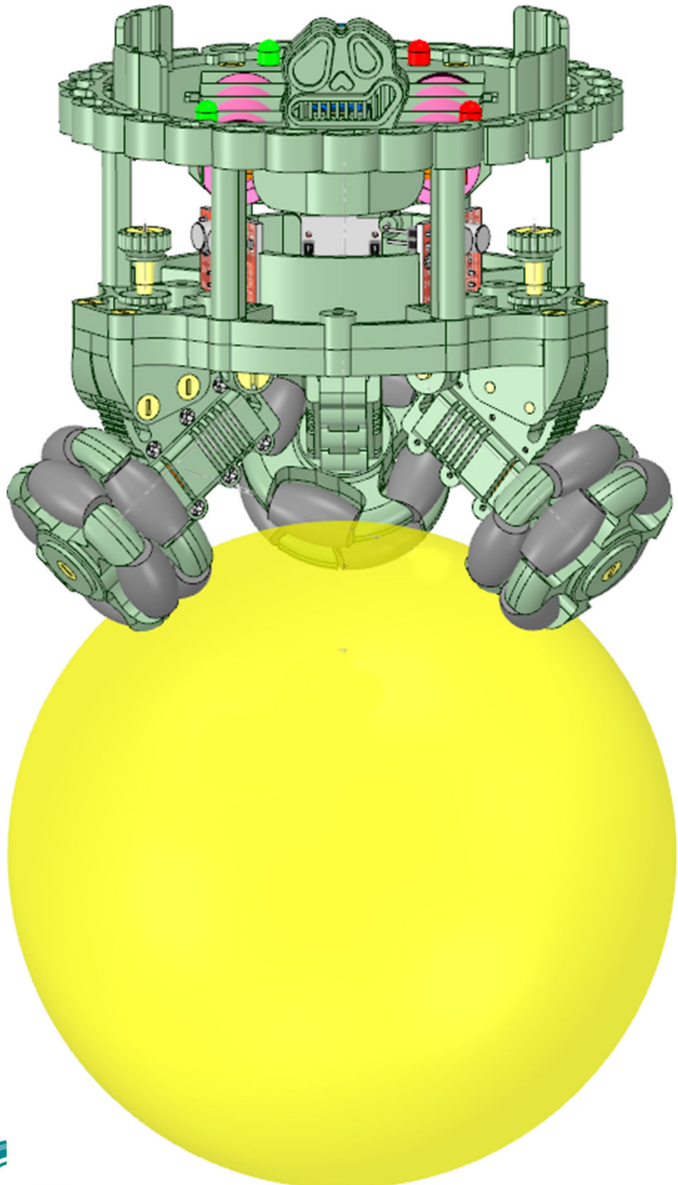
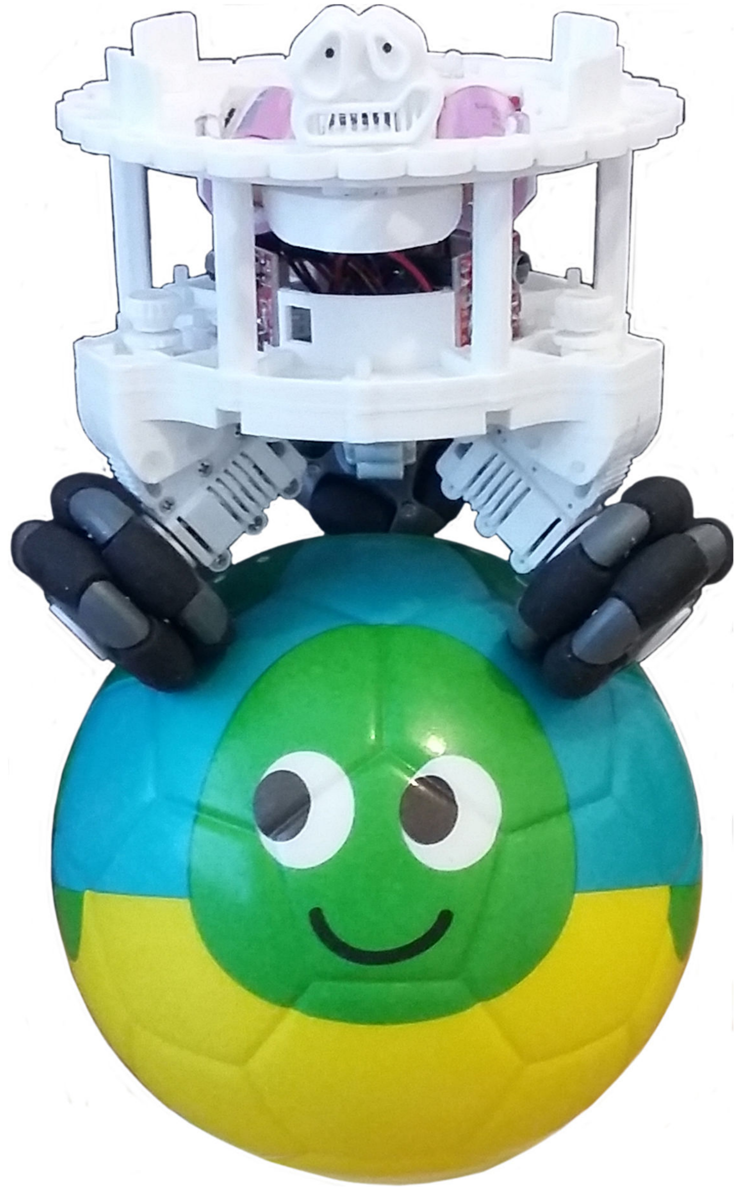
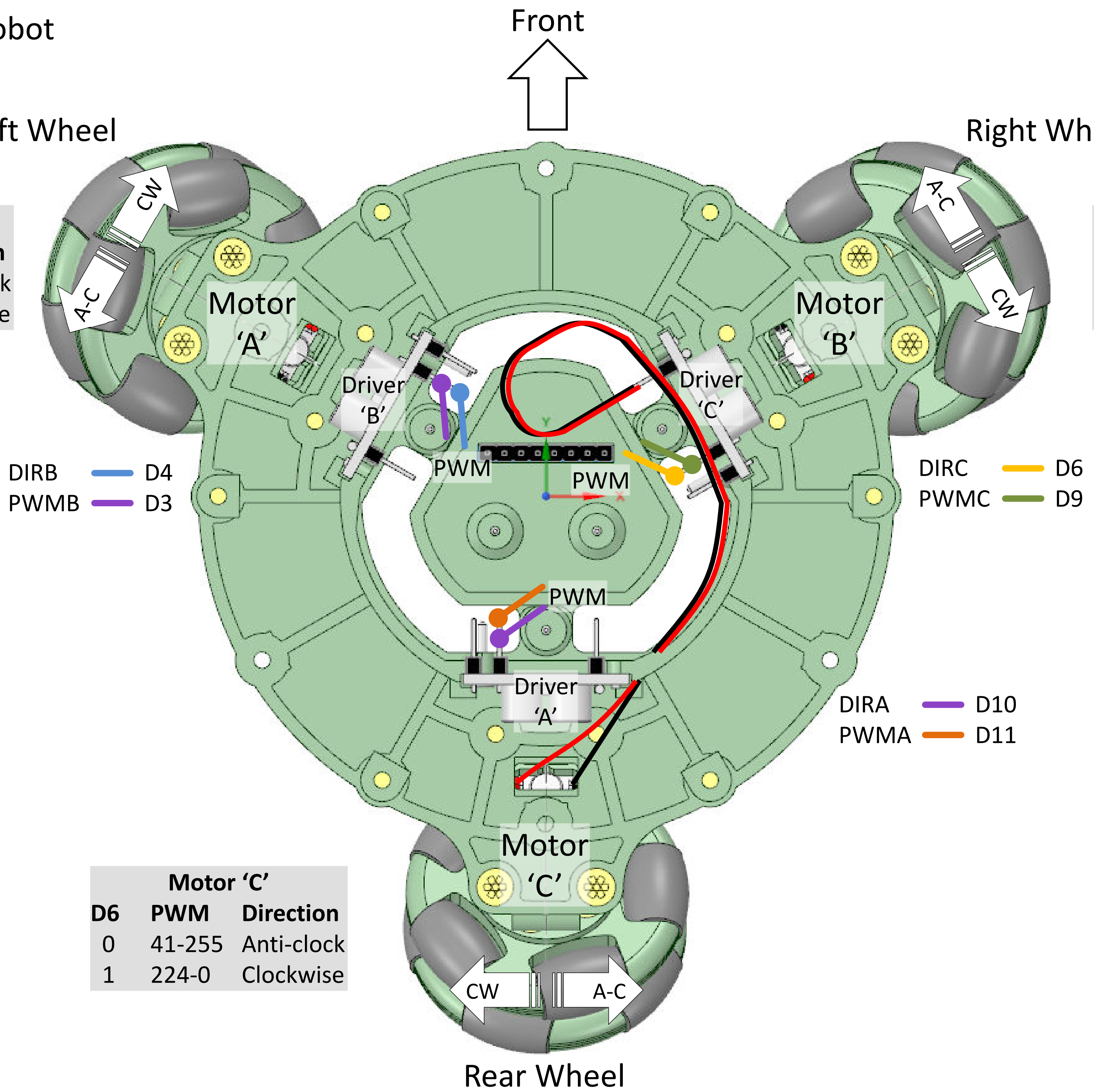
Ball Balancing Robot

Calibration





Ball Balancing Robot
Motor Cal.



Motor 'A'		
D10	**PWM**	**Direction**
0	49-255	Anti-clock
1	223-0	Clockwise

Motor 'B'		
D4	**PWM**	**Direction**
0	36-255	Anti-clock
1	233-0	Clockwise

Motor 'C'		
D6	**PWM**	**Direction**
0	41-255	Anti-clock
1	224-0	Clockwise

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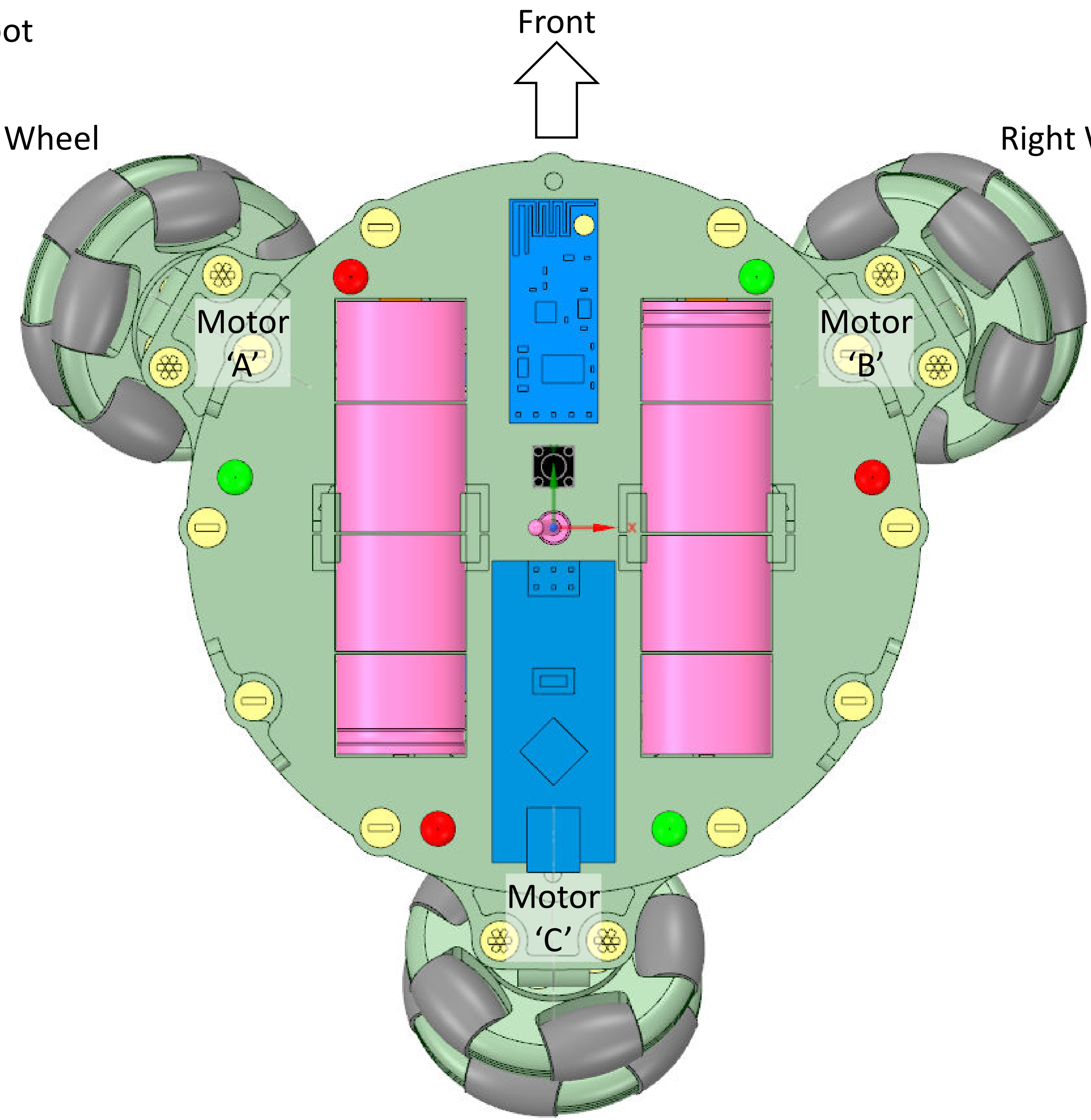
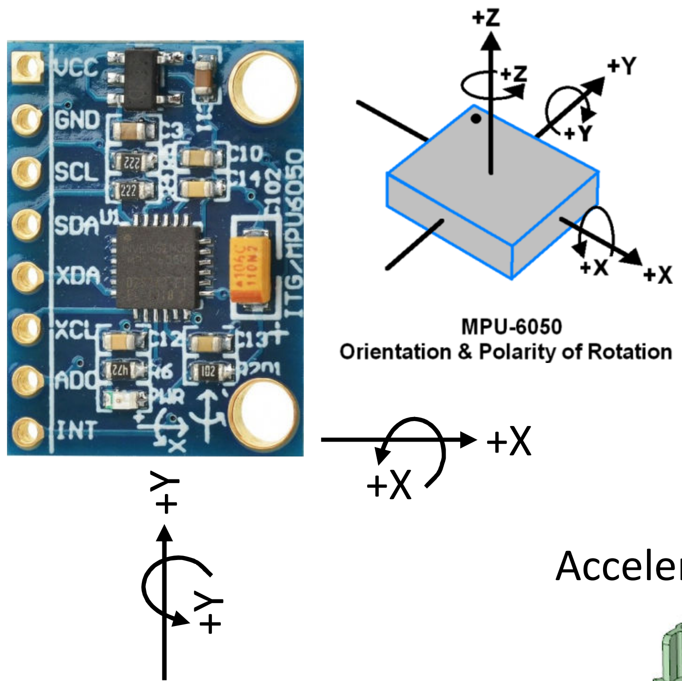
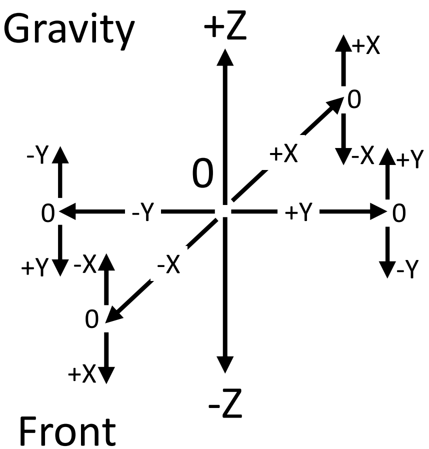
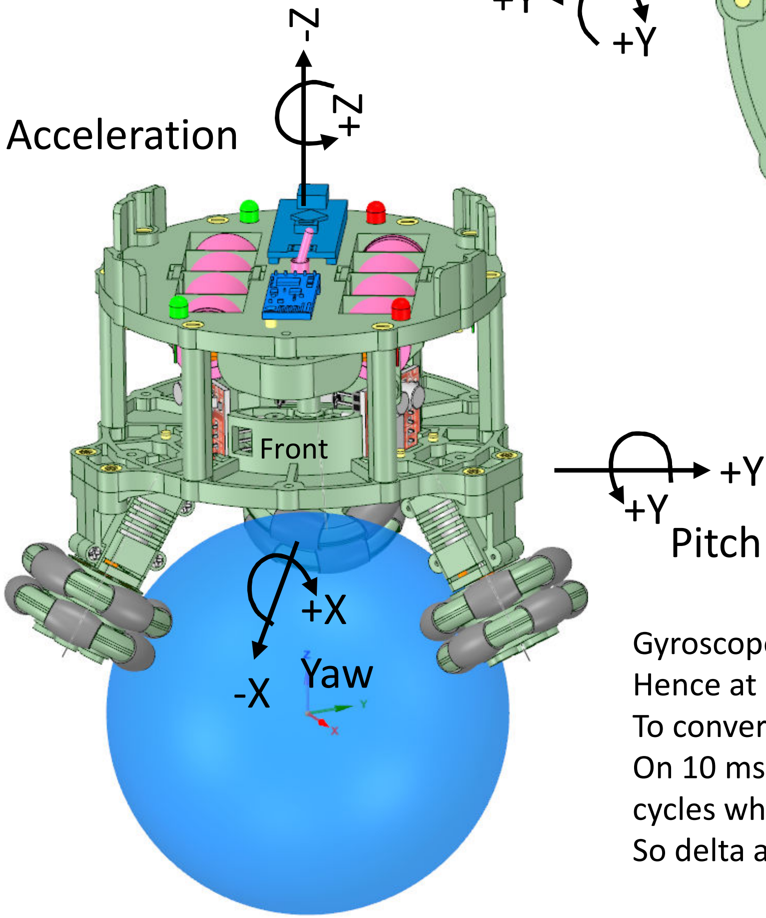
Ball Balancing Robot
Hips Cal.

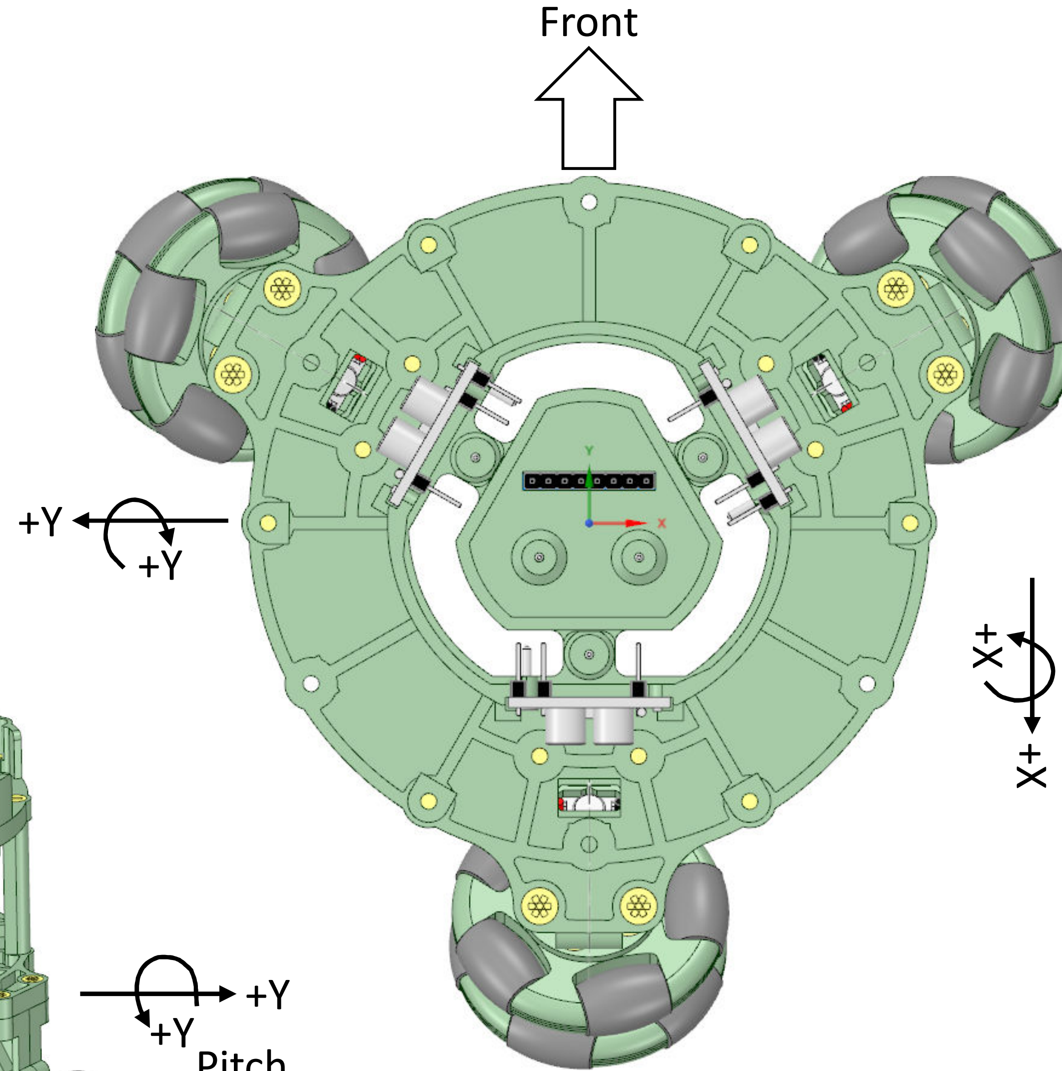


MPU-6050 Orientation









Gyroscopes are set at +/-250 °/sec FSD.
Hence at 32,767 FSD; rotation of 1 °/sec = 131.
To convert this to a gyro angle we use the time between readings.
On 10 ms cycle we would accumulate a count of 1310 over a 100 cycles when rotating at 1 °/sec.
So delta angle per 10ms cycle = gyro rate * 0.00007633

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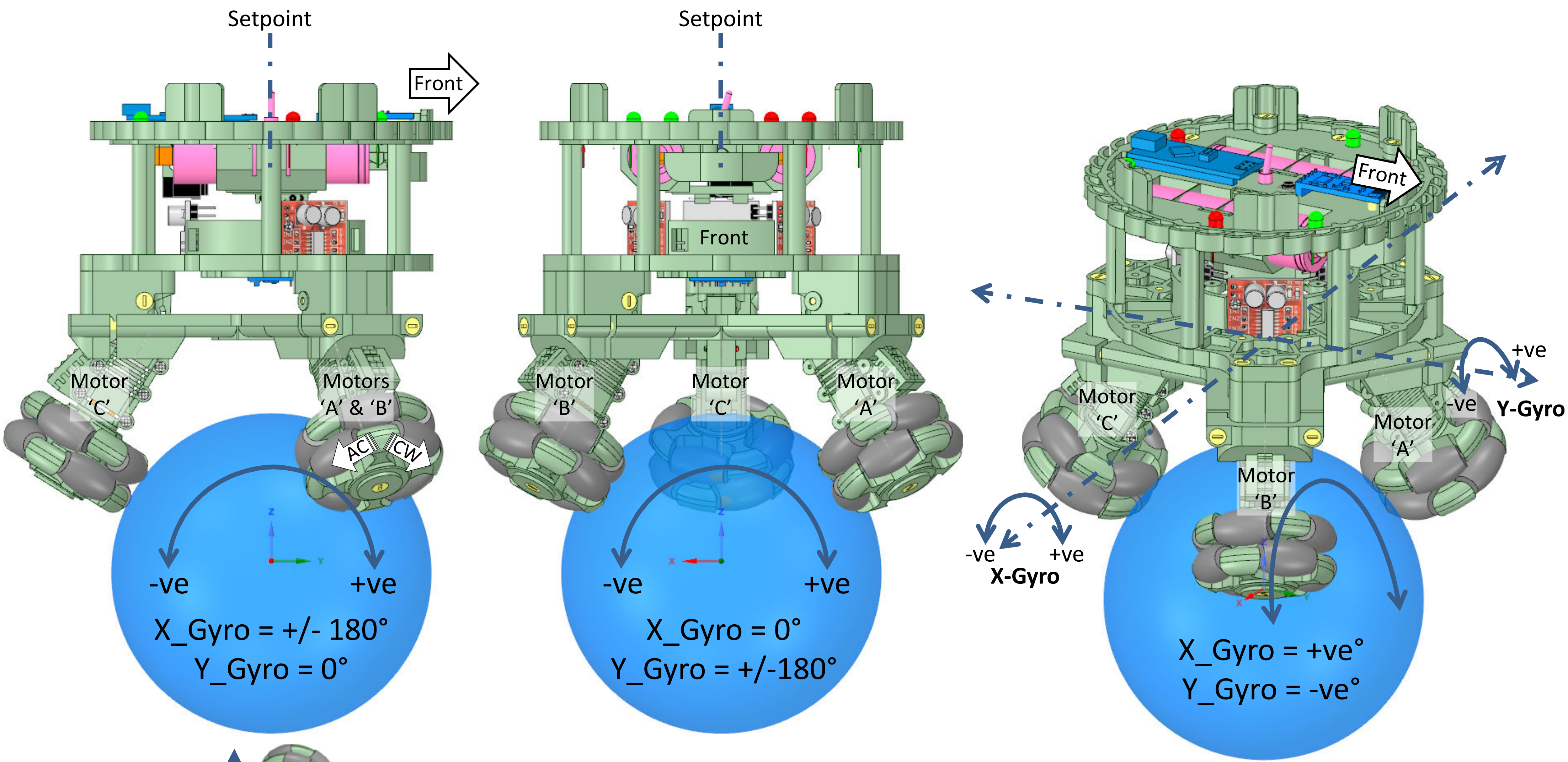
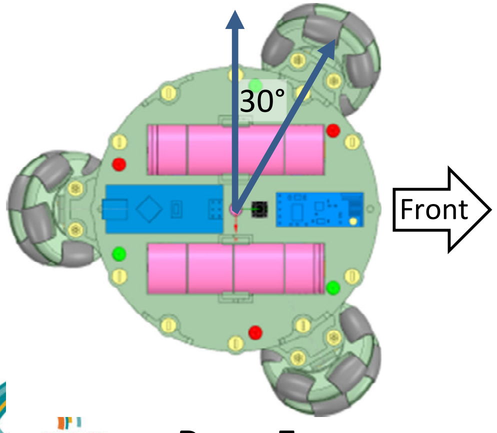


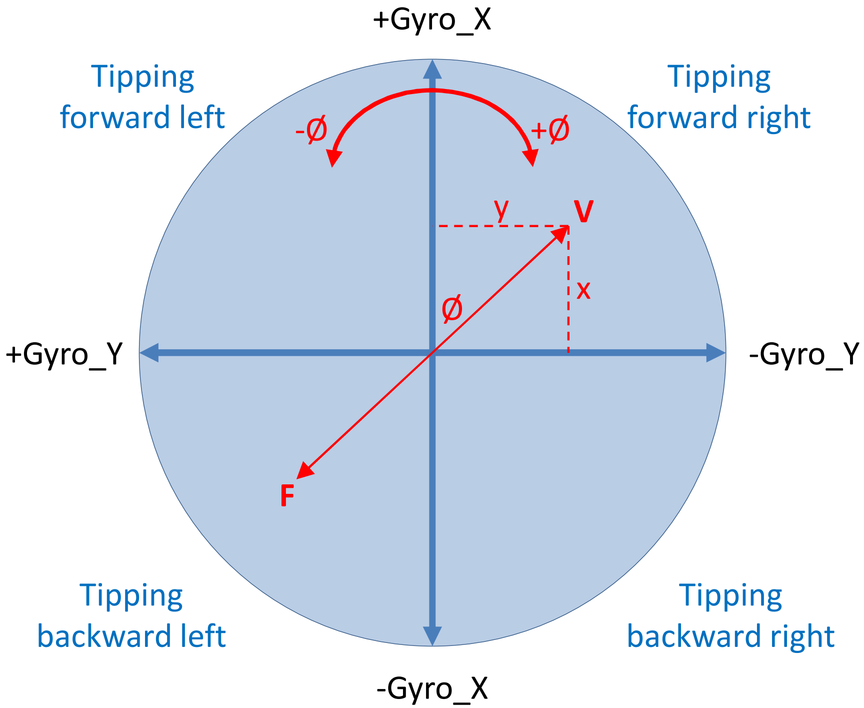


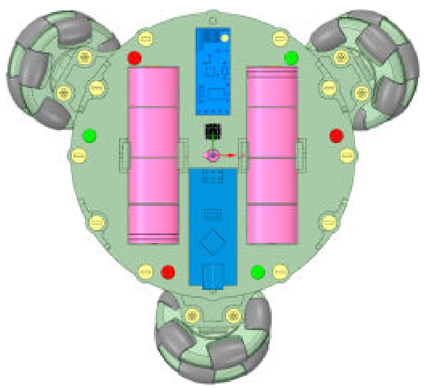
Gyro X & Y angles to Motor clockwise drive relationships:

- Motor A^{CW} = -(X_Gyro * sin(30°)) + (Y_Gyro * sin(60°)) = -X_Gyro*0.5 + Y_Gyro *0.86603
- Motor B^{CW} = (X_Gyro * sin(30°)) + (Y_Gyro * sin(60°)) = X_Gyro*0.5 + Y_Gyro *0.86603
- Motor C^{CW} = Y_Gyro

Note: here we are calling the Pitch gyro X_Gyro and Yaw gyro Y_Gyro to be consistent with the accelerometer values, which are used in the code for gyro drift correction.

Movement angles and vectors





If +X & -Y then: $Ø^{0 \text{ to } +90} = 57.2958 * \tan^{-1}(y/x)$

If +X & +Y then: $Ø^{0 \text{ to } -90} = 57.2958 * \tan^{-1}(y/x)$

If -X & -Y then: $Ø^{90 \text{ to } +180} = 180° - (57.2958 * \tan^{-1}(y/x))$

If -X & +Y then: $Ø^{90 \text{ to } -180} = -180° + (57.2958 * \tan^{-1}(y/x))$

Tilt V = sqrt(sq(x) + sq(y)) V is always +ve

Driving force vector F == PID(-V)

F needs to drive in opposite direction to V, so

If +X & -Y then: $Ø^{90 \text{ to } -180} = -180° + (57.2958 * \tan^{-1}(y/x))$

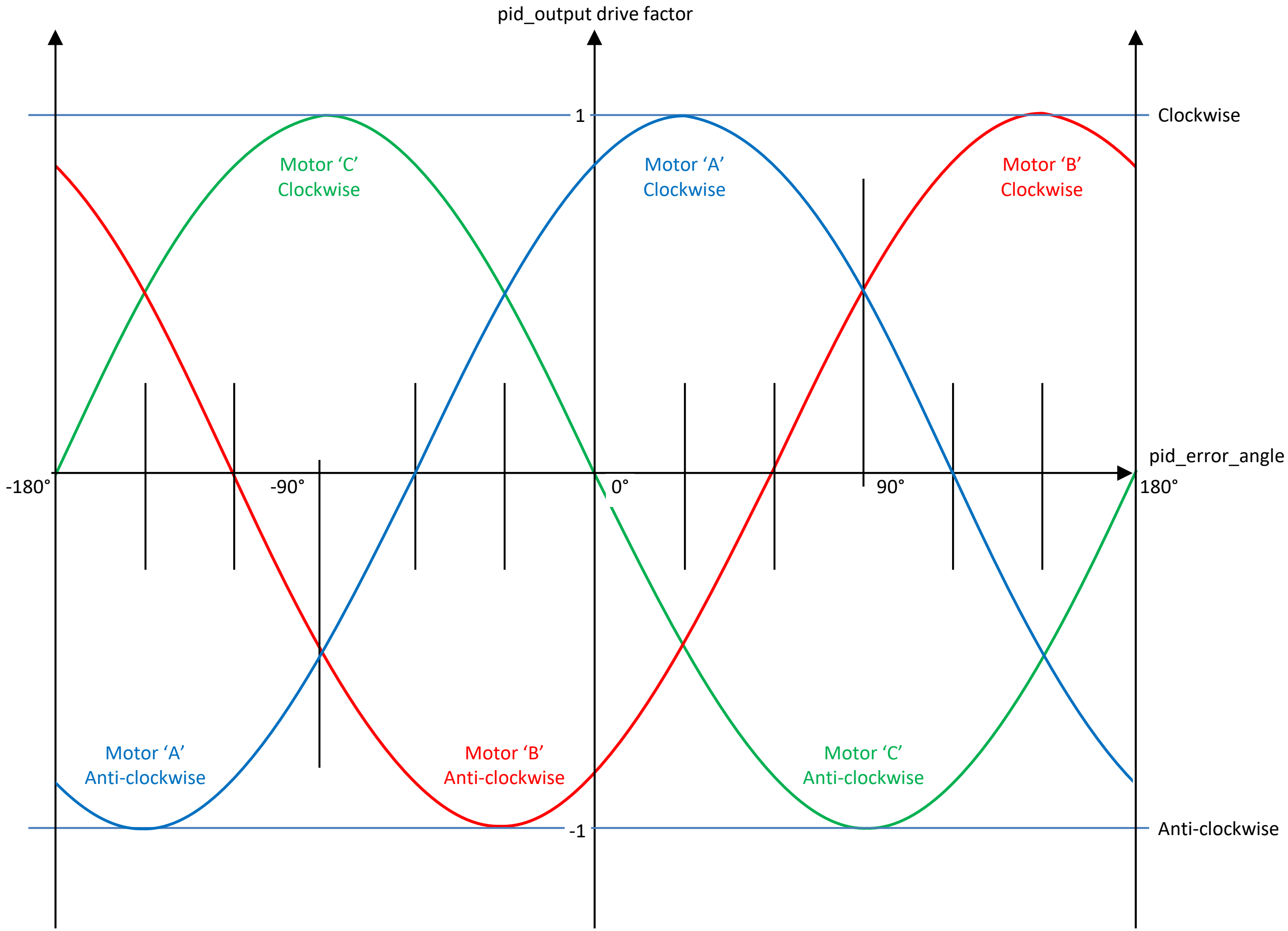
If +X & +Y then: $Ø^{90 \text{ to } +180} = 180° - (57.2958 * \tan^{-1}(y/x))$

If -X & -Y then: $Ø^{0 \text{ to } -90} = -(57.2958 * \tan^{-1}(y/x))$

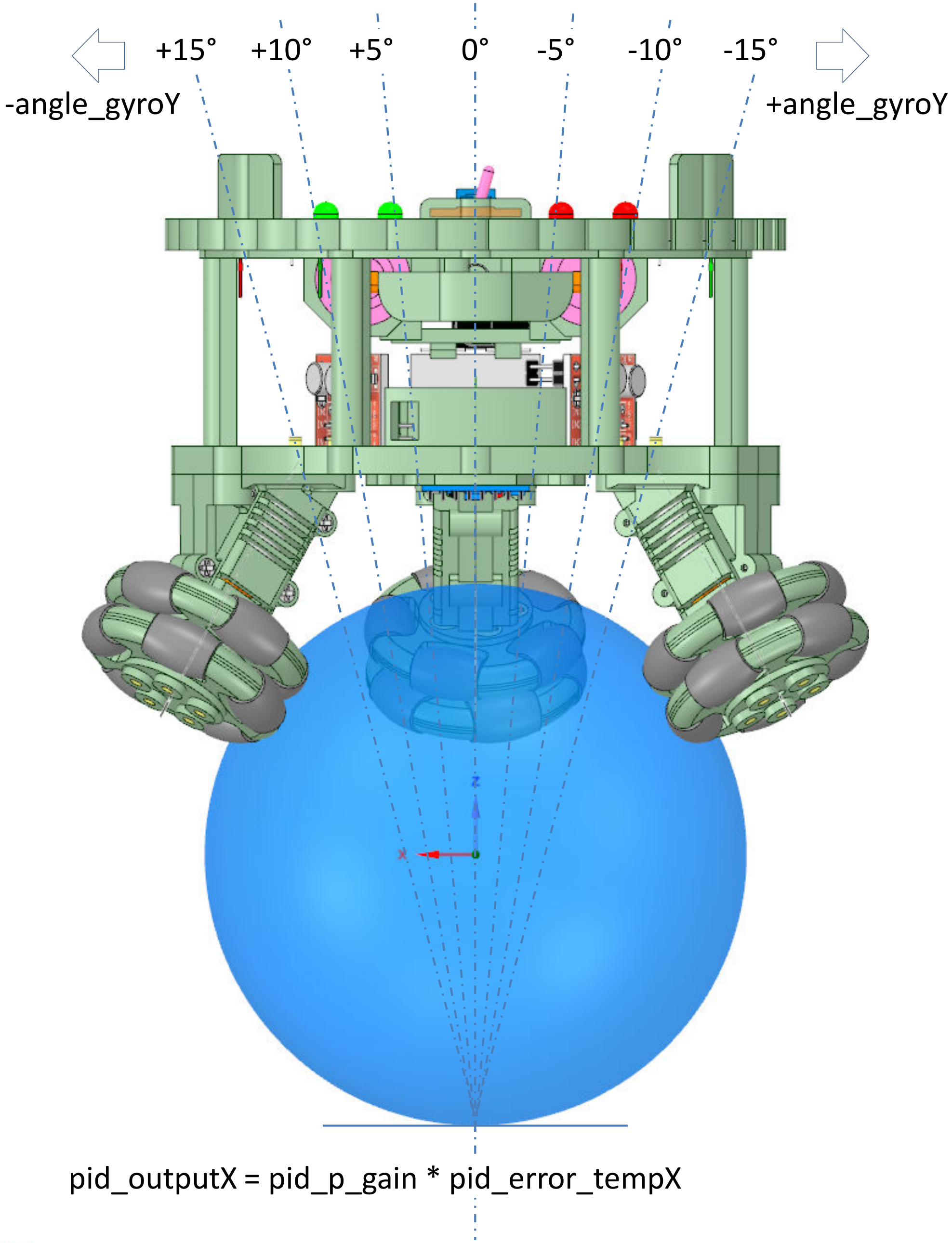
If -X & +Y then: $Ø^{0 \text{ to } +90} = -(57.2958 * \tan^{-1}(y/x))$

Where 1 radian = 57.2958 degrees

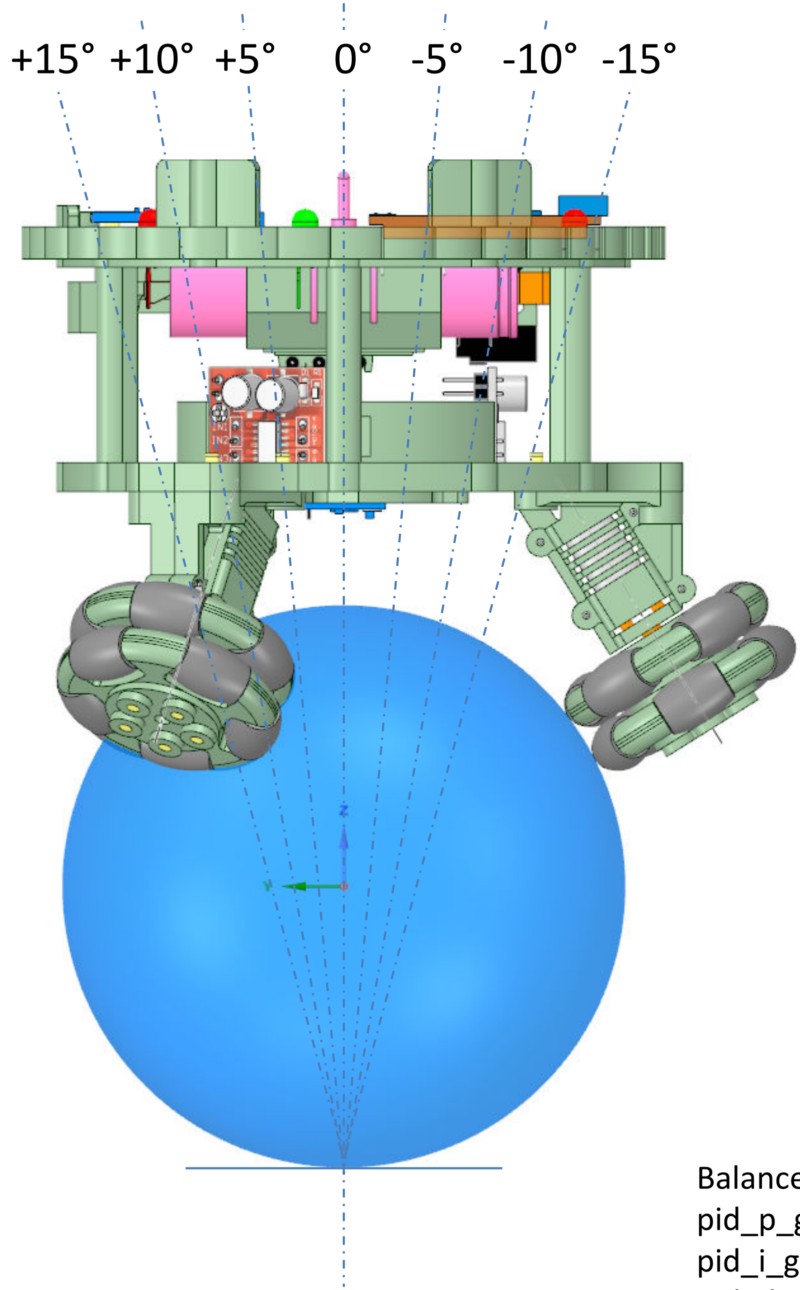
Motor drive factors v error angle



Balancing Gains



pid_outputX = pid_p_gain * pid_error_tempX



BalanceBot Gains:
pid_p_gain = 8.0
pid_i_gain = 0.5
pid_d_gain = 5.0

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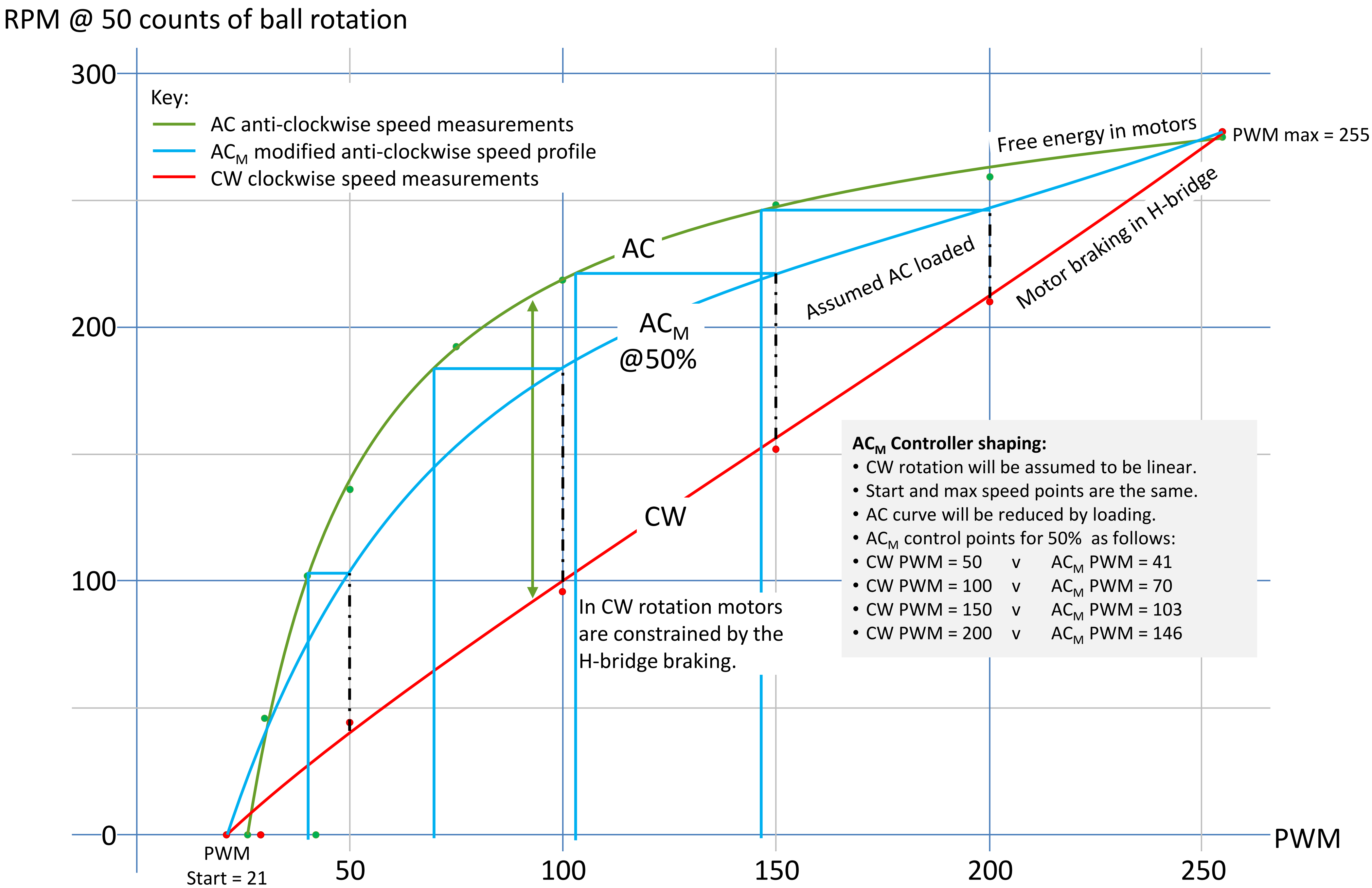

Motor speed curves v PWM

Motor PWM Demand v Power chart