/\*

1. Motor Inertia:

<https://www.motioncontroltips.com/faq-what-is-servo-motor-inertia-and-why-does-it-matter/#:~:text=In%20general%2C%20the%20higher%20the,be%2010%3A1%20or%20lower>.

Motor Inertia Ratio

JL = inertia of load reflected to motor  
JM = inertia of motor ---------------------datasheet

---------------------------Maximum of 10:1

If your application requires high acceleration- deceleration rates or fast cycles, we recommend that load-to-motor inertia ratio of either type motor be reduced to less than 4:1, and in very high dynamic applications, to 1:1.

1. Type of Motor:

<https://www.a-m-c.com/types-of-motors-in-motion-control/>

<https://www.machinedesign.com/motors-drives/article/21826707/motor-selection-guidelines-for-precision-motion-control>

Servo Motor:

* Power efficiency and small size
* Very precise control when there is feedback device (rotary encoder) and servo drive
* Closed loop control
* Constant torque over wide speed range (upto 2500 rpm)
* Load and motor inertia balance

1. Encoder choosing:

<https://www.machinedesign.com/mechanical-motion-systems/article/21836107/whats-the-difference-between-absolute-and-incremental-encoders>

<https://en.wikipedia.org/wiki/Rotary_encoder>

Two types:

* Absolute **(recommended)**
* Types: Mechanical absolute, optical absolute, **magnetic absolute (suitable for insensitivity to vibrations, minor misalignment or shocks, better performance in dust and debris environment)**
  + Remembers its position after a power outage and offers continuous position monitoring
  + Typically have speed, scaling, pre-set, and fieldbus functions
  + Allow you to determine the exact position of a machine and control over the storage of electronic data
  + Multiple interface options: Analog, Ethernet, Fieldbus, Parallel, Serial
  + Single-turn and Multi-turn revolution options available
  + Optical a magnetic measuring principle
  + Absolute encoders have a resolution of up to 16 bits, or 65,536 pulses per revolution (PPR).
* Incremental
  + Good for simple pulse counting or frequency monitoring applications such as speed, direction, and position monitoring
  + More cost-effective and less complex than an absolute encoder
  + A, B, Z, and inverted signals as HTL (Push-Pull) or TTL (RS422).
  + Any pulse count up to 16384 PPR available
  + Flexible scaling functionality
  + Magnetic measuring principle
  + Incremental encoders have a resolution of up to 50,000 PPR.

1. Choosing Encoder type:
   * Absolute->Magnetic Absolute->Gray Encoding Method (recommended)
   * Incremental->
2. Motor Sizing:

* Dependant on maximum torque\*/

1. Selection of Power Supply Adapter:
2. 230 VAC/12 VDC

* Calculation of Power Rating (P): 12V \* Maximum Current drawn by peripherals

Peripherals that are excited with 12 V are:

* + BLDC Motor 1 (Nominal Current = 10 A)
  + [ESCON Controller 1 + DC Motor 2 (6 A)] + [Micro-Controller (0.14 A) with 3.6 V Excitation] + [Limit Switch 1 (0.004 A) with 3.6 V Excitation]
  + [ESCON Controller 2 + BLDC Motor 3 (4.72 A)] + [Limit Switch 2 (0.004 A) with 3.6 V Excitation]
  + [ESCON Controller 3 + BLDC Motor 4 (4.53 A)] + [Limit Switch 3 (0.004 A) with 3.6 V Excitation]
  + [Proximity Sensor (0.066 A)] \* 2 Units = 0.132 A

P = [12 \* (10 + 6 + 4.72 + 4.53 + 0.132)] + [3.6 \* (0.14 + (0.004\*3))]

= [12 \* 25.382] + [3.6 \* 0.152]

= 305.1312 W

Considering a safety factor of 1.5, Power required for the power supply adapter is (305.1312 \* 1.5) = 457.6969 W

|  |  |  |  |
| --- | --- | --- | --- |
| Manufacturer | Mean Well USA Inc. | Cincon Electronics Co. Ltd. | XP Power |
| Part Number | MSP-450-12 | TR160MA120 | AHM150PS12 |
| Power Rating | 450 W | 160 W | 150 W |
| Input Voltage | 85 – 264 VAC | 80 – 264 VAC | 80 – 264 VAC |
| Output Voltage | 12 VDC | 12 VDC | 12 VDC |
| Rated Output Current | 37.5 A | 12.5 A | 12.5 A |
| Efficiency | 88 % | 91 % | 92 % |
| Load Regulation | 0.5 % | 4 % | 3 % |
| Mounting Type | Chassis Mount | Desktop/Wall Mount | Desktop/Wall Mount |
| Converter Type | SMPS | SMPS | SMPS |
| Units Required | 1 | 3 | 3 |
| Application | Medical | Medical | Medical |
| Dimensions (mm) | 218 x 105 x 41 | 150 x 70 x 38 | 200 x 80 x 37 |

1. 230 VAC/5 VDC
   * Calculation of Power Rating (P): 5V \* Maximum Current drawn by peripherals

Peripherals that are excited with 5 V are:

* + [Encoder (Nominal Current = 0.05 A)] \* 4 Units = 0.2 A
  + Load Cell = 0.05 A

P = [5 \* (0.2 + 0.05)]

= 1.25 W

Considering a safety factor of 1.5, Power required for the power supply adapter is (1.25 \* 1.5) = 1.875 W

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Manufacturer | TDK Corporation | CUI Inc. | Artesyn Embedded Power | XP Power |
| Part Number | WMM30CN050 | SWM12-5-E | DA10-050UK | ACM12US05 |
| Power Rating | 25 W | 12 W | 10 W | 10 W |
| Input Voltage | 80 – 264 VAC | 90 – 264 VAC | 90 – 264 VAC | 90 – 264 VAC |
| Output Voltage | 5 VDC | 5 VDC | 5 VDC | 5 VDC |
| Rated Output Current | 5 A | 2.4 A | 2 A | 2 A |
| Efficiency | 85 % | Very High | 79 % | 80.6 % |
| Load Regulation | 6 % | 2 % | N/A (No Load Power = 75 mW) | 5 % |
| Mounting Type | Wall Mount | Wall Mount | Wall Mount | Wall Mount |
| Outlet Type\* | International | Europe | United Kingdom | International |
| Converter Type | SMPS | SMPS | SMPS | SMPS |
| Application | Medical | Medical | Medical | Medical |
| Dimensions (mm) | 96.7 x 58 x 43.25 | 55 x 25 x 55 | 81.3 x 39.5 x 25 | 76 x 30.3 x 48.2 |

\* Adapters can be used to fit into Indian Socket Outlets.

Power Supply selected for 12 VDC: Mean Well MSP-450-12

* EMC Compatibility and Standards Check:

1. Controller Selection: All are Micro-Controller Units
   * Microchip:

* PIC32MK0512MCF064 – 32-bit architecture (for motor driving)
  + Renesas Electronics:
* R5F513T5AGFL – 32-bit architecture (for motor driving)
* R7FA6M3AF3CFP – 32-bit architecture (for motor driving)
  + STMicroelectronics:
* STM8s – 8-bit architecture (for Motor Driving)
* STM32G0 – 32-bit architecture (for Motor Driving)
  + Texas Instruments:
* TMS320F28379D – C2000 real-time control MCUs (for Motor Driving)
* RM46L450 – Hercules MCUs (for Automation & Control applications)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Manufacturer** | **STM** | **STM** | **Renesas** | **Renesas** | **TI** | **TI** | **Microchip** |
| **Part Number** | STM8S903K3 | STM32G031x4(\_C4) | R5F513T5AGFL | R7FA6M3AF3CFP | TMS320F28379D | RM46L450ZWT | PIC32MK0512MCF064 |
| **Architecture** | 8-bit | 32-bit | 32-bit | 32-bit | 16/32-bit | 16/32-bit | 32-bit |
| **Pins Count** | 32 | 48 | 48 | 100 | 176 | 144 | 64 |
| **Max. GPIO** | 28 | 44 | 38 | 76 | 169 | 101 | 49 |
| **External Interrupts** | 28 | 44 | 6 +1 Non-Maskable Interrupt | 16 +1 Non-Maskable Interrupt | 5 | 10 | 49 (5 programmable) |
| **Timers** | 3 (2 16-bit,  1 8-bit) | 6 | 6 | 13 | 6 | 44 | 9 |
| **A/D Channel** | 1 (7 channels) | 1 (12 channels) | 1 (8 channels) | 1 (19 channels) | 2 (12 channels) + 2 (24 channels) | 1 (24 channels) + 1 (12 channels shared with ADC1) | 7 (26 channels) |
| **RAM** | 1 kB | 8 kB | 12 kB | 64 kB | 128 kB | 128 kB | 128 kB |
| **ROM** | 8 kB | 16 kB | 128 kB | 1 MB | 1 MB | 1 MB | 512 kB |
| **UART Pins** | 1 Set | 2 Sets (USART) +  1 Set (Low\_PowerUART) | 3 Sets | 10 Sets | 4 Sets | 2 Sets | 6 Sets |
| **SPI Pins** | 1 Set | 2 Sets | 3 Sets | 2 Sets | 3 Sets | 2 Sets | 6 Sets |
| **I2C Pins** | 1 Set | 2 Sets | 1 Set | 2 Set | 2 Sets | 1 Set | N/A |
| **PWM Pins** | N/A (achieved through Timer) | N/A (achieved through Timer) | 5 Pins | 28 Pins | 24 Pins | 14 PIns | 16 Pins |
| **Operating Frequency** | Upto 12MHz | Upto 64MHz | Upto 32MHz | Upto 120MHz | Upto 200MHz | Upto 200MHz | Upto 120Mhz |
| **Operating Voltage** | 2.95 – 5.5V | 1.7 - 3.6V | 2.7 – 5.5V | 2.7 – 3.6V | 3.3V | 3 – 3.6V | 2.2 – 3.6V  I/O Pins (upto 5V) |
| **Link** |  |  |  | https://www.renesas.com/us/en/document/dst/renesas-ra6m3-group-datasheet?language=en |  |  |  |

**Major Factors for considering Micro-Controller Unit with respect to motion control:**

* + **Timer Control (depends on operating frequency):** Time duration of the control signal given by the micro-controller to the motor driver will depend on the Timer modes and calculations. The precise and higher resolution time values are obtained if the operating frequency is higher. Therefore, higher the operating frequency, better will be the precision of the Timer control. Higher the number of timers, more the number of peripherals that can be controlled individually. In our case, 1 BLDC/DC Motor requires one Motor Driver for height control.
  + **Motor Driver Voltage Signal Compatibility (for BLDC Motor):**

If Micro-controller operates on 3.3V logic and if the signal needed by the driver is 5V, then Level Shifter needs to be used

* + **PWM Pins:** It determines how many motors which requires PWM signal can be controlled, in our case, for 2 servo motors, 2 PWM pins are sufficient
  + **Communication (UART, SPI, I2C) Pins:** Encoders that are used will communicate position and other readings to the micro-controller with the help of some protocol. Higher the number of Communication channels, more the number of peripherals that can be connected to the MCU.

**Decision Analysis and Resolution: specific towards Motion Control using Motor**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Manufacturer**  **->** | **STM** | **STM** | **Renesas** | **Renesas** | **TI** | **TI** | **Microchip** |
| **Part Number**  **->** | **STM8S903K3** | **STM32G031x4(\_C4)** | **R5F513T5AGFL** | **R7FA6M3AF3CFP** | **TMS320F28379D** | **RM46L450ZWT** | **PIC32MK0512MCF064** |
| **Criteria** |  |  |  |  |  |  |  |
| **No. of Timers/Operating Frequency**  **Required: 1** | 3 (2 16-bit,  1 8-bit)/12 MHz | 6/64 MHz | 6/32 MHz | 13/120Mhz | 6/200 MHz | 44/200 MHz | 9/120 MHz |
| **Status/Notes on Timer Pins** | **✓** | **✓** | **✓** | **✓**  Second Alternative because the frequency of operation is also high and 9 Timers are sufficient | **✓** | **✓**  Higher the frequency, more the precision and the number of Timers, more the individually controlled peripherals | **✓** |
| **Motor Driver Voltage Compatibility (for BLDC Motor)**  **Optimal value: 5V** | 2.95 – 5.5V | 1.7 - 3.6V | 2.7 – 5.5V | 2.7 - 3.6V | 3.3V | 3 – 3.6V | 2.2 – 3.6V  I/O Pins (upto 5V) |
| **Status/Notes on Motor Driver Voltage Compatibility** | **X**  Level Shifters needs to be used for converting digital voltage level from micro-controller to motor driver | | **✓**  The I/O voltage from the pins can be directly fed to the motor driver | **X**  Level Shifters needs to be used for converting digital voltage level from micro-controller to motor driver | | | |
| **No. of PWM Pins**  **Required: 2** | N/A (achieved through Timer) | N/A (achieved through Timer) | 5 Pins | 28 Pins | 24 Pins | 14 PIns | 16 Pins |
| **Status/Notes on PWM Pins** | **X**  Without PWM pins, precise control of Servo motors is not achieved. As a second alternative, Timers can be used to produce PWM signals | | **✓** | **✓**  Total number of servo motors that can be controlled is 24 | **✓**  Second Alternative | **✓** | **✓** |
| **Communication Pins**  **(UART/SPI/I2C)**  **Required: (yet to be decided)** | (1,1,1) | (2,2,2) | (3,3,1) | (10,2,2) | (4,3,2) | (2,2,1) | (6,6,0) |
| **Status/Notes on Communication Pins** | - | - | - | - | - | - | - |

**Recommended Controller: Renesas (R7FA6M3AF3CFP)**

1. Proximity Sensor Selection:

|  |  |  |  |
| --- | --- | --- | --- |
| Manufacturer | Omron Automation & Safety | Panasonic Industrial Automation Sales | Autonics Corporation |
| Part Number | E2E-X14C118 2M | GX-N30M | PRDW18-7DN-V |
| Sensor Type | Inductive | Inductive | Inductive |
| Shielding | Shielded | Shielded | Shielded |
| Operating Voltage | 10 – 30 VDC | 12 – 24 VDC | 12 – 24 VDC |
| Operating Current | 16 mA | 10 mA | 10 mA |
| Maximum Load Current | 50 mA | 100 mA | 200 mA |
| Sensing Distance | 14 mm | 8 mm | 7 mm |
| Output Type | NPN | NPN | NPN |
| Operation Mode | NO | NO | NO |
| Response Frequency | 350 Hz | 300 Hz | 300 Hz |
| Dimensions (mm) | (Φ29 x 55.3) | (Φ30 x 39.5) | (Φ29 \* 53.6) |

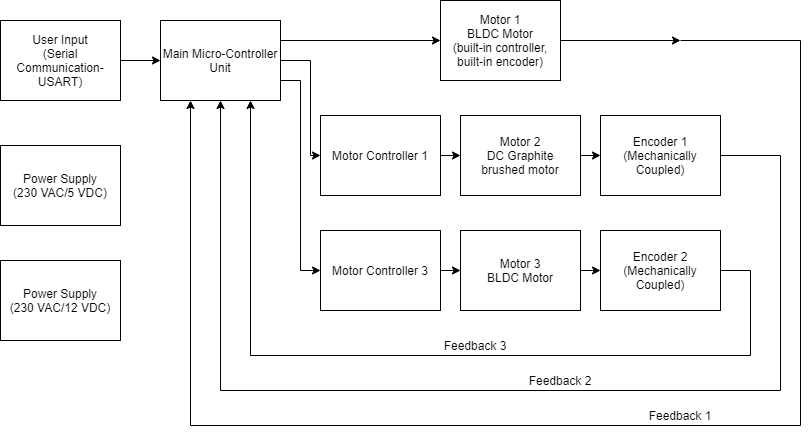
**Requirement specification:**

1. Power Supply: 230 VAC/12 VDC
2. Main Controller: Microcontroller (32-bit architecture)
3. Motor Selection:
   1. Linear Motion (height)-Brushless DC Motor/DC Motor
   2. Rotational Motion 1: Servo Motor
   3. Rotational Motion 2: Servo Motor
4. Encoder (for BLDC Motor):
   1. Incremental Encoder
5. Motor Drivers:
   1. Linear Motor Driver (for BLDC Motor)

|  |  |  |
| --- | --- | --- |
| **Requirement ID** | **Description** | **Notes** |
| SC-EE01 | Power Supply Adaptor - to convert to operational DC Voltage | Used for:   * Converting AC Power to DC Power (230 VAC/12VDC)   Key Parameters:   * Power Rating (max. current drawn) * Type of connector (on the board) |
| SC-EE02 | Main Controller – Micro-Controller Unit | Used for:   * Accepting User Inputs using Serial Interface (UART) * Calculating values for motor control – Timer calculation, PWM time calculation * Feed the signal for BLDC Motor Driver * Feed the PWM signals for Servo Motors * Communicate the readings from Encoders of 3 Motors |
| SC-EE03 | Linear Motion Motor (for vertical movement) – BLDC/DC Motor | Used for:   * Linear Motion Control achieved through driving Lead Screw |
| SC-EE04 | Servo Motor 1 (for rotational movement) | Used for:   * Achieving Rotational Movement for first arm * Additional circuitry for encoder available and is used to measure rotational position and other parameters |
| SC-EE05 | Servo Motor 2 (for rotational movement) | Used for:   * Achieving Rotational Movement for second arm * Additional circuitry for encoder available and is used to measure rotational position and other parameters |
| SC-EE06 | Encoder (for BLDC/DC Motor) | Used for:   * This encoder is mechanically coupled with BLDC/DC motor to measure rotational position and other parameters |
| SC-EE07 | Motor Driver (for BLDC/DC Motor) | Used for:   * Motor is driven with the help of signal from the micro-controller. * General working: for ‘T’ seconds input from Micro-controller, ‘T’ seconds the motor will be driven by the Motor Driver |
|  |  |  |
|  | All three axes should work simultaneously |  |
|  | All the control loops should work simultaneously |  |
|  |  |  |
|  |  |  |
|  |  |  |

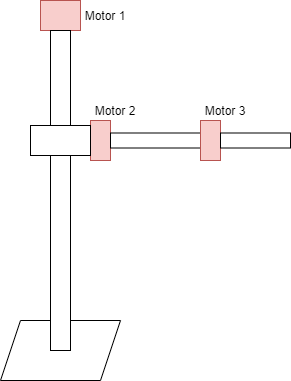
Samyuktha Documentation:

Block Diagram (tentative):



//\*\* Components can be modified, removed depending on motor selection

Rough Sketch:



|  |  |
| --- | --- |
| **Motor Requirements** | |
| Motor Type | Motor 1, Motor 2, Motor 3: Servo Mechanism  DC (Brushless) – BLDC (for less maintenance, repeatability) |
| Operating Voltage | Motor 1, Motor 2, Motor 3: 12 V DC |
| Operating Torque (critical factor)  Safety Factor already considered (value=3) | Motor 1: 0.6 N-m  Motor 2: 22 N-m  Motor 3: 7 N-m |
| Motor Driver | Motor 1, Motor 2, Motor 3: Built-in or additional circuitry |
| Encoder coupling/type | Motor 1, Motor 2, Motor 3: Built-in or mechanically coupled/incremental |
| Mechanical Dimensions/Weight | As compact and lower weight as possible |

* **Motor 1: Torque required 0.6 N-m**

**Option1: Datasheet link:** [**http://cdn.crouzet-motors.com.s3.amazonaws.com/assets/library/Datasheets-and-3D/EN\_SMI21\_80280001.pdf**](http://cdn.crouzet-motors.com.s3.amazonaws.com/assets/library/Datasheets-and-3D/EN_SMI21_80280001.pdf)

Motor Specs

|  |  |
| --- | --- |
| BLDC Model | Crouzet SQ57 |
| **Part Number** | **80280001** |
| Operating Voltage | 12 – 36 VDC |
| Output Power | 82 W |
| Base Speed | 1100 rpm (at 12 VDC) |
| Driver necessary | No |
| Encoder | Built-in (4096 resolution) |
| Weight | 1.62 kg |

Output Power = (2\*pi\*speed\*torque)/(60)

With speed=1100 rpm, output power=82 W (at 12 V DC)

**Torque=0.71 N-m (satisfied).**

* **Motor 2: Torque required 22 N-m**

**Option 1: (Motor + gearbox + controller + external encoder) system**

**Motor:** <https://www.maxongroup.com/medias/sys_master/root/8841087320094/EN-96.pdf>

**Gearbox:** <https://www.maxongroup.com/medias/sys_master/root/8841188868126/EN-353.pdf>

**Controller:** <https://www.maxongroup.com/medias/sys_master/root/8831198887966/2018EN-442-443-445.pdf>

**External Encoder:** <https://www.cuidevices.com/product/resource/amt11.pdf>

Motor Specs

|  |  |
| --- | --- |
| DC Model | Maxon DCX 35 L, DC Graphite brushed |
| **DC Part Number** | **DCX35L01GBKL434** |
| Operating Voltage | 12 VDC |
| Output Power | 80 W |
| Base Speed | 7610 rpm (at 12 VDC) |
| Weight | 380 g |
| Speed Constant | 699 rpm/V |
| Thermal Time Constant Winding | 44.3 s |
| Nominal Current |  |
| Maximum Current Limit |  |

Gearbox Specs

|  |  |
| --- | --- |
| Gearbox Model | Planetary Gearhead GPX 42 UP, 4 stage |
| **Part Number** | **GPX42UPKLSL0243CPLW** |
| Gear Ratio | 243:1 |
| Maximum Torque | 35 N-m |
| Weight | 790 g |

Controller Specs:

|  |  |
| --- | --- |
| Controller Model | Maxon, ESCON Module 50/5 |
| **Part Number** | **438725** |
| Maximum Current | 15A |
| Operating Voltage | 10 – 50 VDC |

Encoder Specifications:

|  |  |
| --- | --- |
| Encoder Model | CUI Devices |
| **Part Number** | **AMT112Q-V-4096** |
| Resolution | 4096 |
| Operating Voltage | 5 VDC |

Speed after gearbox = 7610/243 = **31 rpm**

Output Power = (2\*pi\*speed\*torque)/(60)

With speed=31 rpm, output power=80 W (at 12 V DC)

**Torque=24.4 N-m (satisfied).**

* **Motor 3: Torque required 7 N-m**

**Option 1: (Motor + gearbox + controller + external encoder) system**

**Motor link:** <https://www.maxongroup.com/medias/sys_master/root/8841182969886/EN-241.pdf>

**Gearbox link:** <https://www.maxongroup.com/medias/sys_master/root/8846280032286/20-EN-V2-387-388-389.pdf>

**Controller:** <https://www.maxongroup.com/medias/sys_master/root/8831198887966/2018EN-442-443-445.pdf>

**External Encoder:** <https://www.cuidevices.com/product/resource/amt11.pdf>

Motor Specs

|  |  |
| --- | --- |
| BLDC Model | Maxon EC-max 30 |
| **BLDC Part Number** | **272762** |
| Operating Voltage | 12 VDC |
| Output Power | 60 W |
| Base Speed | 6590 rpm (at 12 VDC) |
| Weight | 300 g |

Gearbox Specs

|  |  |
| --- | --- |
| Gearbox Model | Planetary Gearhead GP 32 C, Ceramic version |
| **Part Number** | **166942** |
| Gear Ratio | 86:1 |
| Maximum Torque | 6 N-m |
| Weight | 190 g |

Controller Specs:

|  |  |
| --- | --- |
| Controller Model | Maxon, ESCON Module 50/5 |
| **Part Number** | **438725** |
| Maximum Current | 15A |
| Operating Voltage | 10 – 50 VDC |

Encoder Specifications:

|  |  |
| --- | --- |
| Encoder Model | CUI Devices |
| **Part Number** | **AMT112Q-V-4096** |
| Resolution | 4096 |
| Operating Voltage | 5 VDC |

Speed after gearbox = 6590/86 = **77 rpm**

Output Power = (2\*pi\*speed\*torque)/(60)

With speed=77 rpm, output power=60 W (at 12 V DC)

**Torque=7.5 N-m (satisfied).**

**Option 2: (Motor + gearbox + controller + external encoder) system into 1 module: All built in**

**Motor link:** <https://robokits.download/downloads/RMCS220x_DCServo_Driver.pdf>

Motor Specs

|  |  |
| --- | --- |
| DC Model | Nema23 High Torque DC Servo Motor |
| **DC Part Number** | **RMCS-2202** |
| Operating Voltage | 12 VDC |
| Output Power | 76.5 W |
| Base Speed | 18000 rpm (at 12 VDC) |
| Gearbox Ratio | 180:1 |
| Speed at Shaft | 100 rpm |
| Driver necessary | No |
| Encoder | Built-in (1800 resolution) |
| Weight | 180 g |

Speed after gearbox = 18000/180 = **100 rpm**

Output Power = (2\*pi\*speed\*torque)/(60)

With speed=100 rpm, output power=76.5 W (at 12 V DC)

**Torque=7.3 N-m (satisfied).**

* **Motor 4: Torque required 0.6 N-m**

**Option 1: (Motor + gearbox + controller + external encoder) system**

**Motor:** <https://www.maxongroup.com/medias/sys_master/root/8846271741982/20-EN-V2-262.pdf>

**Gearbox:** <https://www.maxongroup.com/medias/sys_master/root/8846280032286/20-EN-V2-387-388-389.pdf>

**Controller:** <https://www.maxongroup.com/medias/sys_master/root/8831198887966/2018EN-442-443-445.pdf>

**External Encoder:** <https://www.cuidevices.com/product/resource/amt11.pdf>

Motor Specs

|  |  |
| --- | --- |
| DC Model | Maxon DCX 32 L, DC Graphite brushed |
| **DC Part Number** | **DCX32L01GBKL448** |
| Operating Voltage | 12 VDC |
| Output Power | 70 W |
| Base Speed | 6560 rpm (at 12 VDC) |
| Weight | 320 g |

Gearbox Specs

|  |  |
| --- | --- |
| Gearbox Model | Planetary Gearhead GPX 32, 1 stage |
| **Part Number** | **GPX32AAKLSL05D3CPLW** |
| Gear Ratio | 5.3:1 |
| Maximum Torque | 1.25 N-m |
| Weight | 140 g |

Controller Specs:

|  |  |
| --- | --- |
| Controller Model | Maxon, ESCON Module 50/5 |
| **Part Number** | **438725** |
| Maximum Current | 15A |
| Operating Voltage | 10 – 50 VDC |

Encoder Specifications:

|  |  |
| --- | --- |
| Encoder Model | CUI Devices |
| **Part Number** | **AMT112Q-V-4096** |
| Resolution | 4096 |
| Operating Voltage | 5 VDC |

Speed after gearbox = 6560/5.3 = **1234 rpm**

Output Power = (2\*pi\*speed\*torque)/(60)

With speed=1234 rpm, output power=70 W (at 12 V DC)

**Torque=0.54 N-m (satisfied).**

Tm π