Light Scattering-based High Contrast Optical Touch Sensor Architectures in Transmissive and Reflective Configurations

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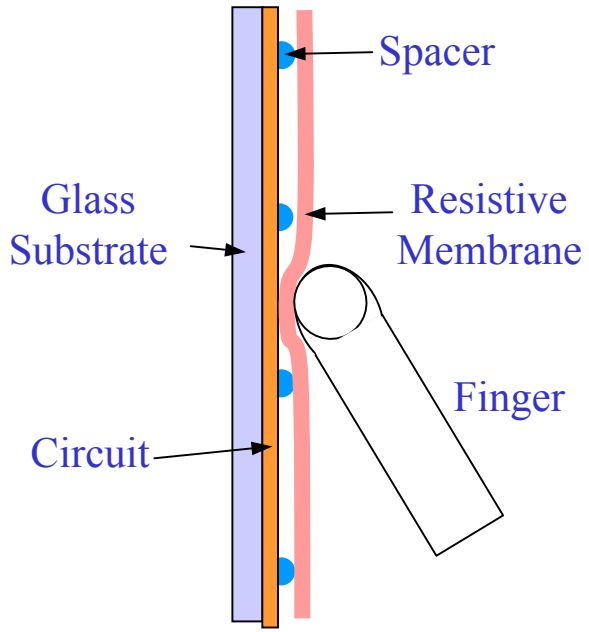
Previous Touch Switch Approaches

I. Resistive Membrane → *Moving Part*



Mechanical Force on the Active Area → A Sub-millimeter Contact Movement

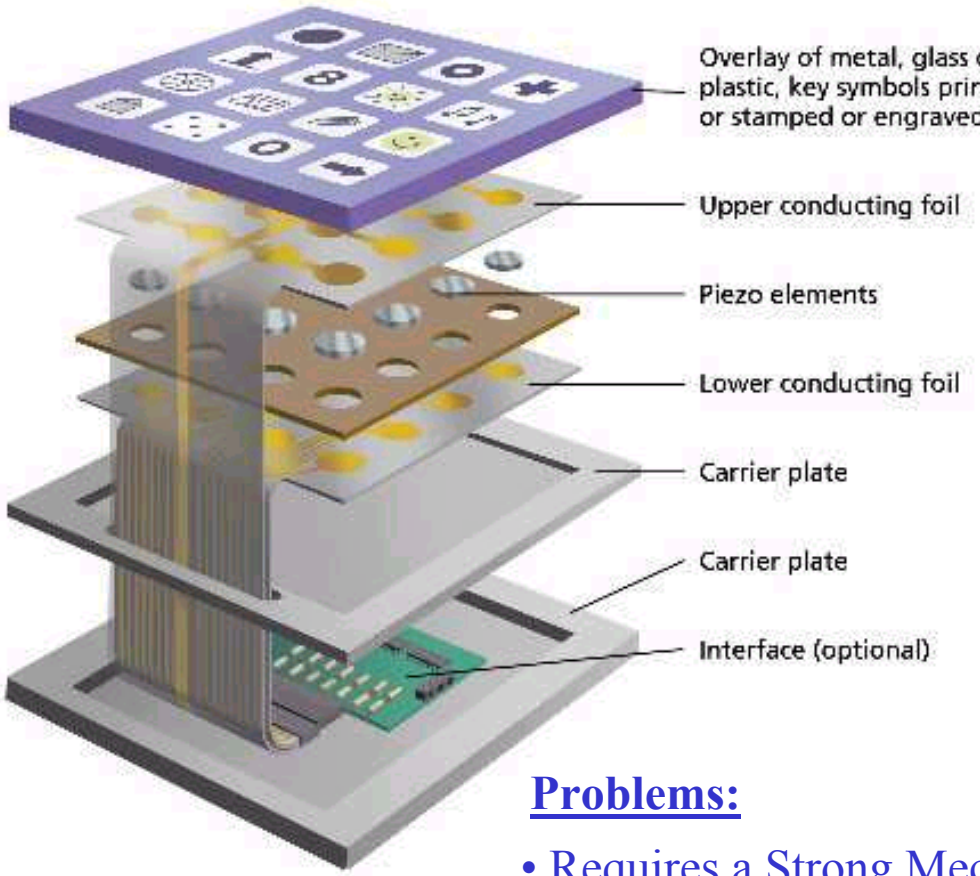
↓

Switching Action with Sufficient Insulation Between Contacts

Problems:

- Mechanical Movement → Wear and Tear Limit the Life of the Touch Switch
- Needs an Additional Light Source for Use in the Dark Area

II. Piezo-electric Technique ➡ *No Moving Part*



Mechanical Force
on the Active Area

⬇

A Small Output Voltage

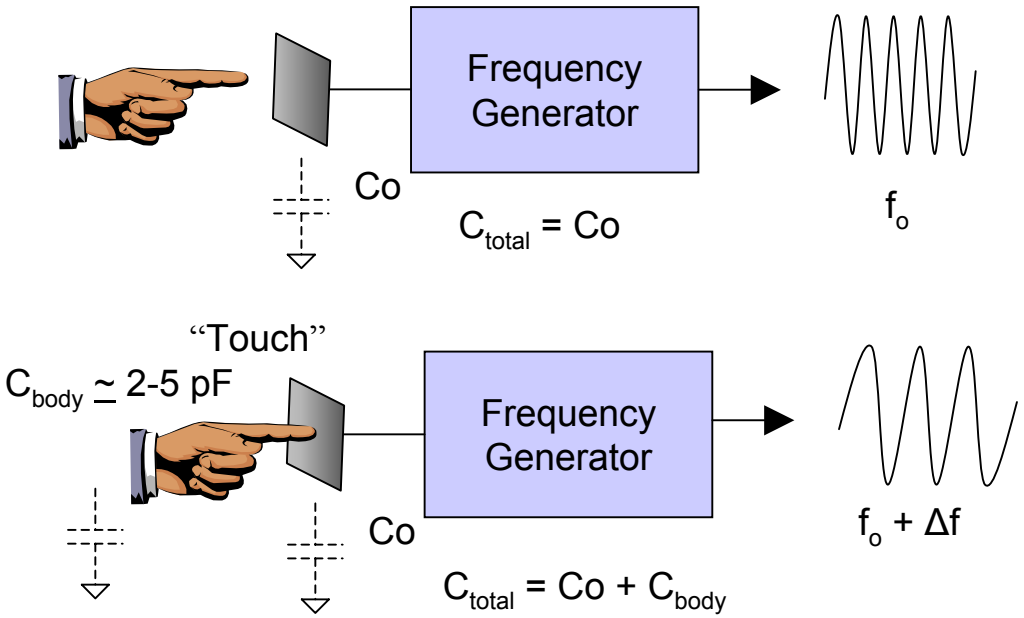
⬇

Activates the Desired
Electrical Load

Problems:

- Requires a Strong Mechanical Force of 3-5 Newtons
- Needs a Specially Designed Circuit to Prevent a High Output Saturation Voltage
- Has Complicated Switch Structure
- Needs an Additional Light Source for Use in the Dark Area

III. Capacitive Technique ➡ *No Moving Part*



Finger Approaches/Touches on the Active Area

⬇

Change in RF Frequency

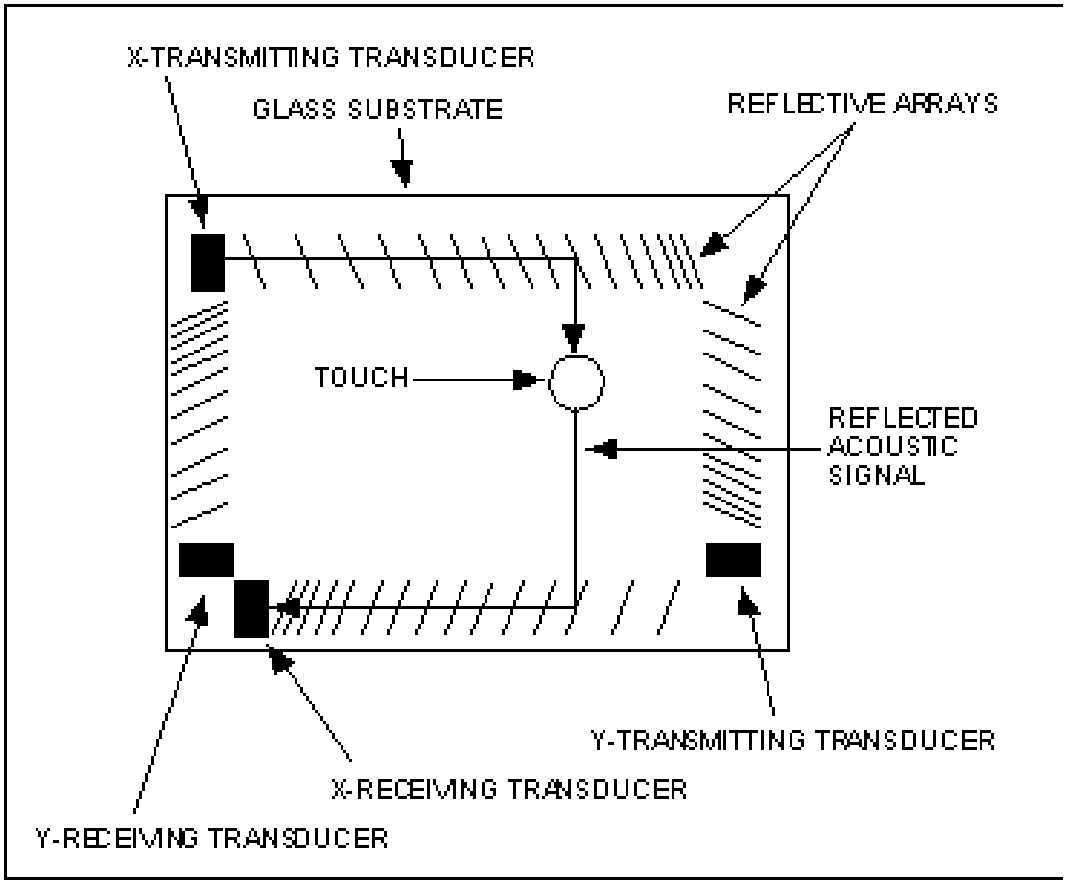
⬇

Activates the Desired Electrical Load

Problems:

- Needs a Specially Designed Circuit to Prevent Voltage Disturbance due to the Electrostatic Inductance Change
- Needs an Additional Light Source for Use in the Dark Area

IV. Acoustic Technique → *No Moving Part*



Finger Touches
on the Active Area

↓

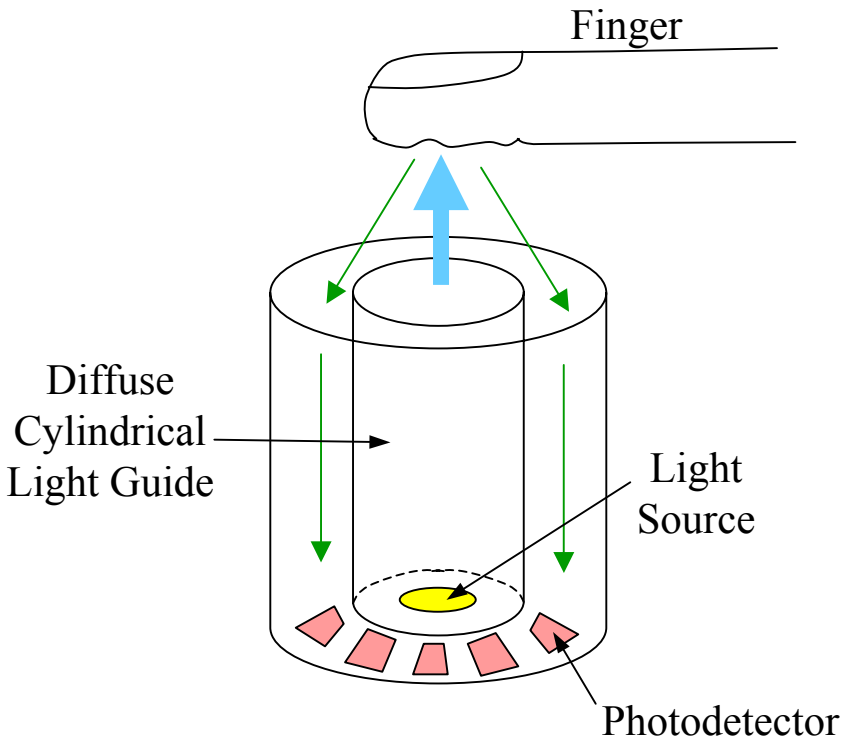
Blocks the
Acoustic Wave

↓

Activates the Desired
Electrical Load

Problem:
- Expensive
- Needs an Additional Light Source for Use in the Dark Area
- High Electrical Power Consumption

V. Optical Technique ➡ *No Moving Part*



Finger Touches
on the Active Area

⬇

Blocks/Reflects the
Optical Wave

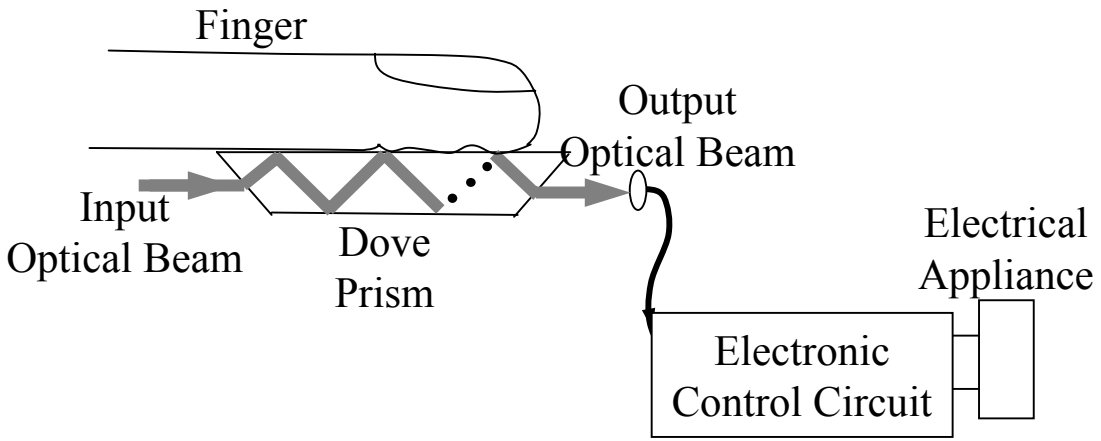
⬇

Activates the Desired
Electrical Load

Problems:

- Leakage Light ➡ The Optical Beam can easily Hit the User Eyes.
- Needs More than One Photodetectors

Our Previous Optical Touch Switch using Total Internal Reflection Concept



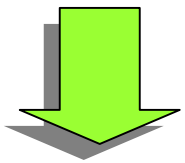
- Key Limitations:

  - ON/OFF Switch Ratio is Low (e.g., 0.23 dB) due to a Small Change of Output Optical Beam
  - High Ambient Illumination can Affect the Switch Operation

Ref.: S. Sumriddetchkajorn, "Optical touch switch baed on total internal reflection," *Opt. Engg.,* V. 42, 787-791, Mar. 2003.

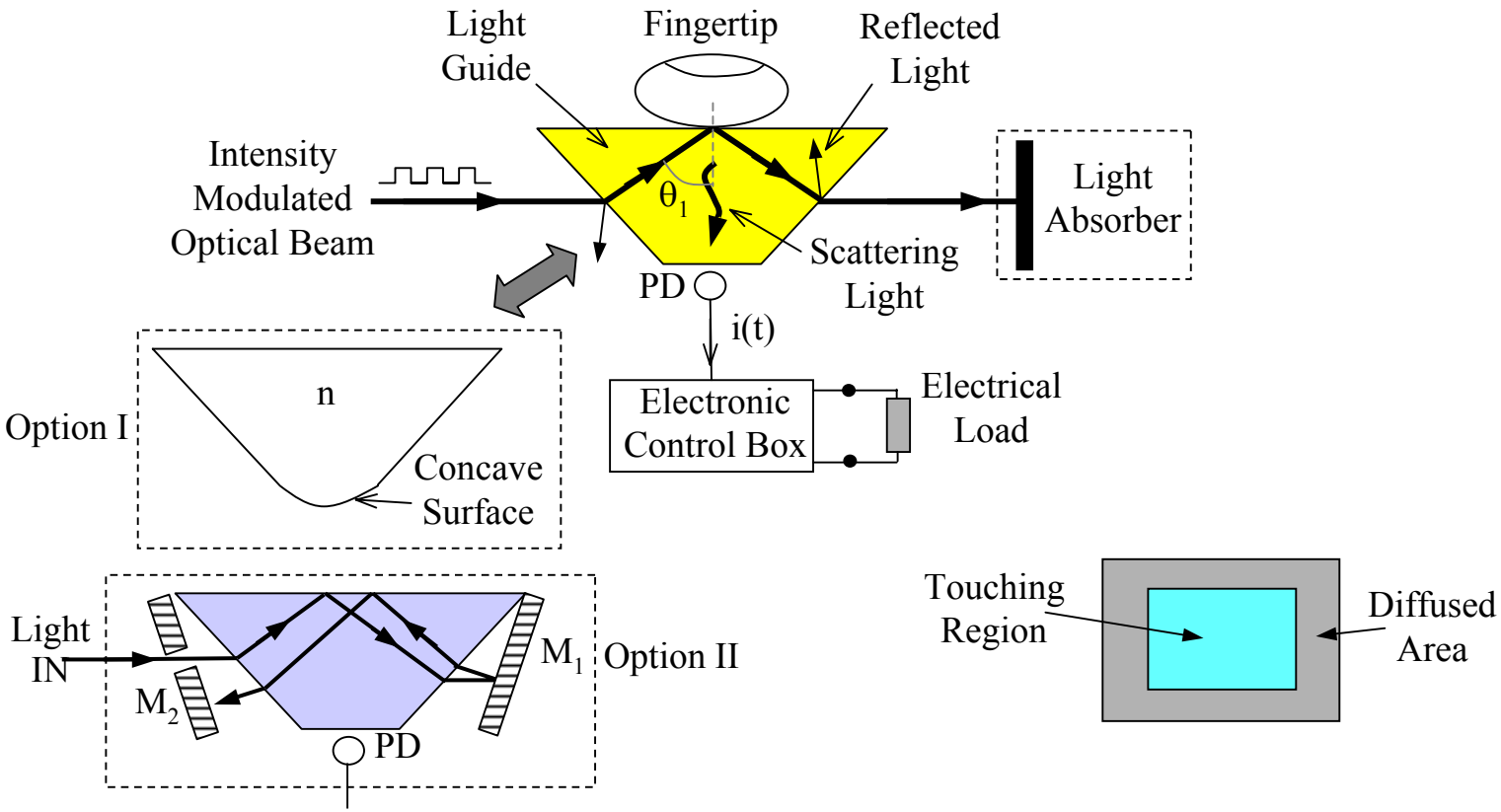
Our Current Optical Touch Switch Approach

Can be Used in the Dark Area + High Switch Sensitivity + No Leakage Light Hits the User = ***How??***



Evanescent Wave + Light Scattering = ***New Optical Touch Switch***

Our Proposed Light Scattering-based Optical Touch Switch Structures

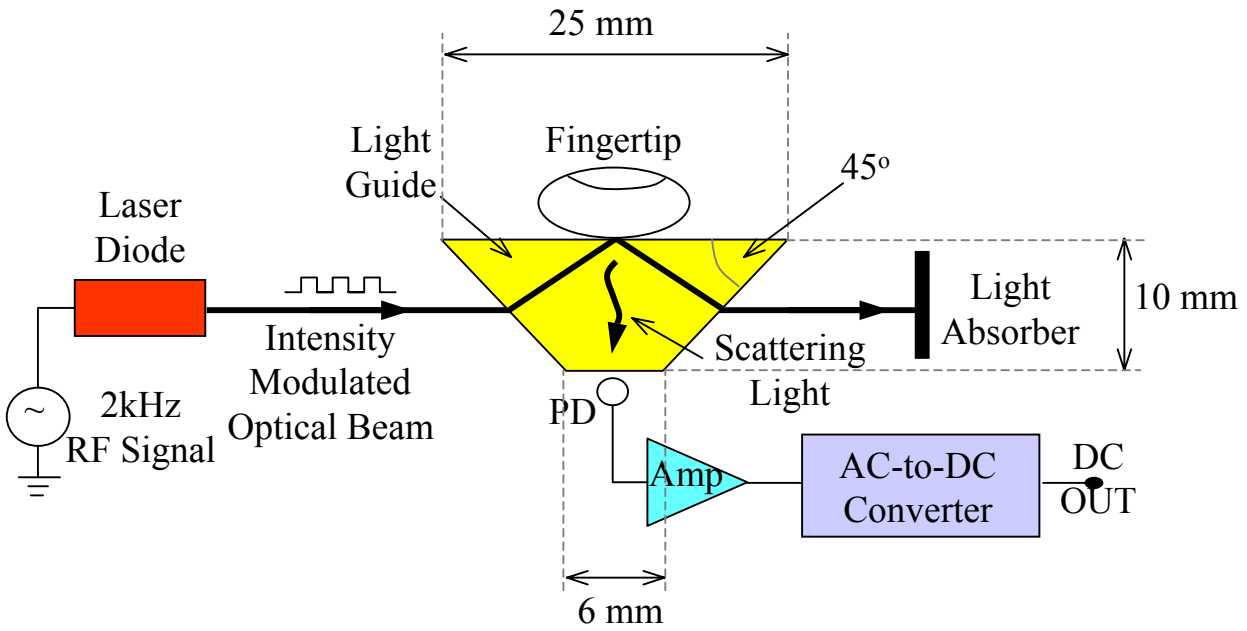


Ref.: S. Sumriddetchkajorn, "Optical touch switch structures," *US Patent*, 6765193, Jul. 20, 2004.

Key Features of Our Light Scattering-based Optical Touch Switch

- No Moving Part Touch Switch
- User Friendliness → Can be Used in the Dark Area
  → No Light Hits the User Eyes
- Ease of Implementation
- Suitability for Both Strong and Weak Mechanical Force
- Adjustable Sensitivity via Number of TIR Points, Shape of Lightguide, and Reflective Design

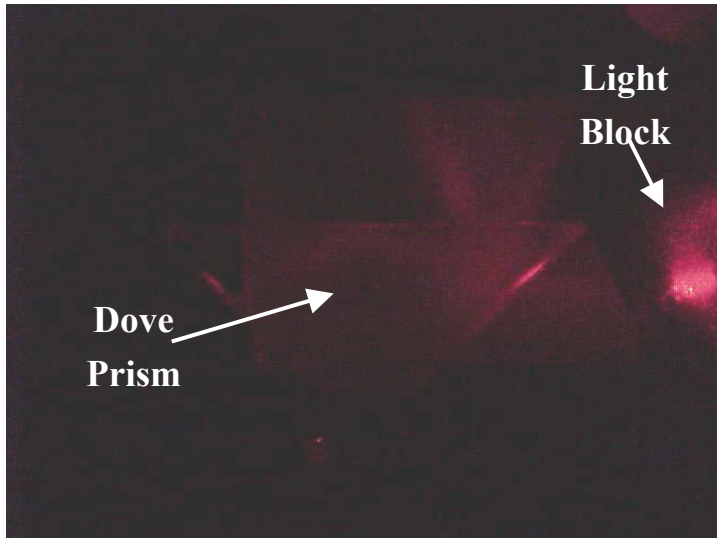
Experimental Demonstration

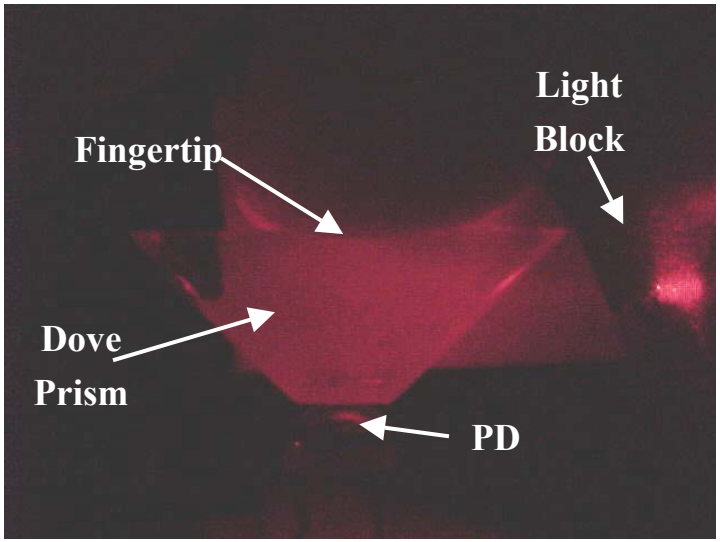


- Dove Prism: 10 mm thick, refractive index of 1.5, and 25 mm long
- Laser diode: 5 mW optical power, 50 nm wavelength band centered at 655 nm, elliptically optical beam profile with a 2mm x 4 mm diameter
- Photodetector: SLD-70BG2
- AC-DC Converter: contains electrical bandpass filter, rectifiler, and inverter

Experimental Results

- Switch Operation Test using a 655 nm Laser Diode





No Fingertip on the touching surface

No Light Scattered to the PD

With Fingertip on the touching surface

Light Scattered to the PD

- Measured Scattered Light: 1.47%

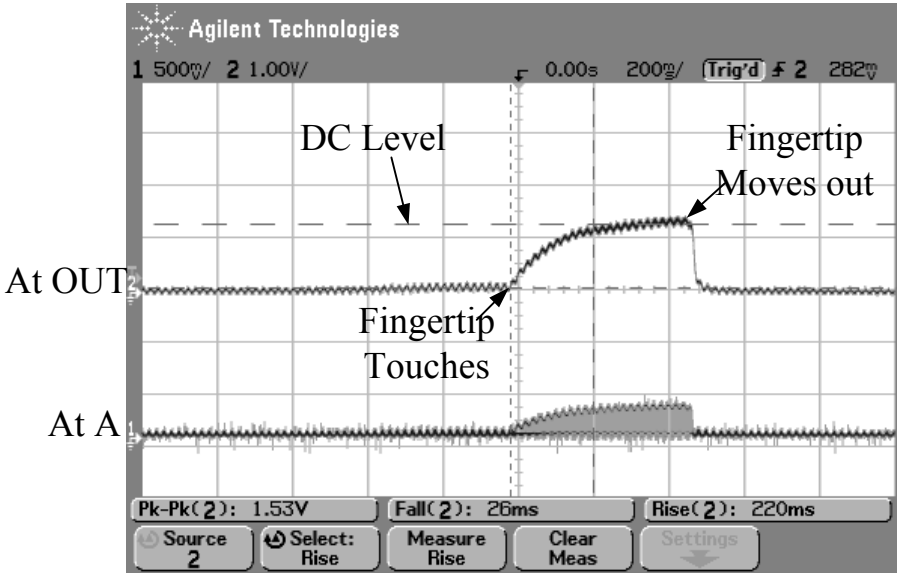
But

ON/OFF Switching Ratio: 24.4 dB

- Switch Response Time

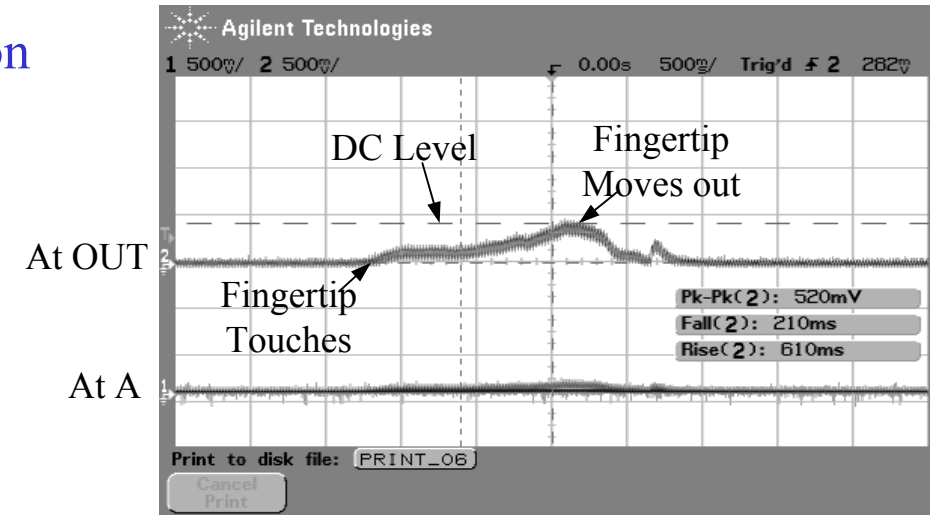
  - Touch/Lift Fingertip Operation

Fast Response Time
- Rise Time: 220 ms
- Fall Time: 26 ms



  - Touch/Slide Fingertip Operation

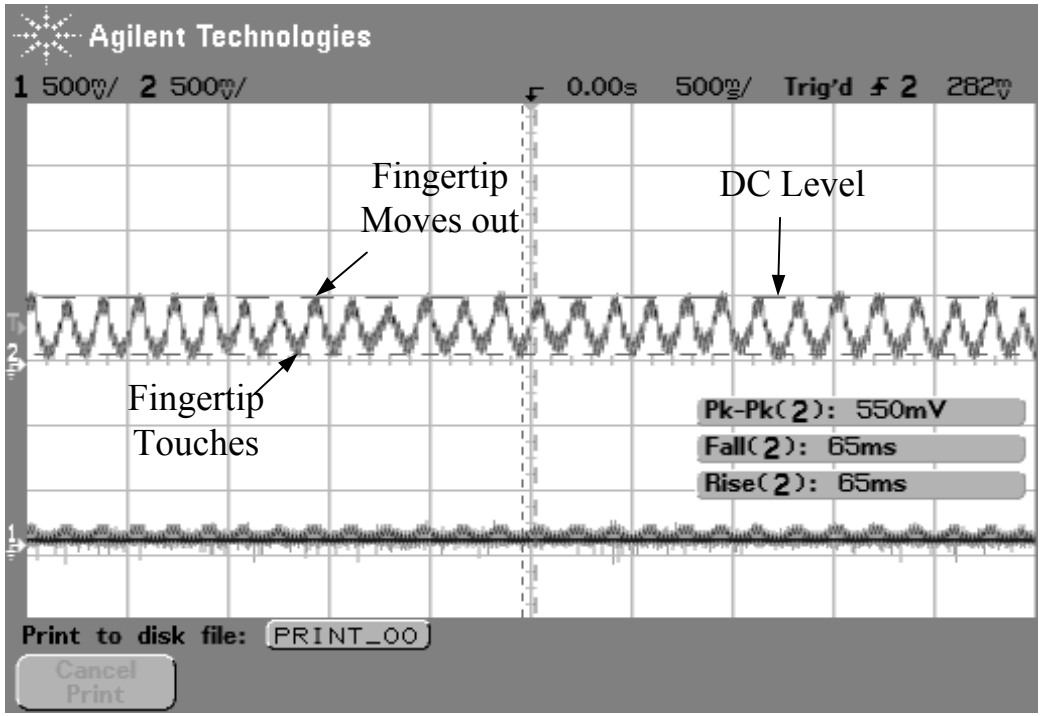
Slower Response Time
- Rise Time: 610 ms
- Fall Time: 210 ms



- Multiple Keystroke Operation

At OUT

At A



- Faster Response Time (Rise Time: 65 ms, Fall Time: 65 ms)
- 6 Keys/Second

Key Limitations for Switch Response Time

- RC Time Constant inside the Electronic Control (e.g., 100 ms)
- Mechanical Movement of the Fingertip

Field Prototype of Our Low Cost Light Scattering-based Optical Touch Switch using Light Emitting Diode

Personal Computer Control

- > 1000 Operations
- Operate Under Both Typical (e.g., 400 Lux) and High Ambient (e.g., 4000 Lux) Illuminations

Without Switch Malfunction

Conclusion

• Novel Optical Touch Switch Module was Proposed and Experimentally Demonstrated

Evanescent Wave + Light Scattering → A Novel High Sensitive Optical Touch Switch

• Key Features Include:
- No Moving Part Switch
- User Friendliness
- Ease of Implementation
- Accepts Both Strong and Weak Mechanical Force
- Adjustable Sensitivity via Number of TIR Points, Shape of Lightguide, and Appropriate Switch Design

• Future Works Relate to Improve and Commercialize Our Light Scattering-based Optical Touch Switch as well as to Test it with Disabled People