How to Move
Canon EF Lenses

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Preface

• This instruction is intended to be helpful to those who are interested in making modifications to camera lenses to explore/reproduce focus sweep, focal stack, and other related imaging techniques for research purposes.

• But we disclaim any responsibilities for the consequences of your following this instruction, so do it at your own risk!
Outline

• Overview & preparation
• Lens modification
• Wiring
• Software
• Putting them together
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The Lens in This Instruction

• Canon EF-S 18-55mm f/3.5-5.6 IS II
  – Comes with a Canon EOS Rebel camera kit
• Any Canon EF lenses may be used
The Goal

- The lens has motors and control circuits inside, and operates according to commands from a camera body.
- All you need is to intercept such communications and send “move focus” commands to the lens.

Normally, a camera body sends commands.

An external board (we use Arduino) sends commands.

Lens

Camera body

Lens

Camera body

Arduino

Hack
Lens Pin-out

- Protocol: SPI (serial peripheral interface)
  - 8 data bits, 1 stop bit

VBAT: 6V power for lens motors
P-GND: Ground for lens motors
VDD: 5.5V power for digital logic
DCL: Data from camera to lens (MOSI)
DLC: Data from lens to camera (MISO)
CLK: Clock
D-GND: Ground for digital logic

MOSI: master output, slave input
MISO: master input, slave output
master: camera in this case
slave: lens in this case
Battery supplies power to the lens motors
Arduino controls the lens digital logic
No need to monitor DLC pin
Battery supplies power to the lens motors
- Arduino controls the lens digital logic
- No need to monitor DLC pin

- Additional wires for synchronization

D-GND  CLK  DLC  DCL  VDD  P-GND  VBAT  6V battery

Arduino

Camera body
Tools & Parts

Batteries can be anything that produces 6V voltage

Four AA batteries

Wire

Camera body (Rebel T3i is used here, but can be any Canon EOS camera)

Battery holder

Arduino (+ USB cable)

Batteries can be anything that produces 6V voltage

Phillips micro screwdriver

Nippers

Pliers

... and

- Solder
- Soldering iron
- Drill
- (Circuit tester)
- (Breadboard)
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Lens Modification

• Our sub-goal here is to wire the pins from outside so that we can send commands from an external board.
Remove the Screws 1/2

- Remove the two micro screws beside the pins
Remove the Screws 2/2

• Remove the four screws on the back side of the lens
FYI

- Those four screws are tight
- You might want to use pliers to unscrew them
Detach the Back Cover

This cable is for image stabilization (anti-camera shake). You can remove it if it gets in your way.
Insert Wires

- Drill six holes in the lens housing under the pins
- Pass six wires through the holes
Solder the Wires

- Make sure to keep track of which wire goes to which pin
- Make sure they are electrically connected using a circuit tester

For ease of soldering, we directly attached wires on top of the pins, making the lens unable to talk with a camera body any more. We could instead solder wires to the lower part of the pins, in which case the lens can still be used as a normal lens.
Reassemble

• Squeeze the wires into the lens housing
• Put the cover back with the screws

No need to put back the two micro screws for fixing the pins
Tricks to Fit the Wires

• Cut out portions of the cover and housing with nippers

To make room for the wired/soldered pins

A few wires can be laid through this gap
Tape the Pins

• To make sure that the lens is electrically disconnected from the camera body
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- **Wiring**
- Software
- Putting them together
Overall View of Wiring

- Modified lens
- Hot shoe
- Power
- Commands
- Shutter release signal
- Battery
- USB cable from a computer (code upload & power supply to Arduino)
- Arduino
Hot Shoe Pin-out

- Shutter release can be detected from flash trigger signal (FLA) at the hot shoe, which can be used for synchronizing lens control.

The other four small pins will not be used.
Attach Wires to the Hot Shoe

- Cut out a square piece of plastic with two holes and insert in the hot shoe with wires
- Or just directly solder wires to the pins
Arduino Pin Assignment

Lens pins: D-GND, CLK, DCL, VDD

Hot shoe pins: GND, FLA

[Diagram showing pin connections on Arduino Uno board]
Full Schematic

- Arduino
- GND 13 11 10
- 6V battery
- GND
- FLA
- D-GND
- CLK
- DLC
- DCL
- VDD
- VBAT
- P-GND
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const int HotShoe_Pin = 8;
const int HotShoe_Gnd = 9;
const int LogicVDD_Pin = 10;
const int Cam2Lens_Pin = 11;
const int Clock_Pin = 13;

void setup() // initialization
{
    pinMode(HotShoe_Pin, INPUT);
    digitalWrite(HotShoe_Pin, HIGH);
    pinMode(HotShoe_Gnd, OUTPUT);
    digitalWrite(HotShoe_Gnd, LOW);
    pinMode(LogicVDD_Pin, OUTPUT);
    digitalWrite(LogicVDD_Pin, HIGH);
    pinMode(Cam2Lens_Pin, OUTPUT);
    pinMode(Clock_Pin, OUTPUT);
    digitalWrite(Clock_Pin, HIGH);
    delay(100);
    send_signal(0x??);
    delay(100);
    send_signal(0x??);
}

void loop()
{
    if(digitalRead(HotShoe_Pin) == LOW) // upon shutter release
    {
        send_signal(0x??); // move focus to infinity
        delay(1000);
        send_signal(0x??); // move focus back to nearest
        delay(1000);
    }
}

void send_signal(byte signal) // SPI command generator
{
    unsigned int i;
    for(i = 0; i < 16; i++)
    {
        digitalWrite(Clock_Pin, i & 1);
        digitalWrite(Clock_Pin, (signal >> (i / 2)) & 1);
    }
}

We are asked not to disclose the commands in public. Please contact me to get the values shown as ??.
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Put Them Together

- Attach the modified lens to the camera body
- Connect the wires
- Turn on the camera
- Turn on the battery
- Turn on the Arduino
- Upload the code to the Arduino
  - This step can be skipped from next time, as the code stays on the board
- Press the shutter button
  - The lens should move
Make it Portable (optional)

• The 6V battery can also be used for supplying power to the Arduino
Schematic for Portable Setting

- **VBAT**
- **P-GND**
- **GND**
- **DLC**
- **DCL**
- **CLK**
- **D-GND**
- **VDD**
- **Vin**
- **GND**
- **Arduino** (pins 9, 8, 13, 11, 10)
- **6V battery**
- **GND**
- **FLA**
Mount Everything

The rubber cover can be ripped off and the parts can be screwed into the camera body.