

Spatial Frequency Modulation for Imaging (SPIFI) in Optical and Mid-IR Wavelength Systems

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Goal

- Use Single Element Detector for 2D Imaging

Approach

- Frequency Encoding Eliminates Need to Scan in Direction of Line Focus
- Fourier Transform Detector Signal to Recover Frequency Space Representation of Object

SPIFI Theory

- SPIFI Mask Provides Linear Frequency “Chopping”^[1]

$$m(x, t) = \frac{\omega(t)}{2} [1 + \text{Cos}(2\pi\kappa xt)]$$

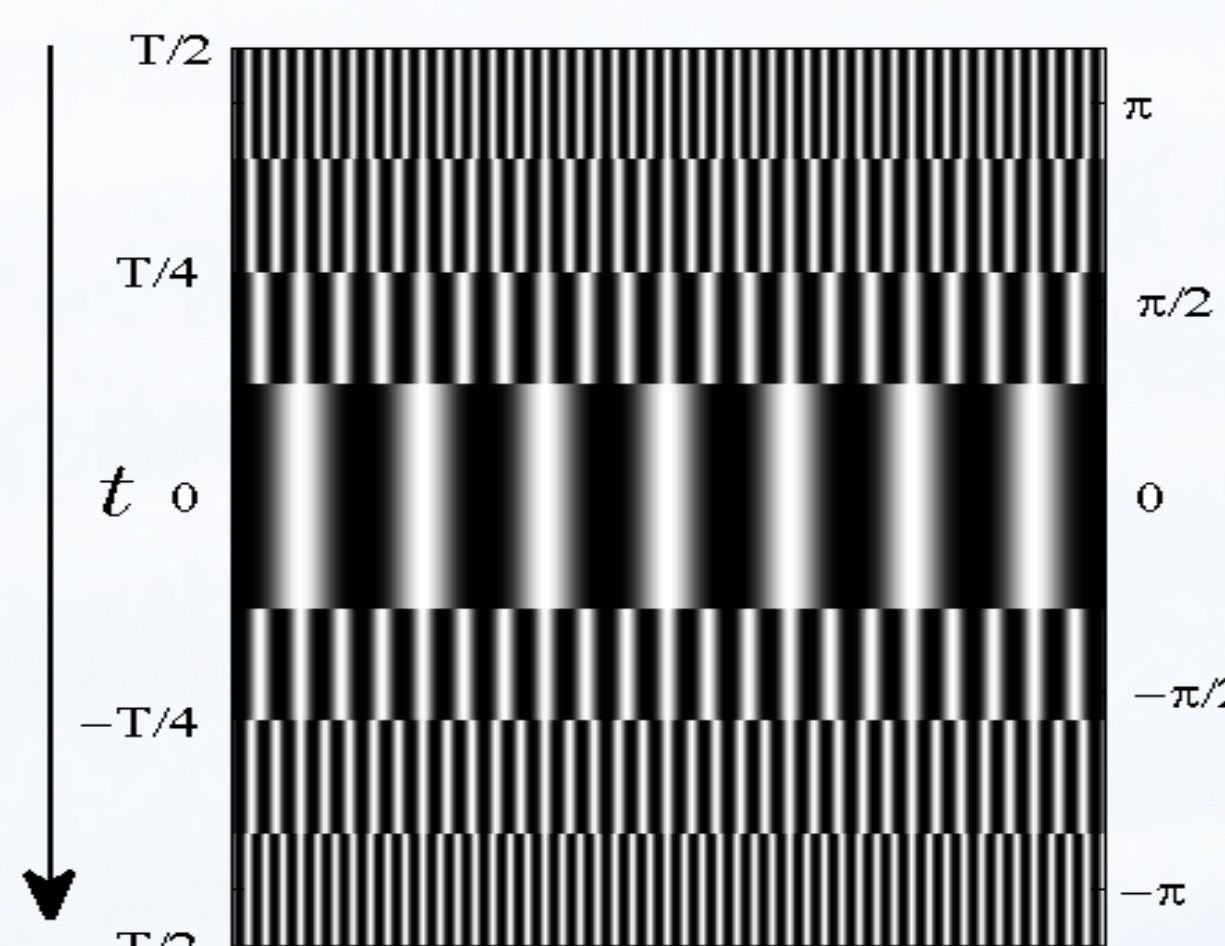


Fig. 1. Modulation Time vs X Position

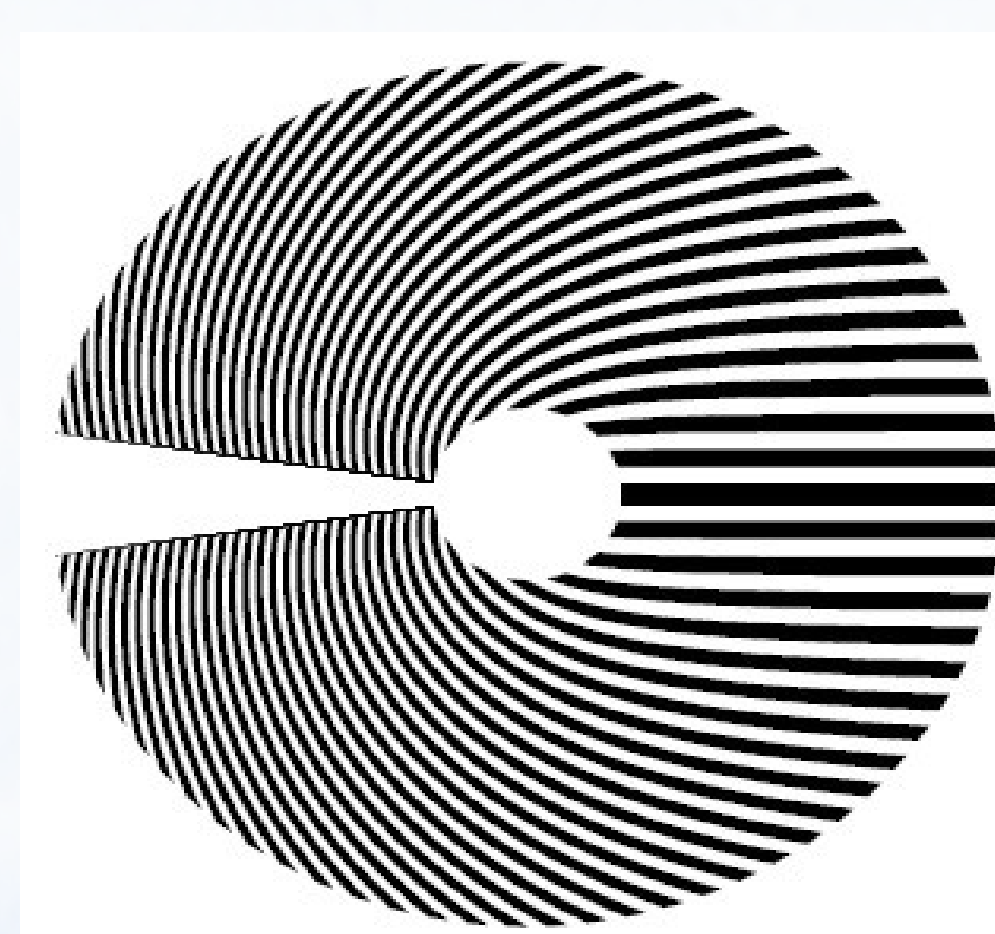


Fig. 2. Optical SPIFI Mask

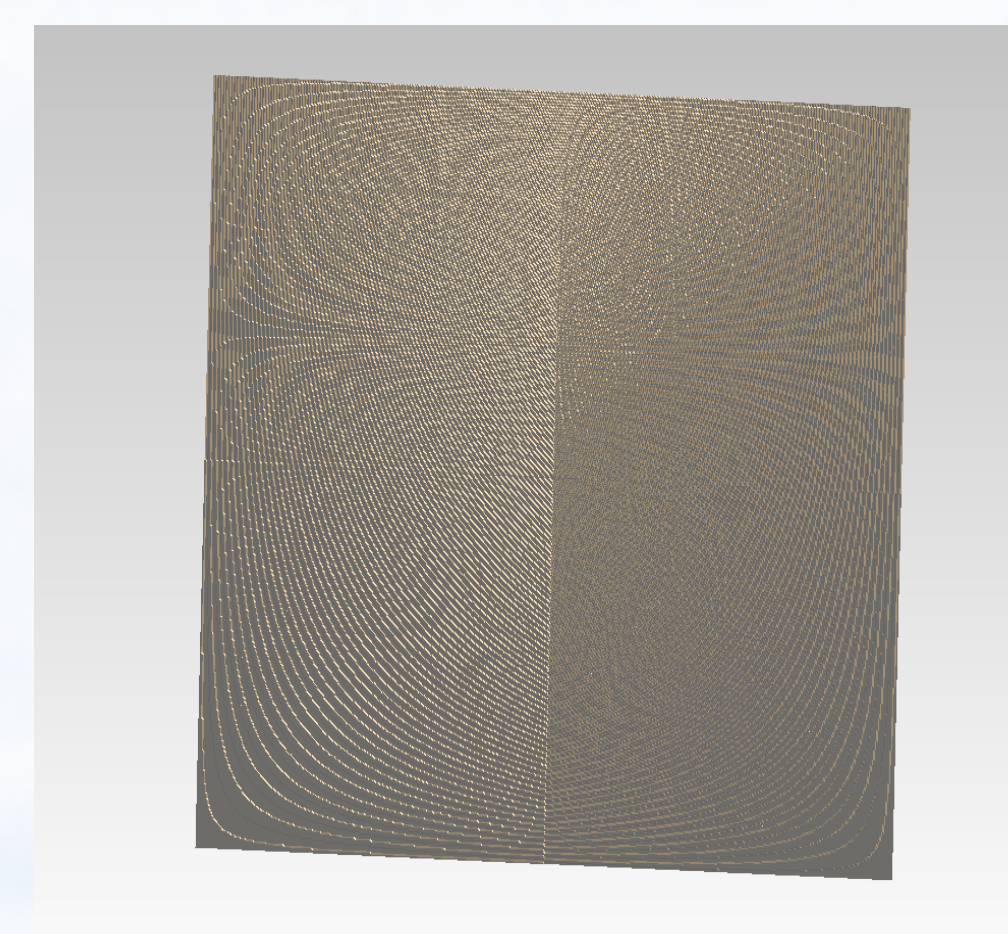


Fig. 3. Thermal SPIFI Mask

- Fourier Transform: Intensity vs. Time → Intensity vs. Frequency
- Upper band of Fourier Transformed Signal^[1]

$$S_{1+}(x' = f\kappa^{-1}) = W(\kappa x') * |u(x')g(x')|^2$$

- Lower Intensity Corresponds to Presence of Object at Mapped Frequency

Results

Optical System

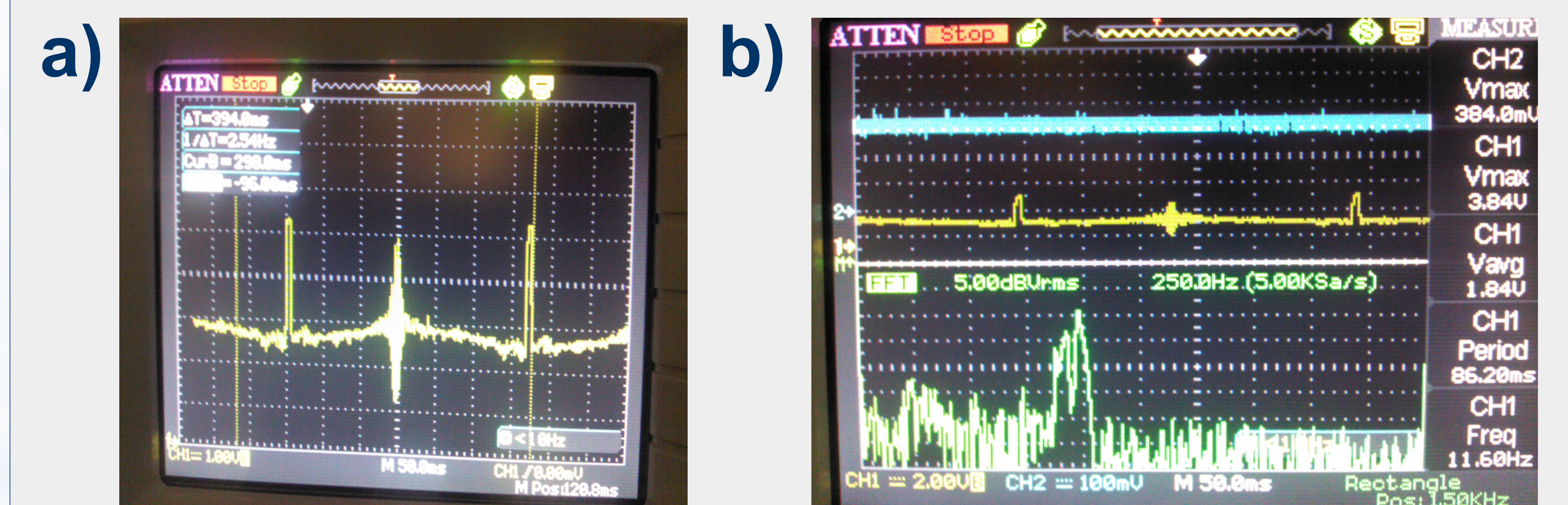


Fig. 5. a) Temporal Signal. b) Fourier Transform of Temporal Signal with a Wire in Beam Path

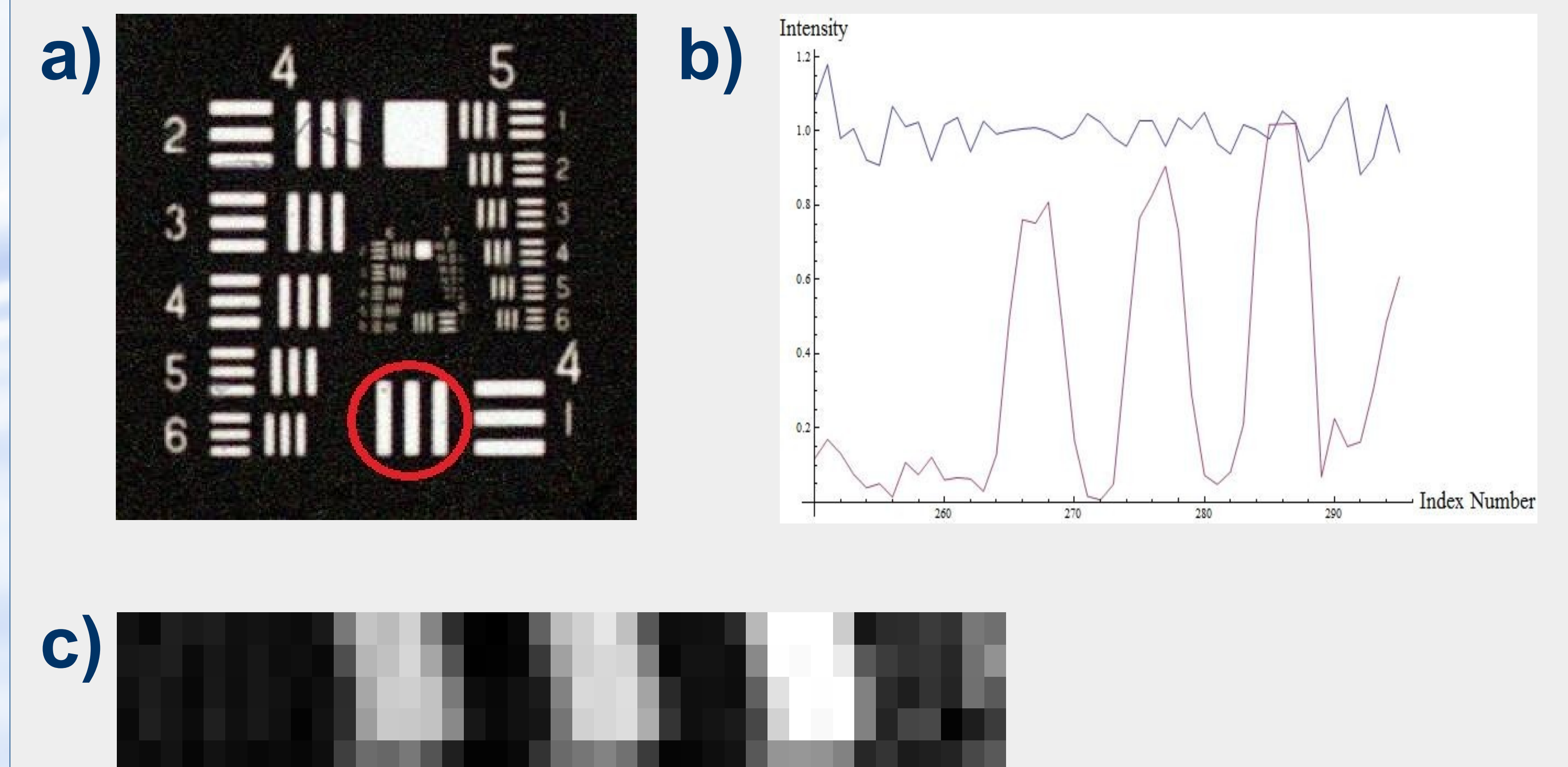


Fig. 6. a) 1951 USAF Test Pattern. b) Normalized 1-D Sample Trial (Purple) with Background (Blue). c) Reconstructed Object (Target Red Circle)

Set-up

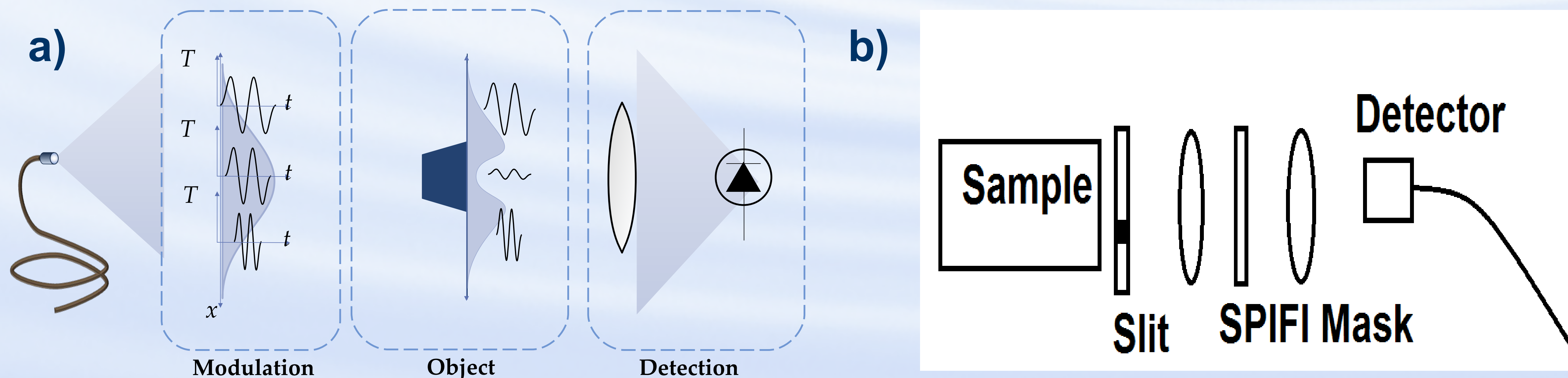


Fig. 4. a) Optical SPIFI Set-up. b) Theoretical Thermal SPIFI Set-up. [1]

- Data Collected and Sent Serially via an Arduino Uno Microcontroller
- Filter (0.01% Transmission) Protects Optical System Detector
- Slit over Thermal Sample to Restrict Detection to 1D

References

1. G. Futia, P. Schlup, D. Winters and R. Bartels, “Spatially-chirped modulation imaging and fluorescent objects on single-element optical detector,” *Opt. Express* **19**, 1626-1640 (2011)

Acknowledgements

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