Thermo-Electric Control Board for Integrated Optical Beam Forming Network

James McKenna

University of California, Santa Barbara Electrical Engineering Major

Yuan Liu, Professor Jonathan Klamkin

Electrical and Computer Engineering Department

Revolutionizing wireless communications

- **Utilizing higher frequency "millimeter wave" (75GHz-110GHz) for communications to drastically improve data transmission rates**
- **Shorter wavelength = More directional beam**
- **Using integrated optics to steer beam**

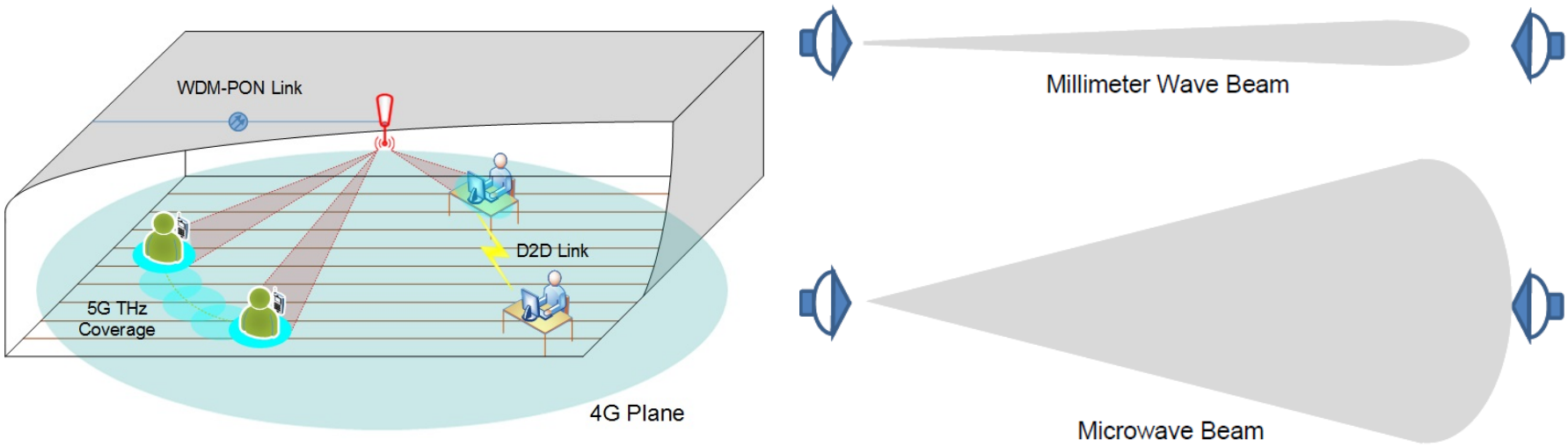
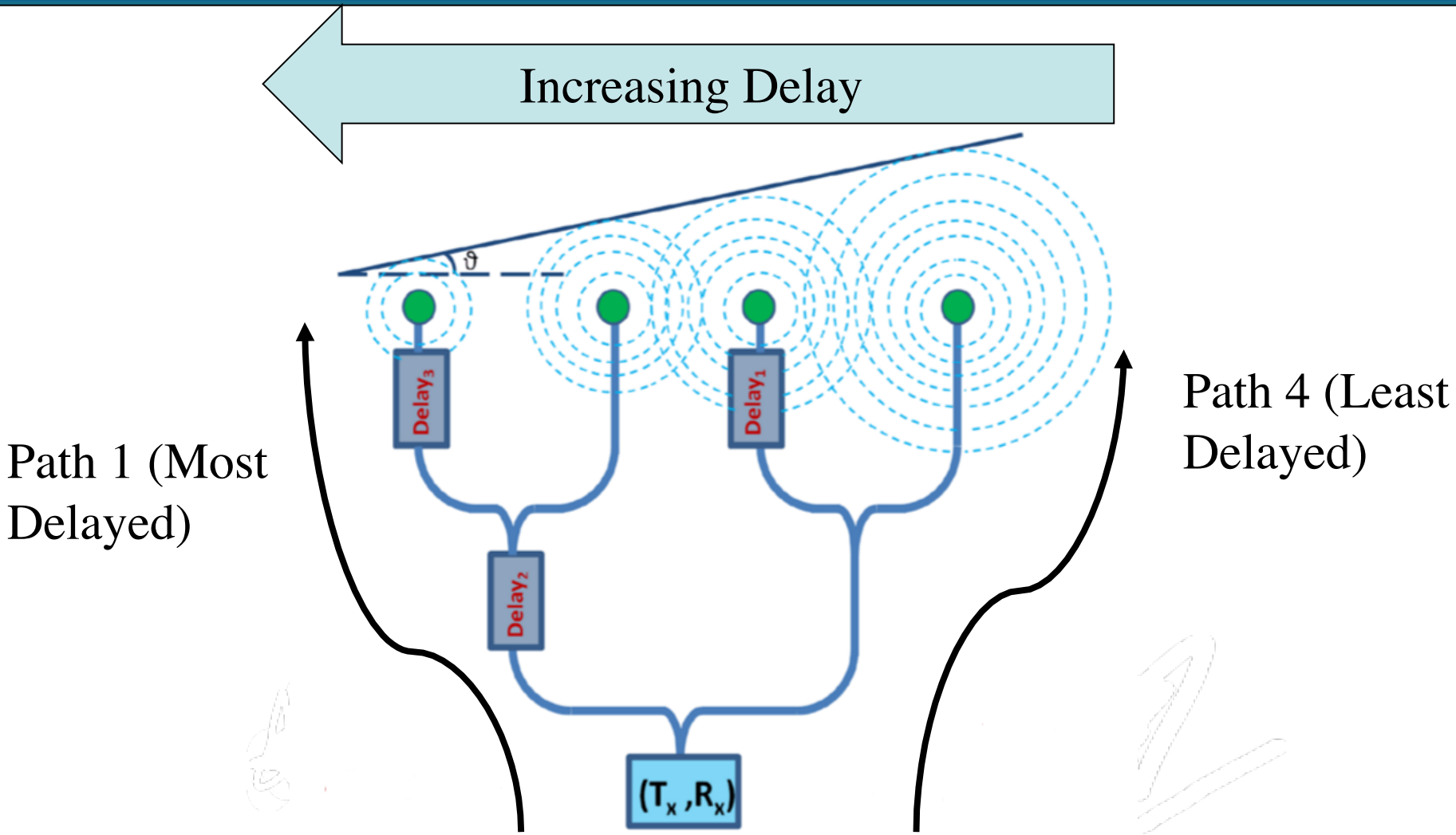


Figure 2: Millimeter wave Links Have Narrow Beams

Adhikari, "Understanding millimeter wave wireless communication," Loea Corporation 2008, pp 4.

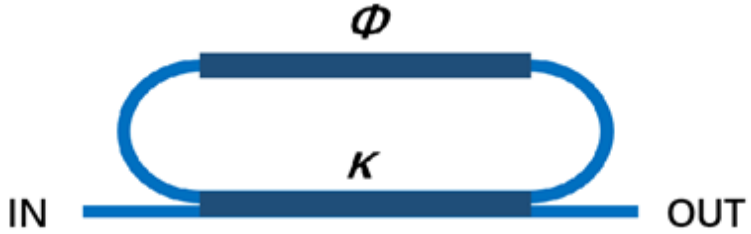
Beam steering schematic



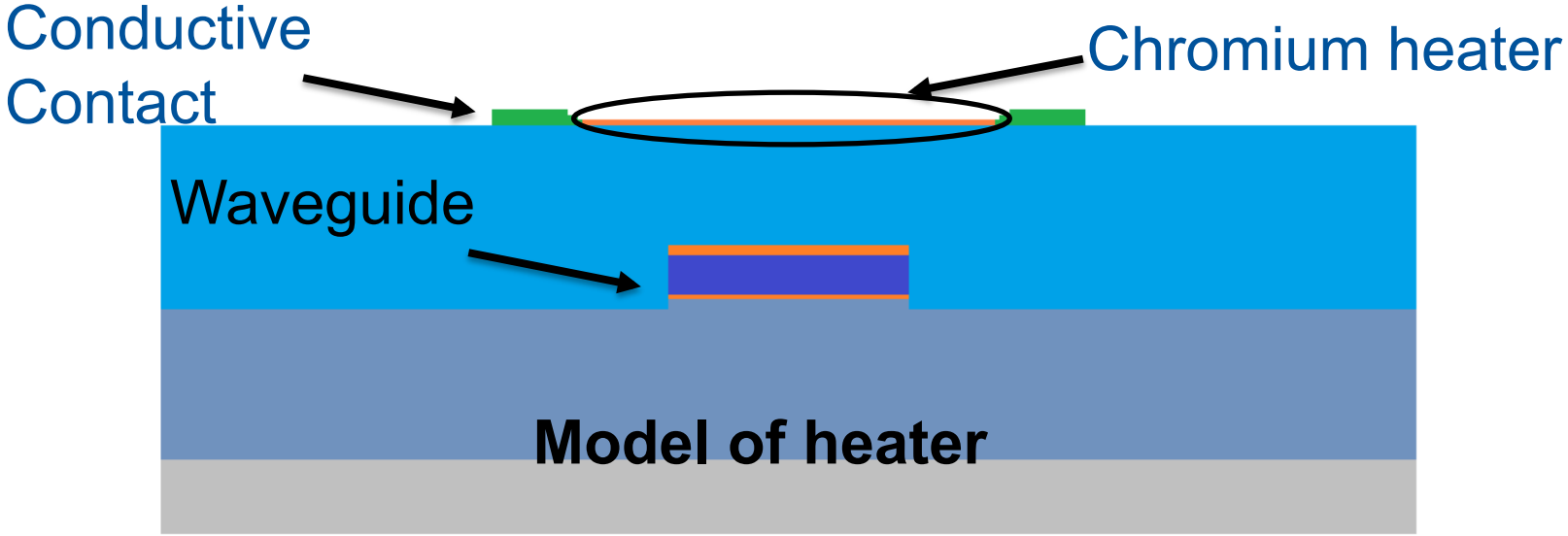
Mckenna, Timothy P., Jeffrey A. Nanzer, and Thomas R. Clark. "Photonic beamsteering of a millimeter-wave array with 10-Gb/s data transmission."*Photonics Technology Letters, IEEE* 26.14 (2014): 1407-1410.

Ring resonator heater model

- **Each delay achieved by ring resonator**



- **Each ring resonator has heater paired with it**



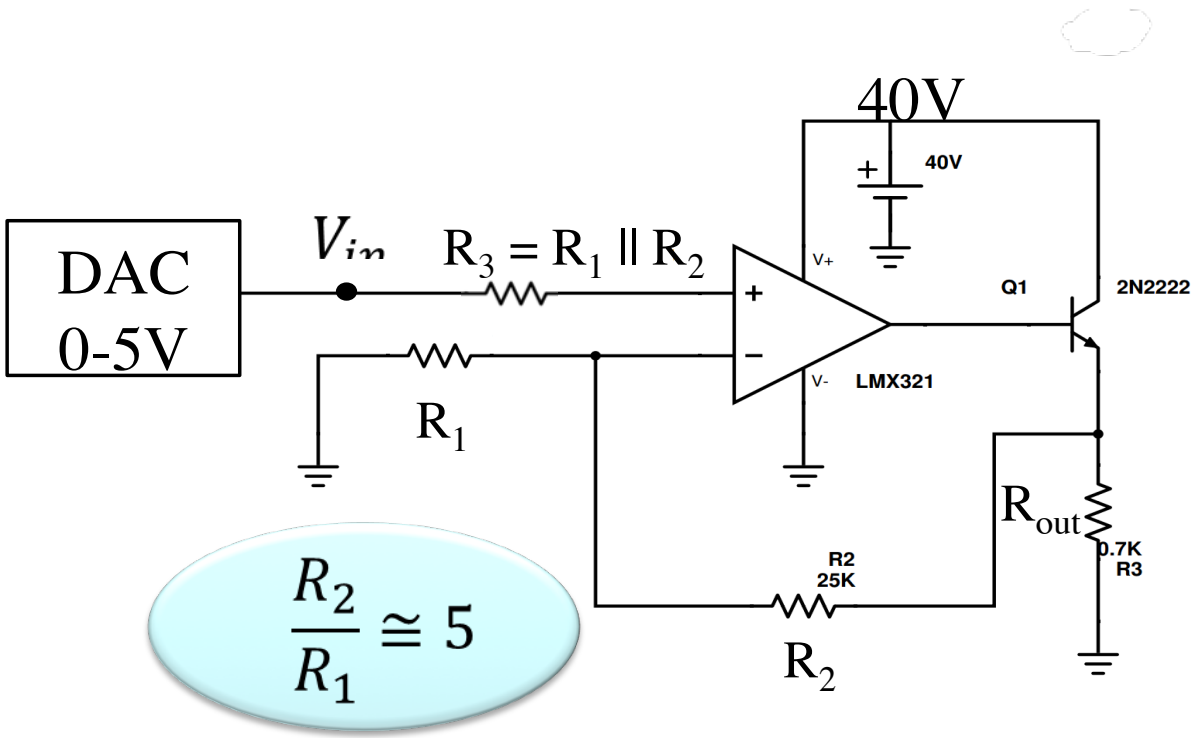
Goal: Design 64-channel programmable current source

- **Need to control 64 independent current sources to tune delays**
- **Controlled from PC via I^2C communication**

Amplifier design

- **Utilizing a common op-amp feedback circuit with several additions to supply large amount of power (> 1 Watt)**

- **Achieve max output conditions of 30 V, 43 mA given a 700 Ohm load**



$$= 6V_{in}$$

$$V_{out} = \left(1 + \frac{R_2}{R_1}\right) V_{in}$$

V_{out} : 0-30 V

DAC Resolution Requirement

- **Current sources must be precise within 0.01 mA**

Since $\boldsymbol{I = \frac{V_{out}}{R\_load}}$

This implies that $\boldsymbol{\Delta I = \frac{\Delta V_{out}}{R_{out}}}$

Our amplifier circuit gives us $\boldsymbol{\Delta V_{out} = 6 * \Delta V_{in}}$

The DAC gives us $\boldsymbol{\Delta V_{in} = 5 * 2^{-n}}$, n = bit resolution

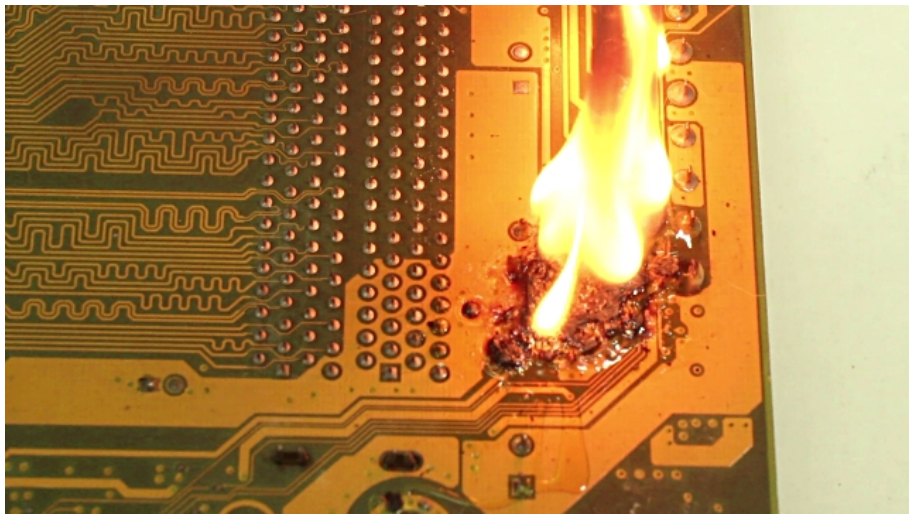
Solving for n, we obtain $n \cong 12\ bits$

Device testing

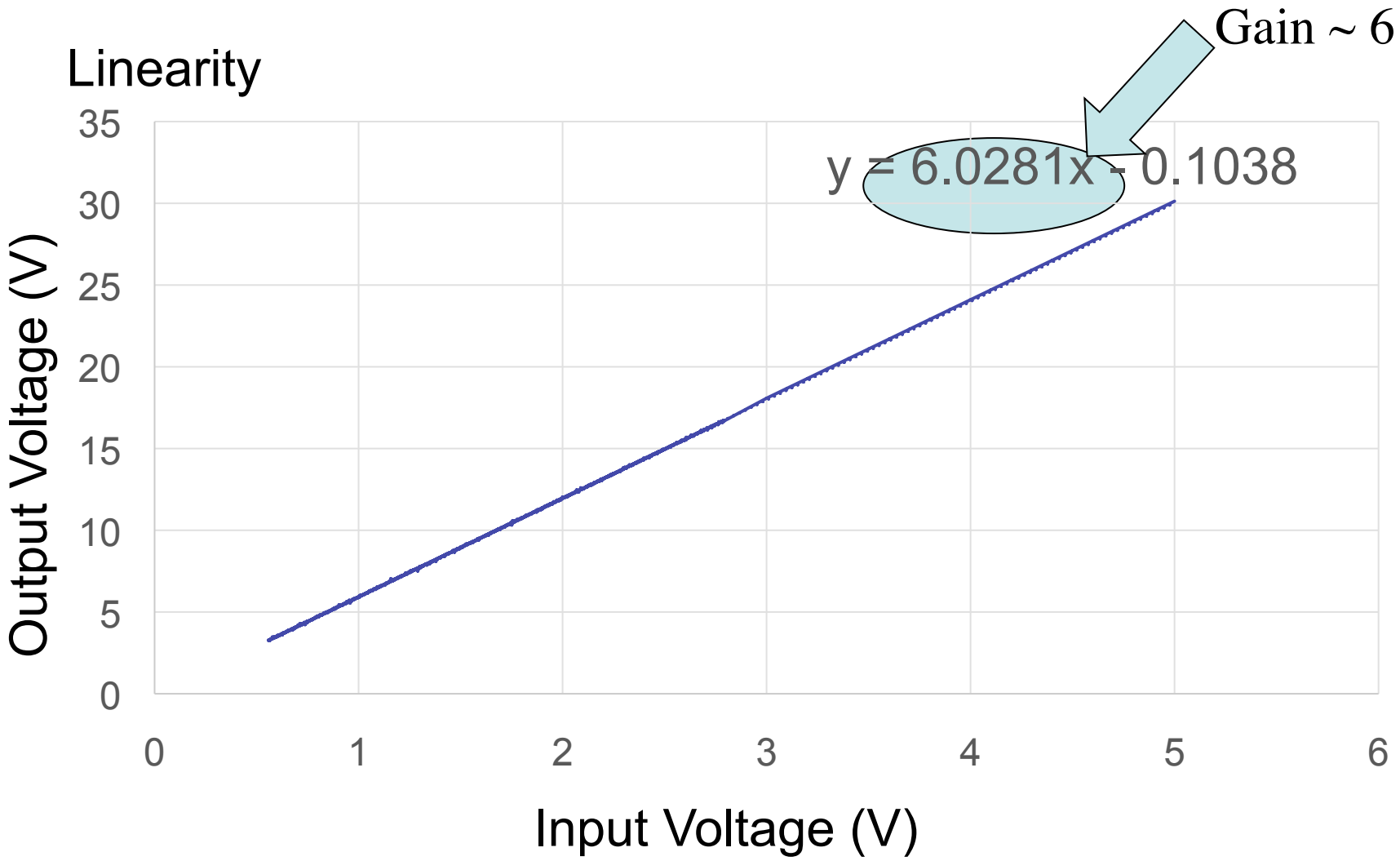
- **Main tests: Linearity and Stability**

- **Linearity: When changing the input voltages, the output varies linearly**

- **Stability: Output does not vary significantly if circuit is running at max power for long periods of time**

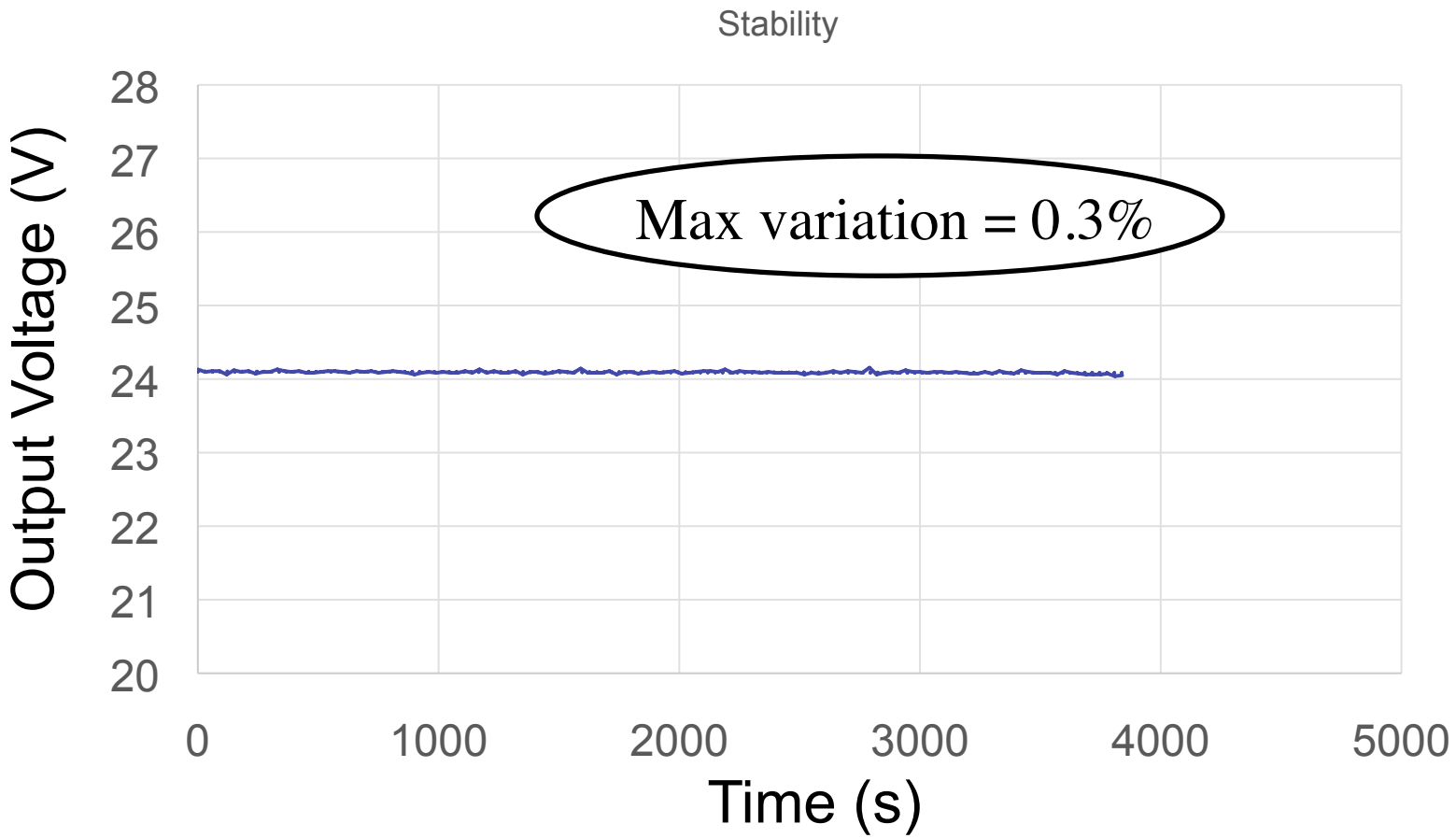


Testing results

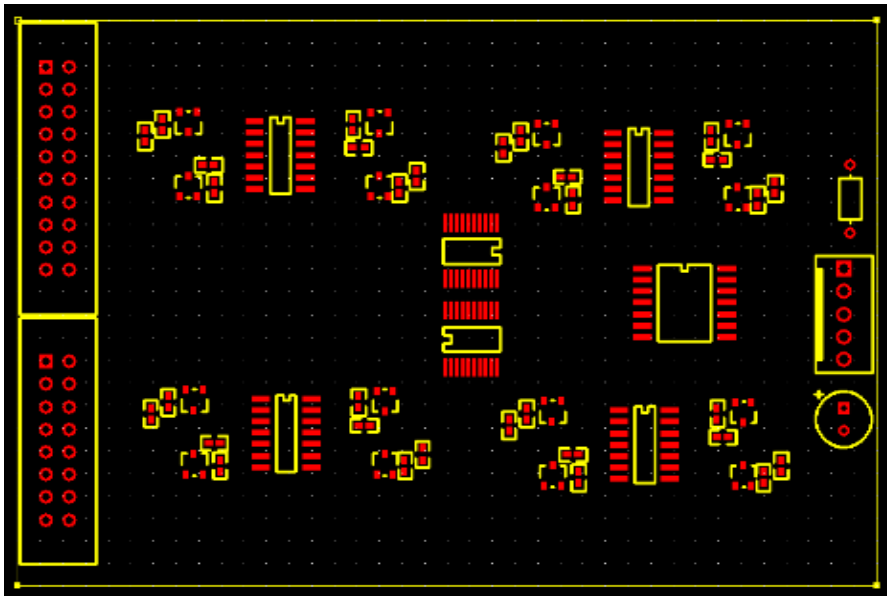


Testing results

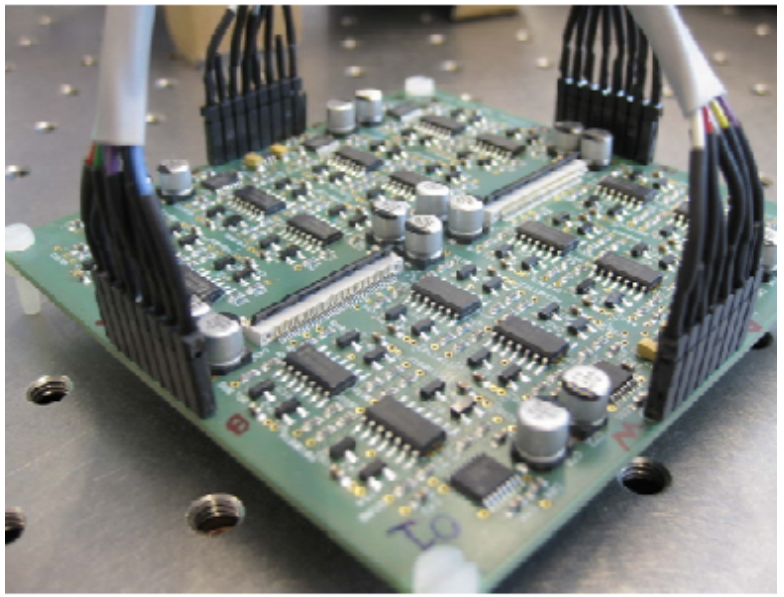
Stability



Final Design



PCB Design For Board (In progress)



Example of another PCB control board

C. Taddei *et al*., "Fully reconfigurable coupled ring resonator-based bandpass filter for microwave signal processing," *Microwave Photonics (MWP) and the 2014 9th Asia-Pacific Microwave Photonics Conference (APMP), 2014 International Topical Meeting on*, Sendai, 2014, pp. 44-47. doi: 10.1109/MWP.2014.6994485

Conclusions and Future Work

- **Next Step: Finish PCB design and solder final board**
- **The thermo-electric control board will help tune and optimize the integrated beam forming network**
- **A successful integrated optical beam forming network will bring us one step closer to revolutionizing wireless communication.**

Acknowledgements

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