VNM SIMULATION., JSC

VNM MOTION FIRMWARE USER MANUAL

Contents

1. Introduction

VNM Simulation., JSC is a sim racing manufacturer based in Vietnam. We strive to design and produce high quality sim racing equipment. Our firmware/software is available to DIY community and unlocks the possibility to make hardware for equipment like ffb wheelbase, pedal set, shifter, steering wheel rim and a motion rig at the cheapest price. We can also supply a complete solution for a car simulator.

VNM Motion Controller firmware is an STM32F401RCT-based firmware package with an accompanying Windows configurator app. The configurator app is used to make setup changes to motion controller (i.e actuator specs, pulse frequency and so on). Almost any servo motor can be used with our firmware.

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2. Firmware specs

- STM32F401RCT microcontroller with 25 MHz crystal
- Supports up to 9 actuators.
- Supports up to 500 kHz pulse frequency.
- Generates exactly the number of pulses that a servo driver needs to rotate one round.
- Filtering for smooth movement.
- Support belt tensioners without feature on motion software.
- Loop time is 1ms
- Can be used with some motion software like SRS, FlyPt Mover, Simtools, Sim-motion software or similar which support configurable string output.

3. Configuration App

VNM CONFIG UI is a central configuration software for all VNM products like VNM Wheelbase, Direct Drive, Shifter, Handbrake, Steering wheel rim, Pedal set, Motion controller…
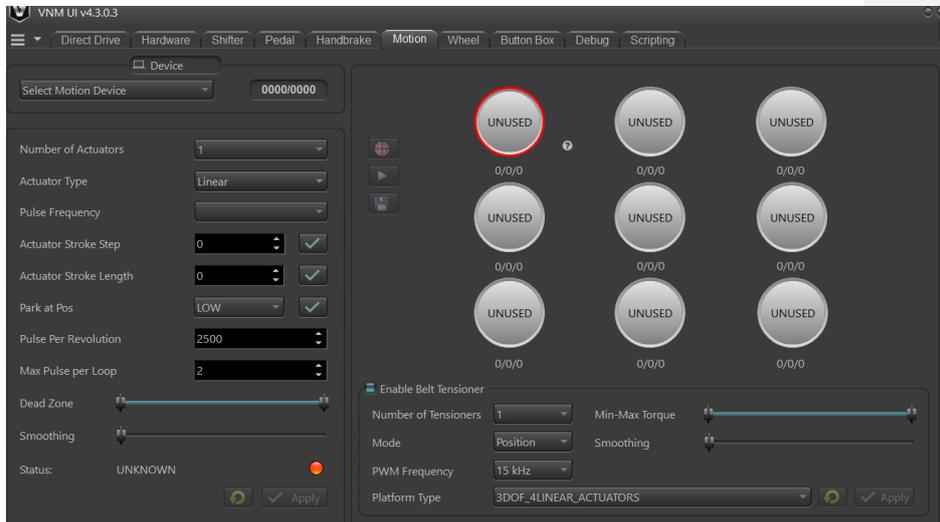
- Select Motion Device: displays the connected VNM Motion Controller.
- Number of actuators: configure the number of actuators of your motion system.
- PWM (Pulse) frequency: this is the output pulse frequency of the controller that can be used as input to the Servo driver. higher pulse frequency, the higher speed of your actuator.
- Step stroke (mm/rev): this is the linear motion of the actuator in mm per revolution of the motor shaft (can be measured with a ruler).
- Stroke length (mm): The distance between the min position and the max position of an actuator (configure for each actuator)
- Park at Pos: choose a position that actuator will park. It is LOW or MID of stroke (configure for each actuator).
- Pulse Per Revolution: it's your encoder's PPR. Normally, one cylce needs Count per spin (CPR = 4*PPR). This value is important because the firmware will use it to generate the correct number of pulses to drive the actuators.
- Max pulse per loop: How many pulses that the controller will generate each time.
- Deadzone (percentage): It is the actuator offset (default 3%). An actuator will move from offset % to (100-offset) % of your stroke length. It is a spare distance for an error deviation.
- Smothing: Higher value, higher smooth.
- Status: it will show the real-time status of your motion controller:
  + Idling: Motion is working but all actuators are not moving.
  + Running: Motion controller is working, and some actuators are moving.
  + Parking: All actuators are moving to 0 position.
  + Running to Min Position: All actuators are moving to its min position until its torque reach is triggered.

+ Calibrating: Motion Controller is in Calibration mode to detect min/max position.
- Status Button: requests configuration of the motion controller.
- Run (Stop): soft emergency button.
- Actuator status:
  + Unused: This actuator isn't used.
  + Not ready: This actuator is used but not yet ready to run.
  + Ready: This actuator is used and ready to run.
- The numbers at each actuator status correspond to actuator stroke ste, actuator stroke length, max pulse (number of pulses required by a servo drive for moving an actuator from offset % to (100-offset) % stroke length).

4. Master List

4.1. Servo set

Any of servo set that supports pulse/dir can use with VNM Motion Controller firmware. It is better if it has torque reach, servo ready output from its driver. If it doesn't have torque reach output, you must add end stop limit switches at both sides of your actuator. If it doesn't have servo ready, you must connect fake servo ready to servo ready pin.

4.2. Motion controller

It is stm32f401RxT (RCT, RDT, RET) kit with 25mhz crystal.

Example :

- STM32F401RET Nucleo with 25mHz crystal

  https://www.digikey.ca/en/products/detail/stmicroelectronics/nucleo-f401re/4695525

  https://www.digikey.com/en/products/detail/ecs-inc/ECS-250-18-4X-F/827533

4.3. Other electronic materials

- Optocoupler HCPL2631 or 6N137 for pulse/dir connections.

https://www.digikey.com/en/products/detail/rochester-electronics-llc/HCPL2631/11558973

https://www.digikey.com/en/products/detail/liteon/6N137/1969175

- Optocoupler PC817 for digital input/output (DI/DO) of servo driver

https://www.digikey.com/en/products/detail/american-bright-optoelectronics-corporation/BPC-817-B-BIN/9678142

Resistor 1.5kohm->2.2kohm, 200ohm->330 ohm, capacitor 100nF.

- Isolated power supply 5V for pulse/dir

- Isolated power supply 12-24V for DI/DO.

To be continued…

4.4. VNM Motion controller

If you don't have time for DIY controller or just want to support VNM Simulation, you can buy VNM Motion Controller that is high quality and includes the following features:

- The anodized Aluminum box reduces noise from other devices.
- Isolates the micro controller from all servo drivers to reduce EMI with very high speed optocoupler and digital isolator.
- Supports up to 9 servos with pulse frequency up to 500khz (configurable).
- The accuracy of pulse generation is almost absolute (see the picture with 100 millions pulse, no pulse is lost).
- Generates exactly the number of pulses that the driver needs so the pulse resolution is very high and smooth movement.
- Automatically correct the position of the actuator in case the servo driver loses pulse causing the actuator reaches the limit.
- Supports up to 2 belt tensioners without belt tensioner feature on a motion software.
- Configure parameters/Monitoring system via VNM Config UI.
- The control loop is 1 ms that is real time with a motion application.
- Signal filtering make the actuator run smoothly in VNM Config UI.
- Unlimited baud rate that mean can run at any speed that a motion software supports.
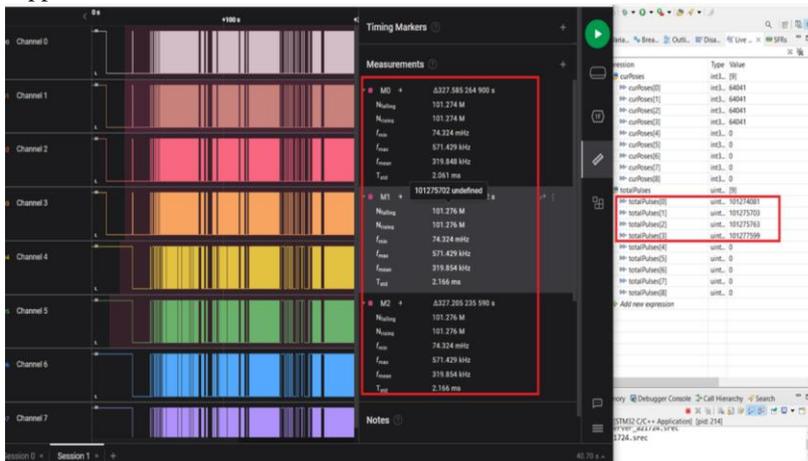
5. Connection

5.1. Connection Pin of stm32F401R(C/D/E)T

- Pulse: PWM Pin

- Dir: Direction Pin
- TReach: Torque Reach Pin
- SReady: Servo Ready Pin
- Index: corresponding to servo 1,2…8,9
- Calibrate: Button to trigger Calibration Process
- USART6: Future use

STM32 Pin	Description	Note
PB6	Pulse 1	
PB5	Torque reach 1	
PB4	Dir 1	
PB3	Servo ready 1	Servo 1
PB7	Pulse 2	
PD2	Torque reach 2	
PC12	Dir 2	
PC11	Servo ready 2	Servo 2
PB8	Pulse 3	
PC13	Torque reach 3	
PC0	Dir 3	
PC15	Servo ready 3	Servo 3
PB9	Pulse 4	
PC3	Torque reach 4	
PC1	Dir 4	
PC2	Servo ready 4	Servo 4
PA0	Pulse 5	
PA7	Torque reach 5	
PC4	Dir 5	
PC5	Servo ready 5	Servo 5
PA1	Pulse 6	
PB10	Torque reach 6	
PB0	Dir 6	
PB1	Servo ready 6	Servo 6
PA3	Pulse 7	
PA4	Torque reach 7	
PA5	Dir 7	
PA6	Servo ready 7	Servo 7
PA8	Pulse 8	
PC8	Torque reach 8	
PC9	Dir 8	
PB15	Servo ready 8	Servo 8
PA9	Pulse 9	Servo 9

PB14	Torque reach 9	
PA10	Dir 9	
PB15	Servo ready 9	
PB12	Calibrate Button	
PA2		Must connect together
PA15	Internal use	
PC6	UART TX	
PC7	UART RX	Future use

5.2. STM32-Servo Driver Connection
 Example of AASD Driver

5.3. Button Connection
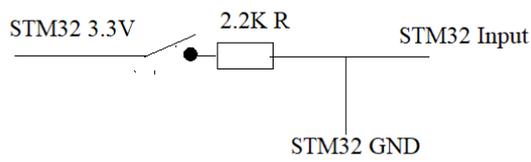
5.4. VNM Motion Controller

Item	Description
CN1->CN7	Use for actuator only
CN8, CN9	Can be used for actuator or belt tensioner (if active belt tensioner, CN8/CN9 are used for tensioner only.
CN10	Future use
DFU button	Click to reset controller, hold few second to change DFU mode. Disconnect USB and reconnect to change Run mode

Calibrate Button	Calibrate motion system
EMC-Stop GX12-4	For emergency and servo enable button
24VDC	For 24v DC input.
USB type C port	Connect to PC

Pin	Description	Note
14	Pulse -	Available for CN1->CN9
3	Pulse +	Available for CN1->CN9
4	Dir +	Available for CN1->CN9
5	Dir -	Available for CN1->CN9
6	Servo on	Available for CN1->CN9
7	Emergency stop	Available for CN1->CN9
9	24V output	Available for CN1->CN9
13	Torque GND	Only available for CN8/CN9
21	Torque Dir	Only available for CN8/CN9
25	Torque VREF	Only available for CN8/CN9

5.5. Mapping Axes to actuators of each model.

Model	AXIS 1	AXIS 2	AXIS 3	AXIS 4	AXIS 5	AXIS 6	AXIS 7	AXIS 8	AXIS 9
3 actuators (2 Fronts + 1 Rear)	FL	FR	R						
4 actuators (1 Fronts + 2 Rear)	F	RR	RL						
4 actuators (2 Fronts + 2 Rear)	FL	FR	RR	RL					
5 actuators (2 Fronts + 2 Rear + TL)	FL	FR	RR	RL	TL				
5 actuators (2 Fronts + 2 Rear + Surge)	FL	FR	RR	RL	SG				
6 actuators (2 Fronts + 2 Rear + TL + Surge)	FL	FR	RR	RL	TL	SG			
6 actuators (2 Fronts + 2 Rear + 2TL)	FL	FR	RR	RL	TLF	TLR			
7 actuators (2 Fronts + 2 Rear + TL+ Surge + Belt)	FL	FR	RR	RL	TL	SG	Belt		
7 actuators (2 Fronts + 2 Rear + 2TL + Surge)	FL	FR	RR	RL	TLF	TLR	SG		
8 actuators (2 Fronts + 2 Rear + 2TL + Surge + Belt)	FL	FR	RR	RL	TLF	TLR	SG	Belt	

6. Servo Driver Parameter setup

6.1. AASD servo driver

Parameter / Function	Description from User Manual	Initial Value	VNM Actuator	What this parameter/function does and when to change it

Pn001	Motor code	3	4	This is the specific code for the motor that came paired with your driver. If you need to set this value (you should not have to), refer to page 46 of the user manual linked above to find the motor code of your motor.
Pn002	Control mode	0	2	"2" is position mode (see page 47 of the user manual linked above).
Pn003	Servo enable mode	0	0	This setting means that the servo motor requires external input to be operated (input from the controller). If you don't have servo on button, set it to 1. If you have servo on button set it to 0
Pn008	Internal around are torque limit (CCW)	300	300	Use as default. Don't need to change
Pn009	Around inside the torque limit (the CW)	-300	-300	Use as default. Don't need to change
Pn024	Reach the predetermined torque	100	100	Torque reach is triggered when the value of torque is greater than or equal to Pn024 set
Pn051	The motor running top speed limit	3000	3000	This is the rated top speed of the motor based on the motor specs (see page 46 of the user manual linked above). Depends on your preference how to adjust this value :D.
Pn052	SigIn1 port functional allocation	1	1	Servo on input. SigIn port function explanation 4.4.1

Pn053	SigIn2 port functional allocation	2	7	Emergency stop input.
Pn054	SigIn3 port functional allocation	19	18	Change direction with speed/torque control.
Pn060	SigOut 1 port functional allocation	2	2	Servo ready output
Pn061	SigOut 2 port functional allocation	1	6	Torque reach value at pn024
Pn076	Emergency stop reset (EMG)	0	1	Enable EMC
Pn096	Command pulse input mode	0	0	Set 1 to Forward/reverse pulse
Pn097	Input command direction	0	0	set pn024 = -150 if you set this param
Pn098	Electronic gear ratio	1	1	Multiple input pulse with gear ratio
Pn109	Position command Acceleration/deceleration mode	1	1	smoothing filter
Pn110	Filter constant time	50	30	in ms
Pn113	The position loop feedforward gain	0	20	position feedforward directly on the speed instruction, can reduce the position tracking error, improve the response. If the feedforward gain is too big, can lead to speed overshoot
Pn114	Position loop feedforward filter time constant	5	10	
Pn115	The position controller gain 1	100	100	In mechanical systems do not produce under the premise of vibration or noise, increase the position loop gain value, to speed up the reaction rate, shorten the positioning time
Pn083	Low voltage detection	200	100	working voltage from >=100V-240V

6.2. Other driver sets
Update later

7. Flash firmware

Download VNM Flash and its manual from https://vnmsimulation.com/download

Choose lastest version of motion controller and download then click select.
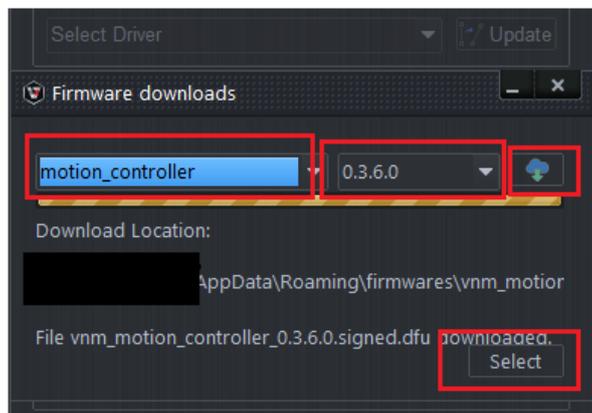
Flashing the firmware follows the VNM Flash manual. Get the controller out of the bootloader mode and reconnect the usb cable after flashing.

8. Motion Software and configuration for VNM Motion Controller firmware

       Currently we just tested with FlyPT Mover/Simtool/Sim motion but it should work with other software that support binary and configurable string output like simtools,…

      The data output string is 22 bytes.
0xFF 0xFF b1 b2 b3 b4 b5 b6 b7 b8 b9 b10 b11 b12 b13 b14 b15 b16 b17 b18 LF CR

      0xFF 0xFF - start of data identifier for the receiving micro controller
      <byte1>< byte2> - 16 bit binary number giving actuator 1
      <byte3>< byte4> - 16 bit binary number giving actuator 2
      <byte5>< byte6> - 16 bit binary number giving actuator 3
      <byte7>< byte8> - 16 bit binary number giving actuator 4
      <byte9>< byte10> - 16 bit binary number giving actuator 5
      <byte11>< byte12> - 16 bit binary number giving actuator 6
      <byte13>< byte14> - 16 bit binary number giving actuator 7
      <byte15>< byte16> - 16 bit binary number giving actuator 8
      <byte17>< byte18> - 16 bit binary number giving actuator 9
      LF   - Line Feed character – 0x0A
      CR - Carriage Return character – 0x0D

      Here are example of configuration:

OUTPUT :: SERIAL

☑ Connect

Type of output	Binary		Interval loops	1	(2 ms)	Open devices
Serial speed	250000		Stop bits	1		Update ports
Data bits	8		Parity	None	Port	

Start string: _____ 0 ms

Output string: `<255><255><Axis1a><Axis2a><Axis3a><Axis4a><Axis5a><Axis6a><0><0><0><0><10><13>`

Stop string: _____ 0 ms

Input string: _____

▲ Debug   Rigs/Directs ◄

```
255 255 127 255 127 255 127 255 127 255 127 255 127 255 000 000 000 000 010 013
```

Pose limits	9999	9999	9999	180.0	180.0	180.0
Drive pose	0	0	0	0.0	0.0	0.0
Pose filtering	VALUE			VALUE		
Center of rotation	0	0	0	mm Gain 1.000 ☐ Auto gain		
Actuator filtering	VALUE					
Position bit output	16	(0 to 65535 in 2 bytes)		Scale 1.000 around 0 ☐		
Calculate speed	☐ Stay on last possible pose ☐ PID	1.000	0.000	0.000		
Speed bit output	8	(-127 to 127 in 1 byte)		Maximum speed 127		
Singularity angle	15.0	º				
Middle	940.0 mm	L1 1250.0 mm		L3 99.1 mm		
Range	50.0 mm	L2 175.0 mm		L4 1250.0 mm		
	Default height	685.0 mm				

9. How to Testing

9.1. Testing with hercules:
- Connect cable USB to PC.
- Open Hercules/ Serial/ Name (Choose port) and Open
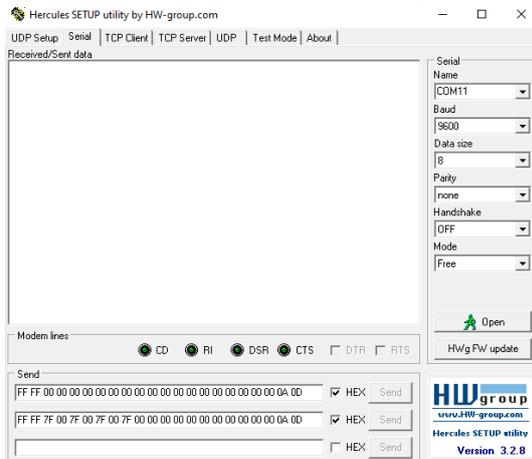
- Send data string like what you set.

2. Testing with flyPT & Sim Tools
- Connect cable USB to PC.
- Open flyPT, Sim Tools and open or create new file.
- Connect port.
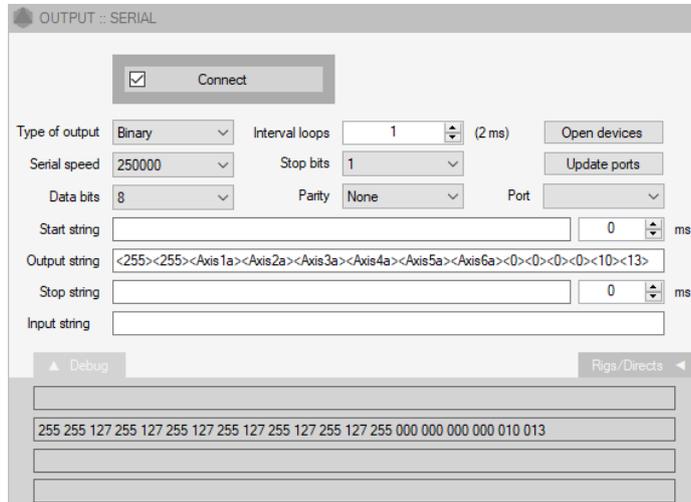
- Test poses, rigs (or connect with game and play).
- You can set up In gain/Out gain, Range and Filter accordingly as your liking.