Augmenting Reality

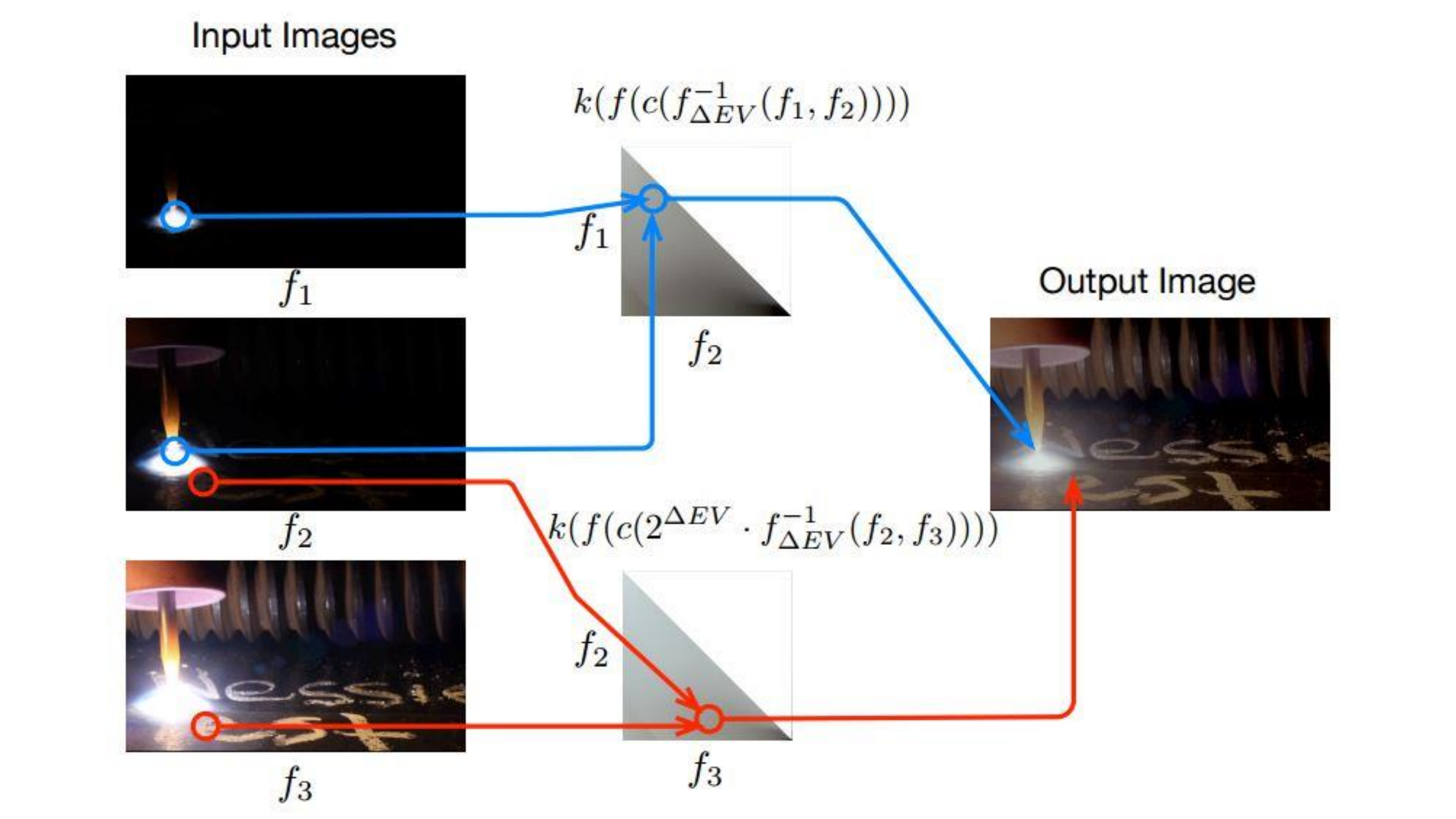
High Dynamic Range Imaging

Sequential Wave Imprinting Machines

By- Sarang Nerkar

Supervisor- Prof. Steve Mann

High Dynamic Range (HDR) Imaging


Input Images
$k(f(c(f^{-1}_{\Delta EV}(f_1, f_2))))$
f_1
f_1
f_2
Output Image
f_2
$k(f(c(2^{\Delta EV} \cdot f^{-1}_{\Delta EV}(f_2, f_3))))$
f_2
f_3
f_3

Goal: Develop a method for optimal exposure selection for HDR

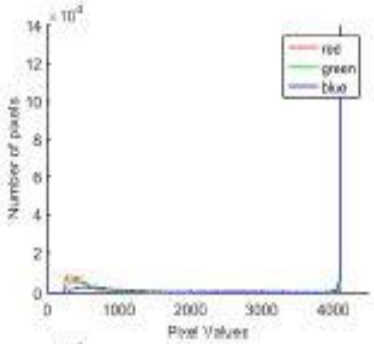
Extrapolative Lightspace Method for HDR Exposure Selection

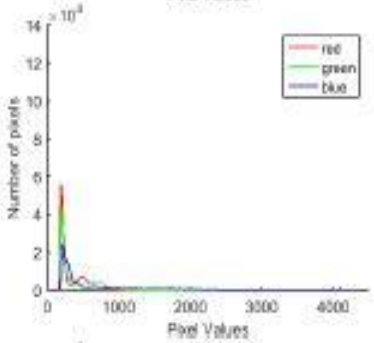
The M exposure settings, $\{E_1, E_2, E_3, ..., E_M\}$, were chosen as follows:

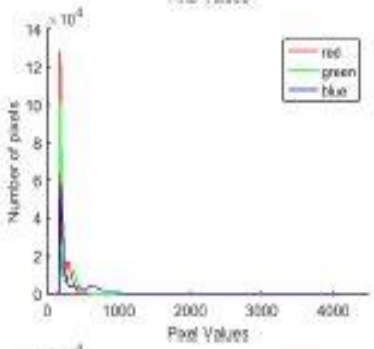
1) Lowest (darkest) exposure value E_1 is set at 1/3 of the difference between the minimum possible exposure setting E_{min} and maximum possible exposure setting E_{max}.
2) Highest (brightest) exposure value E_M is set at 2/3 of the difference between the minimum possible exposure setting E_{min} and maximum possible exposure setting E_{max}.
3) Camera set to E_1, and image I_1 captured.
4) Camera set to E_M, and image I_M captured.
5) Image I_1 is converted to lightspace image L_1.
6) Image I_M is converted to lightspace image L_M.
7) Histogram H_1 formed from L_1.
8) Histogram H_M formed from L_M.
9) Number of saturated pixels s_1 calculated from I_1.
10) Number of saturated pixels s_M calculated from I_M.
11) Affine function derived from s_1 and s_M, and its intercept is calculated at a predicted value of zero pixels saturated. This leads to a new value of E_M.
12) Number of zero-saturated pixels u_1 calculated from H_1.
13) Number of zero-saturated pixels u_M calculated from H_M.
14) Affine function derived from u_1 and u_M, and its intercept is calculated at a predicted value of zero pixels saturated. This leads to a new value of E_1.
15) Repeat to (3).

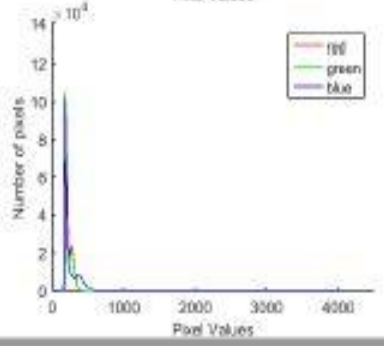
Time

Dark Exposures

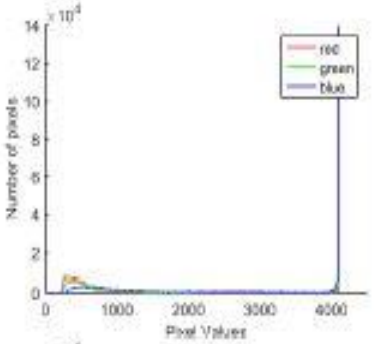


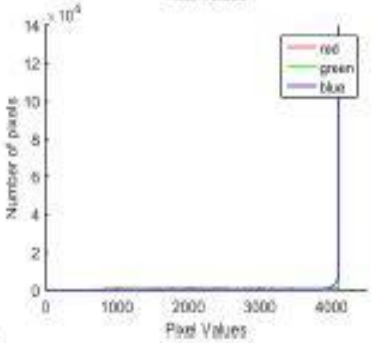


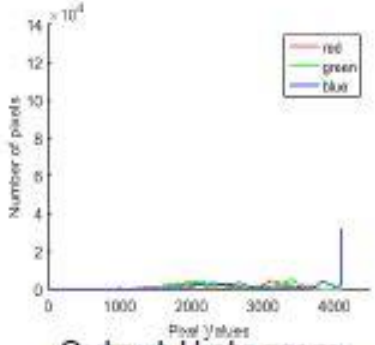




Bright Exposures







Output Histogram

The exposure selection remains the same since the zero saturation metric has been met.

Composited Image - HDR

Composited HDR Image taken on a clear sunny day

Another composited HDR Image taken on a partially cloudy day

Extrapolative Lightspace Method for HDR Video Exposure Selection

Sarang Nerkar, Ryan Janzen, Pete Scourboutakos, and Steve Mann

Abstract—**We propose a method to automatically adjust multiple exposure-value settings for HDR video compositing.**

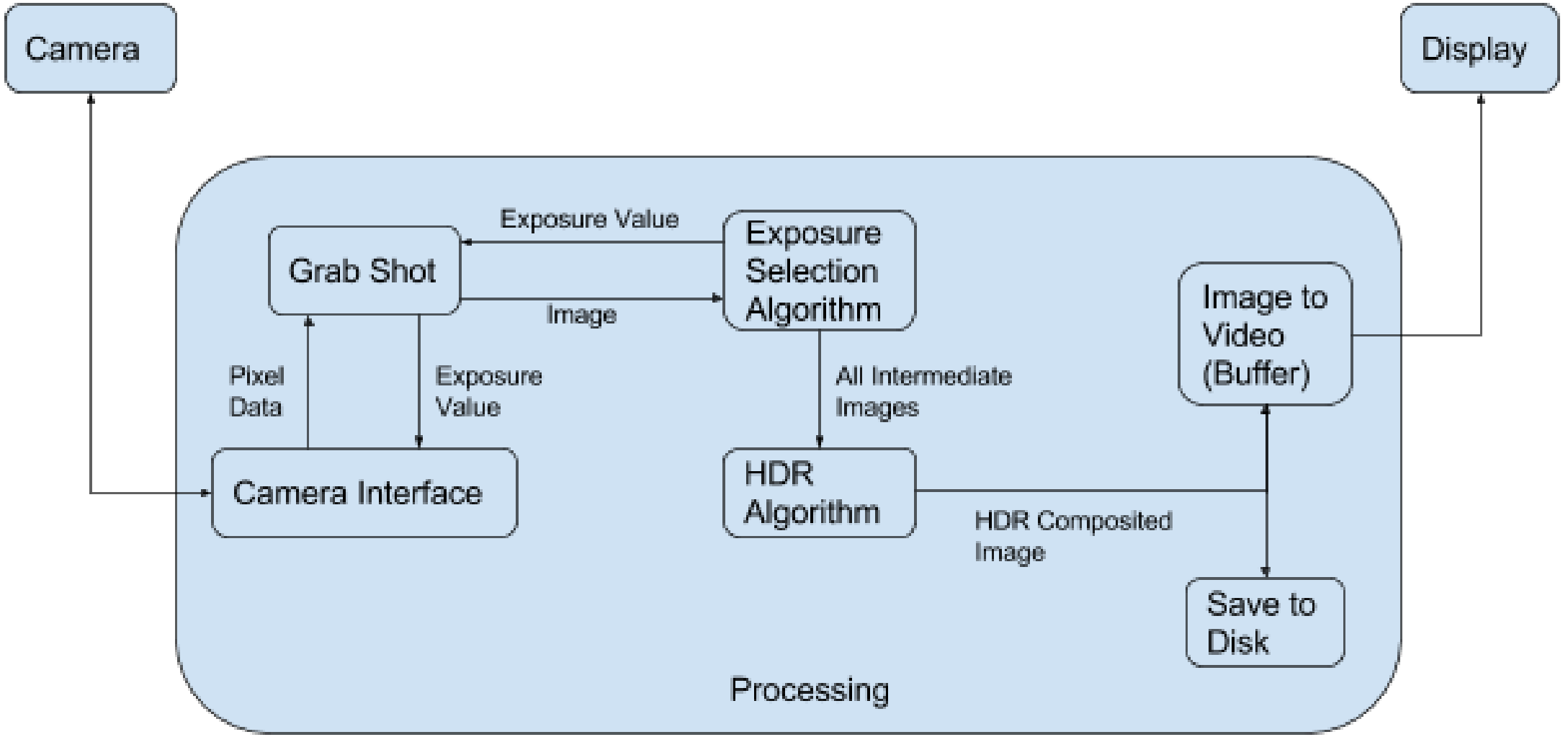
The method uses imagespace-to-lightspace post-conversion and tonal extrapolation to iteratively select optimal exposure settings, as opposed to present systems, which use manually set settings. The limiting factor becomes the image sensor as opposed to the implementation of the algorithm, as in present systems. By choosing the exposure settings with the described algorithm, the high dynamic range sampling process can be adapted to various lighting environments. This algorithm is especially useful for ultra low power capture of optimally selected exposures which can be processed later using well-known HDR compositing methods.

Instead we calibrate a nonlinear model of the camera's response function, which converts a pixel value into an estimated true quantity of light. This true, physical range of values is referred to as lightspace [10].

The M exposure settings, $\{E_1, E_2, E_3, ..., E_M\}$, were chosen as follows:

1) Lowest (darkest) exposure value E_1 is set at 1/3 of the difference between the minimum possible exposure setting E_{min} and maximum possible exposure setting

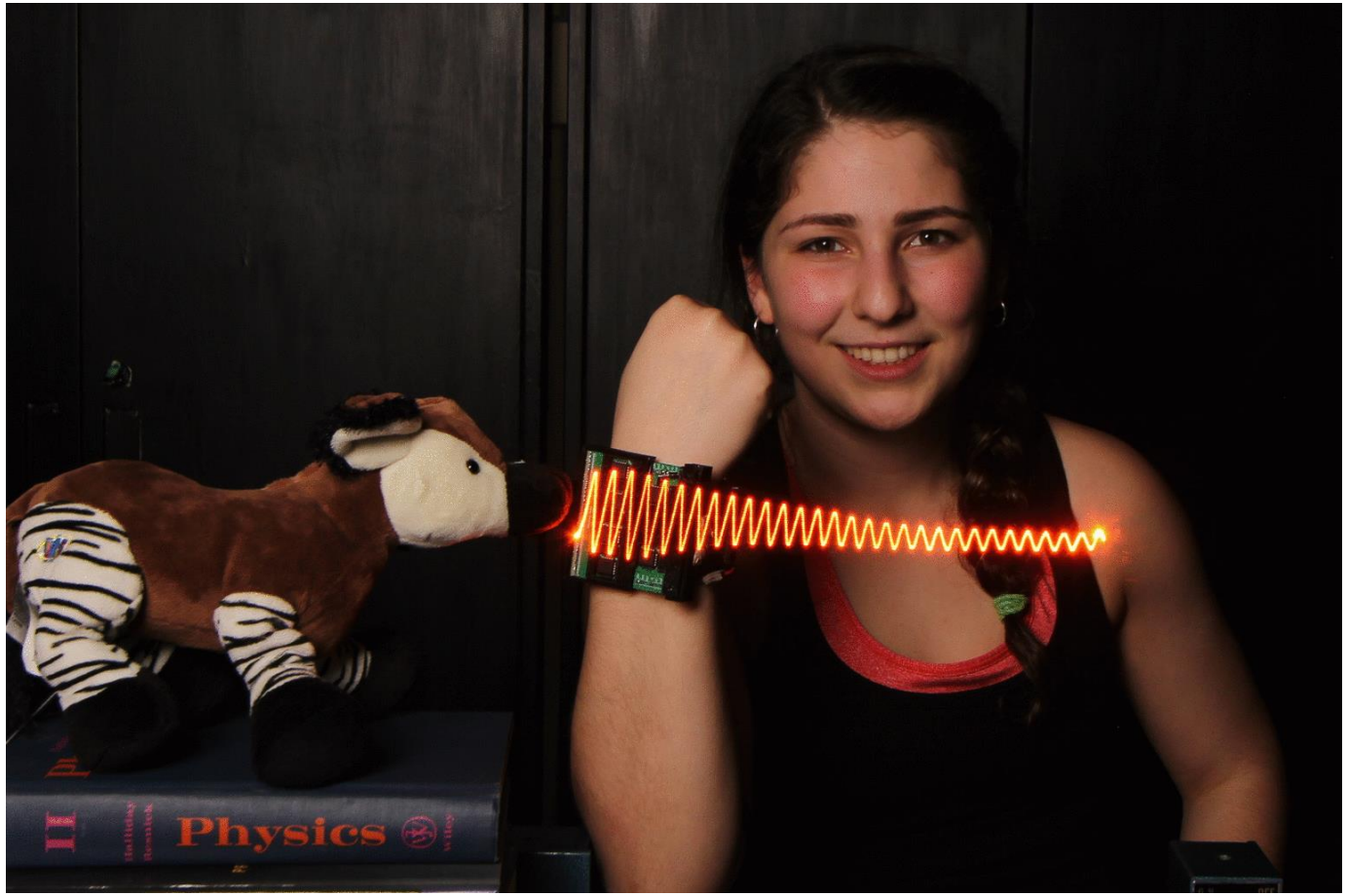
Ongoing and Future Work

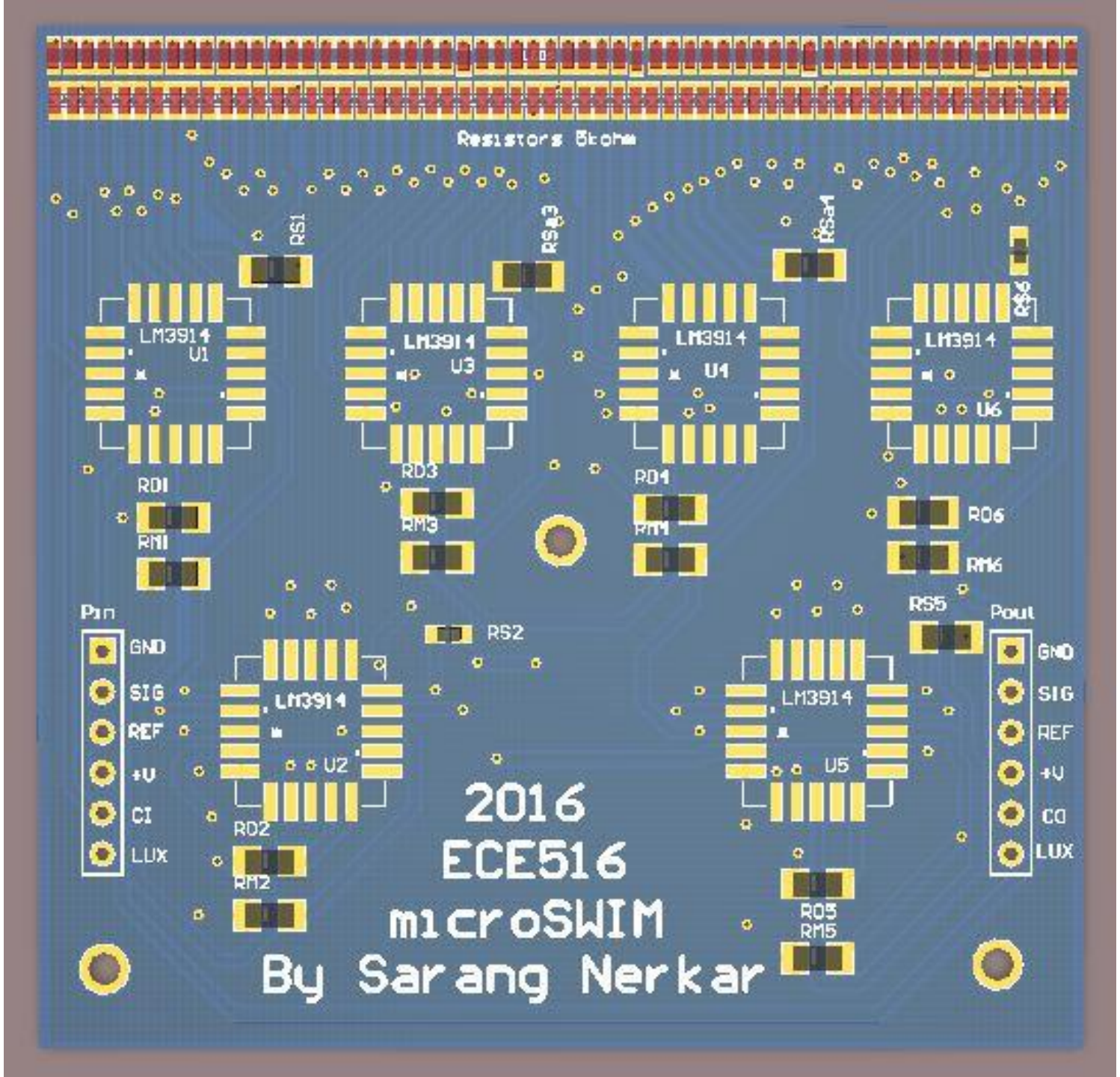


Sequential Wave Imprinting Machine (SWIM)

An augmented reality space-based oscilloscope that visualizes invisible waves

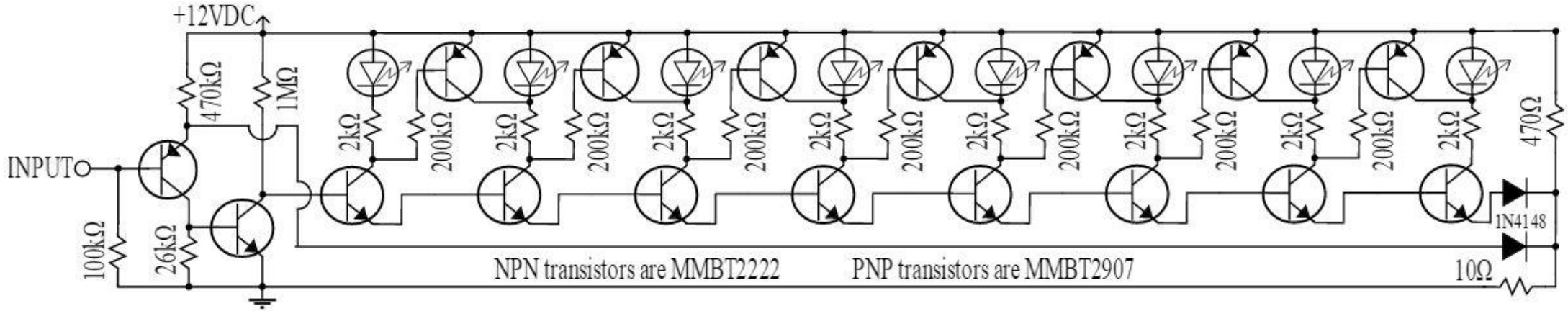
An augmented reality space-based oscilloscope that visualizes invisible waves

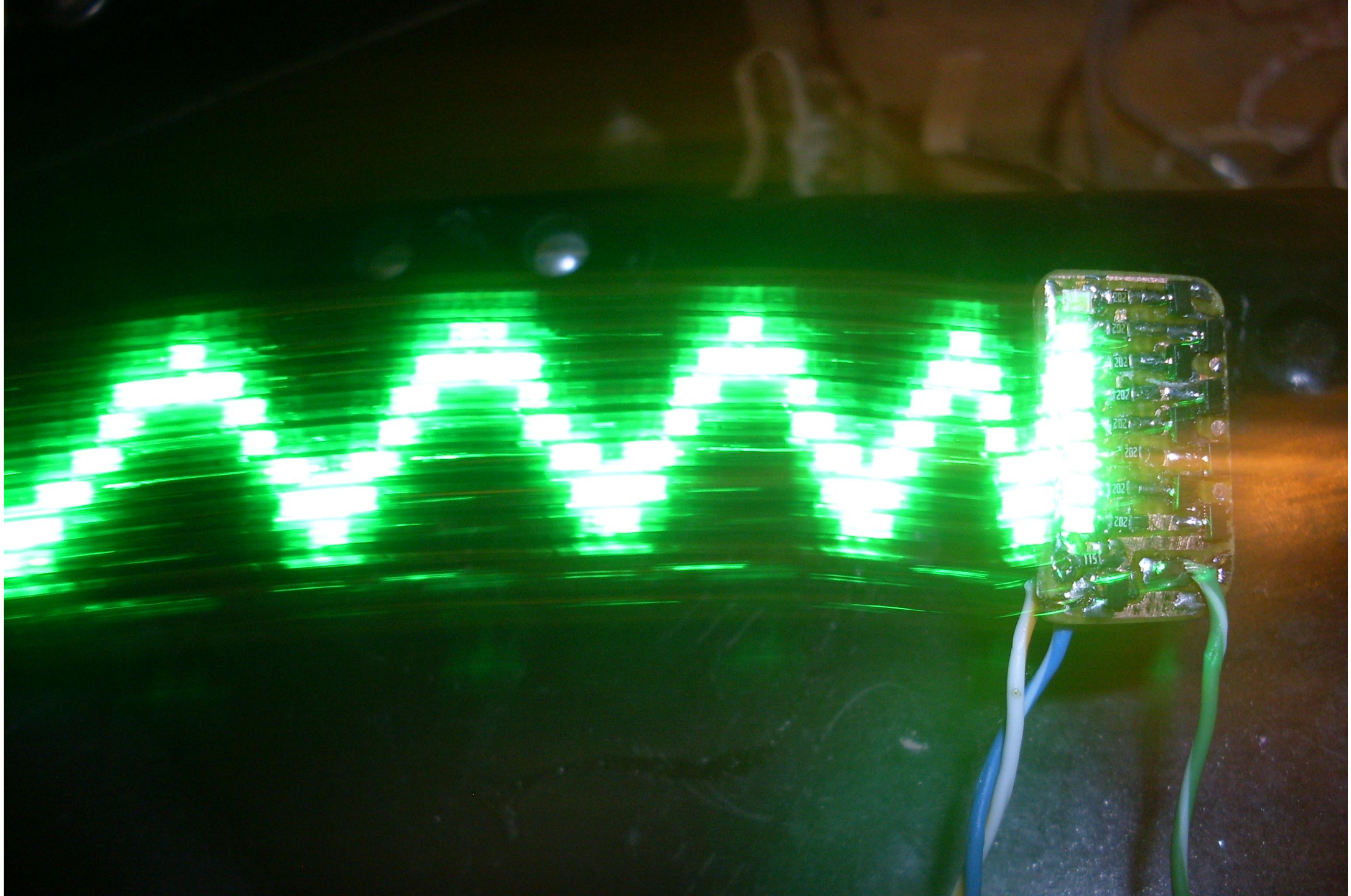



Resistors 5kohm
RS1
RS3
RS4
RS6
LM3914
U1
U3
U4
U6
RD1
RM1
RD3
RM3
RD4
RM4
RD6
RM6
Pin
GND
SIG
REF
+V
CI
LUX
RS2
U2
RD2
RM2
RS5
U5
RD5
RM5
Pout
GND
SIG
REF
+V
CO
LUX
2016
ECE516
microSWIM
By Sarang Nerkar

Limitation of previous design: Size of LM3914 chips

Goal: Design a new SWIM without the use of LM3914 chips to eliminate the size limitation


+12VDC
INPUT
100kΩ
26kΩ
470kΩ
1MΩ
2kΩ
200kΩ
470Ω
1N4148
10Ω
NPN transistors are MMBT2222
PNP transistors are MMBT2907



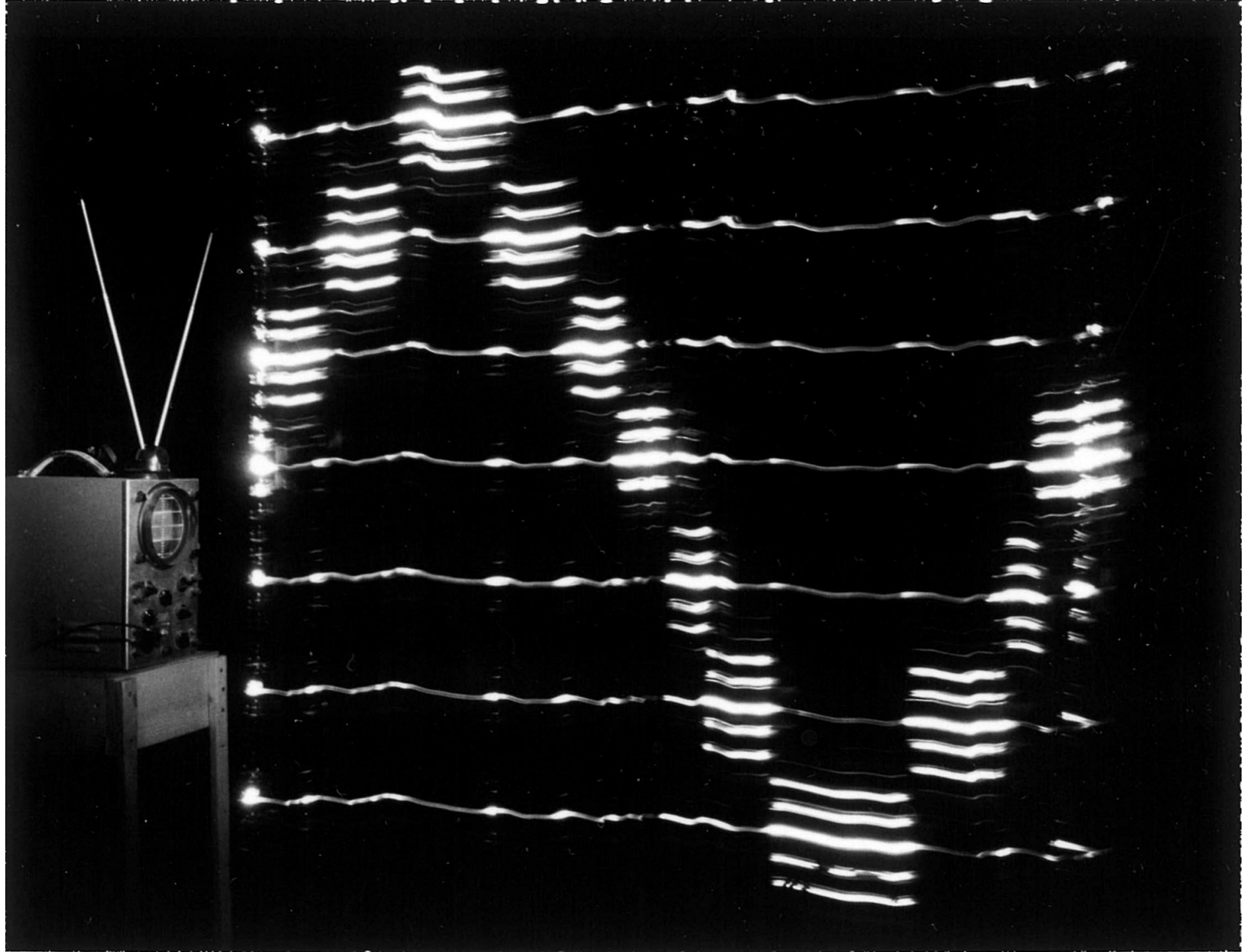
Ongoing and Future Work

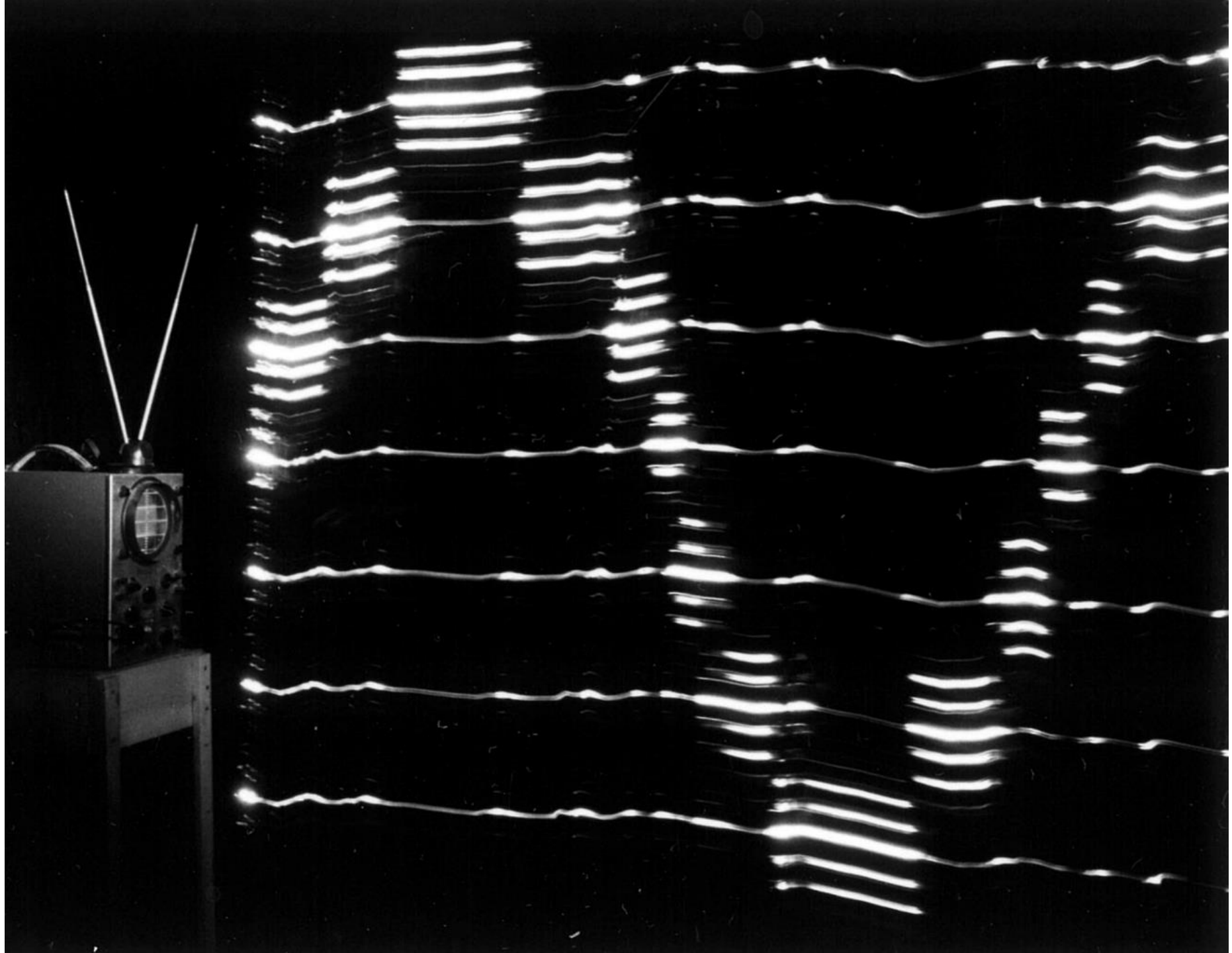
- Eliminate the input voltage limitation for a more scalable product

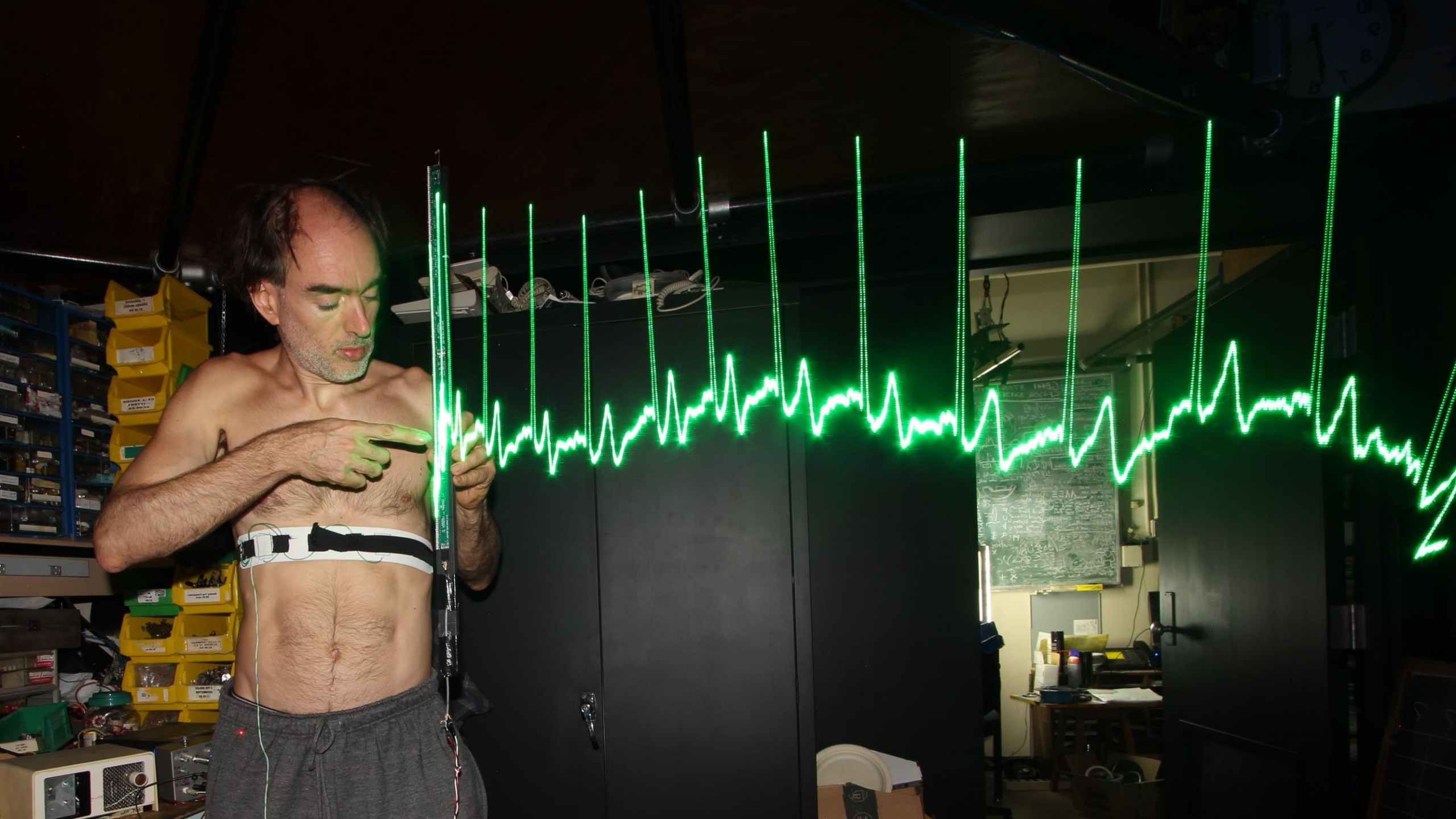
Conclusion

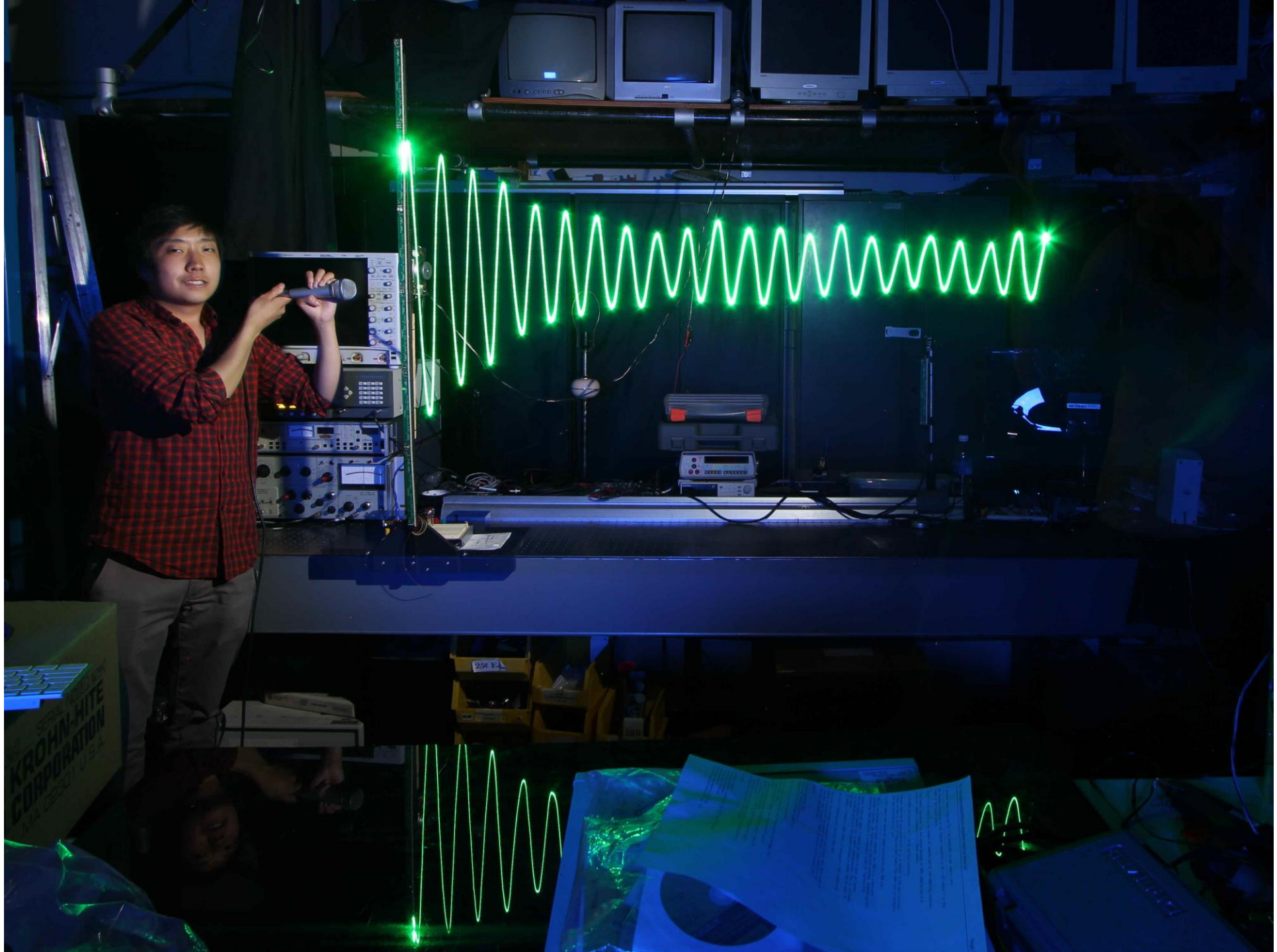
- A method for optimal selection of exposures for high dynamic range imaging was developed.
- A novel circuit design for a smaller/ more wearable sequential wave imprinting machine was developed

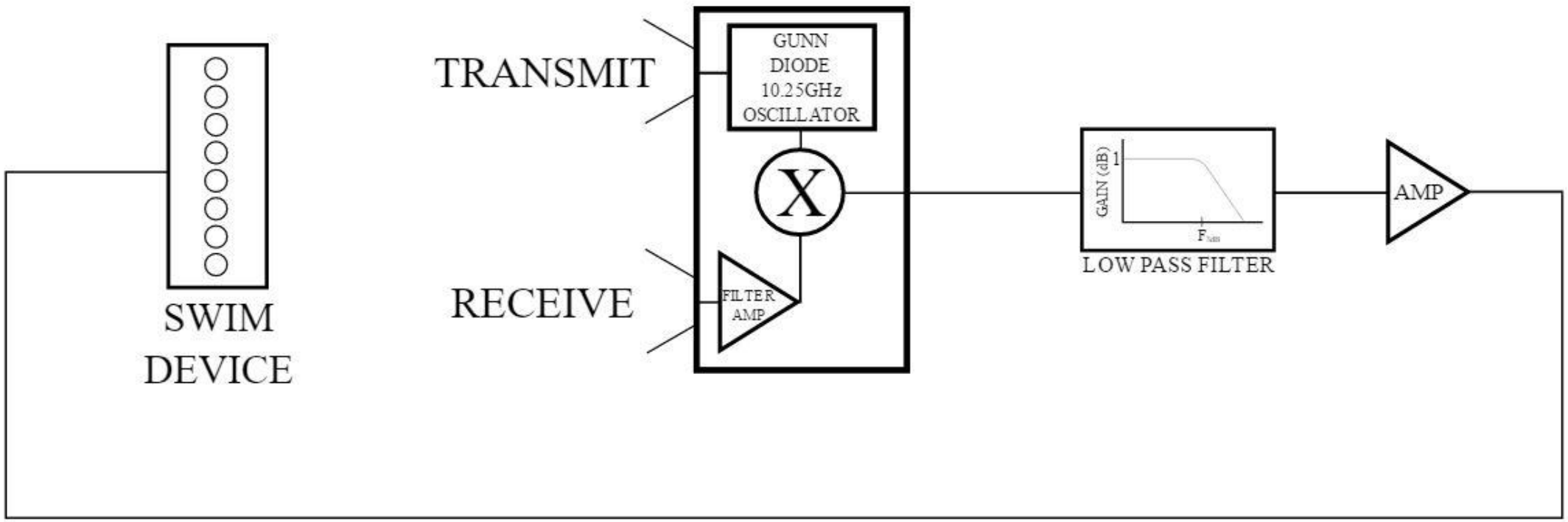
Questions








KROHN-HITE
CORPORATION

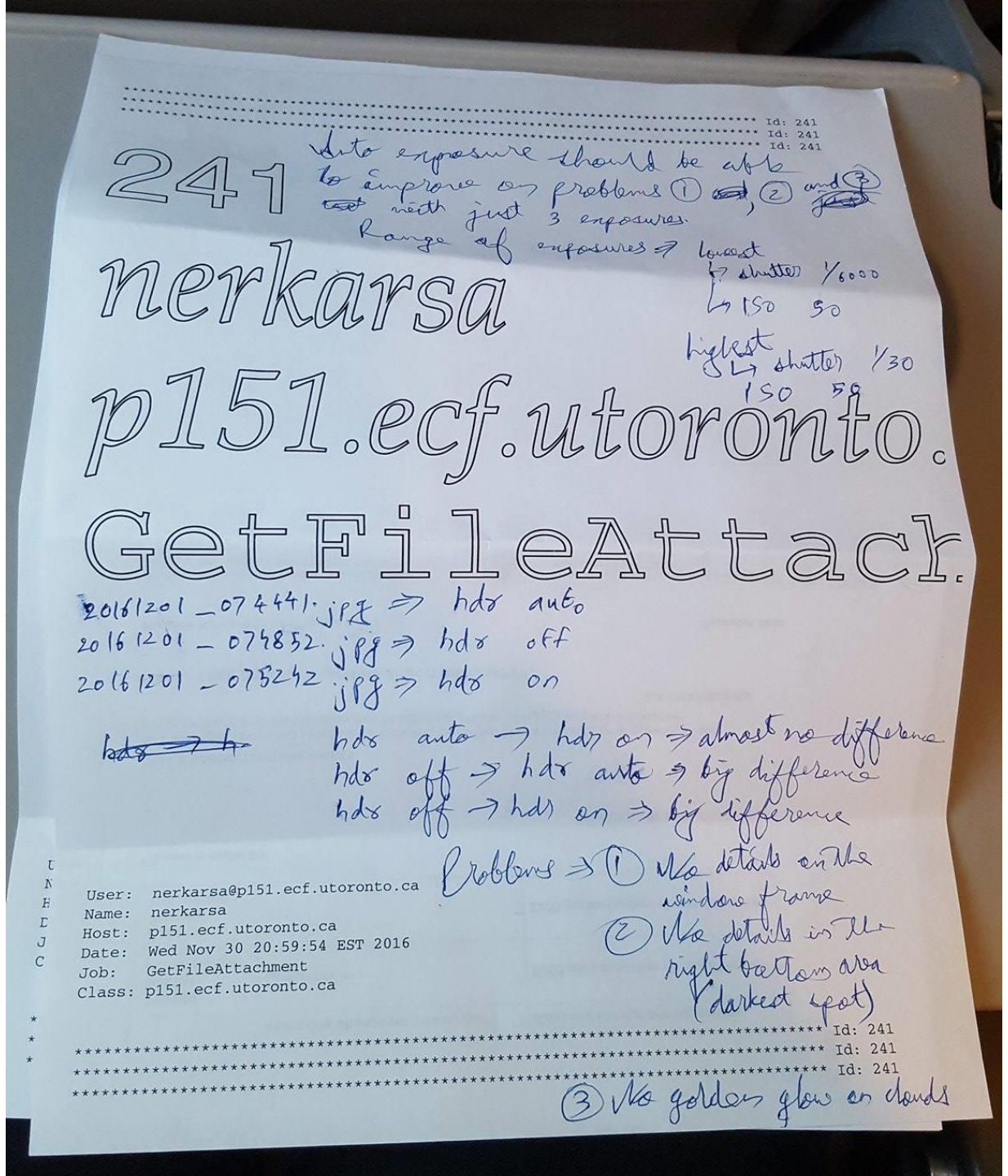

SWIM
DEVICE
TRANSMIT
RECEIVE
GUNN
DIODE
10.25GHz
OSCILLATOR
X
FILTER
AMP
GAIN (dB)
1
LOW PASS FILTER
AMP

Simple in-flight Experiment

HDR OFF

HDR ON

HDR AUTO



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nerkarsa

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GetFileAttach

Auto exposure should be able to improve on problems (1) and (2) with just 3 exposures.

Range of exposures ⇒ lowest
↳ shutter 1/6000
↳ ISO 50

highest
↳ shutter 1/30
ISO 50

20161201_074441.jpg ⇒ hdr auto
20161201_074852.jpg ⇒ hdr off
20161201_075242.jpg ⇒ hdr on

~~hdr ⇒ h~~

hdr auto → hdr on ⇒ almost no difference
hdr off → hdr auto ⇒ big difference
hdr off → hdr on ⇒ big difference

Problems ⇒ (1) No details on the window frame
(2) No details in the right bottom area (darkest spot)
(3) No golden glow on clouds

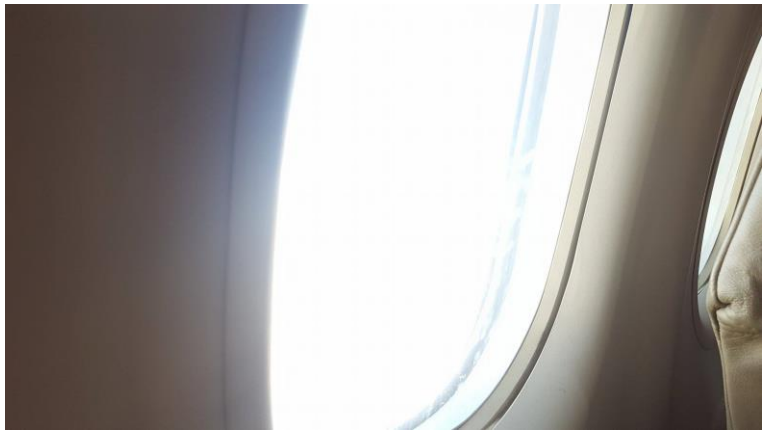
UNBUC

User: nerkarsa@p151.ecf.utoronto.ca
Name: nerkarsa
Host: p151.ecf.utoronto.ca
Date: Wed Nov 30 20:59:54 EST 2016
Job: GetFileAttachment
Class: p151.ecf.utoronto.ca

LOW

MEDIUM

HIGH



Composited HDR