# Adventure Kit 2 (AI Apocalypse) Guidebook

Evan Robinson

2023

## Prologue

How did I get here?

I joined a couple of Facebook groups, in particular Adventure Kit 2: Day 0. That's how. I thought I might be able to gently mentor some people in the writing of code for Arduino systems. And in turn be mentored in the creation of circuitry to for which to write code.

So, when I started the inventr.io Adventure Kit 2 (AI Apocalypse) (hereinafter "Kit 2"), I thought I'd post my progress periodically.

When nobody objected, I continued. Right now, I'm working on Chapter 01, section[1] 4: Solar Simulation Shenanigans[2].

And I'm starting to collect the posts in this document, which I will (probably) eventually post to the Facebook group. I seriously doubt it's going to be worth actually publishing it.

To a large extent, the contents of this document will be the same as the posts I have put in the Facebook group

[1] Unlike Adventure Kit 1: 30 Days Lost in Space, each project in Kit 2 isn't conveniently identifiable by a Globally Unique Identifier (GUID), so I have referred to each individual post in the Course Content as a "section". I hope that's clear enough.

[2] Yes, in the Course Content it's spelled Shinanigans. They're wrong.

## To Do List

Chapter 01: Moving In

1. Do these antiques still work:
    - Install System
    - Run Blink successfully
2. Bad Wiring Systems (Fixing the Lights)
    - Control an LED with the HERO (on/off)
3. Easy Light Toggles (adding button inputs)
    - Set light state using momentary on/off button (down on/up off)
    - Use button to signal Hero to turn light off/on – press changes light from on to off to on
4. Solar Simulation Shenanigans (power grid issues)
    - Use photoresistor to simulate solar charging (more light, more charge)
    - Maintain “battery level”
        - Increase with solar input
        - Decrease with time light is on
        - Only charge if level is below a certain level
        - Turn light off when battery power level drops below a different level
        - Add Green LED indicating 95%+ charge
        - Add Red LED indicating 25%- charge
5. 404 Error: Alarms not found (buzzer)
    - Use buzzer to announce battery low power level
    - Beep periodically when below the low power level
6. Dim the Lights (potentiometer & PWM)
    - Use a potentiometer to set power level
    - Set light intensity (via PWM) according to current desired light power level

Chapter 02: Base Security 101

# Chapter 01: Moving In

## Section 01: Do these antiques still work?

I'm leaving this one for the inventr.io people to manage.  It is how you get all the software downloaded and connect up your HERO board and make sure you know how to compile code, upload it to the board, and make the built in LED light blink to your command.

## Section 02: Bad Wiring Systems

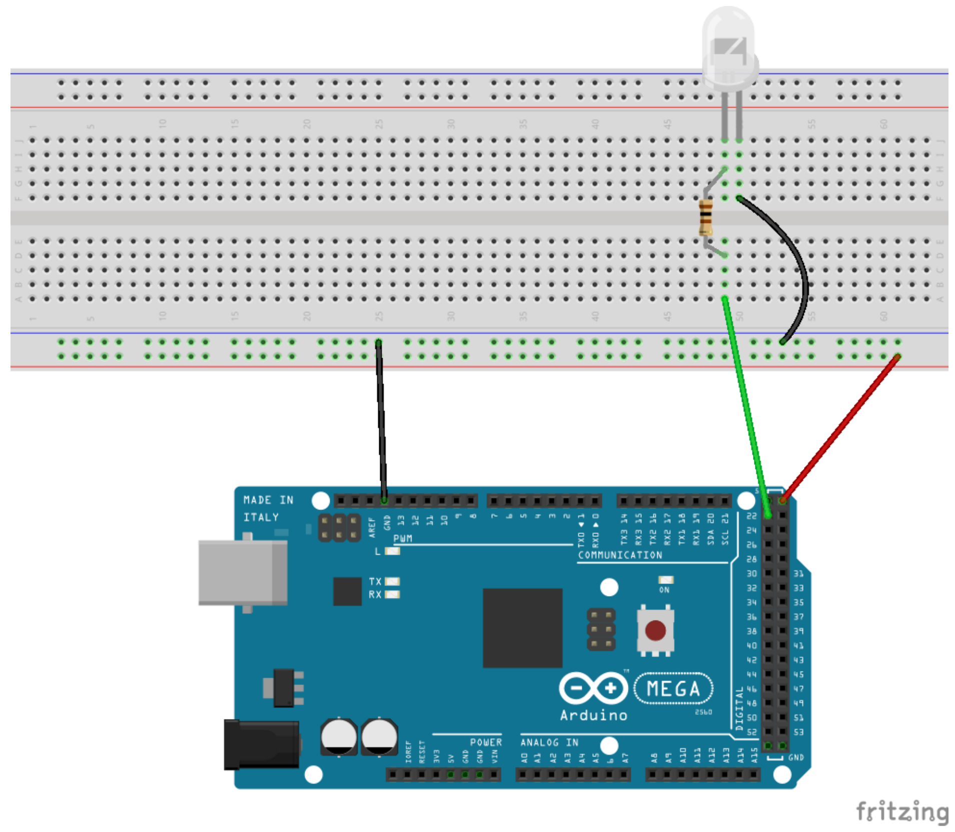
ADDED: I forgot to say that I'm posting these because I hope they will be helpful to people with less experience than I have coding. It's entirely possible I'm wrong, in which case somebody tell me and I'll stop.

I'm also posting these because I'm almost a complete noob at the electronics, and I'm trying to work them from scratch here (still using searches to find things out, but I'm not just copying any circuit that is provided by inventr). So I imagine that at some point somebody will say (roughly) "WTF are you doing? Do it this way!" -- and I'm very happy with that idea.

Feel free to disagree with me. To quote Bull Durham, "I believe what I believe", and I'm not going to insist that y'all agree.

---

My spec: Control an LED with the HERO (on and off).



*Circuit 1: Section 2: Bad Wiring Systems*

| |
|---|
| *White LED* |
| *Resistor 100 Ω* |

## Code:

```
#include <Arduino.h>

const uint8_t whiteLEDControlPin = 22;
const int ledOnIndefintely = 0;

// put function forward declarations here:
void turnLEDOnFor(int millis = 1000, uint8_t pin = whiteLEDControlPin);
void turnLEDOff(uint8_t pin = whiteLEDControlPin);

void setup() {
  pinMode(whiteLEDControlPin, OUTPUT);
}

#define THROW_AWAY_CODE[3]

void loop() {
#ifdef THROW_AWAY_CODE
  digitalWrite(whiteLEDControlPin, HIGH);
  delay(1000);
  digitalWrite(whiteLEDControlPin, LOW);
  delay(1000);
#else
  turnLEDOnFor(300);
  delay(300);
#endif
}

// put function definitions here:
void turnLEDOnFor(int millis, uint8_t pin) {
  digitalWrite(pin, HIGH);
```

[3] An explanation of the #ifdef THROW_AWAY_CODE ... #else ... #endif:

The four lines of code between #ifdef THROW_AWAY_CODE and #else are only compiled if the macro THROW_AWAY_CODE has been defined earlier in the source file.

As the code is, THROW_AWAY_CODE has been defined, and those four lines will be executed. So far as I'm concerned, that is the simplest solution to this particular spec.

HOWEVER, as I plan to use this code as the basis for future code, I have already refactored the code into what I consider a more obvious, understandable, usable, and extendable form.

I may be wrong about any one or more of those adjectives: I may find in the future that this code (the code outside the THROW_AWAY_CODE macro region) is less obvious, less understandable, less usable, and/or less extendable. But it's my current judgement that I'm doing future me a favor here.

```
  if (millis != ledOnIndefintely) {
    delay(millis);
    turnLEDOff();
  }
}

void turnLEDOff(uint8_t pin) {
  digitalWrite(pin, LOW);
}
```

*Code Block 1: Section 2: Bad Wiring Systems*

## Commentary:

1. Use of 'const' instead of #define

   I prefer using 'const int constantName = XX' to '#define CONSTANT_NAME XX primarily because I've been programming for long enough that I've seen other people make a lot of mistakes, I've made a lot of mistakes, and I've used enough tool sets that had bugs in them that I dislike #define.

   Why?

   Because #define is a *textual substitution*, not a syntactic or semantic substitution. Those are big words that means #define is like doing a search/replace on your code. If you've ever tried to, say, replace each use of 'end' in a file with 'END', you will have discovered that you have oddities like 'sEND' and 'trEND' which you did not intEND[4].

   Furthermore, #define can be used to create more complex substitutions, such as '#define MAX(x, y) x > y x : y' which replaces 'MAX(x,y) with a complex expression (the c++ 'ternary operator') which almost certainly needs to be fully parenthesized[5] to deliver what the author intended.

   Because such substitutions happen in the scanning and tokenizing section of the compiler (I know, way more than you want to hear), the code as compiled is not easily available to the programmer, which means the bug is **hard to find**.

   Not Good.

[4] This is a common enough error that Word repeatedly replaced 'intEND' with 'intend' while I was writing this.

[5] #define MAX(x, y) (((x) > (y)) (x) : (y)): which is hardly the most readable thing in the world – although I've seen worse.

And if either 'x' or 'y' are not simple identifiers or numeric constants but instead are *statements*, it gets worse fast. Consider, just for a moment, what happens in this MAX macro if x is 'counter++', which may be textually substituted in twice, so you *might* get two increments instead of one. But that's not the real problem. The real problem is that you didn't intend for the values 'passed' to MAX(x, y) to be *effected at all*, much less twice.

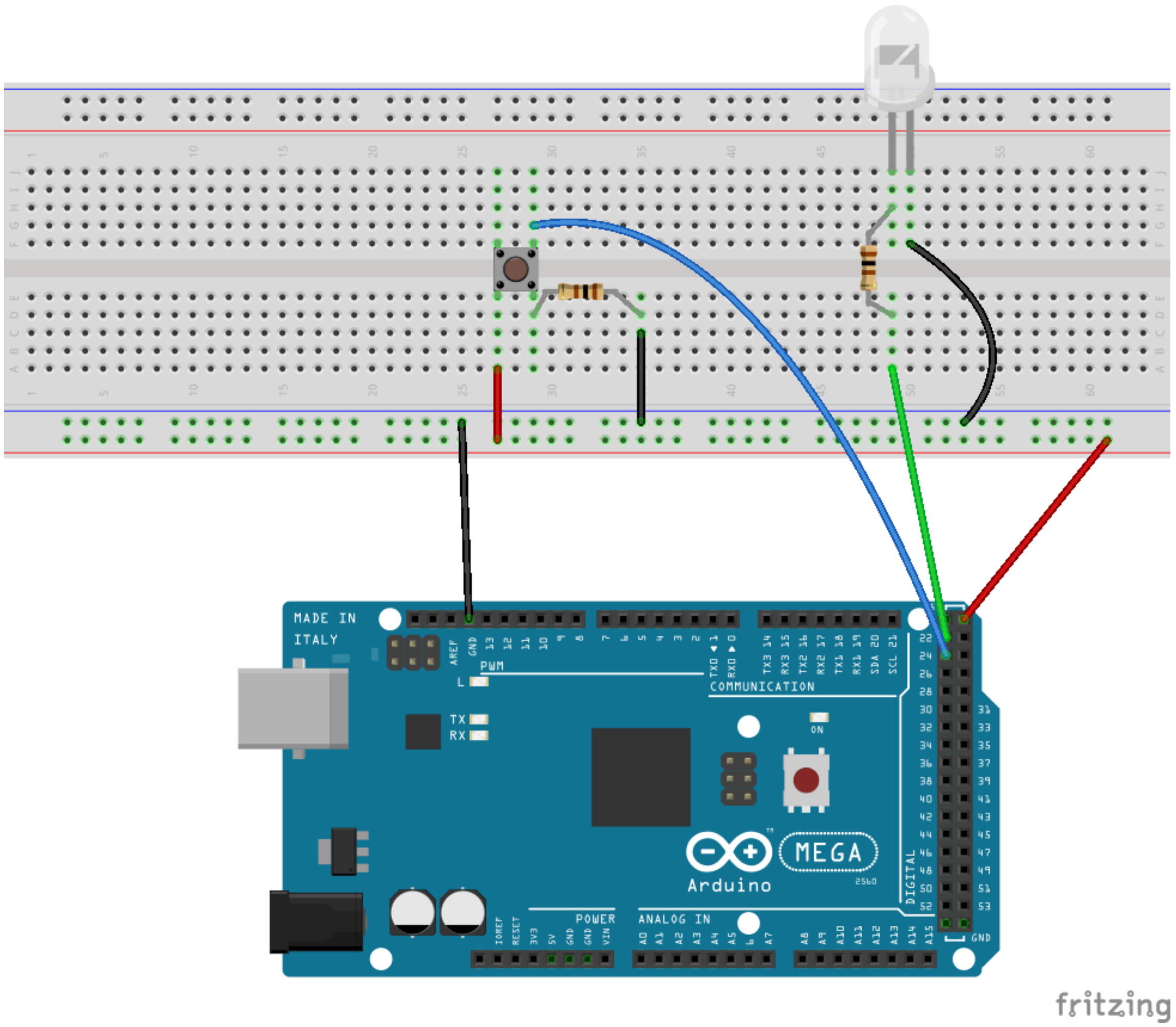
2. Use of default parameters

   The ‘int millis = 1000, uint8_t pin = whiteLEDControlPin’ portion of the forward declarations uses something called ‘default parameters’. Essentially, if I call the function turnLEDOnFor() without any parameters, it uses these. If I call it with a single parameter, it is as though I gave it *only the first* parameter (millis). Thus by passing whiteLEDControlPin as a default parameter, I preserve my option to control any LED with turnLEDOnFor() and turnLEDOff(), but I don’t need to provide the pin parameter every time I call them.

## Section 03: Easy Light Toggles

My spec:

1) toggle light state using momentary on/off button (directly);
2) use button to signal Hero to toggle light from off to on and back



*Circuit 2: Section 3: Easy Light Toggles*

| |
|---|
| *White LED* |
| *Resistor 100 Ω (on LED)* |
| *Resistor 10K Ω (on Switch)* |
| *Momentary On Switch* |

### Code:

```
#include <Arduino.h>

const uint8_t whiteLEDControlPin = 22;
const uint8_t buttonInputPin = 24;
const int ledOnIndefintely = 0;
const long debounceInterval = 50L;
const int buttonPressed = 1;

// put function forward declarations here:
void turnLEDOnFor(int millis = 1000, uint8_t pin = whiteLEDControlPin);
void turnLEDOff(uint8_t pin = whiteLEDControlPin);
void toggleInteriorLights(void);

void setup() {
  pinMode(whiteLEDControlPin, OUTPUT);
  turnLEDOff();
  pinMode(buttonInputPin, INPUT);

  Serial.begin(9600);
  Serial.println("setup complete");
}

void loop() {
  static int previousPinValue = 0;
  static long previousDebounceTime = millis();
  int pinValue = digitalRead(buttonInputPin);

  if ((millis() - previousDebounceTime) < debounceInterval) {
    // debouncing: if the transition was less than debounceInterval ms ago, ignore it
    return;
  }

  if (previousPinValue != pinValue) {
    previousPinValue = pinValue;
    if (pinValue == buttonPressed) {
      toggleInteriorLights();
    }
  }
}

// put function definitions here:
void toggleInteriorLights(void) {
  static bool lightIsOn = false;

  if (lightIsOn) {
    turnLEDOff();
    lightIsOn = false;
  }
  else {
    turnLEDOnFor(ledOnIndefintely);
    lightIsOn = true;
  }
}

void turnLEDOnFor(int millis, uint8_t pin) {
  digitalWrite(pin, HIGH);
  if (millis != ledOnIndefintely) {
    delay(millis);
    turnLEDOff();
  }
}

void turnLEDOff(uint8_t pin) {
  digitalWrite(pin, LOW);
}
```

*Code Block 2: Section 3: Easy Light Toggles*

## Commentary:

1. 'toggleInteriorLights()'

   This is the first indication that the code is going to become more Literate.  Everything else in the code here and that we've seen so far is very hardware specific.  Very much in the Arduino/electronics domain, if you will.  The code that runs the lighting refers to LED and lots of variable names reference 'pin' of one sort or another.

   What I mean by "in the Arduino … domain" is that the code is not talking about the fantasy inventr.io is providing us.  Instead, its talking about the microcontroller and the things on the breadboard.

   The next Section, Solar Simulation Shenanigans, will change this in a big way by *refactoring the code into the problem domain*.

2. Debouncing

   "Debouncing" a key or button refers to managing the moments where it is so close to closing or opening that the value presented by the electronics is indeterminate or changing back and forth so quickly that it may be 0 one millisecond, 1 the next, and 0 again the one after that.

   Humans do not operate at that speed.

   So we introduce code to make sure that the state of the switch is stable for some period of time that humans can operate at.  In this code, the simplest possible debouncing: ignoring any state change in the switch return value for at least 50ms.  It's not perfect, but for the learning experience it is good enough.

## Interlude: Refactoring

Refactoring is restructuring your code to make it better. What does "better" mean?

For my purposes, it means "easier to understand". Because that means "easier to change", "easier to reuse", "easier to fix", and "easier to build upon".

You will find a variety of definitions online for the word "refactoring". Common among them is the idea that this change does not change the underlying function, and that the changes are made systematically – sometimes to the extent of following a bunch of rules.

I use the word somewhat loosely.

I was introduced to the word "refactoring" in 1999, when I worked at Adobe Systems in the core technology group. Jon Reid, one of my team, got very interested in the book when it came out. As I was no longer primarily a programmer, I got the gist but haven't ever done the formal process.

In this case, there are going to be two major things happening to the code: I'm going to introduce some classes (real Object Oriented Programming stuff!); and I'm going to rename and re-organize the code from the hardware/microcontroller oriented names and organization into what I call the "*problem domain*[6]" – instead of building circuits and writing code to make electronic components do certain things, I'm going to start creating a "post-apocalyptic dwelling".

So no more referring to the lights as "LEDLights" or anything like that. These lights are the *interior lights* of our house. The button isn't constantly referred to using the buttonInputPin, now it's called the *interiorLightsButton*.

### Classes:

led.h / led.cpp:

[6] The first time I remember using this specific term, I was a Technical Director at Electronic Arts providing advice to the team that was designing and building Madden Football for the 3DO console. We were discussing how the developers should handle kickoffs, and the designer was talking about force applied to the football and vectors and directions.
I stopped him and said (approximately) "you want the code to mirror the problem domain. How does a kicker think about kicking the football? They don't say to themselves 'I'm gonna hit this ball with 72 Newtons of force in a horizontal vector of 22° to the right of center at an upward angle of 42.5°'. They say to themselves 'kick away to the right side', 'onside straight ahead looking for a pooch up', or 'I want the ball to bounce straight up near the right sideline and goal line".
These last three descriptions exist in the world of *football*, not the world of *physics*. Yes, they will eventually get translated to the world of physics, but that's not how they start.

The LED class encapsulates the basic functioning of an LED on the breadboard, with a pulldown resistor (as opposed to a pullup resistor – made evident by the use of HIGH as on and LOW as off). It provides a *constructor* (used to create the object, bind it to the relevant pin, and set the necessary pinMode), *methods* (functions) to turn the LED on and off, and a *method* to determine whether the LED is currently on.

Classes in c++ (opinions differ as to whether the Arduino language is a full implementation of c++ or not. I have no opinion) are generally *declared* (described from an external point of view) in a .h file and *defined* (described sufficiently to create executable code) in a .cpp file.

Classes are the basic unit of *inheritance* (the re-use of code by creating *subclasses* or derivative classes which extend their *superclass* or ancestor class). Effectively that means that I can create a subclass of LED which would have the same public interface but run different code where necessary (if creating a class to control an RGB LED, or a BiColor LED). The public interface can be extended to include additional necessary functionality (as to set the color of an RGB LED).

```
/*
    led.h
    Evan Robinson, 2023-09-30

    Class to manage LED on arduino
    Presumes HIGH is on, LOW is off
*/

#ifndef led_h
#define led_h

#include <Arduino.h>

class LED {
    public:
        LED(uint8_t pin);
        void turnOn();
        void turnOff();
        bool isOn();
    private:
        uint8_t _pin;
        bool _isOn;
};

#endif
```

*Code Block 3: Interlude: led.h (the declaration of the class LED)*

```
/*
    led.cpp
    Evan Robinson, 2023-09-30

    Class to manage LED on arduino
    Presumes HIGH is on, LOW is off
*/

#include "led.h"
#include <Arduino.h>

LED::LED(uint8_t pin) {
    _pin = pin;
    pinMode(_pin, OUTPUT);
    turnOff();
}

void LED::turnOn() {
    digitalWrite(_pin, HIGH);
    _isOn = true;
}

void LED::turnOff() {
    digitalWrite(_pin, LOW);
    _isOn = false;
}

bool LED::isOn() {
    return _isOn;
}
```

*Code Block 4: Interlude: led.cpp (the definition of the class LED)*

button.h / button.cpp:

The Button class encapsulates the basic function of a momentary on push button (or switch), again with a pulldown resistor (so HIGH is pressed, LOW is not pressed).

```
/*
    button.h
    Evan Robinson, 2023-09-30

    Class to manage momentary button on arduino
    Presumes HIGH is pressed, LOW is not pressed
    Press occurs on down press of button
*/

#ifndef button_h
#define button_h

#include <Arduino.h>

class Button {
    public:
        Button(uint8_t pin);
        bool isPressed();
        bool hasChanged();
        int value();
    protected:

    private:
        uint8_t _pin;
        int _value;
        int _valueHasChanged;
};

#endif
```

*Code Block 4: Interlude: button.h (the declaration of the class Button)*

Note that there is only one method where the value of the push button is read from the hardware.  This guarantees that any necessary housekeeping will be done no matter how the user programmer accesses the value.

```
/*
    Button.cpp
    Evan Robinson, 2023-09-30

    Class to manage momentary button on arduino
    Presumes HIGH is pressed, LOW is not pressed
    Press occurs on down press of button
*/

#include "button.h"
#include <Arduino.h>

Button::Button(uint8_t pin) {
    _pin = pin;
    pinMode(_pin, INPUT);
    _value = value();
    _valueHasChanged = false;
}

bool Button::isPressed() {
    _value = value();
    return (_value == HIGH);
}

int Button::value() {
    // TBD: Debounce
    int currentValue = digitalRead(_pin);
    _valueHasChanged = (_value != currentValue);
    // if (_valueHasChanged) {
    //     Serial.println(currentValue);
    // }
    return digitalRead(_pin);
}

bool Button::hasChanged() {
    return _valueHasChanged;
}
```

*Code Block 5: Interlude: button.cpp*

```
/*
  Simulated post-apocalyptic dwelling

  Supports simulated interior lighting (interiorLights)
    controlled by a momentary switch (interiorLightsButton)
    which toggles lights on and off
*/
#include <Arduino.h>
#include "button.h"
#include "led.h"

// Hardware values
const uint8_t whiteLEDControlPin = 22;
const uint8_t buttonInputPin = 24;

// Dwelling Contents
Button interiorLightsButton = Button(buttonInputPin);
LED interiorLights = LED(whiteLEDControlPin);

// Forward Declarations
void interiorLighting(void);

// Arduino Setup
void setup() {
}

// Arduino Loop
void loop() {
  // Loop every 1/10th seconds
  delay(100);

  interiorLighting();
}

// Local Functions
void interiorLighting() {
  // Turn interiorLights on and off
  if (interiorLightsButton.isPressed()) {
    if (interiorLightsButton.hasChanged()) {
        if (interiorLights.isOn()) {
          Serial.println("Lights Off");
          interiorLights.turnOff();
        }
        else {
          Serial.println("Lights On");
          interiorLights.turnOn();
        }
    }
  }
}
```

*Code Block 5: Interlude: main.cpp*

Although the file is still called main.cpp, it bears little resemblance to its predecessor.  The pin definitions are the same, but no setup happens in setup() anymore because it's all handled by the constructors under the // Dwelling Contents comment.

The interior lights are now fully managed by a single function call in loop(): interiorLighting();

interiorLighting() asks interiorLightsButton if it 'isPressed'.  If it is, and it 'hasChanged', then it's time for us to toggle the interior lights from on to off or off to on.

We are now in the problem domain, doing things to our simulated dwelling instead of our real physical circuitry.

Now it's time to add the simulated battery and solar charging systems.

## Section 04: Solar Simulation Shenanigans

Code:

Commentary

## Section 05: 404 Error: Alarms not found

Code:

Commentary

## Section 06: Dim the Lights!

Code:

Commentary

# Chapter 02: Base Security 101