Self-Propelled Metal Detecting Robot

November 4, 2018

Top Level Specifications:

- **The Robot(SPMD) has two main tasks:**
  1. The 1st task is to sweep a 2-meter square area while searching for buried metallic objects.
     - *The SPMD travels a 2 meter distance and then disengages the left driving wheel allowing it to pivot on the inactive wheel. The rotating point will be dictated using the encoder feed backs from each motor speed.*
     - *The deactivated driving wheel is re-engaged once the SPMD has rotated 180° from its previous path.*
     - *The SPMD stops forward travel when it completes the sweep of a 2 meter square area (approx. 5 row sweeps). It also temporarily stops (5-10 seconds) when the metal detecting coil detects an object. This signal (1.1v) activates an ISR that temporarily disables the PWM driving waveform.*
     - *The (1.1v) signal will be amplified up to a logic "Hi" of 3.3v (i.e. Board Vcc). An external "push-button" will substitute this signal for 1st milestone.*

  2. The 2nd task happens when a buried object is detected. A marker indicating the approximate location of the positive signal will be dispensed.
     - *The area will be marked through a colored cardboard puck that is dispensed along with an audible signal (beep).*
     - *The detector signal is read by the ATxmega128B1 board's External voltage measure (ADCB3) port. The 1.1v (amplified 3.3v) signal interrupts the oscillating (C) motor's operation and engages the "marker" (D) motor operation.*
     - *This allows the robot to continue detecting while the marked area can be searched.*

Other Specs:

- The SPMD's design constraints:
  1. *The majority of the chassis and moving parts must be non-metallic. Needs to be made of wood, plastic, fiberglass, cardboard, glue, zip-ties. Any metallic components cannot occupy the "Metal-Free" zone around the moving coil.*
  2. *The large toroidal, magnetic coil produces field fringes that could interfere with a gyroscopic sensor. Any sensitive circuit boards, sensors need to be at the far end of the machine chassis.*
  3. *The robot must be front heavy to promote traction so to help with turning accuracy and limit slippage.*
  4. *The sensing coil needs to sweep perpendicular to the SPMD direction of travel and match its oscillating speed to the SPMD's forward travel.*

Challenges:

The SPMD has three major design challenges.

- The first being the prohibitive use of metallic parts:

  This makes for a large robot chassis with very little usable space. Nothing metallic can be within 5 inches of the sensing coil and its oscillating path. This creates a large "no-metal" zone right above/around the oscillating coil that takes up the majority of usable mounting space. This pushes all batteries, wiring, circuit boards, DC motors and even plastic wheels (mounting screws) to the outer edges.

- The second issue is the use of certain electrical sensors (i.e. digital compass).

  The large toroidal, magnetic, coil produces the magnetic field which detects objects. This produces magnetic field fringes that might cause interference to any digital compass and other sensors accuracy/consistency.

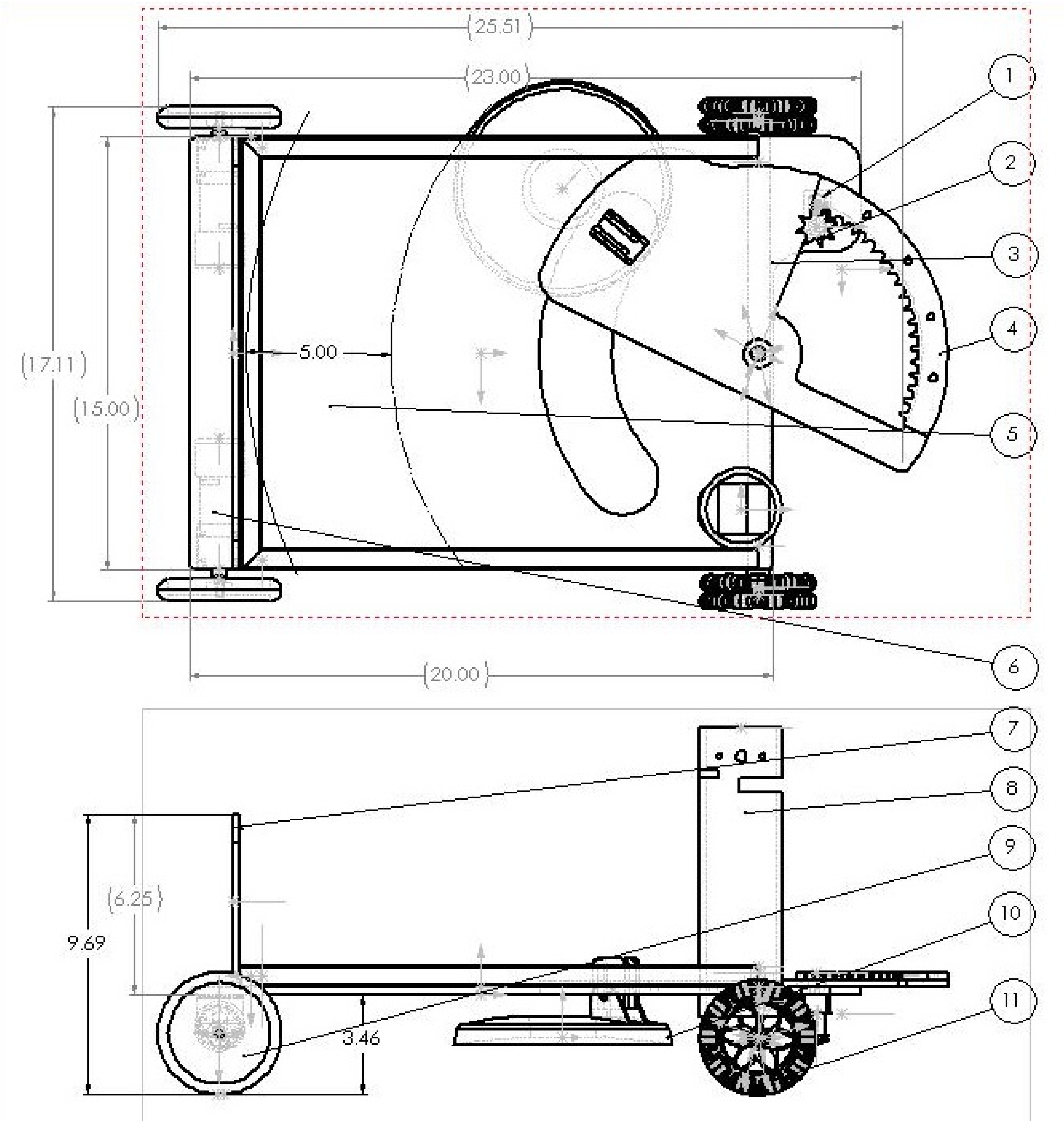
- The third challenging issue is the metal detectors sensitivity:

  The SPMD utilizes the circuit board and sensing coil from a ***Bounty Hunter/Pioneer Ex*** *metal detector. Any sensitivity setting above "Shallow" produces erratic signals. Also, the sensing coil becomes inaccurate at a fast oscillating frequency. This in turn slows down the forward travel of the SPMD. The rate of the sensing coils oscillation must closely match the robots forward velocity to optimize accuracy.*

Solutions to possible problems (Extreme measures):

- Coil field still interfering? Elongating the body of the SPMD to increase the "No-Metal" zone of the sensing coil. Increasing weight on top of driving wheels.
- If SPMD forward travel is driving straight? Install digital compass sensor at end of large antenna (3ft). Pushing it far away and in front of the robot should clear the interference signal.
- Oscillating gear mechanism keeps breaking teeth? Double thickness of rack-n-pinion system.

**1st draft of SPMD robot chassis*



1.) *130-DC motor w/ external gear sys.*

2.) *Driving pinion attached to 130-DC motor w/ external gear(rack-n-pinion)*

3.) *Oscillating base arm*

4.) *Oscillating rack (rack-n-pinion)*

5.) *"Free-Metal" zone*

6.) *Front driving DC-gear motors w/ Encoders*

7.) *Electrical/power mounting face*

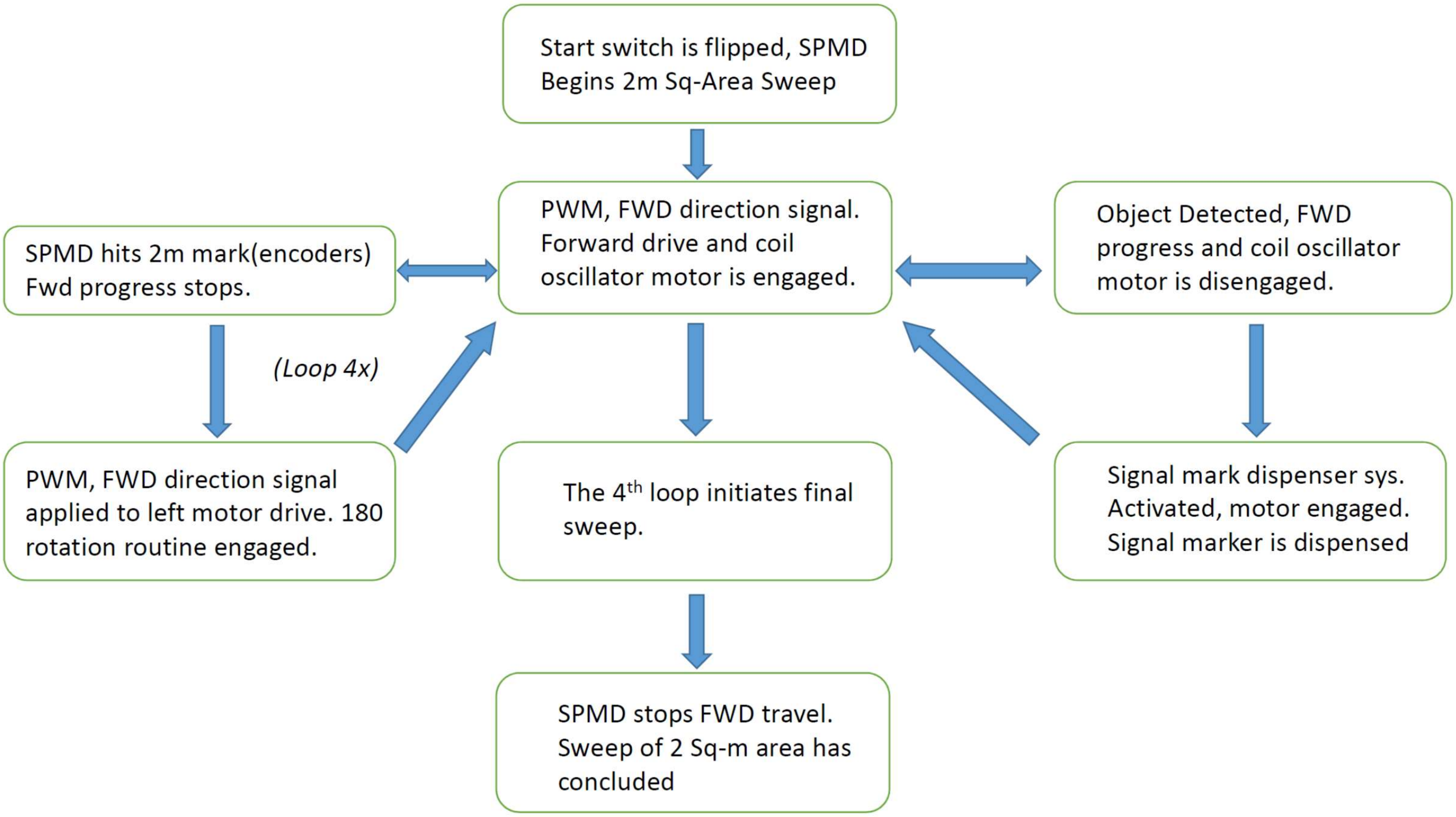
8.) *"Signal-marker" dispensing tower*

9.) *Front driving wheels*

10.) *Detecting coil*

11.) *Fixed, rear Omni wheels*

Block Diagram:



Functional:

- Start Switch starts the robots sweep program.
- Drive motors receive PWM, forward drive signal. Oscillating coil arm is activated. Robot drives forward while sweeping coil side to side.
- Sensing coil detects object, sends signal. Signal interrupts oscillating arm and forward drive signal
- Auxiliary D-motor engaged, signal marker dispenser drops puck.
- (Re-engage)Drive motors receive PWM, forward drive signal. Oscillating coil arm is activated. Robot drives forward while sweeping coil side to side.
- SPMD reaches 2-meter mark at of single row sweep, disengage forward drive.
- SPMD initiates 180º turn routine: Left drive motor receives PWM, forward drive signal.
- (Re-engage)Drive motors receive PWM, forward drive signal. Oscillating coil arm is activated. Robot drives forward while sweeping coil side to side.
- SPMD initiates 4th instance of 180º turn routine. Robot begins final row sweep.
- (Final row sweep)Drive motors receive PWM, forward drive signal. Oscillating coil arm is activated. Robot drives forward while sweeping coil side to side.
- SPMD reaches final 2-meter mark, disengage forward drive. Sweep program has ended.

Milestones:

- **Sean,** get the SPMD to sweep the 2 meter square area (Nov.15):
  - *Calibrate code to allow execution of a 180° turn through driving wheels (H-bridge). The robot should be able to accurately execute (4-5) 180° turns after 2 meters of travel and then stop.*
  - *The DC motor's encoder will need to be integrated into the code to measure approx. actual gear motor speed.*

- **Sal,** calibrate the coil oscillating motor with the "Signal-Marker" dispenser motor (Nov27):
  - *Use the metal detecting signal 1.1v (3.3v) to trigger the secondary (C, D) motors. The detecting coils signal of 1.1v (3.3v) stops the oscillating arm (C-motor) for 5-10 seconds*
  - *Then engages the signal-marker dispenser (D-motor) for 1-3 seconds.*

- **Sean and Sal,** integrate both systems and all the peripherals (Dec. 4):
  - *When a metal object is detected A, B, C-motors pause while D-motor runs its routine.*
  - *Optimize SPMD for speed, accuracy and max sweep area (3 square meters?).*

Parts list & Power requirements:

No.	Description	Qty.	Status	Ref P/N
1	Acrylic sheet (48''x24''x0.1875'')	1	*Have*	*n/a*
2	Fr. Driving Plastic Wheels	2	*Have*	**Disco-Bot*
3	Rr. Plastic Omni-Wheels	2	*Have*	**Disco-Bot*
4	Acrylic solid cylinder stock	1	*Have*	*Assy/ dowels*
5	Mount, DC Gear Motor	2	*Have*	**Disco-Bot*
	(electrical)			
13	Dual H-bridge	2	*Have*	
14	Pmod RS232	1	*Have*	**USART*
15	XmegaBoard w/ Prog. module	1	*Have*	*ATxmega128B1/ ATxmega256A3BU*
16	Bread Board inserts	1	*Have*	Dimensions: 84x55mm
17	Battery (9v)	4	*Have*	
18	Plastic Holder, Battery (9v)	4	*Need*	
19	Battery-AA(9v)	3	*Have*	
20	Plastic Holder, Battery (AA)	1	*Need*	*(3)-AA battery holder*
21				
22	DC Gear Motor w/ Encoder (6v)	2	*Have*	**Disco-Bot*
23	DC motor-(130 Size), offset shaft	2	*Have*	*Solarbotics: RB-Sbo-01*

**Voltage/current needs*

Description	Reqd. (V)	Reqd. (mA)	Source (V)	Source (mAh)	Regulator?
ATxmega board (MC)	3	500	4.5	500	No
(2)-6v driving motors	6	480	9	-	Yes(6v)
Or (2)-12v driving motors	12max	620	9(para.)	-	No
(2)-Auxiliary motors	3(max)	250(max)	3	200	No
Metal detector system	(9+9)	n/a	n/a	n/a	No

**n/a due to the system being repurposed, existing*