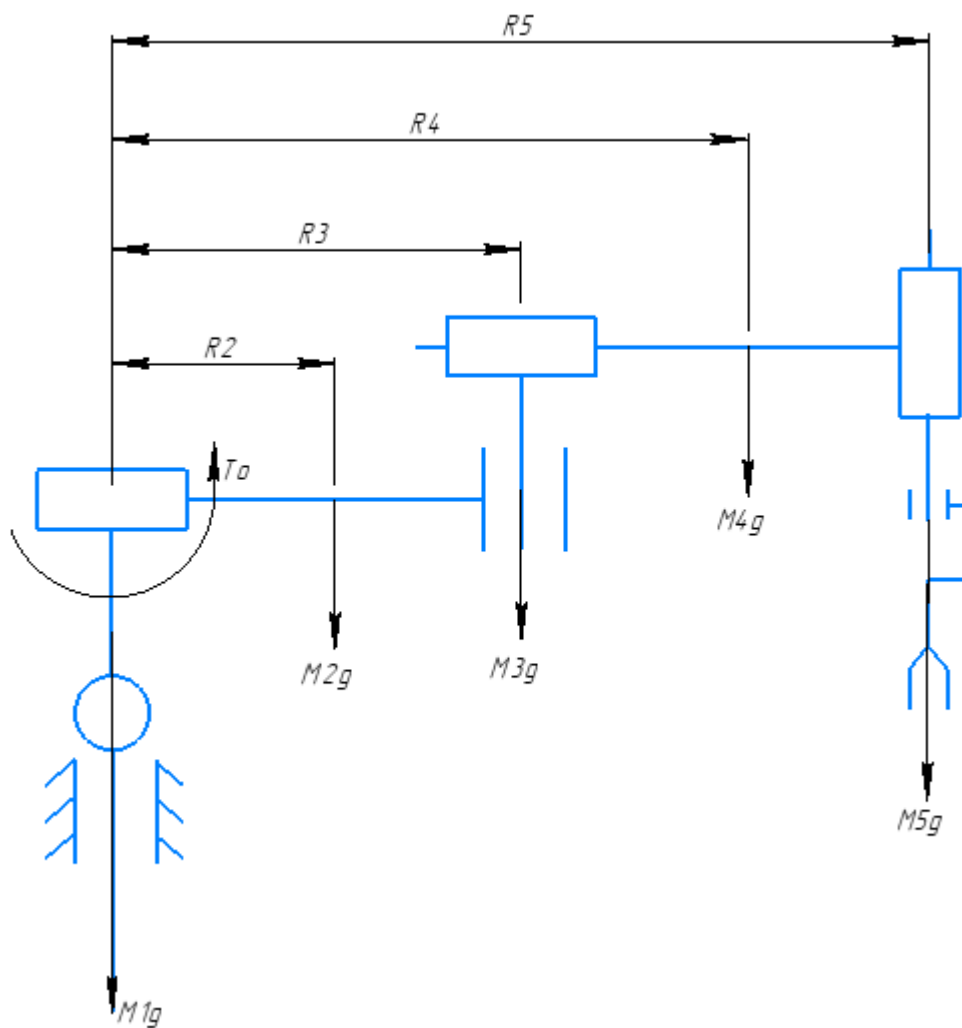


Рисунок 9 — Манипулятор №2 с изображением приложенных сил

$R2 := 0.3$	$L1 := 0.1$	$k1 := 1$	
$R3 := 0.6$	$L2 := 0.2$	$k2 := 1$	$M1 := k1 \cdot (L1 + L2) = 0.3$
$R4 := 0.8$	$L3 := 0.6$	$k3 := 1$	$M2 := k2 \cdot L3 = 0.6$
$R5 := 1$	$L4 := 0.15$	$k4 := 1$	$M3 := k3 \cdot L4 = 0.15$
	$L5 := 0.4$	$k5 := 1$	$M4 := k4 \cdot L5 = 0.4$
	$L6 := 0.6$	$k6 := 1$	$M5 := k5 \cdot L6 + 5 = 5.6$
		$k7 := 1$	

$$To1 := M1 \cdot g + M2 \cdot g \cdot R2 + M3 \cdot g \cdot R3 + M4 \cdot g \cdot R4 + M5 \cdot g \cdot R5 = 63.645 \frac{\text{m}}{\text{s}^2}$$

Рисунок 10 — Фрагмент листа MathCAD с расчётом момента, противодействующего опрокидыванию для манипулятора №2

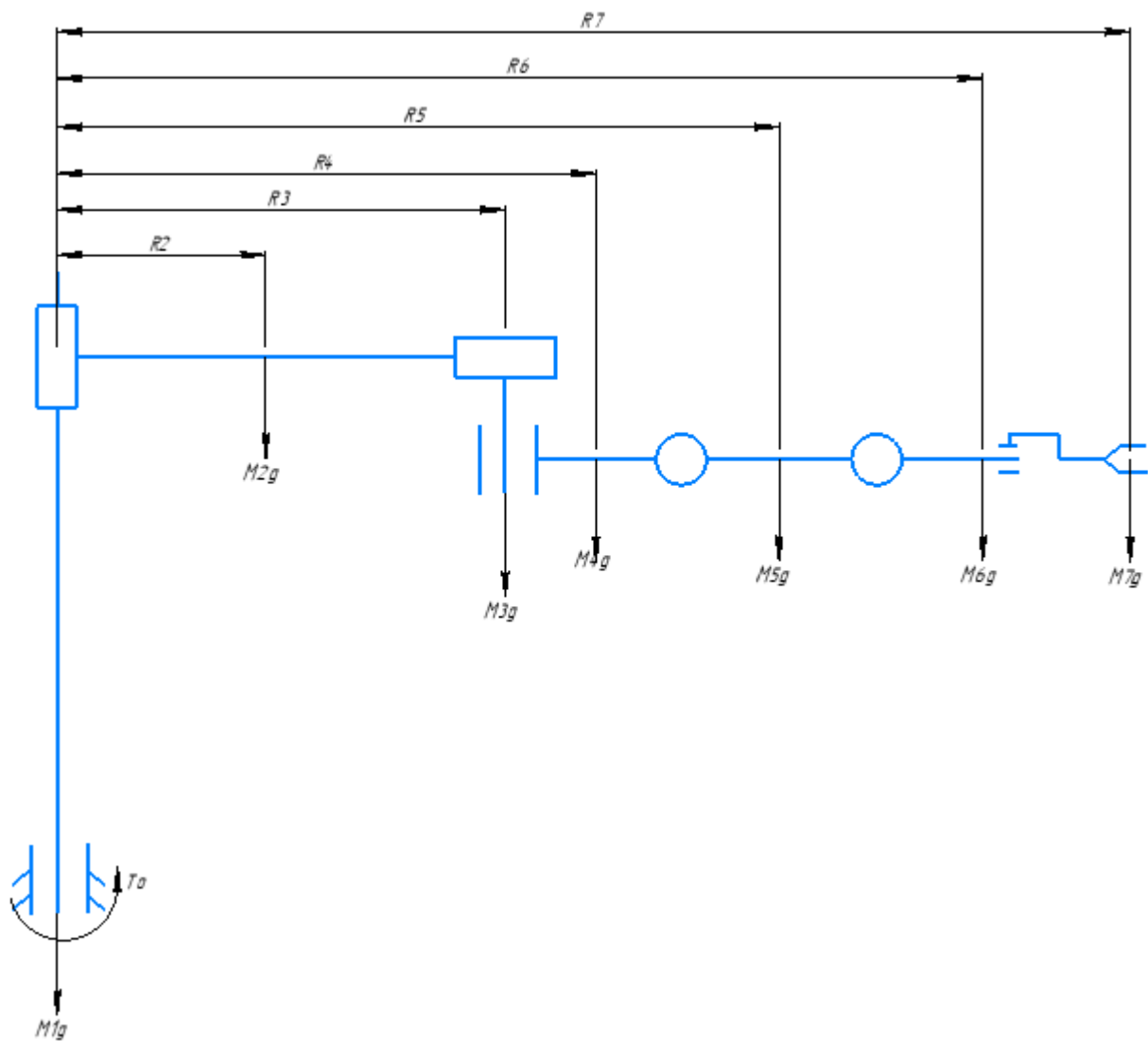


Рисунок 11 — Манипулятор №3 с изображением приложенных сил

$R2 := 0.25$	$L1 := 1$	$k1 := 1$	$M1 := k1 \cdot L1 = 1$
$R3 := 0.5$	$L2 := 0.5$	$k2 := 1$	$M2 := k2 \cdot L2 = 0.5$
$R4 := 0.6$	$L3 := 0.2$	$k3 := 1$	$M3 := k3 \cdot L3 = 0.2$
$R5 := 0.8$	$L4 := 0.2$	$k4 := 1$	$M4 := k4 \cdot L4 = 0.2$
$R6 := 1$	$L5 := 0.2$	$k5 := 1$	$M5 := k5 \cdot L5 = 0.2$
$R7 := 1.1$		$k6 := 1$	$M6 := k6 \cdot L6 = 0.6$
		$k7 := 1$	$M7 := 5$

$$T_{01} := M1 \cdot g + M2 \cdot g \cdot R2 + M3 \cdot g \cdot R3 + M4 \cdot g \cdot R4 + M5 \cdot g \cdot R5 + M6 \cdot g \cdot R6 + M7 \cdot g \cdot R7 = 74.58 \frac{\text{m}}{\text{s}^2}$$

Рисунок 12 — Фрагмент листа MathCAD с расчётом момента, противодействующего опрокидыванию для манипулятора №3

По результатам расчёта и анализа рабочих зон для дальнейшей работы был выбран манипулятор №1. Обновленная рабочая зона выбранного манипулятора

с учётом геометрии платформы, на которой он установлен, представлена на рисунке 13.

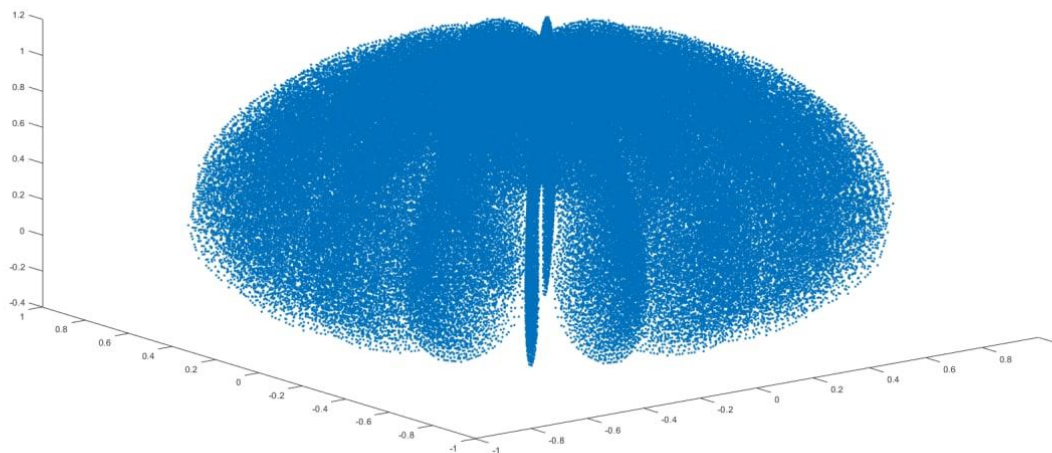


Рисунок 13 — Рабочая зона манипулятора №1 с учётом платформы

На рисунке 14 показано сравнение рабочих зон. Представлены графики рабочих зон без учёта манипулятора, с учётом манипулятора, «отброшенные» точки и «отброшенные» точки на графике рабочей зоны.

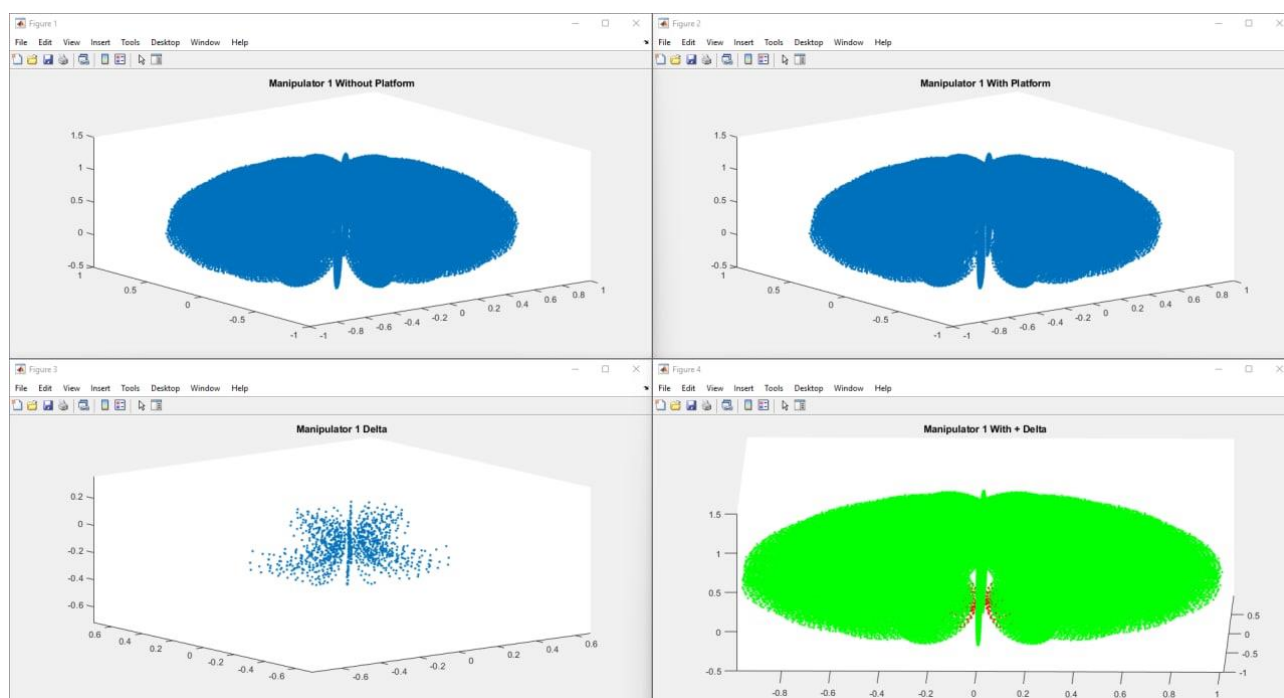


Рисунок 14 — Сравнение рабочих зон манипулятора 1 без учёта платформы и с учётом платформы

2. Задающее устройство

На рисунках 15 – 16 представлены рабочая зона дельта-робота и карта ошибок соответственно.

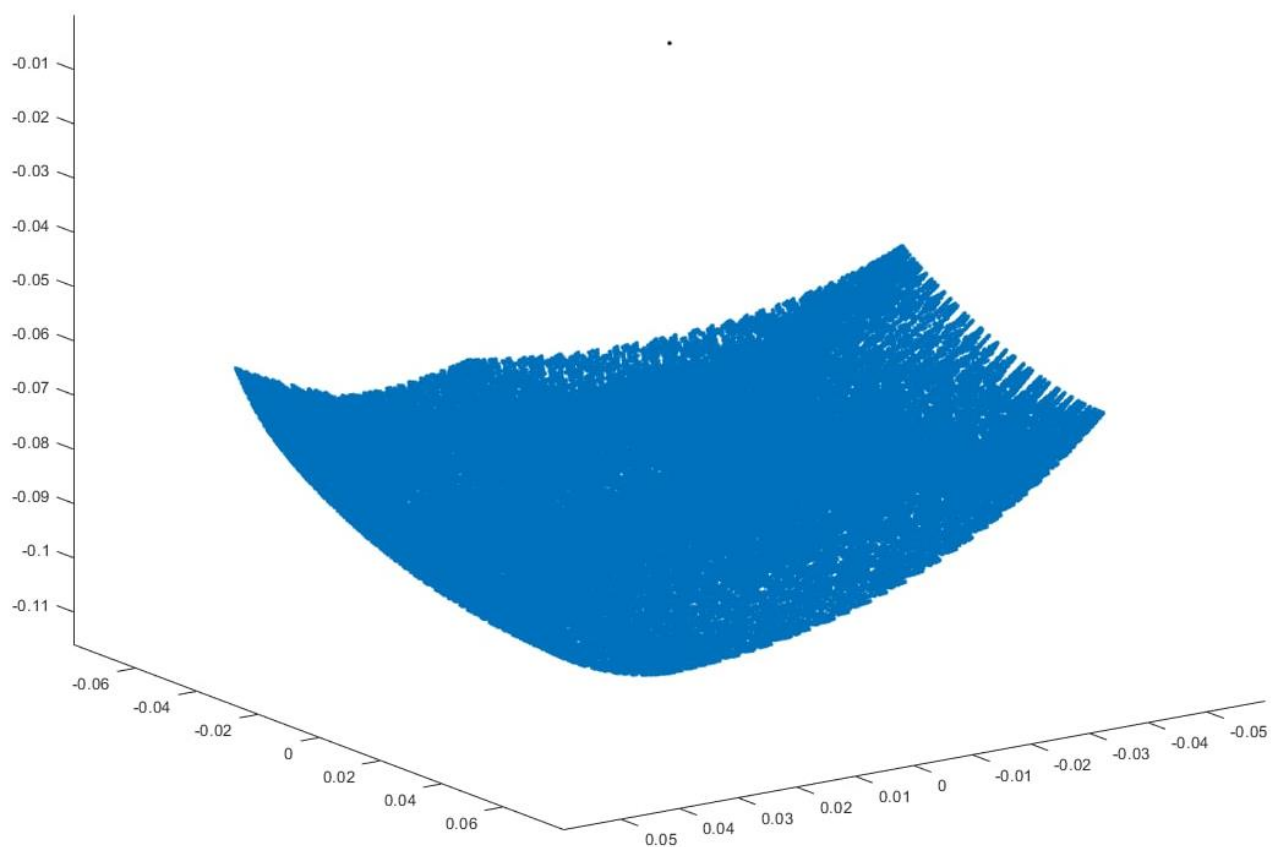


Рисунок 15 — Рабочая зона дельта-робота

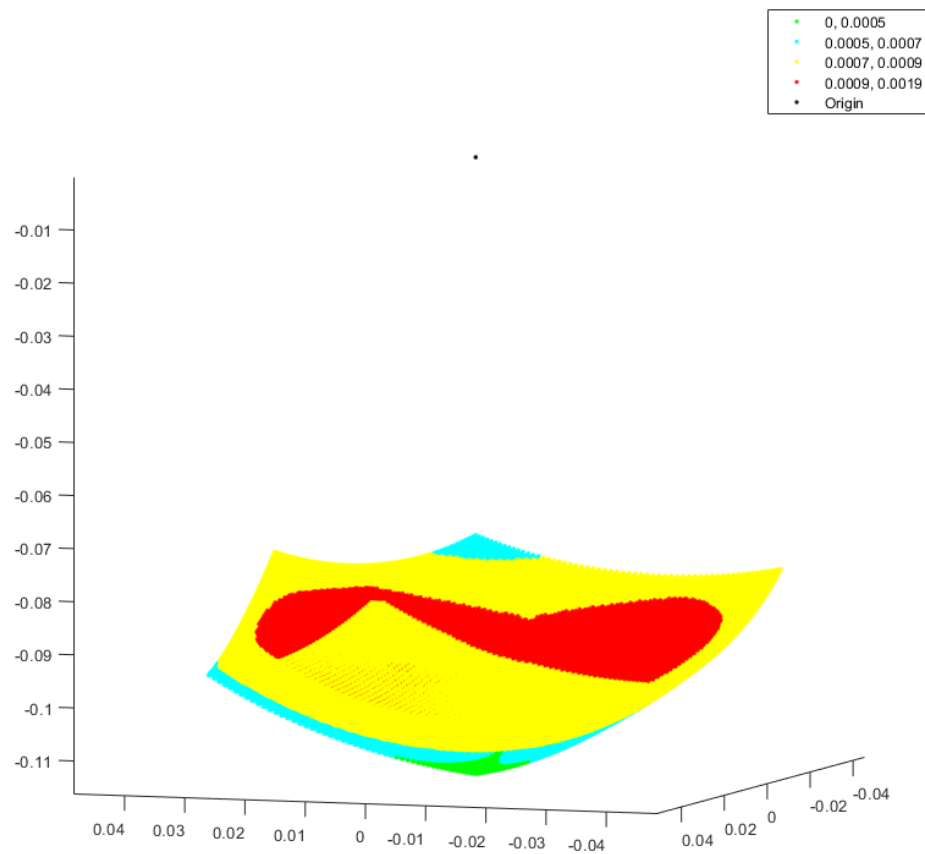


Рисунок 16 — Карта ошибок дельта робота

На рисунке 17 представлена рабочая зона манипулятора и рабочая зона дельта-робота, умноженная на коэффициент масштабирования 28.

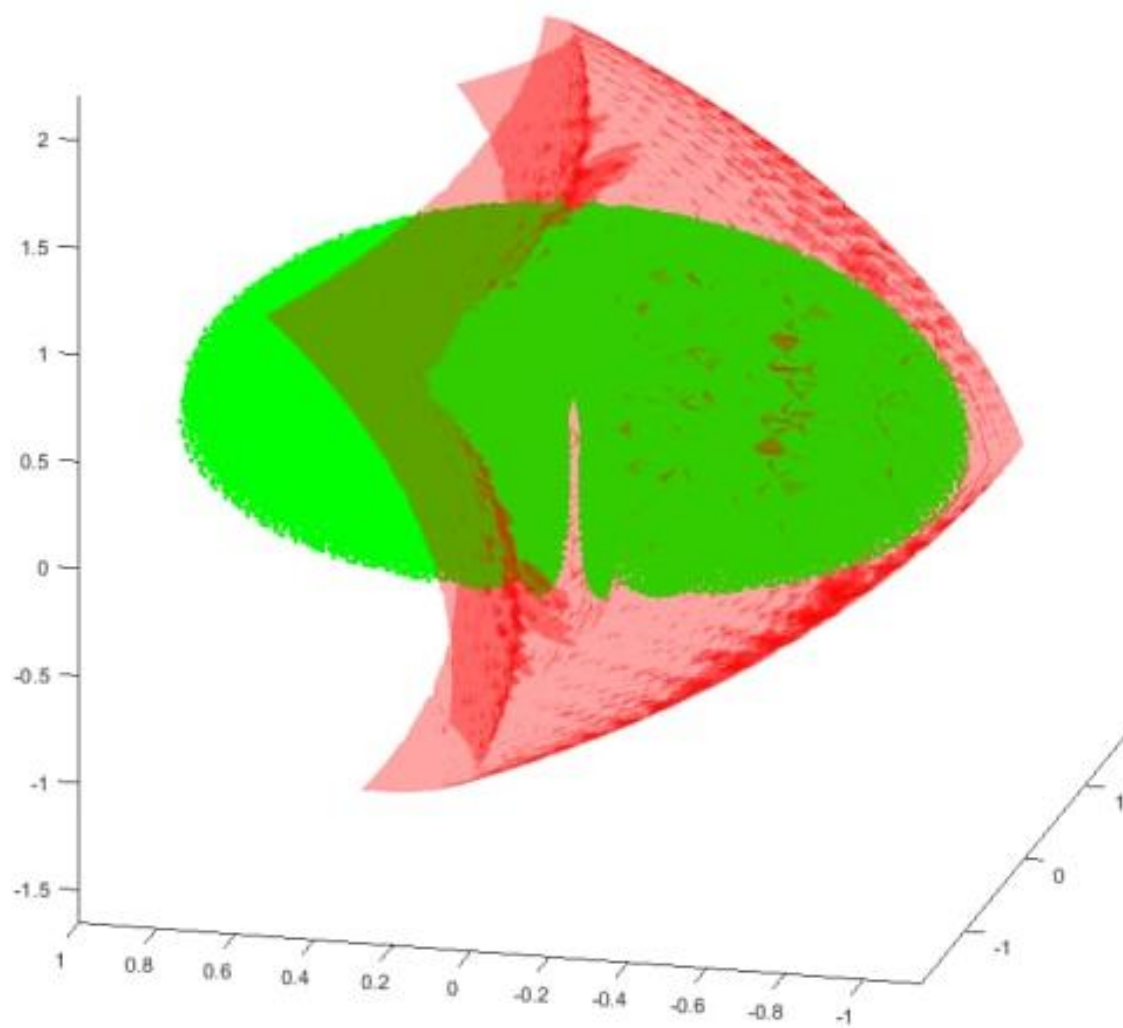


Рисунок 17 — Рабочие зоны

3. Подбор компонентов шарнира

В таблице 1 представлены некоторые характеристики выбранных компонентов шарниров. Фрагменты документации с подробным описанием выбранных компонентов доступны в Приложении А.

Таблица 1 — Выбранные компоненты

№ шарнира		0	1	2	3	4	5	6
Необходимый момент, Нм		3,61	145,41	66,51	30,02	10,28	$2,24 \cdot 10^{-5}$	1
Двигатель	Модель	JCM38x12S	JCM85x26D	JCM69x10S	JCM69x10S	JCM38x12S	JCM38x06S	JCM38x06S
	Номинальный момент, Нм	0,14	2,58	0,57	0,57	0,14	0,07	0,07
	Пиковый момент, Нм	0,42	7,75	1,71	1,71	0,42	0,21	0,21
Редуктор	Модель	CSD-14-2A	CSG-25-2UH	CSG-17-2UH	CSG-17-2UH	CSG-14-1U-CC-F	CSD-14-2A	Червячный редуктор
	Средний момент, Нм	4,8	140	51	34	11	4,8	
	Пиковый момент, Нм	12	204	70	44	28	12	
	Передаточное отношение	50	100	100	50	100	50	
Датчик	Модель	INC-4-75	INC-4-58	INC-4-58	INC-4-58	INC-4-37	INC-4-37	INC-4-37
	Воспринимаемая скорость, об/мин	10000						

На рисунке 18 представлен расчёт масс шарниров в килограммах. Масса шарнира складывается из масс двигателя, редуктора и датчика и умножается в четыре раза, чтобы учесть остальные компоненты шарнира.

$$\begin{aligned}
 m_{\text{joint}0} &:= (94 + 60 + 158)10^{-3} = 0.312 & m_{\text{joint}0} &:= 4m_{\text{joint}0} = 1.248 \\
 m_{\text{joint}1} &:= (650 + 1500 + 118)10^{-3} = 2.268 & m_{\text{joint}1} &:= 4m_{\text{joint}1} = 9.072 \\
 m_{\text{joint}2} &:= (180 + 680 + 118)10^{-3} = 0.978 & m_{\text{joint}2} &:= 4m_{\text{joint}2} = 3.912 \\
 m_{\text{joint}3} &:= (180 + 680 + 118)10^{-3} = 0.978 & m_{\text{joint}3} &:= 4m_{\text{joint}3} = 3.912 \\
 m_{\text{joint}4} &:= (94 + 295 + 62)10^{-3} = 0.451 & m_{\text{joint}4} &:= 4m_{\text{joint}4} = 1.804 \\
 m_{\text{joint}5} &:= (64 + 60 + 158)10^{-3} = 0.282 & m_{\text{joint}5} &:= 4m_{\text{joint}5} = 1.128 \\
 m_{\text{joint}6} &:= 1.5 & m_{\text{joint}6} &:= 1.5
 \end{aligned}$$

Рисунок 18 — Фрагмент листа Mathcad с расчётом масс шарниров

На рисунке 19 представлена компоновка шарнира 4.

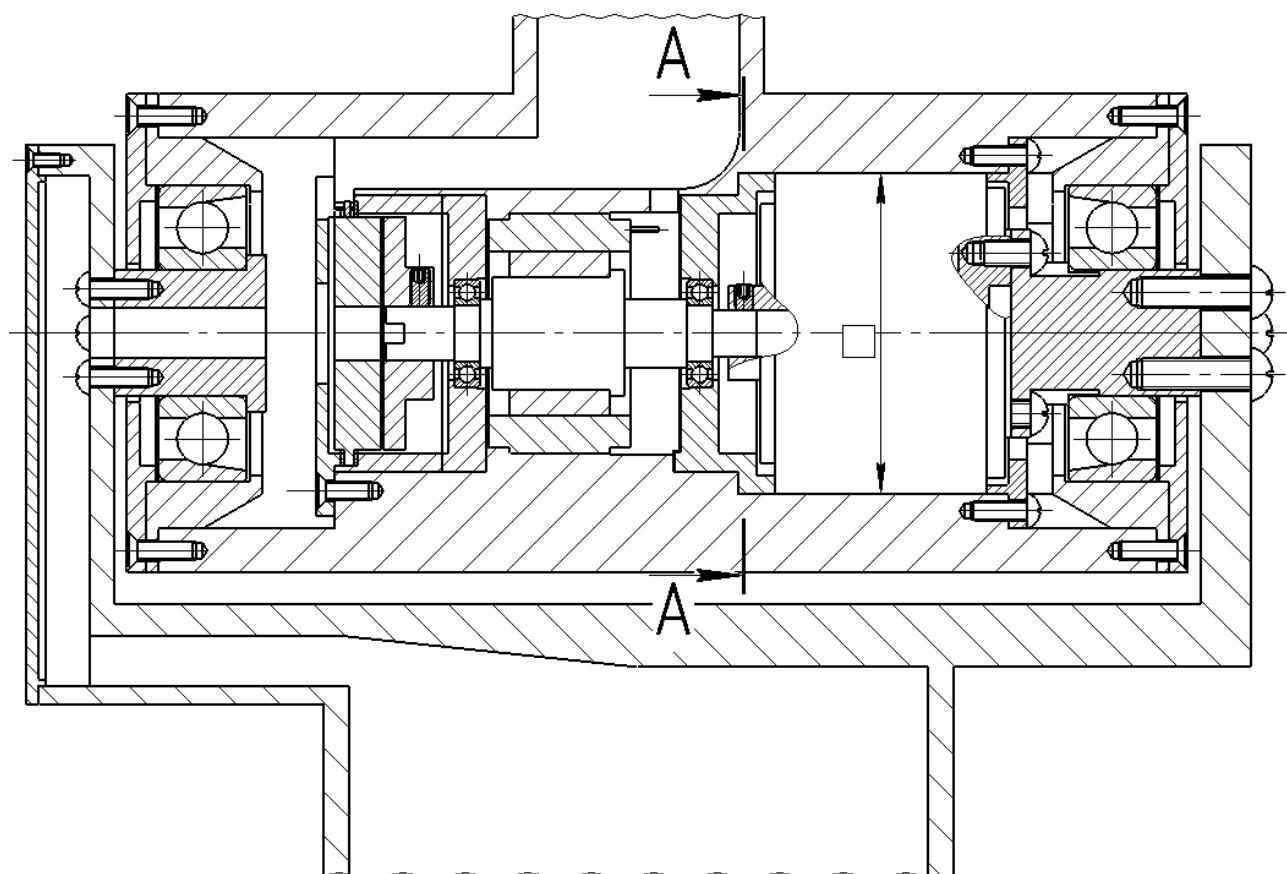


Рисунок 19 — Компоновка шарнира 4

На рисунке 20 представлен концепт устройства шарнира 5.

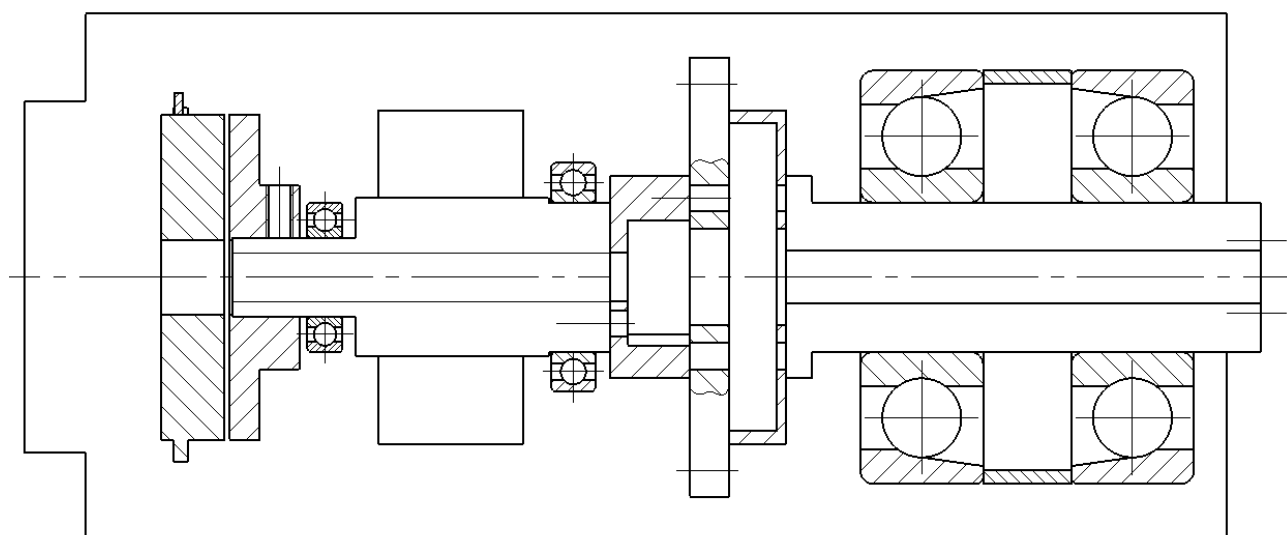


Рисунок 20 — Концепт устройства шарнира 5

На рисунке 21 представлен концепт устройства схвата.

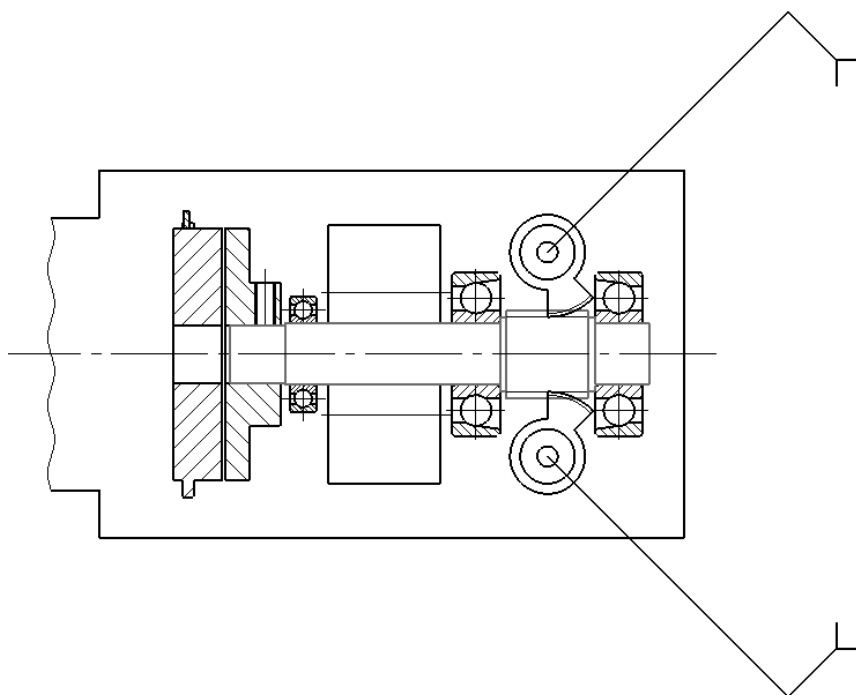


Рисунок 21 — Концепт устройства схвата

4. Расчёт манипулятора

Рисунки 22—23 демонстрируют расстояния от оси до элементов манипулятора.

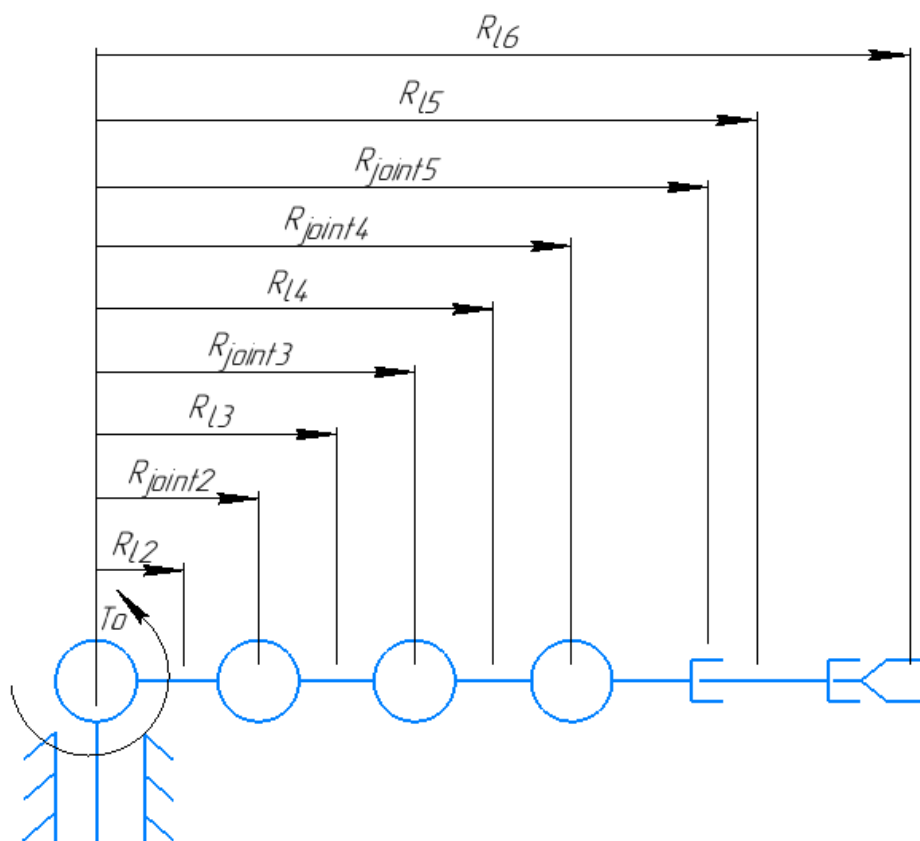


Рисунок 22 — Обозначение расстояний

$R_{L1} := 0 = 0$	$R_{joint1} := 0 = 0$
$R_{L2} := R_{L1} + 0.5 \cdot 12 = 0.2$	$R_{joint2} := R_{joint1} + 12 = 0.4$
$R_{L3} := R_{L2} + 0.5 \cdot 12 + 0.5 \cdot 13 = 0.525$	$R_{joint3} := R_{joint2} + 13 = 0.65$
$R_{L4} := R_{L3} + 0.5 \cdot 13 + 0.5 \cdot 14 = 0.75$	$R_{joint4} := R_{joint3} + 14 = 0.85$
$R_{L5} := R_{L4} + 0.5 \cdot 14 + 0.5 \cdot 15 = 0.925$	$R_{joint5} := R_{joint4} + 14.5 = 0.9$
$R_{L6} := R_{L5} + 0.5 \cdot 15 = 1$	

Рисунок 23 — Значения расстояний

В таблице 2 приведены некоторые характеристики манипулятора, необходимые для расчёта.

Таблица 2 — Характеристики манипулятора

Характеристика	Значение
Материал	Ал5
σ_t	180 МПа
Плотность материала	2680 кг/м ³
Толщина стенки	4 мм
Угловое ускорение	0,3 рад/с
Диаметры звеньев 1 – 4	100 мм
Диаметр звена 5	40 мм
Коэффициент запаса	2

На рисунке 24 представлен расчёт масс звеньев в кг.

$$K(d) := \frac{\pi}{4} \cdot [d^2 - (d - 2 \cdot \Delta)^2] \cdot \rho$$

$$k1 := K(d_1) = 3.233$$

$$m_{11} := k1 \cdot l1 = 0.647$$

$$m_{11} := 1.25 m_{11} = 0.808$$

$$k2 := K(d_2) = 3.233$$

$$m_{12} := k2 \cdot l2 = 1.293$$

$$m_{12} := 1.25 m_{12} = 1.617$$

$$k3 := K(d_3) = 3.233$$

$$m_{13} := k3 \cdot l3 = 0.808$$

$$m_{13} := 1.25 m_{13} = 1.01$$

$$k4 := K(d_4) = 3.233$$

$$m_{14} := k4 \cdot l4 = 0.647$$

$$m_{14} := 1.25 m_{14} = 0.808$$

$$k5 := K(d_5) = 1.212$$

$$m_{15} := k5 \cdot l5 = 0.182$$

$$m_{15} := 1.25 m_{15} = 0.227$$

Рисунок 24 – Фрагмент листа Mathcad с расчётом масс звеньев

Подробный расчёт необходимых моментов представлен в файле «Манипулятор 1.xmcd».

Для выходного вала, через который проходят провода, проведён расчёт максимальных допустимых сил на срез и момент.

На рисунке 25 представлены расчёт максимальных допустимых сил на срез и момент.

$$\begin{aligned}
d_{\text{нар}} &:= 20 \cdot 10^{-3} & d_{\text{отв}} &:= 8 \cdot 10^{-3} & l_{\text{вал}} &:= 24 \cdot 10^{-3} \\
J_{\text{сеч_вал}} &:= \frac{\pi}{64} \cdot (d_{\text{нар}}^4 - d_{\text{отв}}^4) & A_{\text{сеч_вал}} &:= \frac{\pi}{4} \cdot (d_{\text{нар}}^2 - d_{\text{отв}}^2) \\
\sigma_{t_ст3} &:= 205 \cdot 10^6 \quad \text{Па} \\
K_{\text{зап_вал}} &:= 2 \\
M_{\text{max}} &:= \frac{2 \cdot \sigma_{t_ст3} \cdot J_{\text{сеч_вал}}}{K_{\text{зап_вал}} \cdot d_{\text{нар}}} = 78.442 \quad \text{Нм} \\
F_{\text{max}} &:= \frac{M_{\text{max}}}{l_{\text{вал}}} = 3.268 \times 10^3 \quad \text{Н} & \frac{F_{\text{max}}}{10^3} &= 3.268 \quad \text{кН} \\
\sigma_{\text{срез_ст3}} &:= 0.2 \cdot \sigma_{t_ст3} = 4.1 \times 10^7 \\
F_{\text{срез}} &:= \frac{\sigma_{\text{срез_ст3}}}{K_{\text{зап_вал}}} \cdot A_{\text{сеч_вал}} = 5.41 \times 10^3 & \frac{F_{\text{срез}}}{10^3} &= 5.41 \quad \text{кН}
\end{aligned}$$

Рисунок 25 – Фрагмент листа Mathcad с расчётом масс звеньев

Приложение А. Характеристики компонентов шарниров.

Шарнир:0

Двигатель:

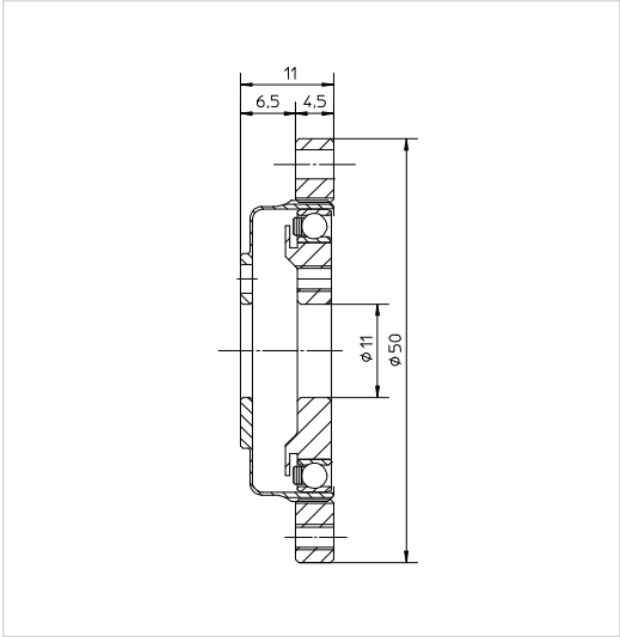
Электродвигатель	JCM38×06S	JCM38×12S
Номинальная мощность, Вт	56	58
Номинальный момент, Нм	0,07	0,14
Пиковый момент, Нм	0,21	0,42
Номинальная скорость, об/мин	8000	4000
Номинальный ток фазы, А _{азелл}	3,2	3,2
Постоянная момента, Нм/А _{азелл}	0,022	0,043
Постоянная мотора, Нм/√Вт	0,03	0,05
Напряжение питания, В _{азелл}	24	24
Сопротивление (фаза-фаза), Ом	0,6	0,86
Индуктивность (фаза-фаза), мГн	0,24	0,5
Максимальный КПД, %	90	88
Число пар полюсов	7	7
Момент инерции ротора, кг·см ² *	0,01	0,02
Масса (статор + ротор), г *	64 (54+10)	94 (74+20)
Внешний диаметр статора D, мм	38	38
Внутренний диаметр ротора d, мм	18	18
Диаметр лобовых частей G, мм	36,2	36,2
Длина ротора l, мм *	8	16
Длина штырьковых лепестков h, мм	5	5
Длина статора L (max), мм	16,5	22,5

* – для исполнения без датчиков Холла

Редуктор:

Illustration 11.1

CSD-14-2A [mm]



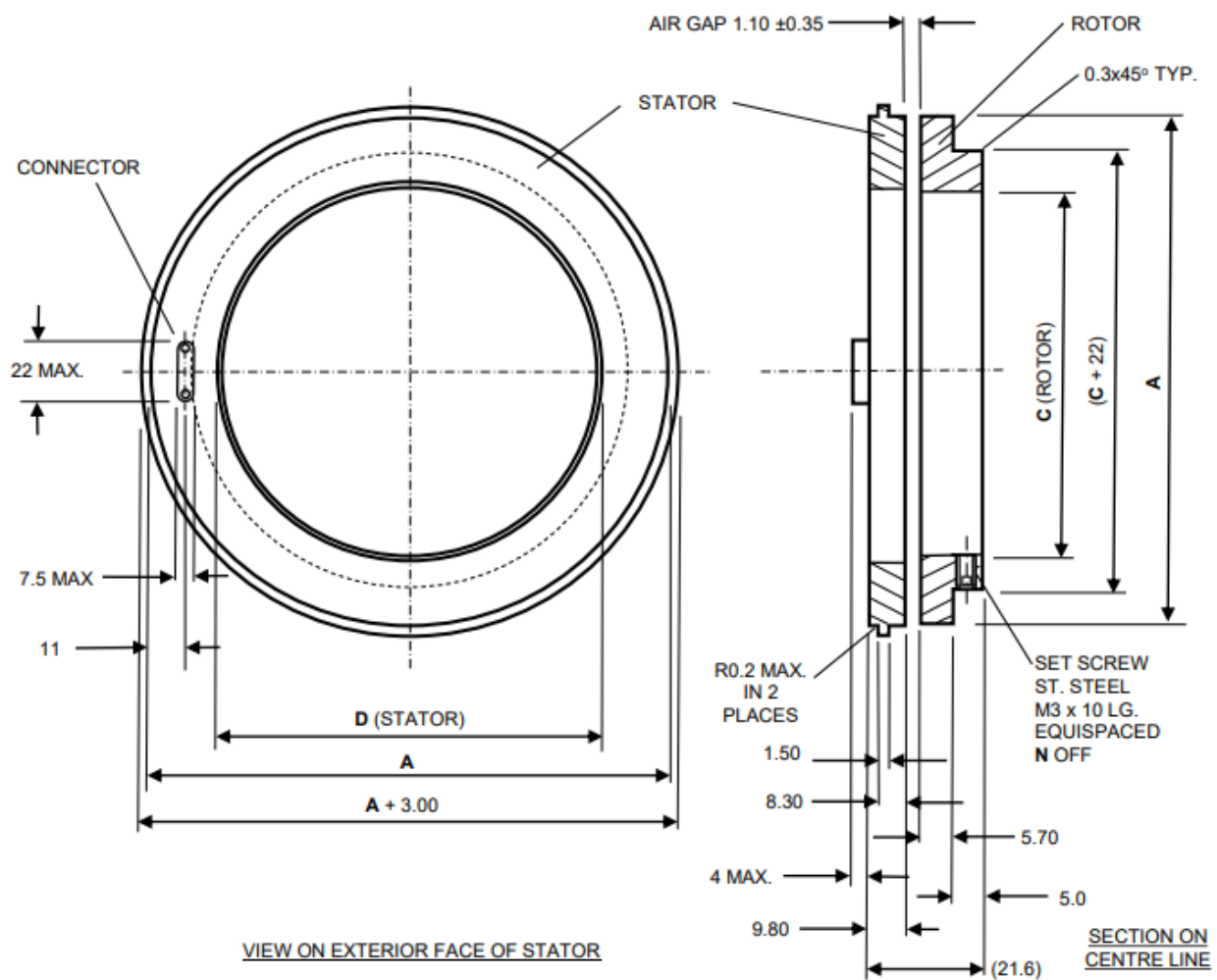
	Unit	CSD-14-2A	
Ratio	i []	50	100
Repeatable peak torque	T_{rp} [Nm]	12	19
Average torque	T_{ra} [Nm]	4.8	7.7
Rated torque	T_{rn} [Nm]	3.7	5.4
Momentary peak torque	T_{mr} [Nm]	24	31
Maximum input speed (oil lubrication)	$n_{in(max)}$ [rpm]	14000	
Maximum input speed (grease lubrication)	$n_{in(max)}$ [rpm]	8500	
Average input speed (oil lubrication)	$n_{av(max)}$ [rpm]	6500	
Average input speed (grease lubrication)	$n_{av(max)}$ [rpm]	3500	
Moment of inertia	J_{in} [$\times 10^{-4}$ kgm ²]	0.021	
Weight	m [kg]	0.06	

Датчик угла:

INC-4-75	
Dim. A : Stator / Rotor Body O.D.	75.00
Dim. C : Rotor I.D.	35.00
Dim. D : Stator I.D.	35.80
N Number of Set Screws	3
Max. radial misalignment	
Rotor & Stator fixings	

NOTES

1. 3D CAD MODEL FILES AVAILABLE ON WWW.CELERAMOTION.COM
2. UNIT SHOWN WITH AXIAL CONNECTOR AC1
3. SEE SECTION 9.3. FOR CORRESPONDING SERVO CLAMPS
4. ALL DIMS IN mm – DO NOT SCALE
5. 3RD ANGLE PROJECTION
6. TOLERANCES:- 0 DECIMAL PLACES = ± 0.5
1 DECIMAL PLACES = ± 0.2
2 DECIMAL PLACES = ± 0.1



Шарнир 1.

Двигатель:

Электродвигатель	JCM50×14S	JCM69×10S	JCM69×18S	JCM69×35D	JCM85×26D	CM100×30D
Номинальная мощность, Вт	100	180	214	391	405	690
Номинальный момент, Нм	0,32	0,57	1,15	2,2	2,58	4,4
Пиковый момент, Нм	0,96	1,71	3,45	6,6	7,75	13,2
Номинальная скорость, об/мин	3000	3000	1700	1700	1500	1500
Номинальный ток фазы, A _{ном.л}	2,8	5,1	5,7	11,0	12,2	20,4
Постоянная момента, Нм/A _{ном.л}	0,11	0,11	0,2	0,2	0,212	0,215
Постоянная мотора, Нм/√Вт	0,1	0,15	0,22	0,35	0,44	0,62
Напряжение питания, В _{ном.л}	48	48	48	48	48	48
Сопротивление (фаза-фаза), Ом	1,75	0,8	1,1	0,42	0,32	0,16
Индуктивность (фаза-фаза), мГн	0,8	0,65	1,2	0,61	0,55	0,35
Максимальный КПД, %	89	90	89	89	91	92
Число пар полюсов	10	10	10	10	10	10
Момент инерции ротора, кг·см ² *	0,082	0,2	0,35	0,62	1,26	2,7
Масса (статор + ротор), г *	125 (95+30)	180 (140+40)	285 (220+65)	507 (390+117)	650 (490+160)	1105 (850+255)
Внешний диаметр статора D, мм	50	69	69	69	85	100
Внутренний диаметр ротора d, мм	30	42	42	42	52	59
Диаметр лобовых частей G, мм	48	66	66	66	81,5	95,5
Длина ротора l, мм *	16	12	20	37	28	32
Длина штырьковых лепестков h, мм	5	5	5	5	5	5
Длина статора L (max), мм	24,7	25	33	50	41,5	48,5

Редуктор:

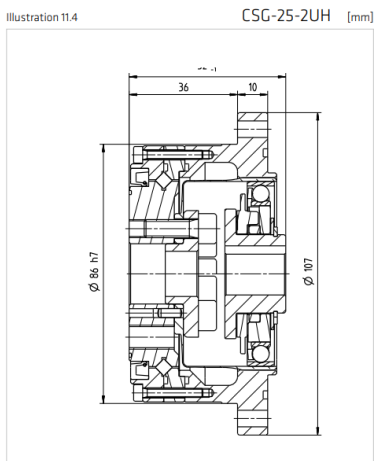


Table 10.4

	Unit	CSG-20-2UH					CSG-25-2UH				
Ratio	i []	50	80	100	120	160	50	80	100	120	160
Repeatable peak torque	T _R [Nm]	73	96	107	113	120	127	178	204	217	229
Average torque	T _A [Nm]	44	61	64	64	64	72	113	140	140	140
Rated torque	T _N [Nm]	33	44	52	52	52	51	82	87	87	87
Momentary peak torque	T _M [Nm]	127	165	191	191	191	242	332	369	395	408
Maximum input speed (oil lubrication)	n _{in(max)} [rpm]	10000					7500				
Maximum input speed (grease lubrication)	n _{in(max)} [rpm]	6500					5600				
Average input speed (oil lubrication)	n _{av(max)} [rpm]	6500					5600				
Average input speed (grease lubrication)	n _{av(max)} [rpm]	3500					3500				
Moment of inertia	J _n [x10 ⁻⁴ kgm ²]	0.193					0.413				
Weight	m [kg]	0.98					1.5				

Датчик угла:

Measurement & Elec. Data for Digital Comms Interfaces - Product Options SSI1-9, SPI, ASI1, ASI2 & BiSS-C

INC-x-58		
Measurement	Absolute over 360°. Note this is true absolute - no motion required at start up	
Resolution (121001 Product Option)	12bits 4,096counts per rev 316.4arc-secs 1536micro-rads	
Resolution (141001 Product Option)	14bits 16,384counts per rev 79.1arc-secs 384micro-rads	
Resolution (161001 Product Option)	16bits 65,536counts per rev 19.77arc-secs 96micro-rads	
Resolution (171001 Product Option)	17bits 131,072counts per rev 9.89arc-secs 48micro-rads	
Resolution (181001 Product Option)	18bits 262,144counts per rev 4.94arc-secs 24micro-rads	
Resolution (191001 Product Option)	19bits 524,288counts per rev 2.47arc-secs 12micro-rads	
Resolution (201001 Product Option)	20bits 1,048,576counts per rev 1.24arc-secs 6micro-rads	
Repeatability	+/-1	count
Static Accuracy over 360°	≤75arc-seconds or 0.36milliradians	
Internal Position Update Period	<0.1	millisecond
Thermal Drift Coefficient	≤0.50	ppm/K Full-Scale
Max. Speed for Angle Measurement	10,000	r.p.m.
Data Outputs	RS422 Compatible, supports SSI (Serial Synchronous Interface), ASI (asynchronous serial interface), SPI or BiSS-C	
Power Supply	5VDC(4.5-32VDC) or 12VDC (4.5-32VDC) or 24VDC (4.5-32VDC)	
Current Consumption	<100 (typically <75 and does not change significantly with voltage supply)	
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage	
Connector (ACx & RCx Product Options)	Harwin Data Mate Vertical Plug 10 Way with 2 Jack Screws Type M80-500-10-42 or M80-510-10-42 or M80-540-10-42	
Mating Connector (ACx & RFCx)	Harwin Data Mate Vertical Socket Type M80-461-10-42 (alternative M80-461-10-05)	
Zero Setting	Via Connector Pin or Integral Cable - see details for set and reset in relevant Section for Connector, Cable or Comms Interface	
Power Up Time To 1st Measurement	<500	millisecond

Measurement & Electrical Data for A/B/Z Pulses Comms Interfaces - Product Option ABZ1-6

INC-x-58		
Measurement	Incremental with reference mark. Position of reference mark programmable by user.	
Resolution	As above (limited to 17-bits) - resolution defined as one edge of A/B pulse train	
Repeatability	+/-1	count
Static Accuracy over 360°	≤75arc-seconds or 0.36milliradians	
Internal Position Update Period	<0.1	millisecond
Thermal Drift Coefficient	≤1	ppm/K Full-Scale
Max. Speed for Angle Measurement	10 to 16bits = 7200r.p.m. 17bits = 3600r.p.m.	
Data Outputs	A/B pulses with Z pulse ref. Z position settable from connector/cable. Z pulse width selectable by Product Option/ Part Number.	
Power Supply	5VDC±10% or 12VDC (8-32VDC) or 24VDC (8-32VDC)	
Current Consumption	<150 (does not vary significantly with supply voltage)	
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage	
Connector (ACx & RFCx Product Options)	As above - resolution defined as one edge of A/B pulse train	
Mating Connector (ACx & RFCx)	Harwin Data Mate Vertical Socket Type M80-461-10-42 (alternative M80-461-10-05)	
Z Position Setting	Via Connector Pin or Integral Cable - see details for set and reset in relevant Section for Connector, Cable or Comms Interface	
Power Up Time To 1st Measurement	<500	millisecond

Шарнир 2.

Двигатель:

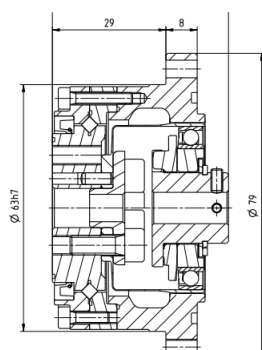
Электродвигатель	JCM50×14S	JCM69×10S
Номинальная мощность, Вт	100	180
Номинальный момент, Нм	0,32	0,57
Пиковый момент, Нм	0,96	1,71
Номинальная скорость, об/мин	3000	3000
Номинальный ток фазы, А _{фазы}	2,8	5,1
Постоянная момента, Нм/А _{фазы}	0,11	0,11
Постоянная мотора, Нм/√Вт	0,1	0,15
Напряжение питания, В _{пит}	48	48
Сопротивление (фаза-фаза), Ом	1,75	0,8
Индуктивность (фаза-фаза), мГн	0,8	0,65
Максимальный КПД, %	89	90
Число пар полюсов	10	10
Момент инерции ротора, кг·см ² *	0,082	0,2
Масса (статор + ротор), г *	125 (95+30)	180 (140+40)
Внешний диаметр статора D, мм	50	69
Внутренний диаметр ротора d, мм	30	42
Диаметр лобовых частей G, мм	48	66
Длина ротора l, мм *	16	12
Длина штырьковых лепестков h, мм	5	5
Длина статора L (max), мм	24,7	25

* – по исполнению без участия Уполн

Редуктор:

Illustration 11.2

CSG-17-2UH [mm]



	Unit	CSG-14-2UH			CSG-17-2UH			
Ratio	i []	50	80	100	50	80	100	120
Repeatable peak torque	T _R [Nm]	23	30	36	44	56	70	70
Average torque	T _A [Nm]	9.0	14	14	34	35	51	51
Rated torque	T _N [Nm]	7.0	10	10	21	29	31	31
Momentary peak torque	T _M [Nm]	46	61	70	91	113	143	112
Maximum input speed (oil lubrication)	n _{in (max)} [rpm]	14000			10000			
Maximum input speed (grease lubrication)	n _{in (max)} [rpm]	8500			7300			
Average input speed (oil lubrication)	n _{av (max)} [rpm]	6500			6500			
Average input speed (grease lubrication)	n _{av (max)} [rpm]	3500			3500			
Moment of inertia	J _m [x10 ⁻⁴ kgm ²]	0.033			0.079			
Weight	m [kg]	0.52			0.68			

Датчик угла:

Measurement & Elec. Data for Digital Comms Interfaces - Product Options SSI1-9, SPI, ASI1, ASI2 & BiSS-C

INC-x-58			
Measurement	Absolute over 360°. Note this is true absolute - no motion required at start up		
Resolution (121001 Product Option)	12bits	4,096counts per rev	316.4arc-secs 1536micro-rads
Resolution (141001 Product Option)	14bits	16,384counts per rev	79.1arc-secs 384micro-rads
Resolution (161001 Product Option)	16bits	65,536counts per rev	19.77arc-secs 96micro-rads
Resolution (171001 Product Option)	17bits	131,072counts per rev	9.89arc-secs 48micro-rads
Resolution (181001 Product Option)	18bits	262,144counts per rev	4.94arc-secs 24micro-rads
Resolution (191001 Product Option)	19bits	524,288counts per rev	2.47arc-secs 12micro-rads
Resolution (201001 Product Option)	20bits	1,048,576counts per rev	1.24arc-secs 6micro-rads
Repeatability	+/-1		
Static Accuracy over 360°	≤75arc-seconds or 0.36milliradians		
Internal Position Update Period	<0.1		
Thermal Drift Coefficient	≤0.50		
Max. Speed for Angle Measurement	10,000		
Data Outputs	RS422 Compatible, supports SSI (Serial Synchronous Interface), ASI (asynchronous serial interface), SPI or BiSS-C		
Power Supply	5VDC(4.5-32VDC) or 12VDC (4.5-32VDC) or 24VDC (4.5-32VDC)		
Current Consumption	<100 (typically <75 and does not change significantly with voltage supply)		
Reverse Polarity	PGU Reverse polarity protected to max. supply voltage		
Connector (ACx & RCx Product Options)	Harwin Data Mate Vertical Plug 10 Way with 2 Jack Screws Type M80-500-10-42 or M80-510-10-42 or M80-540-10-42		
Mating Connector (ACx & RFCx)	Harwin Data Mate Vertical Socket Type M80-461-10-42 (alternative M80-461-10-05)		
Zero Setting	Via Connector Pin or Integral Cable - see details for set and reset in relevant Section for Connector, Cable or Comms Interface		
Power Up Time To 1st Measurement	<500		

Measurement & Electrical Data for A/B/Z Pulses Comms Interfaces - Product Option ABZ1-6

INC-x-58			
Measurement	Incremental with reference mark. Position of reference mark programmable by user.		
Resolution	As above (limited to 17-bits) - resolution defined as one edge of A/B pulse train		
Repeatability	+/-1		
Static Accuracy over 360°	≤75arc-seconds or 0.36milliradians		
Internal Position Update Period	<0.1		
Thermal Drift Coefficient	≤1		
Max. Speed for Angle Measurement	10 to 16bits = 7200r.p.m. 17bits = 3600r.p.m.		
Data Outputs	A/B pulses with Z pulse ref. Z position settable from connector/cable. Z pulse width selectable by Product Option/ Part Number.		
Power Supply	5VDC±10% or 12VDC (8-32VDC) or 24VDC (8-32VDC)		
Current Consumption	<150 (does not vary significantly with supply voltage)		
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage		
Connector (ACx & RFCx Product Options)	As above - resolution defined as one edge of A/B pulse train		
Mating Connector (ACx & RFCx)	Harwin Data Mate Vertical Socket Type M80-461-10-42 (alternative M80-461-10-05)		
Z Position Setting	Via Connector Pin or Integral Cable - see details for set and reset in relevant Section for Connector, Cable or Comms Interface		
Power Up Time To 1st Measurement	<500		

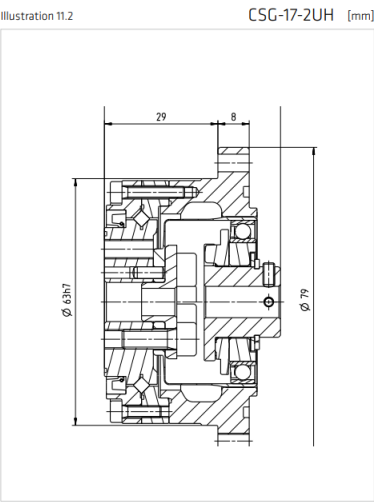
Шарнир 3.

Двигатель:

Электродвигатель	JCM50×14S	JCM69×10S
Номинальная мощность, Вт	100	180
Номинальный момент, Нм	0,32	0,57
Пиковый момент, Нм	0,96	1,71
Номинальная скорость, об/мин	3000	3000
Номинальный ток фазы, A _{ном}	2,8	5,1
Постоянная момента, Нм/A _{ном}	0,11	0,11
Постоянная мотора, Нм/√Вт	0,1	0,15
Напряжение питания, В _{ном}	48	48
Сопротивление (фаза-фаза), Ом	1,75	0,8
Индуктивность (фаза-фаза), мГн	0,8	0,65
Максимальный КПД, %	89	90
Число пар полюсов	10	10
Момент инерции ротора, кг·см ² *	0,082	0,2
Масса (статор + ротор), г *	125 (95+30)	180 (140+40)
Внешний диаметр статора D, мм	50	69
Внутренний диаметр ротора d, мм	30	42
Диаметр лобовых частей G, мм	48	66
Длина ротора l, мм *	16	12
Длина штырьковых лепестков h, мм	5	5
Длина статора L (max), мм	24,7	25

* – для исполнения без патинки Уолла

Редуктор:



	Unit	CSG-14-2UH			CSG-17-2UH			
Ratio	i []	50	80	100	50	80	100	120
Repeatable peak torque	T _R [Nm]	23	30	36	44	56	70	70
Average torque	T _A [Nm]	9.0	14	14	34	35	51	51
Rated torque	T _N [Nm]	7.0	10	10	21	29	31	31
Momentary peak torque	T _M [Nm]	46	61	70	91	113	143	112
Maximum input speed (oil lubrication)	n _{in (max)} [rpm]	14000			10000			
Maximum input speed (grease lubrication)	n _{in (max)} [rpm]	8500			7300			
Average input speed (oil lubrication)	n _{av (max)} [rpm]	6500			6500			
Average input speed (grease lubrication)	n _{av (max)} [rpm]	3500			3500			
Moment of inertia	J _{in} [x10 ⁻⁴ kgm ²]	0.033			0.079			
Weight	m [kg]	0.52			0.68			

Датчик угла:

Measurement & Elec. Data for Digital Comms Interfaces - Product Options SSH-9, SPI, ASI, ASH2 & BiSS-C

INC-58			
Measurement	Absolute over 360°. Note this is true absolute - no motion required at start up		
Resolution (12/1001 Product Option)	12bits	4,096counts per rev	316.4arc-secs 1556micro-rads
Resolution (14/1001 Product Option)	14bits	16,384counts per rev	79.1arc-secs 384micro-rads
Resolution (16/1001 Product Option)	16bits	65,536counts per rev	19.77arc-secs 96micro-rads
Resolution (17/1001 Product Option)	17bits	131,072counts per rev	9.88arc-secs 48micro-rads
Resolution (18/1001 Product Option)	18bits	262,144counts per rev	4.94arc-secs 24micro-rads
Resolution (19/1001 Product Option)	19bits	524,288counts per rev	2.47arc-secs 12micro-rads
Resolution (20/1001 Product Option)	20bits	1,048,576counts per rev	1.24arc-secs 6micro-rads
Repeatability	±1°		
Static Accuracy over 360°	±175arc-seconds or 0.36milliradians		
Internal Position Update Period	≤0.1		
Thermal Drift Coefficient	≤0.50		
Max. Speed for Angle Measurement	10,000		
Data Outputs	RS422 Compatible, supports SSI (Serial Synchronous Interface), ASI (asynchronous serial interface), SPI or BiSS-C		
Power Supply	5VDC(4.5-32VDC) or 12VDC (4.5-32VDC) or 34VDC (4.5-32VDC)		
Current Consumption	<100 (typically <75 and does not change significantly with voltage supply)		
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage		
Connector (ACx & RCx Product Options)	Harwin Data Mate Vertical Plug 10 Way with 2 Jack Screws Type M80-500-10-42 or M80-510-10-42 or M80-540-10-42		
Mating Connector (ACx & RFCx)	Harwin Data Mate Vertical Socket Type M80-461-10-42 (alternative M80-461-10-05)		
Zero Setting	Via Connector Pin or Integral Cable - see details for set and reset in relevant Section for Connector, Cable or Comms Interface		
Power Up Time To 1st Measurement	<500		

Measurement & Electrical Data for A/BIZ Pulses Comms Interfaces - Product Option ABZ1-6

INC-58			
Measurement	Incremental with reference mark. Position of reference mark programmable by user		
Resolution	As above (limited to 17-bits) - resolution defined as one edge of A/B pulse train		
Repeatability	±1°		
Static Accuracy over 360°	±175arc-seconds or 0.36milliradians		
Internal Position Update Period	≤0.1		
Thermal Drift Coefficient	≤1		
Max. Speed for Angle Measurement	10 to 18bits = 7200 p.p.m. 17bits = 3600 p.p.m.		
Data Outputs	A/B pulses with Z pulse ref. Z position selectable from connector/cable. Z pulse with selectable by Product Option/ Part Number.		
Power Supply	5VDC±10% or 12VDC (8-32VDC) or 24VDC (8-32VDC)		
Current Consumption	<150 (does not vary significantly with supply voltage)		
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage		
Connector (ACx & RFCx Product Options)	As above - resolution defined as one edge of A/B pulse train		
Mating Connector (ACx & RFCx)	Harwin Data Mate Vertical Socket Type M80-461-10-42 (alternative M80-461-10-05)		
Z Position Setting	Via Connector Pin or Integral Cable - see details for set and reset in relevant Section for Connector, Cable or Comms Interface		
Power Up Time To 1st Measurement	<500		

INC-58		
Operating Temp.	Minus 45 to +85 Minus 60 to +85Celsius for 12VCT & 24VCT Product Option. Minus45 to +105Celsius max. for 9HT Product Option Operation outside limits to be qualified by user	Celsius
Storage Temp.	Minus 55 to +125 (Minus 60 to +125 for 24CT Product Option)	Celsius
Temperature Shock	ML-STD-810G, Method 553.6, Procedure I-B (T=-40°C, T=+60°C)	
IP Rating - Rotor & Stator	IP67 for <60 minutes & 1m depth (Installed with mechanically protected connector or AFL1.9 or VFL1.9 Product Options) For additional protection for long term immersion at depth, specify product option AFL2.42 or VFL2.42 Product Option For immersion at depths of >100m select Extended Range High Pressure Option	
IP Rating - Connector	IP50 (ACx or RCx Product Option). See Section 4.7 for IP Rating of AFLx & VFLx Product Option	
Humidity	RH 0-99% standard. Selected Extended Range Option C & appropriate connector for condensing humidity or long term immersion	
Salt Fog	(Installed with protected cable/connector or any integral axial cable) Complies with DEF STAN 00-35 Pt 3 Iss. 4, Test CN2 Salt Mist Test. Select Extended Range Option C and appropriate connector for environments with significant exposure to salt fog	
Bio Hazards	(Installed with protected cable/connector or any integral axial cable) Complies with DEF STAN 00-35 Pt 4 Iss. 4 Section 11 (Hazards)	
Induced Dust & Sand	Complies with DEF STAN 00-35 Pt3 Iss 4, Test CL25 (Turbulent Dust) Cat 1. Selected Extended Range Option C and appropriate connector for environments with abrasive dust or sand.	
Mechanical Impact Resistance	IK07 - when installed - suitable for mechanical impacts from objects of >200grams from 1m height	
Shock	IEC 60068-2-27 100g for 11ms - axial & radial - suitable for most airborne, marine & armoured vehicles ML-STD-810G, Method 516.6, Procedure I-Functional Shock - axial and radial - 40 g 11 ms, sawtooth waveform For more extreme or prolonged conditions specify Extended Product Option G & preferably Integral Axial Cable	
Vibration	IEC 60068-2-6 20g for 10-2000Hz - axial and radial - suitable for most high vibration & airborne environments ML-STD-810G, Method 514.6, Procedure I - axial and radial - Category 20, for tracked vehicles For more extreme or prolonged conditions specify Extended Product Option G and preferably Integral Axial Cable	
Environmental pressure range	0 to 7 (i.e. vacuum to 7). See Extended Product Range High Pressure Option for higher operating pressures	Bar
Max. permissible press. change rate	1	Bar/second
EMC Radiated Susceptibility	(Installed) Complies with IEC 61000-6-2 - suitable for fitment in hard EMC environments	
EMC Radiated Emissions	(Installed) Complies with IEC 61000-6-4 - suitable for fitment adjacent to EMC sensitive devices	
Materials - all Product Options		
Rotor & Stator Housing	Standard range - Al alloy (6061-T6 or 6064-T6) with SurTec50. Sensor surfaces: FR4 grade epoxy Product Option A or S - Alzom finish al. alloy (6061-T6 or 6064-T6). Sensor surfaces: FR4 grade epoxy	
Connector (ACx or RCx Product Option)	PPS with Stainless Steel Screw Fixings and Gold & Tin Electrical Connections	
Miscellaneous - all Product Options		
Mass Shaft Clamp Rotor (max.)	43	grams
Mass Plain Rotor (max.)	32	grams
Mass Servo Clamp Rotor (AC1)	43	grams
Mom. of Inertia Shaft Clamp Rotor (max.)	2.0E-05	Kgm ²
Mom. of Inertia Plain Rotor (max.)	1.8E-05	Kgm ²
MTBF	0.22 failures per 1M hours based on MIL-HBK-217+ method for ground military vehicles at 20Celsius average	
MTBF	0.35 failures per 1M hours based on MIL-HBK-217+ method for naval shelled at 35Celsius average	
Hazardous materials	Standard range - Hazardous materials not used. RoHS compliant. RoHS certificate available. REACH statement available.	
Outgassing materials	Complies with NASA class'n as low outgas mat. with TML <1% & CVCM <0.1% at 125C & 24hrs vacuum to ASTM E-595-90	
ITAR classification	Not ITAR controlled. No ITAR components	
Approvals	Flammability Rating UL94V-0. Standard range - RoHS compliant - RoHS certificate available. REACH statement available.	
Marking	Zetex, logo, CE & UL94V-0 printed on Rotor & Stator bases, Serial No. labelled on exterior diameter of Stator housing Extended Product Range Option E - engraved serial number and part number on exterior faces of Stator & Rotor	
Country of Manufacture	UK	
Export Licence Requirements	Not required for standard product options	

Шарнир 4.

Двигатель:

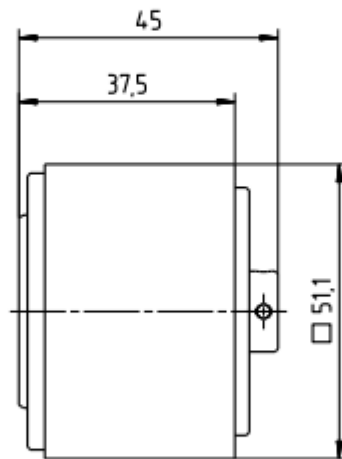
Электродвигатель	JCM38×06S	JCM38×12S
Номинальная мощность, Вт	56	58
Номинальный момент, Нм	0,07	0,14
Пиковый момент, Нм	0,21	0,42
Номинальная скорость, об/мин	8000	4000
Номинальный ток фазы, А _{азелл}	3,2	3,2
Постоянная момента, Нм/А _{азелл}	0,022	0,043
Постоянная мотора, Нм/√Вт	0,03	0,05
Напряжение питания, В _{азелл}	24	24
Сопротивление (фаза-фаза), Ом	0,6	0,86
Индуктивность (фаза-фаза), мГн	0,24	0,5
Максимальный КПД, %	90	88
Число пар полюсов	7	7
Момент инерции ротора, кг·см ² *	0,01	0,02
Масса (статор + ротор), г *	64 (54+10)	94 (74+20)
Внешний диаметр статора D, мм	38	38
Внутренний диаметр ротора d, мм	18	18
Диаметр лобовых частей G, мм	36,2	36,2
Длина ротора l, мм *	8	16
Длина штырьковых лепестков h, мм	5	5
Длина статора L (max), мм	16,5	22,5

* – для исполнения без датчиков Холла

Редуктор:

Illustration 22.2

CSF-14-1U-CC-F [mm]



	Unit	CSF-14-1U-CC-F			
Ratio	i []	30	50	80	100
Repeatable peak toque	T_R [Nm]	9.0	18	23	28
Average torque	T_A [Nm]	6.8	6.9	11	11
Rated torque	T_N [Nm]	4.0	5.4	7.8	7.8
Momentary peak torque	T_M [Nm]	17	35	47	54
Maximum input speed (grease lubrication)	$n_{in(max)}$ [rpm]	8500			
Average input speed (grease lubrication)	$n_{av(max)}$ [rpm]	3500			
Moment of inertia	J_{in} [$\times 10^{-4}$ kgm ²]	340			
Weight	m [g]	295			

Датчик угла:

4.11 Measurement, Electrical & Environmental Data (37mm)

Measurement, Electrical, Environmental & Material Data for 37mm IncOder

Measurement		
Measurement	Absolute over 360°. Note this is true absolute - no motion required at start-up	
Resolution (101001 Product Option)	10bit 1,024counts per rev 1265.6arc-secs 6144micro-rads	
Resolution (121001 Product Option)	12bit 4,096counts per rev 316.4arc-secs 1536micro-rads	
Resolution (141001 Product Option)	14bit 16,384counts per rev 79.1arc-secs 394micro-rads	
Resolution (161001 Product Option)	16bit 65,536counts per rev 19.77arc-secs 96micro-rads	
Resolution (171001 Product Option)	17bit 131,072counts per rev 2.47arc-secs 48micro-rads	
Repeatability	±1	count
Static Accuracy over 360°	<150arc-seconds or <0.73milliradians	
Internal Position Update Period	<0.1	
Thermal Drift Coefficient	<1.0	
Max. Speed for Angle Measurement	10,000	
Max. Physical Speed	10,000	
Electrical		
Data Outputs	RS422 Compatible, supports SS (Serial Synchronous Interface), ASI (asynchronous serial interface), SPI or BiSS-C.	
Power Supply	5VDC (4.5-5VDC) or 12VDC (4.5-14VDC)	
Current Consumption	<100 (typically <75 and does not change significantly with voltage supply)	
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage	
Zero Setting	Zero Set or Reset to factory value via Electronics Module	
Power Up Time To 1st Measurement	<500	
Environment		
Operating Temp.	Minus 45 to +85 (+65 at +8VDC power supply)	
Storage Temp.	Operation outside limits to be qualified by user. At temperatures >85Celsius, duration should be minimised.	
Temperature Shock	Minus 55 to +125	
IP Rating - Rotor & Stator	ML-STD-810G, Method 503.5, Procedure I-B (T1=-40 °C, T2=65 °C)	
Humidity	IP67 for >40 minutes & 1m depth	
Salt Fog	RH 0-99% non-condensing - but unaffected by occasional condensation	
Bio Hazards	Complies with DEF STAN 00-35 Pt 3 Iss. 4, Test CN2 Salt Mist Test	
Induced Dust & Sand	Complies with DEF STAN 00-35 Pt 3 Iss. 4, Section 11 (Hazards)	
Shock	IEC 60068-2-27 100g for 11ms - axial & radial - suitable for most airborne, marine & armoured vehicles	
Vibration	ML-STD-810G, Method 516.6, Procedure I-Functional Shock - axial and radial - 40 g 11 ms, sawtooth waveform	
Environmental pressure range	IEC 60068-2-6 20g for 10-2000Hz - axial and radial - suitable for most high vibration & airborne environments	
Max. permissible press. change rate	ML-STD-810G, Method 514.6, Procedure I - axial and radial - Category 20, for tracked vehicles	
EMC Radiated Susceptibility	0 to 4 (in other words vacuum to 4)	
EMC Radiated Emissions	1 Bar/second	
EMC Radiated Emissions	(Installed) Complies with IEC 61000-6-2 - suitable for fitment in harsh EMC environments	
EMC Radiated Emissions	(Installed) Complies with IEC 61000-6-4 - suitable for fitment adjacent to EMF sensitive devices	
Miscellaneous		
Mass Set-Screw Rotor (max.)	10 (for 8mm bore)	
Mass Plain Rotor (max.)	7 (for 8mm bore)	
Mass Screw Mount Stator (max.)	20 (for 8mm bore)	
Mass E-Module in Housing	25	
MTBF	0.22 failures per 1M hours based on MIL-HBK-217+ method for ground military vehicles at 20Celsius average	
MTBF	0.35 failures per 1M hours based on MIL-HBK-217+ method for naval sheltered at 35Celsius average	
Hazardous materials	Standard range - Hazardous materials not used. RoHS compliant. RoHS certificate available. REACH statement available.	
Outgassing materials	Complies with NASA classin as low outgas mat. with TML <1% & CVCM <0.1% at 125C & 24hrs in vacuum to ASTM E-595-90	
ITAR classification	Not ITAR controlled. No ITAR components.	
Approvals	Flammability Rating UL94V-0. Standard range - RoHS compliant - RoHS certificate available. REACH statement available.	
Marking	Zellflex, logo, CE & UL94V-0 printed on Rotor & Stator faces; Serial Number label.	
Country of Manufacture	Extended Product Range Option E - engraved serial number and part number on exterior faces of Stator & Rotor	
Export Licence Requirements	UK	
Export Licence Requirements	Not required for standard product options	

Шарнир 5.

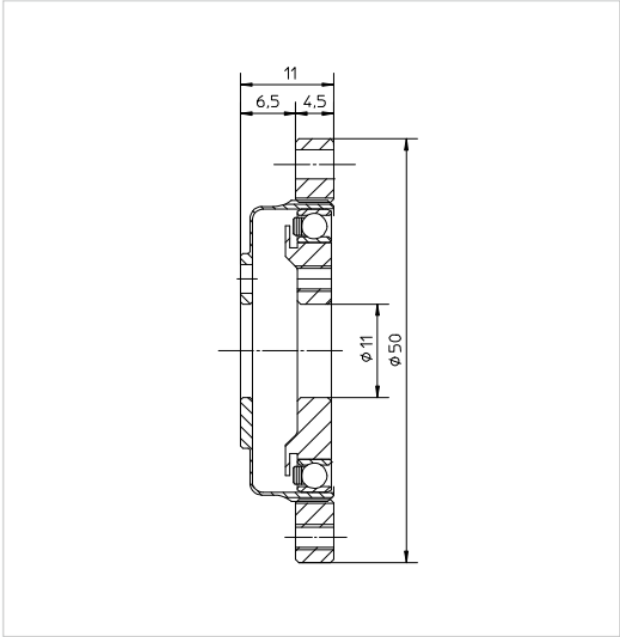
Двигатель:

Электродвигатель	JCM38×065
Номинальная мощность, Вт	56
Номинальный момент, Нм	0,07
Пиковый момент, Нм	0,21
Номинальная скорость, об/мин	8000
Номинальный ток фазы, A _{фазы}	3,2
Постоянная момента, Нм/A _{фазы}	0,022
Постоянная мотора, Нм/√Вт	0,03
Напряжение питания, В _{пит}	24
Сопротивление (фаза-фаза), Ом	0,6
Индуктивность (фаза-фаза), мГн	0,24
Максимальный КПД, %	90
Число пар полюсов	7
Момент инерции ротора, кг·см² *	0,01
Масса (статор + ротор), г *	64 (54+10)
Внешний диаметр статора D, мм	38
Внутренний диаметр ротора d, мм	18
Диаметр лобовых частей G, мм	36,2
Длина ротора l, мм *	8
Длина штырьковых лепестков h, мм	5
Длина статора L (max), мм	16,5

Редуктор:

Illustration 11.1

CSD-14-2A [mm]



	Unit	CSD-14-2A	
Ratio	i []	50	100
Repeatable peak torque	T_{rp} [Nm]	12	19
Average torque	T_{ra} [Nm]	4.8	7.7
Rated torque	T_{rn} [Nm]	3.7	5.4
Momentary peak torque	T_{rt} [Nm]	24	31
Maximum input speed (oil lubrication)	$n_{in(max)}$ [rpm]	14000	
Maximum input speed (grease lubrication)	$n_{in(max)}$ [rpm]	8500	
Average input speed (oil lubrication)	$n_{av(max)}$ [rpm]	6500	
Average input speed (grease lubrication)	$n_{av(max)}$ [rpm]	3500	
Moment of inertia	J_{in} [$\times 10^{-4}$ kgm ²]	0.021	
Weight	m [kg]	0.06	

Датчик угла:



4.11 Measurement, Electrical & Environmental Data (37mm)

Measurement, Electrical, Environmental & Material Data for 37mm IncOder

Measurement		
Measurement	Absolute over 360° Note this is true absolute - no motion required at start-up	
Resolution (101001 Product Option)	10bit 1,024counts per rev 1265.6arc-secs 6144micro-rads	
Resolution (121001 Product Option)	12bit 4,096counts per rev 316.4arc-secs 1536micro-rads	
Resolution (141001 Product Option)	14bit 16,384counts per rev 79.1arc-secs 394micro-rads	
Resolution (161001 Product Option)	16bit 65,536counts per rev 19.77arc-secs 96micro-rads	
Resolution (171001 Product Option)	17bit 131,072counts per rev 2.47arc-secs 48micro-rads	
Repeatability	+/-1	
Static Accuracy over 360°	<150arc-seconds or <0.73milliradians	
Internal Position Update Period	<0.1	
Thermal Drift Coefficient	<1.0	
Max. Speed for Angle Measurement	10,000	
Max. Physical Speed	10,000	
Electrical		
Data Outputs	RS422 Compatible, supports SS (Serial Synchronous Interface), ASI (asynchronous serial interface), SPI or BiSS-C.	
Power Supply	5VDC (4.5-8VDC) or 12VDC (4.5-14VDC)	
Current Consumption	<100 (typically <75 and does not change significantly with voltage supply)	
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage	
Zero Setting	Zero Set or Reset to factory value via Electronics Module	
Power Up Time To 1st Measurement	<500	
Environment		
Operating Temp.	Minus 45 to +85 (+65 at +8VDC power supply)	
Storage Temp.	Operation outside limits to be qualified by user. At temperatures >85Celsius, duration should be minimized.	
Temperature Shock	Minus 55 to +125	
IP Rating - Rotor & Stator	ML-STD-810G, Method 503.5, Procedure I-B (T1=-40 °C, T2=65 °C.)	
Humidity	IP67 for >40 minutes & 1m depth	
Salt Fog	RH 0-99% non-condensing - but unaffected by occasional condensation	
Bio Hazards	Complies with DEF STAN 00-35 Pt 3 Iss. 4, Test CN2 Salt Mist Test	
Induced Dust & Sand	Complies with DEF STAN 00-35 Part 3 Issue 4, Test CL25 (Turbulent Dust) Cat 1	
Shock	IEC 60068-2-27 100g for 11ms - axial & radial - suitable for most airborne, marine & armoured vehicles	
Vibration	ML-STD-810G, Method 516.6, Procedure I-Functional Shock - axial and radial - 40 g 11 ms, sawtooth waveform	
Environmental pressure range	IEC 60068-2-6 20g for 10-2000Hz - axial and radial - suitable for most high vibration & airborne environments	
Max. permissible press. change rate	ML-STD-810G, Method 514.6, Procedure I - axial and radial - Category 20, for tracked vehicles	
EMC Radiated Susceptibility	0 to 4 (in other words vacuum to 4)	
EMC Radiated Emissions	1	
EMC Radiated Immunity	(Installed) Complies with IEC 61000-6-2 - suitable for fitment in harsh EMC environments	
EMC Radiated Emissions	(Installed) Complies with IEC 61000-6-4 - suitable for fitment against EMI sensitive devices	
Miscellaneous		
Mass Set-Screw Rotor (max.)	10 (for 8mm bore)	
Mass Plain Rotor (max.)	7 (for 8mm bore)	
Mass Screw Mount Stator (max.)	20 (for 8mm bore)	
Mass E-Module in Housing	25	
MTBF	0.22 failures per 1M hours based on MIL-HBK-217+ method for ground military vehicles at 20Celsius average	
MTBF	0.35 failures per 1M hours based on MIL-HBK-217+ method for naval sheltered at 35Celsius average	
Hazardous materials	Standard range - Hazardous materials not used. RoHS compliant. RoHS certificate available. REACH statement available.	
Outgassing materials	Complies with NASA class as low outgas mat. with TML <1% & CVCM <0.1% at 125C & 24hrs in vacuum to ASTM E-595-90	
ITAR classification	Not ITAR controlled. No ITAR components.	
Approvals	Flammability Rating UL94V-0. Standard range - RoHS compliant. RoHS certificate available. REACH statement available.	
Marking	Zellflex, logo, CE & UL94V-0 printed on Rotor & Stator faces; Serial Number label.	
Country of Manufacture	Extended Product Range Option E - engraved serial number and part number on exterior faces of Stator & Rotor	
Export Licence Requirements	UK	
	Not required for standard product options	

Шарнир 6.

Двигатель:

Электродвигатель	JCM38×065
Номинальная мощность, Вт	56
Номинальный момент, Нм	0,07
Пиковый момент, Нм	0,21
Номинальная скорость, об/мин	8000
Номинальный ток фазы, А _{фазы}	3,2
Постоянная момента, Нм/А _{фазы}	0,022
Постоянная мотора, Нм/√Вт	0,03
Напряжение питания, В _{пит}	24
Сопротивление (фаза-фаза), Ом	0,6
Индуктивность (фаза-фаза), мГн	0,24
Максимальный КПД, %	90
Число пар полюсов	7
Момент инерции ротора, кг·см ² *	0,01
Масса (статор + ротор), г *	64 (54+10)
Внешний диаметр статора D, мм	38
Внутренний диаметр ротора d, мм	18
Диаметр лобовых частей G, мм	36,2
Длина ротора l, мм *	8
Длина штырьковых лепестков h, мм	5
Длина статора L (max), мм	16,5

Редуктор:

Червяк с коэффициентом передачи 50

Датчик угла:



4.11 Measurement, Electrical & Environmental Data (37mm)

Measurement, Electrical, Environmental & Material Data for 37mm IncOder

Measurement		
Measurement	Absolute over 360°. Note this is true absolute - no motion required at start-up	
Resolution (101001 Product Option)	10bits 1,024counts per rev 1265.6arc-secs 6144micro-rads	
Resolution (121001 Product Option)	12bits 4,096counts per rev 316.4arc-secs 1536micro-rads	
Resolution (141001 Product Option)	14bits 16,384counts per rev 79.1arc-secs 394micro-rads	
Resolution (161001 Product Option)	16bits 65,536counts per rev 19.77arc-secs 96micro-rads	
Resolution (171001 Product Option)	17bits 131,072counts per rev 2.47arc-secs 48micro-rads	
Repeatability	+/-1	
Static Accuracy over 360°	<150arc-seconds or <0.73milliradians	
Internal Position Update Period	<0.1	
Thermal Drift Coefficient	<1.0	
Max. Speed for Angle Measurement	10,000	r.p.m
Max. Physical Speed	10,000	r.p.m
Electrical		
Data Outputs	RS422 Compatible, supports SS (Serial Synchronous Interface), ASI (asynchronous serial interface), SPI or BiSS-C.	
Power Supply	SVDG (4.5-8VDC) or 12VDC (4.5-14VDC)	
Current Consumption	<100 (typically <75 and does not change significantly with voltage supply)	
Reverse Polarity	PSU Reverse polarity protected to max. supply voltage	
Zero Setting	Zero Set or Reset to factory value via Electronics Module	
Power Up Time To 1st Measurement	<500	
Environment		
Operating Temp.	Minus 45 to +85 (+65 at +8VDC power supply)	Celsius
Storage Temp.	Operation outside limits to be qualified by user. At temperatures +85Celsius, duration should be minimized.	Celsius
Temperature Shock	Minus 55 to +125	Celsius
IP Rating - Rotor & Stator	ML-STD-810G, Method 503.5, Procedure I-B (T1=-40 °C, T2=+65 °C.)	
Humidity	IP67 for >40 minutes & 1m depth	
Salt Fog	RH 0-99% non-condensing - but unaffected by occasional condensation	
Bio Hazards	Complies with DEF STAN 00-35 Pt 3 Iss. 4, Test CN2 Salt Mist Test	
Induced Dust & Sand	Complies with DEF STAN 00-35 Pt 4 Issue 4, Test CL25 (Turbulent Dust) Cat 1	
Shock	IEC 60068-2-27 100g for 11ms - axial & radial - suitable for most airborne, marine & armoured vehicles	
Vibration	ML-STD-810G, Method 516.6, Procedure I-Functional Shock - axial and radial - 40 g 11 ms, sawtooth waveform	
Environmental pressure range	IEC 60068-2-6 20g for 10-2000Hz - axial and radial - suitable for most high vibration & airborne environments	
Max. permissible press. change rate	ML-STD-810G, Method 514.6, Procedure I - axial and radial - Category 20, for tracked vehicles	
EMC Radiated Susceptibility	0 to 4 (in other words vacuum to 4)	
EMC Radiated Emissions	1	
EMC Radiated Susceptibility	(Installed) Complies with IEC 61000-6-2 - suitable for fitment in harsh EMC environments	
EMC Radiated Emissions	(Installed) Complies with IEC 61000-6-4 - suitable for fitment adjacent to EMF sensitive devices	
Miscellaneous		
Mass Set-Screw Rotor (max.)	19 (for 8mm bore)	grams
Mass Plain Rotor (max.)	7 (for 8mm bore)	grams
Mass Screw Mount Stator (max.)	20 (for 8mm bore)	grams
Mass E-Module in Housing	25	grams
MTBF	0.22 failures per 1M hours based on MIL-HBK-217+ method for ground military vehicles at 20Celsius average	
MTBF	0.35 failures per 1M hours based on MIL-HBK-217+ method for naval sheltered at 35Celsius average	
Hazardous materials	Standard range - Hazardous materials not used. RoHS compliant. RoHS certificate available. REACH statement available.	
Outgassing materials	Complies with NASA class as low outgas mat. with TML <1% & CVCM <0.1% at 125C & 24hrs in vacuum to ASTM E-595-90	
ITAR classification	Not ITAR controlled. No ITAR components.	
Approvals	Flammability Rating UL94V-0. Standard range - RoHS compliant. RoHS certificate available. REACH statement available.	
Marking	Zellflex, logo, CE & UL94V-0 printed on Rotor & Stator faces; Serial Number label.	
Country of Manufacture	Extended Product Range Option E - engraved serial number and part number on exterior faces of Stator & Rotor	
Export Licence Requirements	UK	
Export Licence Requirements	Not required for standard product options	