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)

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **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) |

**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)**

**/\*** Reasons:

* Optimal no. of pins (64)
* Upto 49 external interrupts-from 6 different digital logic sensors

Reasons for not choosing STM Microcontrollers:

* Pulse width modulation achieved through Timers, which when fed as PWM input (critical) for driving 2 servo motors may be relatively inaccurate when compared to dedicated PWM pins

Reasons for not choosing TI Microcontrollers:

* The architecture is very complex for the specified requirements
* Unnecessary usage of hardware with most of the pins not connected
* Although the RAM & ROM is higher, the code that we will use would not be demanding for the RAM & ROM specified values (128 kB & 1MB)

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