Functional Description - Photovoltaic Martian Bugs

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The Photovoltaic Martian Bugs are small, autonomous, mobile, solar-powered robots equipped with a basic sensor array. The inputs will include one or more collision detectors, several buttons, two light meters, and an infrared transceiver. These inputs control the operation of the bugs in the primary operating modes. The outputs include status LEDs, infrared communication, and motion. The inputs and outputs are depicted in Figure 1.

The bugs have two modes of operation as shown in Figure 2. In the default sleep mode, the bugs wait for the light level detected by the light meter to be sufficient to enter active mode. Once in active mode the bug moves and interacts with its environment according to one or more behavioral settings. The backup battery will charge during this mode if sufficient power is available. If the light meter detects that the light level has become insufficient to maintain active mode, the controller circuitry will be alerted, and the bug will gracefully return to sleep mode.

The bugs have four behaviors during active mode. In the default random walk behavior, the bug moves N units forward, and then turns M degrees, continuously, where N and M are randomly chosen at each step. While the bug is moving it may make contact with obstacles (walls, feet, other bugs, etc.). In such an event the bug will stop, back up a fixed distance and turn 45 degrees away from the object. The bug will determine what direction to turn with a set of antenna-like feelers attached to contact switches. When the bug makes contact with one feeler it will back up and turn away from the object. For example, if the bug were to make contact with the left feeler, it would back up and turn right. If it made contact with both feelers at the same time it would back up and randomly turn left or right.

The bugs will remain in random walk mode until the light level drops below satisfactory levels. If the light level becomes too low to maintain continuous operation, the bug will enter into the forage behavior and begin moving towards the area with more light. It will continue foraging until the light level returns to a predefined acceptable range or a sufficient energy source is located.

If the bug encounters a particularly well-lit area, it will stop moving, and transmit a signal over infrared transmitters indicating the light level in the area. It will continue this behavior for a set period of time to allow other bugs to detect the signal and converge on the well-lit area. After this, the bug will go back to foraging for even stronger light sources.

As suggested above, during the forage mode, the bug may receive a beacon signal from another bug that has found a strong light source. If this happens, the foraging bug will change to convergence mode and move towards the beaconing bug. It will continue to do this either as long as the light level keeps increasing or as long as it keeps receiving beacon signals. Once the light level has plateaued the converging bug will resume foraging for light sources.

During any of these behaviors in the active mode, the bug may receive input from several operator buttons mounted on the bug's body. This is shown in Figure 2. A halt button would transition the bug to a hibernation state, in which the bug remains powered on but does not move. This state can be seen in the mode diagram in Figure 2 as the soft off feature. Such a mode could be used to repair the sensors or locomotion systems of the bug "live", or to attach the bug to a host system for debugging. Pushing the halt button again would return the bug to the previous active behavior. A second button would be a true power button that would disconnect the battery and solar panels from the rest of the system. This state is also depicted in Figure 2 as the hard off feature.

At any time during the active mode, the power may be interrupted. This includes pushing the power button, running the battery out, or insufficient current from the solar cells. For the latter condition, the bug would gracefully enter a low power consumption state, powering off the motors and the active sensors and switching the microcontroller to standby, with all other available current directed to trickle-charging the battery. Once the light level returns the bug would power up normally. The other two conditions are "hard power-off" and "soft power-off". Pushing the power button is hard power-off; the solar cells will continue to charge the battery, but the bug will be incapable of returning to active mode on its own. The battery also charges in the soft power-off condition, but the bug will be able to resume upon proper sensory input.

To provide real time status of the bugs current operational mode and behavioral status a dual color LED will be used. The LED will change color according to the current mode of operation. To determine the behavioral state in each of the modes the LED will be pulsed in a unique pattern for each behavior.

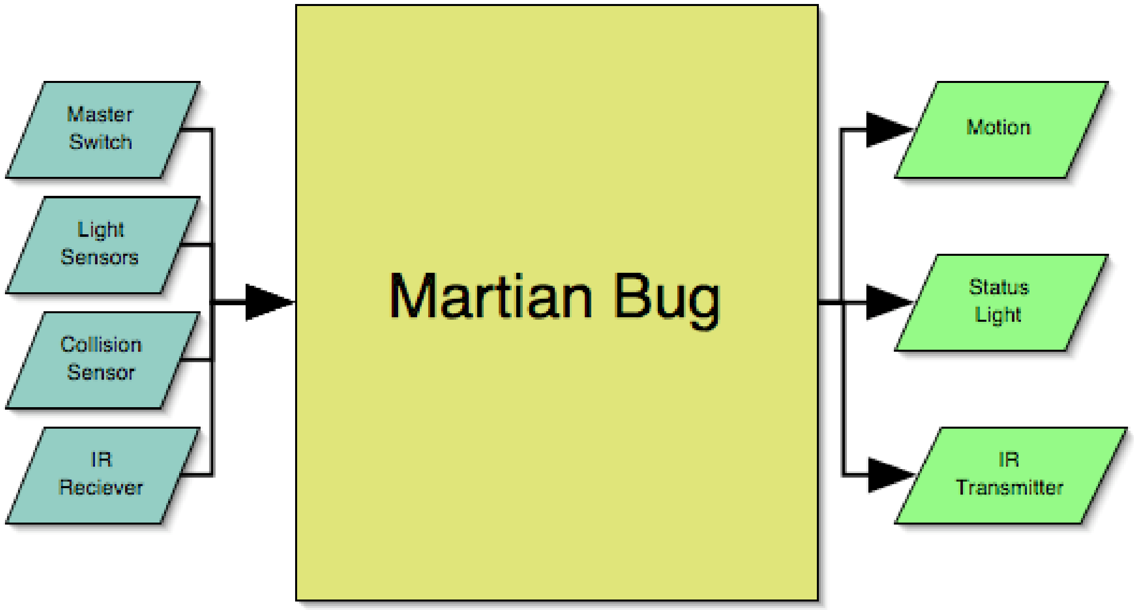

Figure 1: Overall Block Diagram

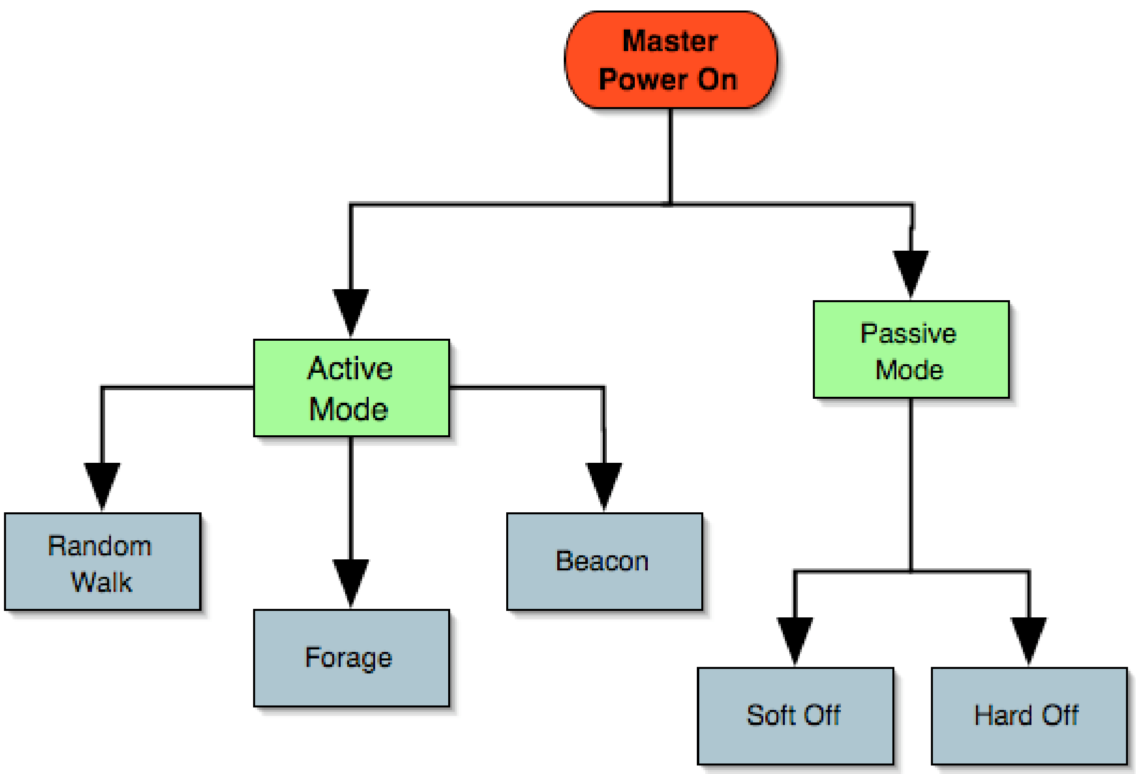

Figure 2: Mode Organizational Chart