

Capturing Lightning

Chris Dzombak
@cdzombak

for the Haus Series

2011-10-18

About Me

- CSE senior
 - formerly CE
- Software developer at Nutshell
 - Android, JS/JQuery, HTML, CSS3, PHP, MySQL
- Hobbies: photography, lighting design, journalism
- And making cool stuff

Capturing Lightning

- Device to sense lightning and trigger a camera (any DSLR)



Accomplishments

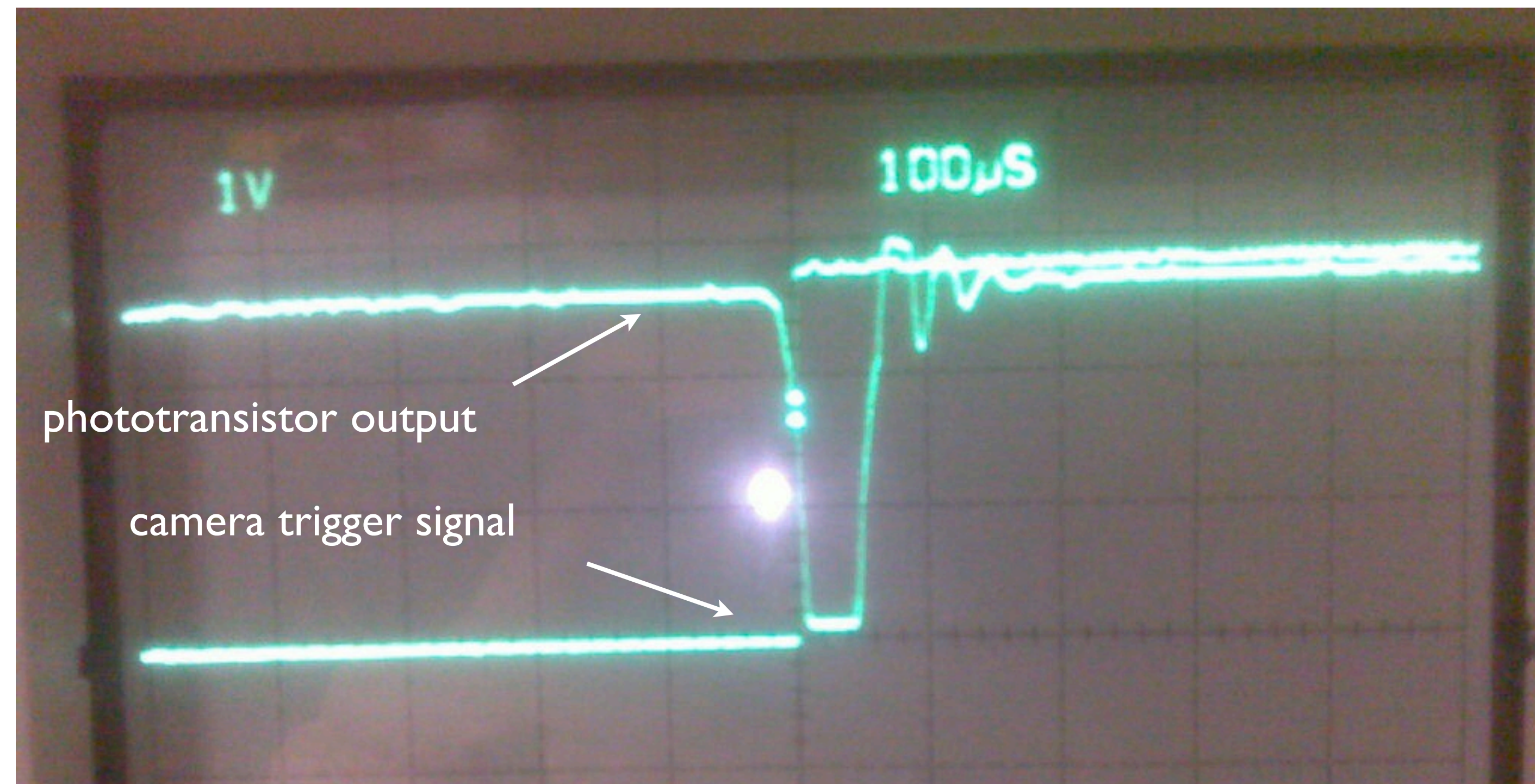
- Reliably senses barely-visible test flashes
- Triggers camera
- Microsecond-order delay
- Not much real-world testing yet (scheduling issues)

Lightning

- Lightning strikes composed of several individual “strokes”
 - Spaced tens of milliseconds apart
 - Strokes are microseconds long
- On average; stats vary widely
 - <http://www.youtube.com/watch?v=dukkO7c2eUE>

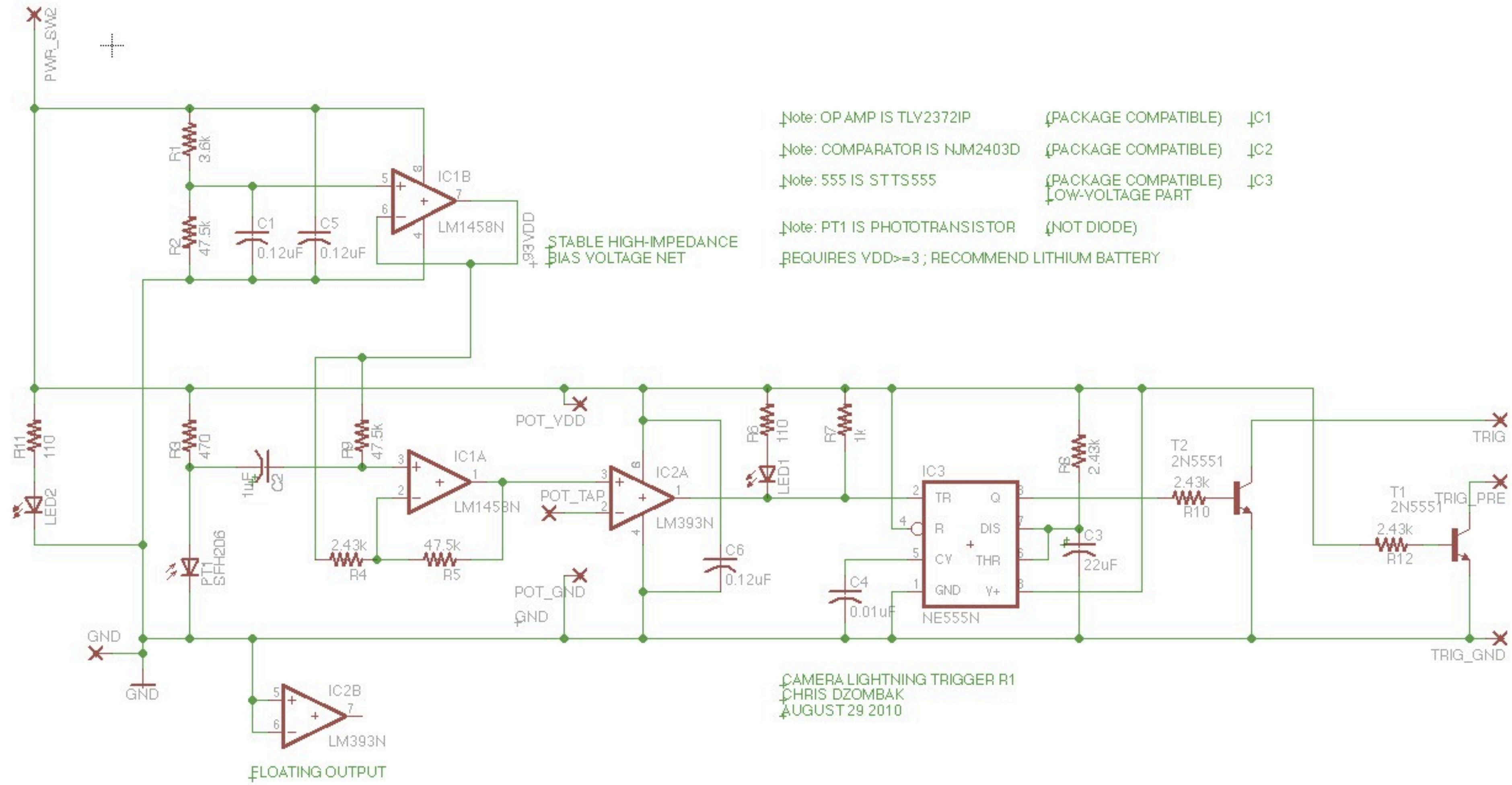
Delay

- Delay through my device is single microseconds
- Trigger delay on the Nikon D700 is ~ 47 ms



So, in theory, it works.

How?

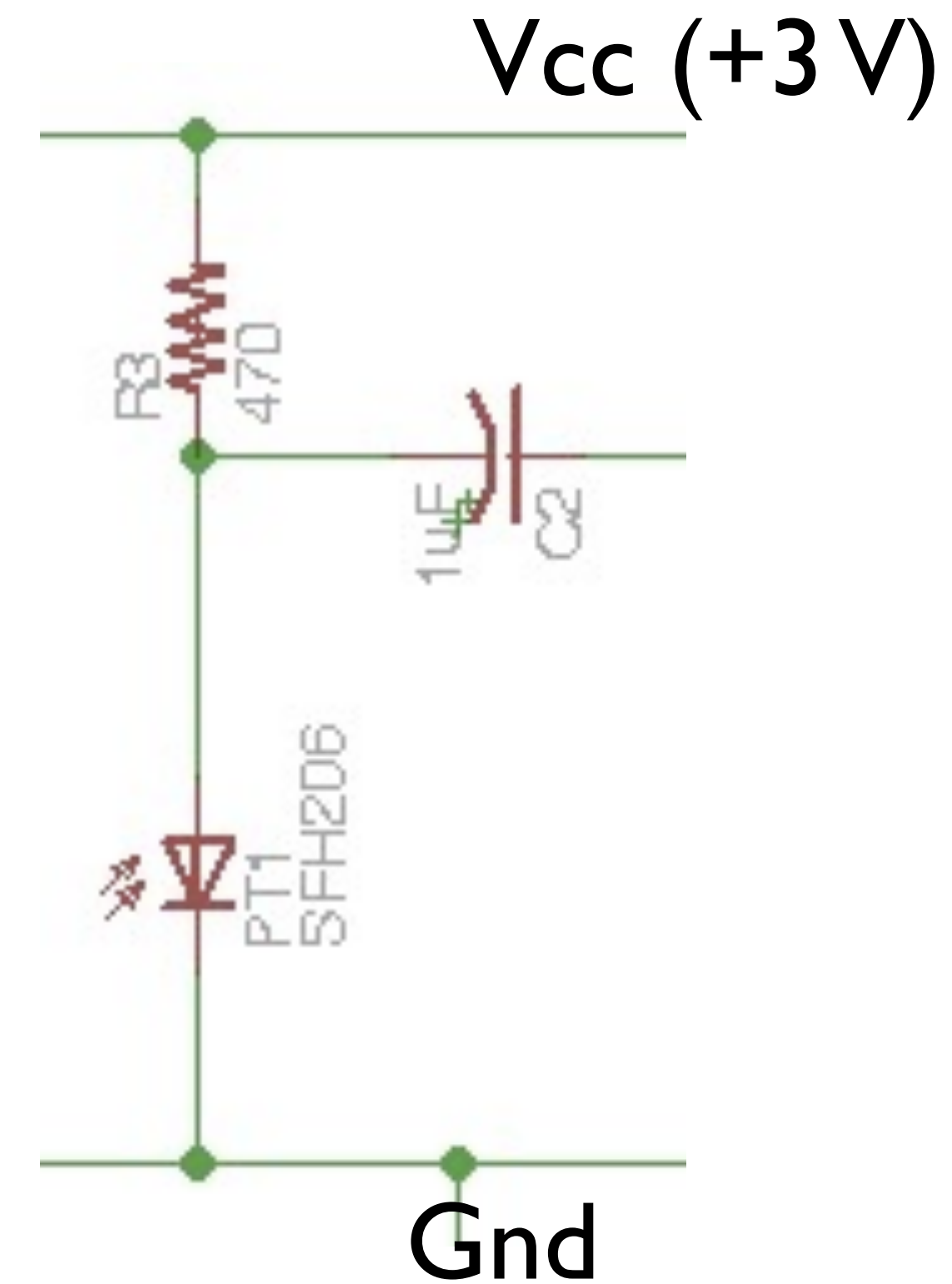


How?

- Simple.
- Phototransistor → Capacitor → Op Amp → Comparator → Trigger (555 + transistor)
- And some LEDs indicate status

How?

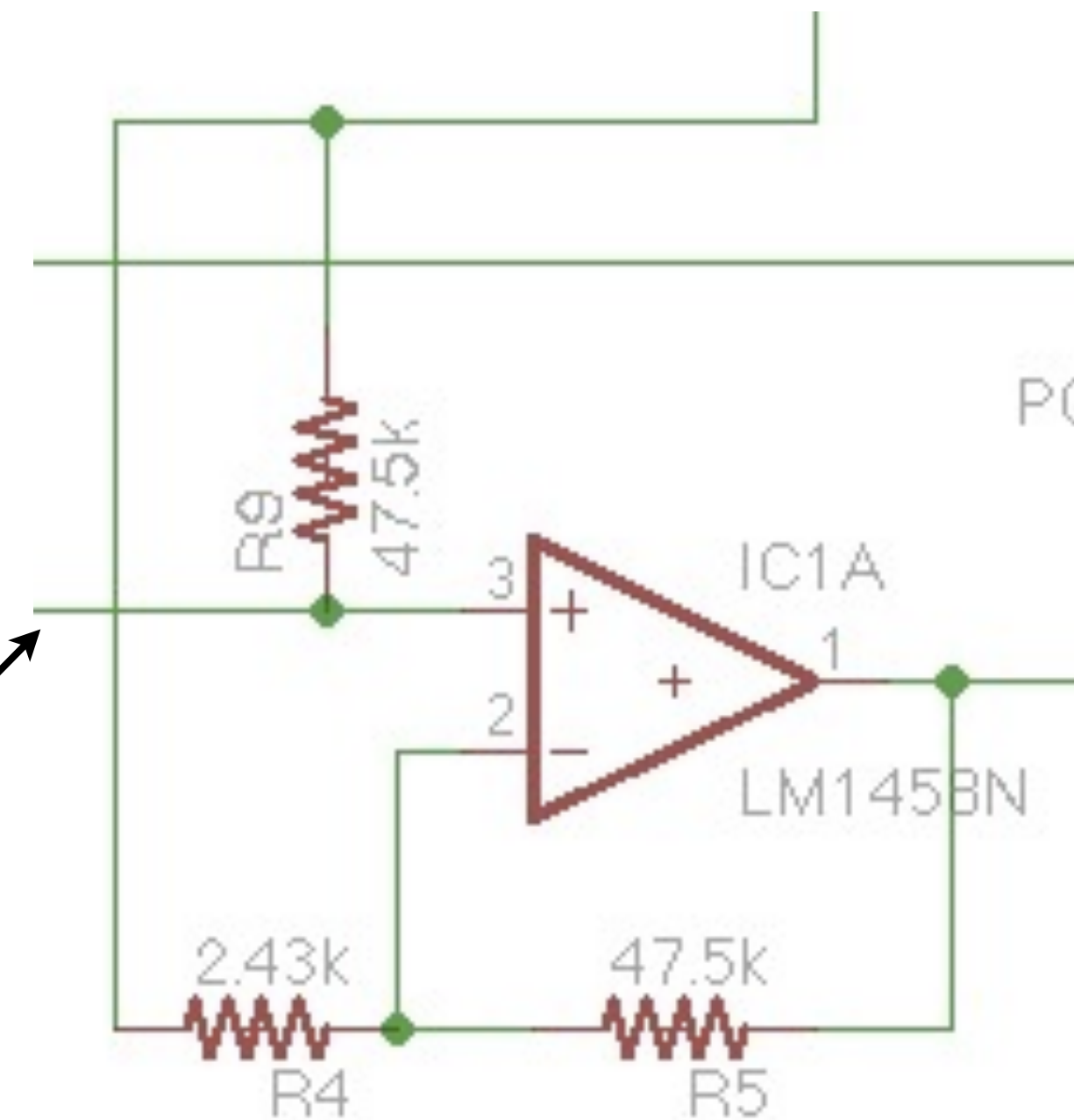
- Phototransistor connected (with another R) from +Vcc to ground
- Light causes voltage drop “above” phototransistor
- Capacitor filters out slow changes



How?

- Op amp amplifies these fast light-level changes (voltage drops)
- Pretty high gain, chosen experimentally
- Currently about 20

input from phototransistor/capacitor



Aside: Biasing the Op Amp

- Op amps need $+V_{cc}$ and $-V_{cc}$
- But we only have 0 and 3V!
- Solution: connect op amp's $-V_{cc}$ to ground
 - $+V_{cc}$ is still +3 V

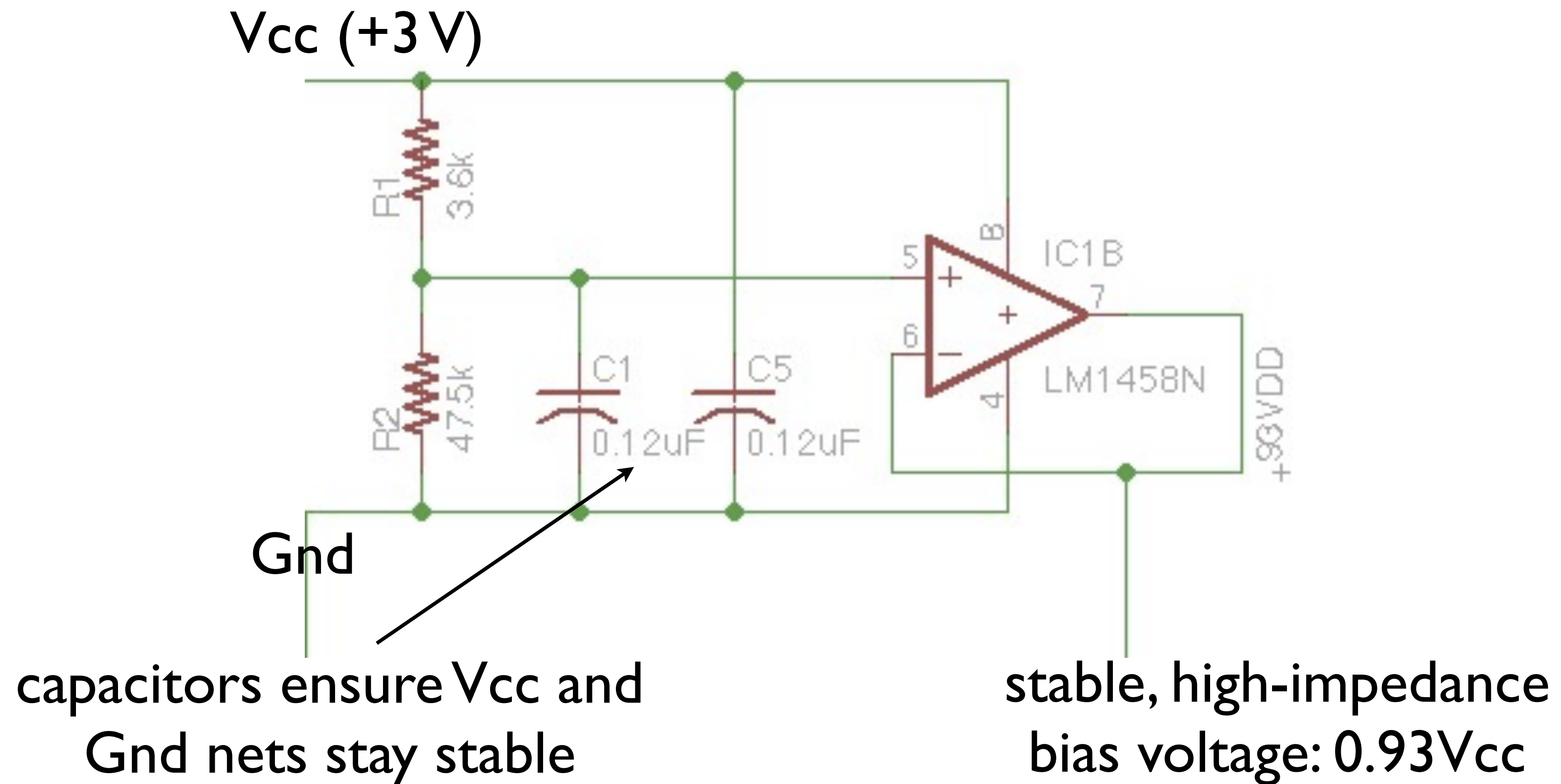
Aside: Biasing the Op Amp

- Op amp can now drive 0 V to 3 V
 - Side note: Chose rail-to-rail op amp
- Need to “bias” our input so “zero” value is between 0 and 3 V
 - Unlike EECS215 circuits

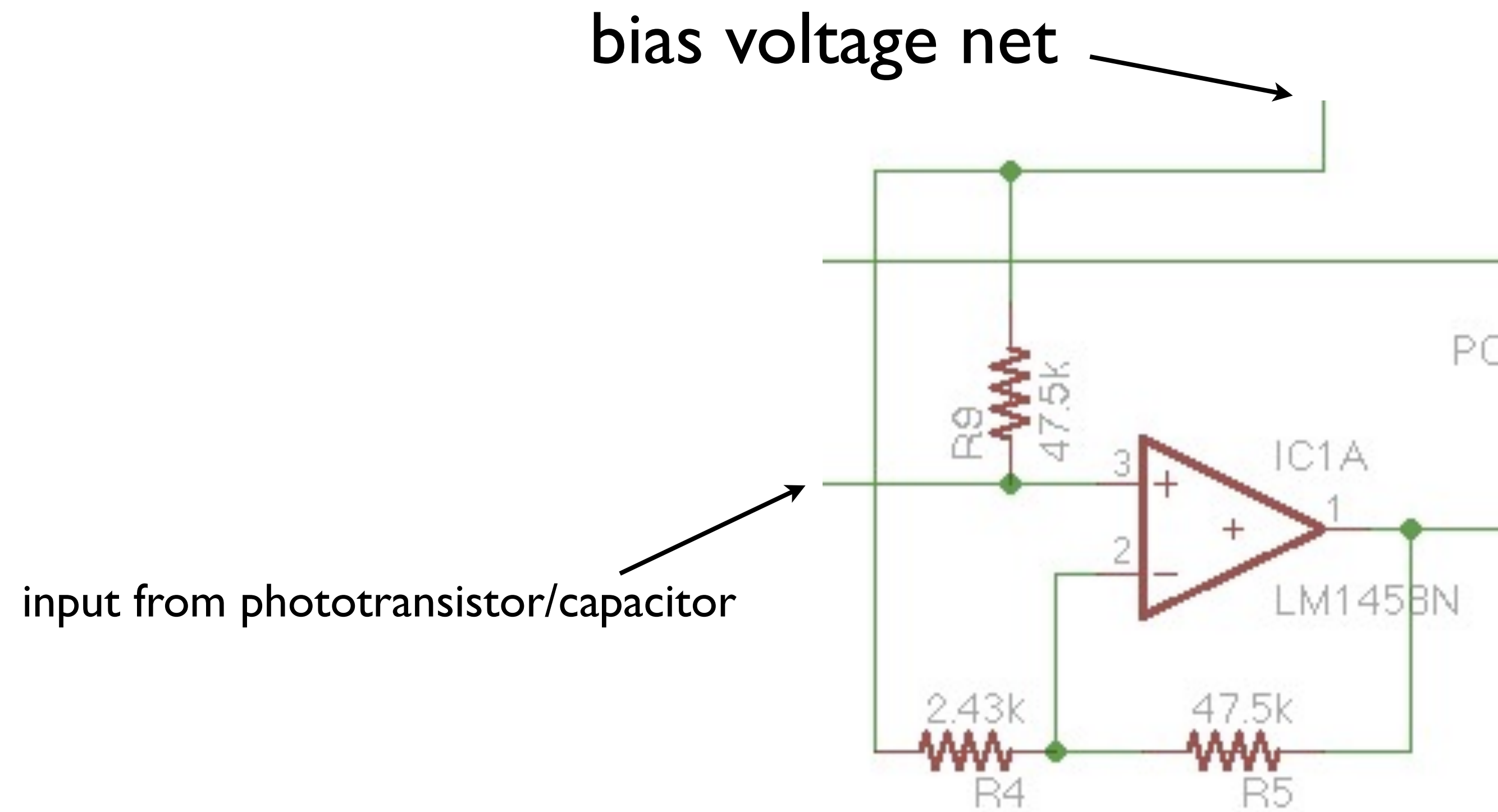
Aside: Biasing the Op Amp

- We know input to the op amp will be driven lower, not higher
 - don't care if it goes high
- Use voltage divider to get $0.93 \times V_{cc}$
 - Buffer through another op amp for high impedance

Aside: Biasing the Op Amp



Aside: Biasing the Op Amp



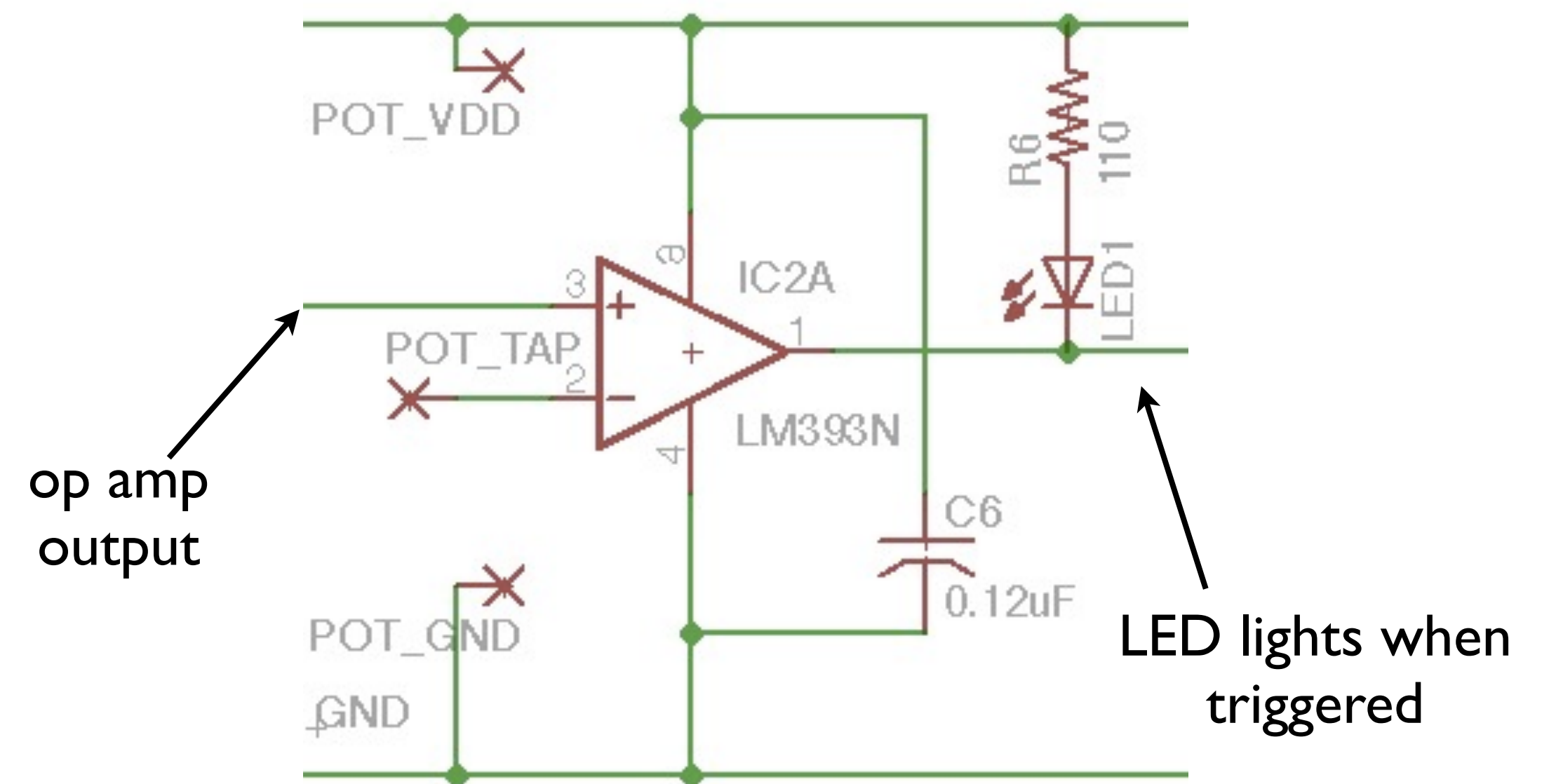
The rest of this should look familiar from EECS215.

How?

- Comparator takes two signals
- Outputs 1 if $a < b$; 0 if $b < a$
- Potentiometer across V_{cc}/Gnd lets user choose a threshold
- In practice, this is probably unnecessary

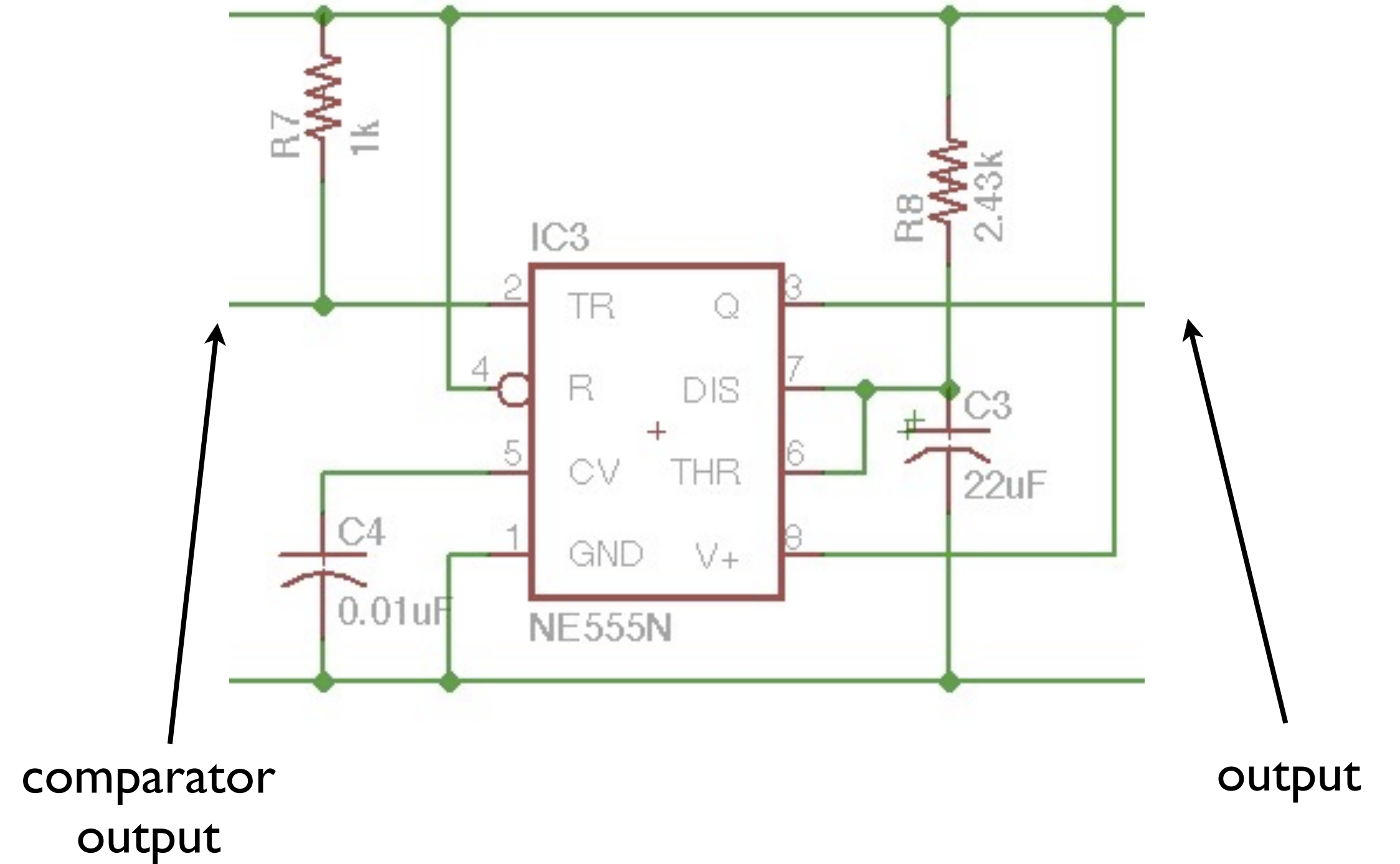
How?

- Comparator compares op amp output to sensitivity chosen on potentiometer
- Drives low if triggered; high otherwise



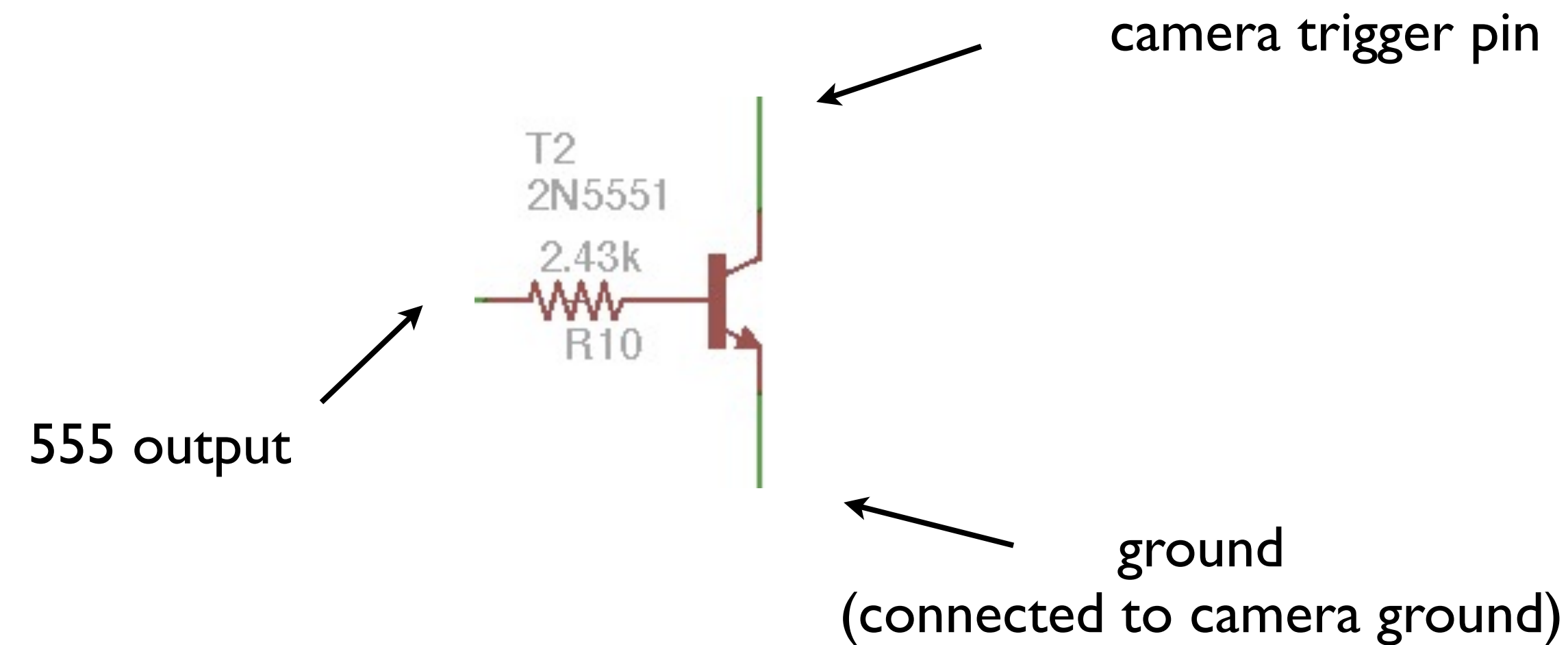
How?

- 555 circuit drives a 50ms signal high to trigger camera
- Can't just drive camera from comparator; signal is too fast



How

- Finally, transistor connects two pins on camera's multipurpose connector.
- 47ms later, *click*!



Challenges

- Testing
 - considering building a lightning simulator
- Single-supply op amp
 - and other factors (choosing rail-to-rail amp, choosing a proper gain)
- Low-voltage parts
 - most 555's are 5V

Recommended Reading

- TI - Op Amps for Everyone
 - Immensely useful: basics, analysis, single-supply, noise, active filter design
 - <http://www.ti.com/lit/an/slod006b/slod006b.pdf>

Questions?