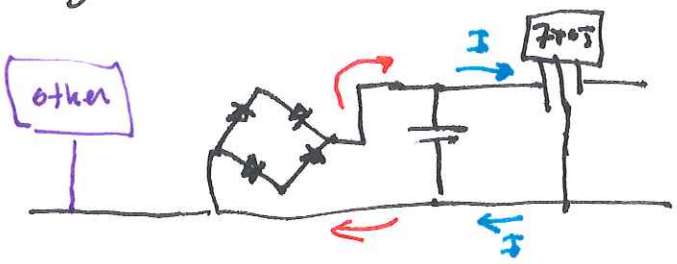
noise / interference

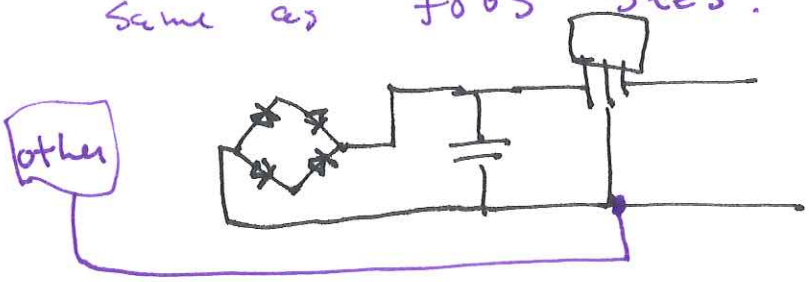
"ground" - may not be at one voltage due to brg currents



most of the time the circuit is powered by capacitor with a more-or-less steady current I

However the capacitor is recharged very quickly at peak of cycle; This recharge time may be a $\frac{1}{5}$ of the capacitor drain time and carry the same charge ⇒ There are 50×I spikes every $\frac{1}{120}$ sec in the cap recharge lines - particularly in the ground wires. (Harmonics!)

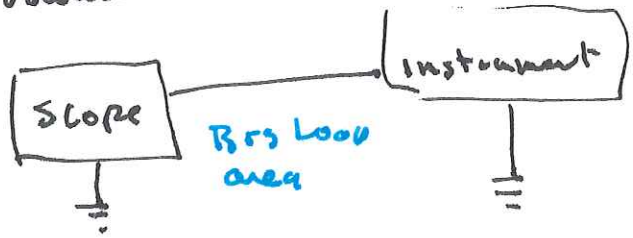
The ground that "other" is using is Not the same as 7805 sees.



Further - these 50×I 120 Hz currents → magnetic fields — any loop will pickup voltage given by Lenz Law.

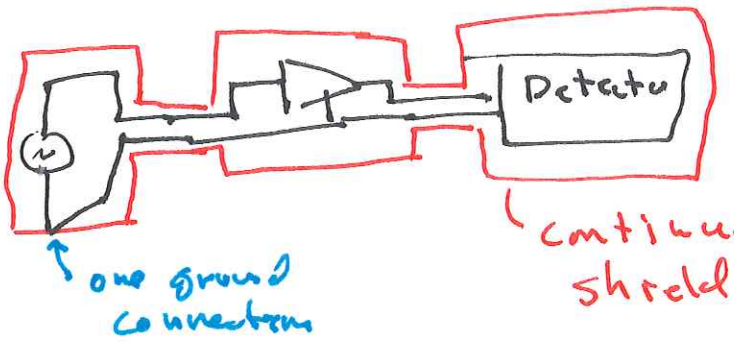
Solution - use twisted pairs - A small & alternates

"Ground Loops" same thing with multiple connection to ground



"ground" will vary around loop

Solution - only one connection to ground



Capacitive coupling — wires with different voltages and small separations are capacitors — pF

if the signal has "high" impedance ($10^7\,\Omega$)

$$f_{-3dB} = \frac{1}{2\pi RC} = 16\ \text{kHz}$$

($R = 10^7$, $C = 10^{-12}$)

higher freq noise will pass to signal

Magnetic couplings — "mu-metal" shield iron box

Radio Frequency "RF" coupling — Ferrites chokes

"guards" — same as signal but driven by follower

Triboelectrics — cables

Piezoelectric

$\frac{1}{f}$ (flicker noise)

shot noise: $I_{rms} = (2eIB)^{1/2}$ (DC = I, bandwidth = B)

$\Delta t = \frac{1}{2B}$; $N = \frac{I\Delta t}{e}$; $I_{noise} = \frac{e\sqrt{N}}{\Delta t} = \sqrt{\frac{eI}{\Delta t}}$

$= \sqrt{2eIB}$

Johnson $U_{rms} = (4kTRB)^{1/2}$

"density" $\frac{U_{rms}}{\sqrt{B}} = (4kTR)^{1/2}$