WILSONVILLE ROBOTICS
FRC TEAM 1425 "ERROR CODE XERO"
CARTBOT CONTROL SYSTEM

6 JUNE 2017 7:28 PM

ISSUES/TBD

1. power-on screen message (team and/or individual credits?)
2. add electrical schematics/specifications
3. calibrate and document the joystick-to-motor controller curves
4. verify polarity of joystick X/Y axes and motor controller L/R outputs
5. Check the battery low-voltage thresholds for reasonable behavior under load. We don't want unnecessary "charge required" faults but we also want to protect the battery.
6. Check the battery voltage bar graph scaling and adjust spec/code as needed for best utility.
7. Disable the backlight to conserve power when CartBot has been in POWER ON state for more than 3 (TBD) minutes or when the battery voltage is dangerously low (below 10.0V ?)
8. Are there other types of faults that we could reasonably detect?

CHASSIS

CONNECTORS

- IEC 320 C5 power inlet with detachable cord, charger
- Anderson Power Products SB50, red, battery
- cable with molded D9M connector, connects to control panel

FUSES/BREAKERS

- 110V fuse holder (AGC 1A) for charger power
- 2 40A snap-action breakers (internal) for motors
- 1 3A snap-action breaker (internal) for control system

INDICATORS

- charger power (green)
- charger activity (red)
- decorative lighting?

CONTROL PANEL

CONNECTORS

- D9F connector, connects to cable from chassis

CONTROLS

- main power switch
- 2 motor enable (aka "safety" or "deadman") switches, wired in parallel
- Joystick, X-Y analog, spring return to center

INDICATORS

- 4-line x 20-character LCD display, LED backlight, white-on-blue
- speaker/buzzer?
- decorative lighting?

OPERATING STATES

There are 8 defined operating states: POWER OFF, CHARGING, POWER ON, INIT, DISABLED, ENABLED, CONTROL FAULT and BATTERY FAULT. Conditions and outputs for each state are described below. Note that the Arduino is not powered in the CHARGING or POWER OFF states, so those states don't appear in the software.

For safety, software shall not allow transitions to the ENABLED state when the joystick is not centered.
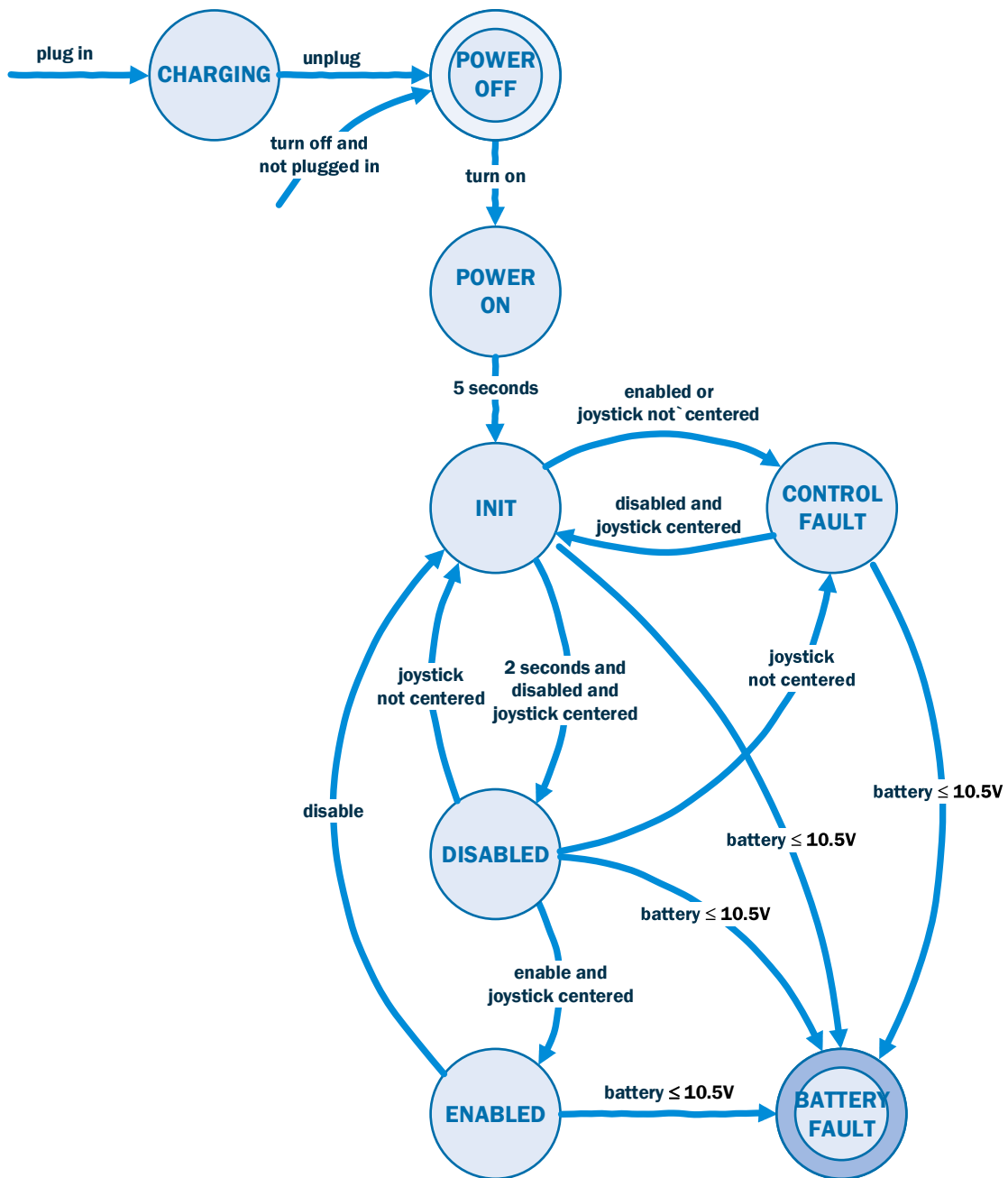
POWER OFF

This is the normal start state for the system.

ENTRY CONDITIONS

- charger power disconnected
- main power switch OFF

OUTPUTS

- charger power indicator OFF
- charger activity indicator OFF
- Arduino power OFF
- motor controller power OFF
- 4x20 display blank, backlight OFF

Power off

EXIT CONDITIONS

- to state CHARGING when charger power is connected
- to state POWER ON when the switch is turned ON (and charger power is not connected)

CHARGING

System hardware (via a relay driven by the charger power circuits) forces the system to the CHARGING state whenever the charger is plugged in to AC power.

ENTRY CONDITIONS

- charger power connected
- main power switch may be ON or OFF

OUTPUTS

- charger power indicator ON
- charger activity indicator OFF, FLASHING or ON, depending on battery charge status
- Arduino power OFF
- motor controller power OFF
- 4x20 display blank, backlight OFF

EXIT CONDITIONS

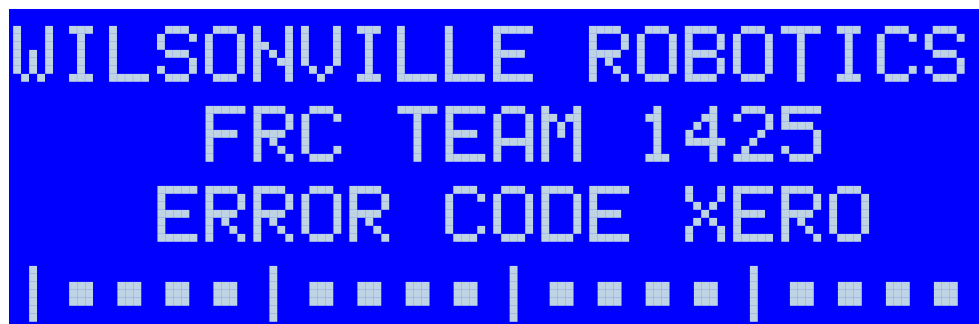- to state POWER OFF when charger power is disconnected

POWER ON

The Arduino starts in this state when power is first turned on. The system displays a "splash screen" for a few seconds while waiting for the battery voltage measurement to stabilize.
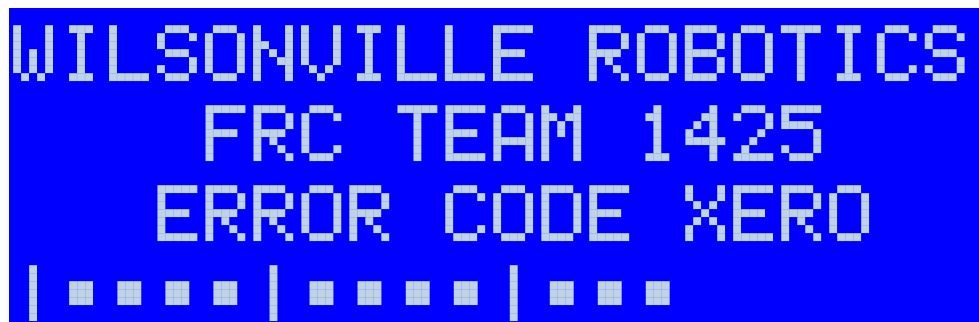
CONDITIONS

- charger power disconnected
- main power switch ON
- battery voltage sufficient to allow Arduino to power up
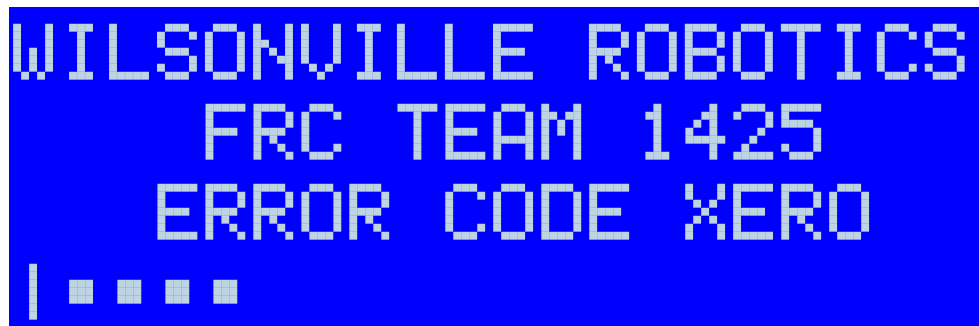
OUTPUTS

- charger power indicator OFF
- charger active indicator OFF
- Arduino power ON
- motor controller power OFF
- display backlight ON
- display rows 1-3 show credits
- display row 4 shows battery voltage bar graph, 10.5V..14.0V with markers every 5 divisions (approx. 0.2V) as shown

Power on, full charge (>13.8V)

Power on, 12.8V

Power on, 11.0V

EXIT CONDITIONS

- to state CHARGING when charger power is connected
- to state POWER OFF when the power switch is turned OFF
- to state INIT after 3 seconds

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INITIALIZING (INIT)

In the INIT state, the system verifies that the battery voltage is sufficient for operation and that the controls are all in safe (disabled, joystick centered) positions.

ENTRY CONDITIONS

- charger power disconnected
- main power switch ON
- both safety switches RELEASED
- joystick CENTERED
- battery voltage > 10.5V

OUTPUTS

- charger power indicator OFF
- charger active indicator OFF
- Arduino power ON
- motor controller power ON
- motors STOPPED
- display backlight ON
- display row 1 shows "CHECKING CONTROLS"
- display row 2 shows "please wait"
- display row 3 shows "Low Battery" if the battery is below 11.2V, else blank.
- display row 4 shows battery voltage bar graph

Initializing, full charge (>13.8V)

Initializing, 11.8V

Initializing, low battery (10.8V)
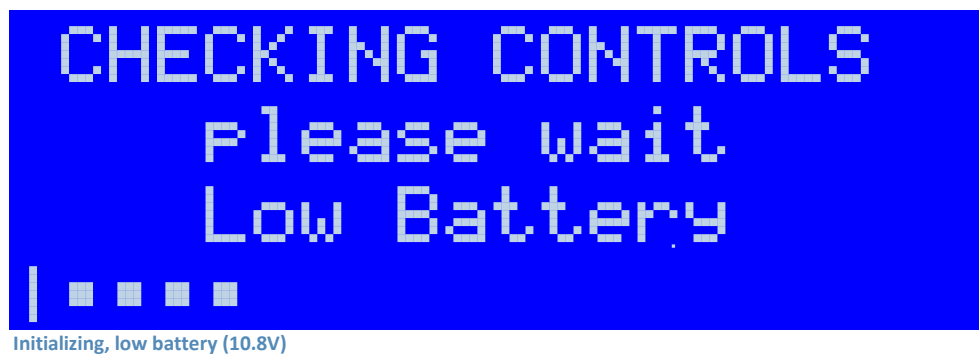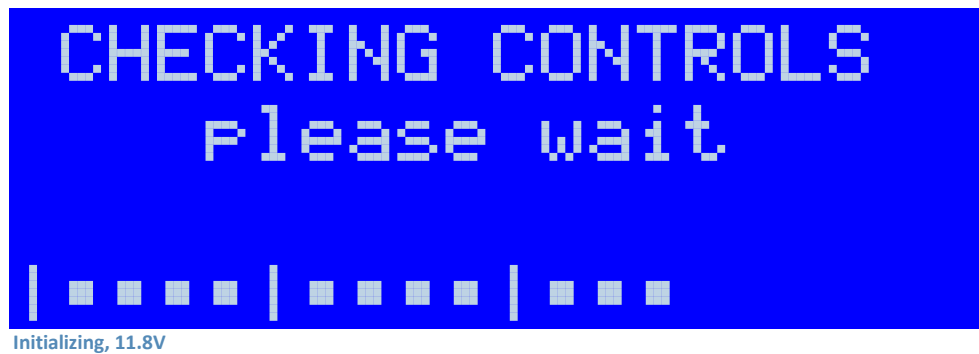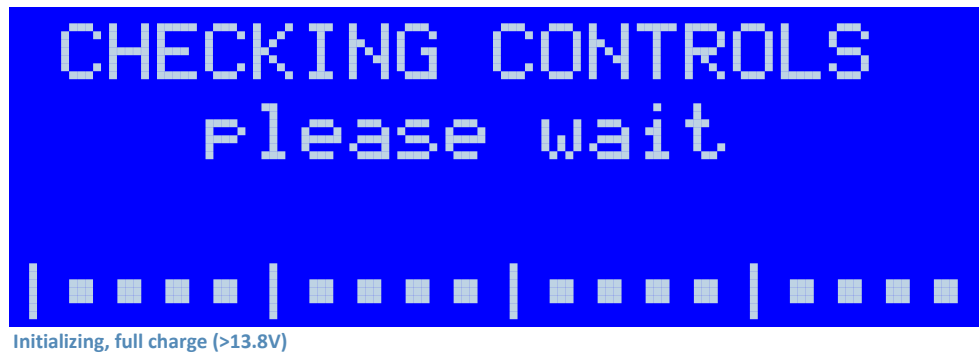
EXIT CONDITIONS

- to state CHARGING when charger power is connected
- to state POWER OFF when the power switch is turned OFF
- to state BATTERY FAULT when the battery is below 10.5V
- to state CONTROL FAULT when either safety button is pressed
- to state CONTROL FAULT when the joystick isn't centered
- to state DISABLED after 3 seconds

ENTRY CONDITIONS

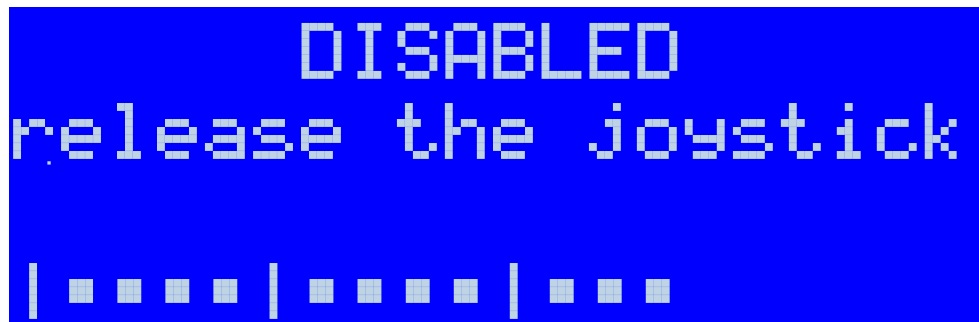- charger power disconnected
- main power switch ON
- battery voltage ≤ 10.5V
- enable button(s) pressed and/or joystick not centered

OUTPUTS

- charger power indicator OFF
- charger active indicator OFF
- Arduino power ON
- motor controller power ON
- motors STOPPED
- display backlight ON
- display row 1 shows "DISABLED"
- display row 2 shows "release the button" if either button is pressed, else "release the joystick" if joystick isn't centered, else "release the kraken"[1]
- display row 3 shows "Low Battery" if the battery is below 11.2V, else blank.
- display row 4 shows battery voltage bar graph, 10.5V..12.4V with 10.5, 11.0, 11.5, 12.0 distinguished as shown (in this state, the row will be blank or showing just the 10.5V marker)
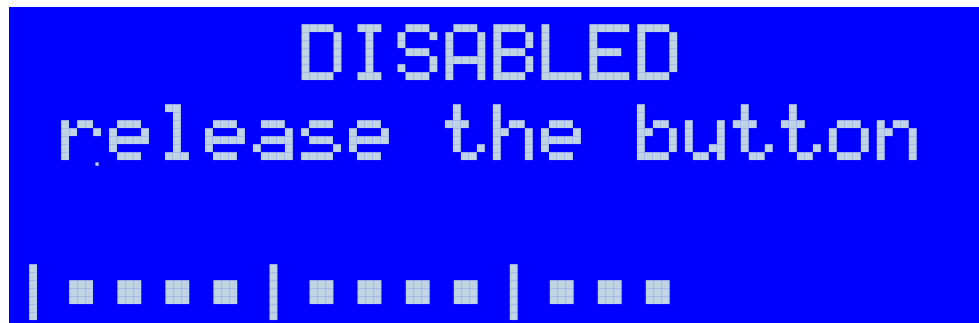
Control Fault (button pressed), 11.8V

Control Fault (joystick not centered), 11.8V

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[1] There is no kraken. This case can't happen.

- to state CHARGING when charger power is connected
- to state POWER OFF when the power switch is turned OFF
- to state BATTERY FAULT when the battery is below 10.5V
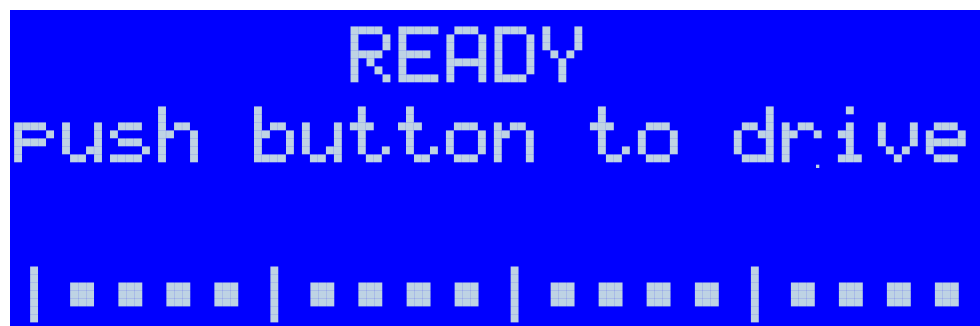- to state INIT when both safety button are released AND the joystick is centered

DISABLED

The system enters the DISABLED state once it determines that the battery is OK and the controls are operating properly.
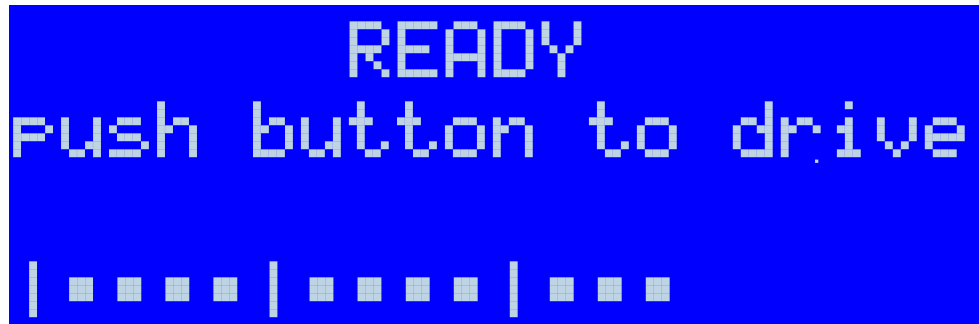
CONDITIONS

- charger power disconnected
- main power switch ON
- both safety switches RELEASED
- joystick CENTERED
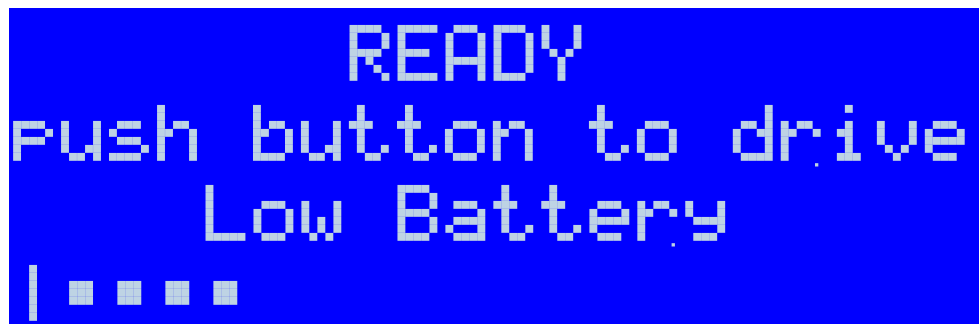- battery voltage > 10.5V

OUTPUTS

- charger power indicator OFF
- charger active indicator OFF
- Arduino power ON
- motor controller power ON
- motors STOPPED
- display backlight ON
- display row 1 shows "READY"
- display row 2 shows "push button to drive"
- display row shows "Low Battery" warning when the battery voltage is less than 11.2V, else blank.
- display row 4 shows battery voltage bar graph

Disabled, full charge (>13.8V)

```
         READY
push button to drive


|■■■■|■■■■|■■■
```
Disabled, not moving, 11.8V

```
         READY
push button to drive
     Low Battery
|■■■■
```
Disabled, low battery (10.8V)

EXIT CONDITIONS

- to state CHARGING when charger power is connected
- to state POWER OFF when the power switch is turned OFF
- to state BATTERY FAULT when the battery is below 10.5V
- to state INIT when both safety button are released AND the joystick is centered

ENABLED (DRIVING)

Pressing either safety button enables the robot drive.

CONDITIONS

- charger power disconnected
- main power switch ON
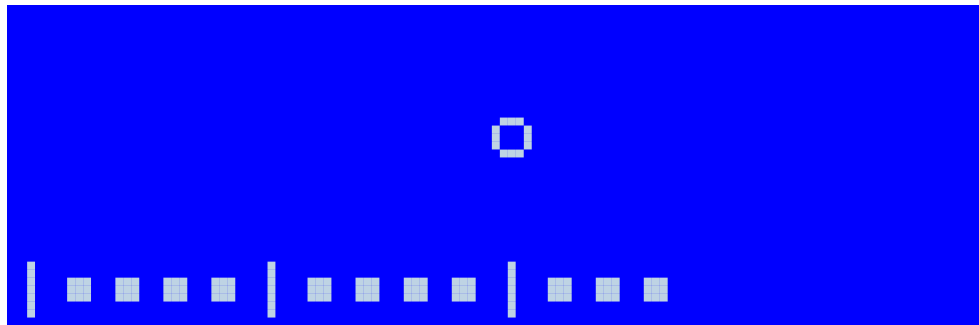- either one or both safety switches PRESSED
- battery voltage > 10.5V

OUTPUTS

- charger power indicator OFF
- charger active indicator OFF
- Arduino power ON
- motor controller power ON
- motors MOVING as directed by joystick

Motion isn't linear! Only forward motion has a "fast" speed. Reverse and turn-only motions are limited to "slow" speed. Actual speeds TBD.

- display rows 1-2 show direction and speed
- display row 3 shows "Low Battery" warning when the battery voltage is less than 11.2V, else blank
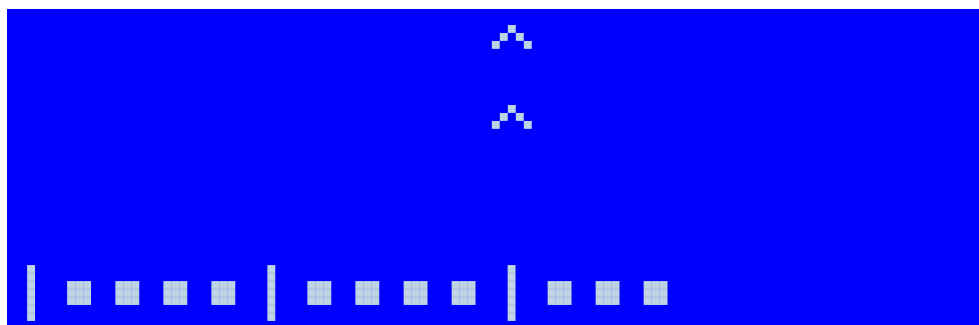- display row 4 shows battery voltage bar graph

These pictures are approximations; the display should use the HD74480 A02 arrow characters rather than the ASCII characters shown here.

Stopped
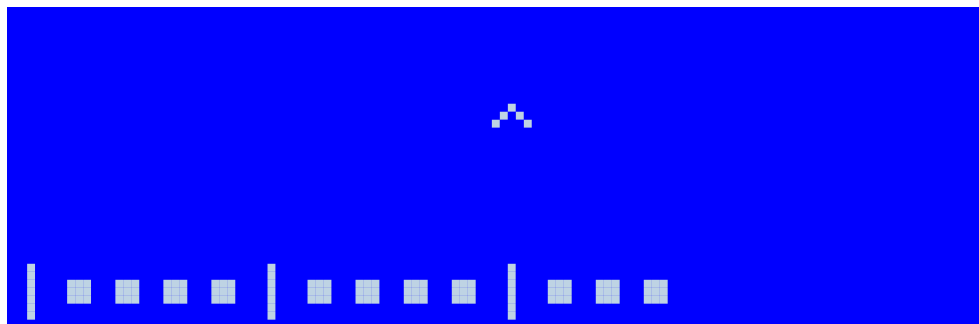
Moving forward slowly
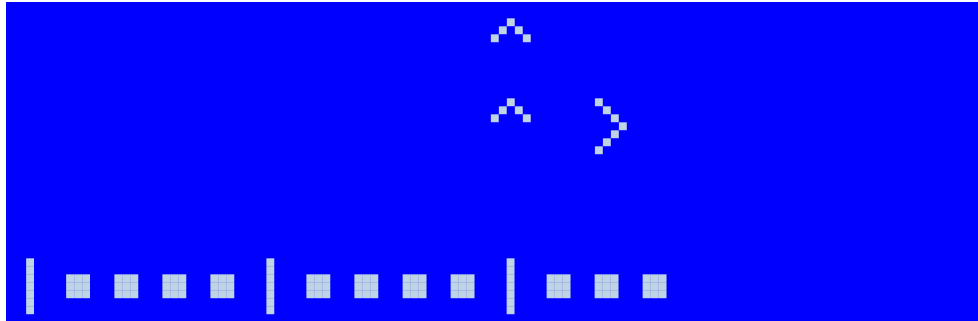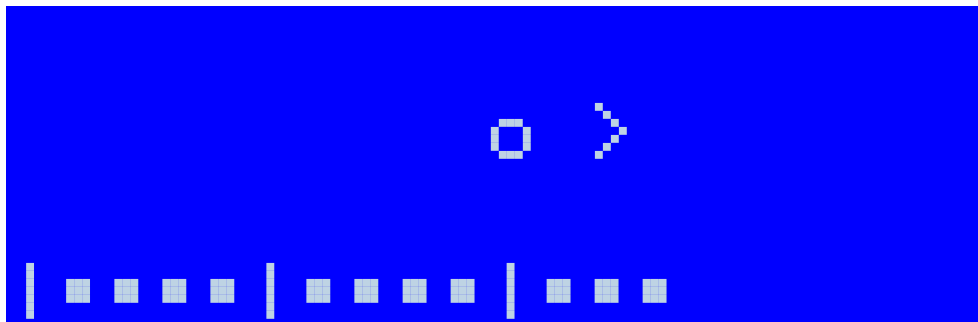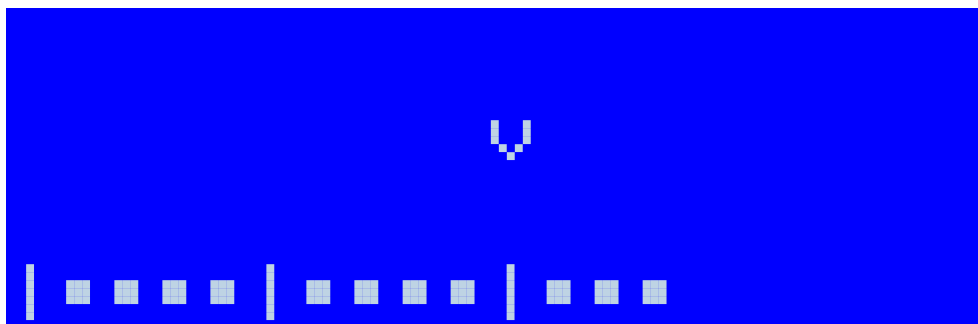

Moving forward faster

Moving forward and turning right

Turning in place

Moving backward

Moving forward slowly, low battery (10.8V)

EXIT CONDITIONS

- to state CHARGING when charger power is connected

- to state POWER OFF when the power switch is turned OFF
- to state BATTERY FAULT when the battery is below 10.5V
- to state INIT when both safety button are released

BATTERY FAULT

ENTRY CONDITIONS
- charger power disconnected
- main power switch ON
- battery voltage ≤ 10.5V

OUTPUTS
- charger power indicator OFF
- charger active indicator OFF
- Arduino power ON
- motor controller power ON
- motors STOPPED
- display backlight ON
- display row 1 shows "BATTERY TOO LOW"
- display row 2 shows "Recharge battery"
- display row 3 shows "before operating"
- display row 4 shows battery voltage bar graph
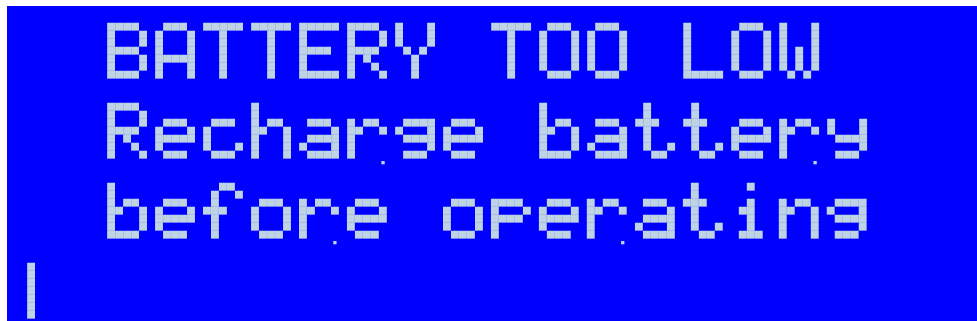
Power on, battery fault (≤ 10.5V)

EXIT CONDITIONS
- to state CHARGING when charger power is connected
- to state POWER OFF when the power switch is turned OFF

		Vin	Vdiv	AnalogRead	Scaled Vmin..Vmax
divider top		10k			
Divider bottom		5.1k			
Vref (Vcc)		5.00			
Vmin		10.50	3.55	725	0
Vmax		13.80	4.66	953	20
		10.40	3.51	718	-1
		10.50	3.55	725	0
		10.60	3.58	732	0
		10.70	3.61	739	1
		10.80	3.65	746	1
		10.90	3.68	753	2
		11.00	3.72	760	3
		11.10	3.75	767	3
		11.20	3.78	773	4
		11.30	3.82	780	4
		11.40	3.85	787	5
		11.50	3.88	794	6
		11.60	3.92	801	6
		11.70	3.95	808	7
		11.80	3.99	815	7
		11.90	4.02	822	8
		12.00	4.05	829	9
		12.10	4.09	836	9

		12.20	4.12	843	10
		12.30	4.15	849	10
		12.40	4.19	856	11
		12.50	4.22	863	12
		12.60	4.26	870	12
		12.70	4.29	877	13
		12.80	4.32	884	13
		12.90	4.36	891	14
		13.00	4.39	898	15
		13.10	4.42	905	15
		13.20	4.46	912	16
		13.30	4.49	919	17
		13.40	4.53	925	17
		13.50	4.56	932	18
		13.60	4.59	939	18
		13.70	4.63	946	19
		13.80	4.66	953	20
		13.90	4.69	960	20
		14.00	4.73	967	21
		14.10	4.76	974	21
		14.20	4.80	981	22
		14.30	4.83	988	23
		14.40	4.86	995	23