High Resolution Digitally Trimmable Resistor

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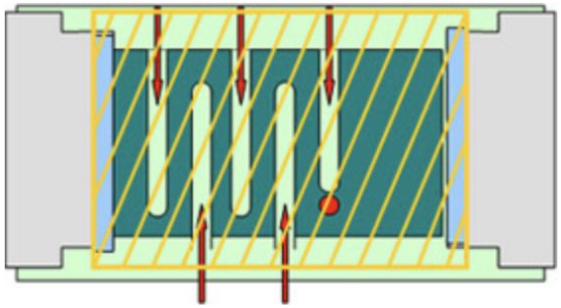

Trimming (conceptual drawing)

Project Description

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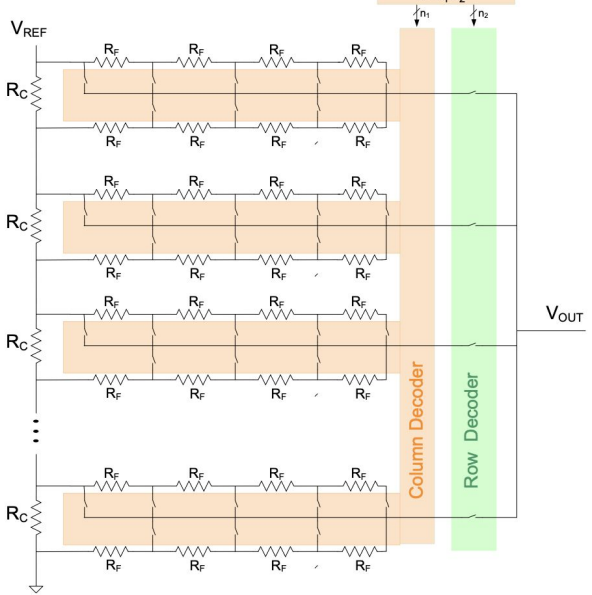


Project Statement:
To design a high resolution digitally trimmable resistor. It should be capable of adjusting its resistance value by ±1%, should be re-trimmable infinitely many times.

Project Description

- There is a need to modify resistance values for resistors that are in the wild
- Analog trimmable resistors exist
  - Expensive
  - Difficult/impossible to trim once the IC has been packaged
  - Very few adjustments can be made if any
- Digital trimmable resistors exist
  - low-resolution
  - Poor temperature coefficients
  - Large physical area
- Need to improve the digital trimmable resistor design to get desired outcome.

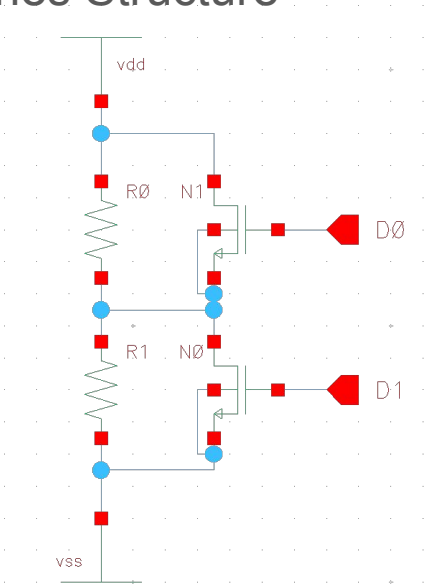
Current Solutions on the Market

Currently trimming resistors in IC is done with various methods.

- Laser Trimming - Pre-packaging method
- Anti-Fuse Trim - Utilizes fuses to create new current paths
- Magnetic Tunnel Junction Element - Experimental space device
- On-Chip Heater - Used in precise measurement devices
- Digital Trimming - Controls a resistance value using a digital input
    - Series Resistor Structure - Utilizes resistors in series
    - Parallel Resistor Structure - Utilizes resistors in parallel

Current Solutions on the Market Continued

Series Structure

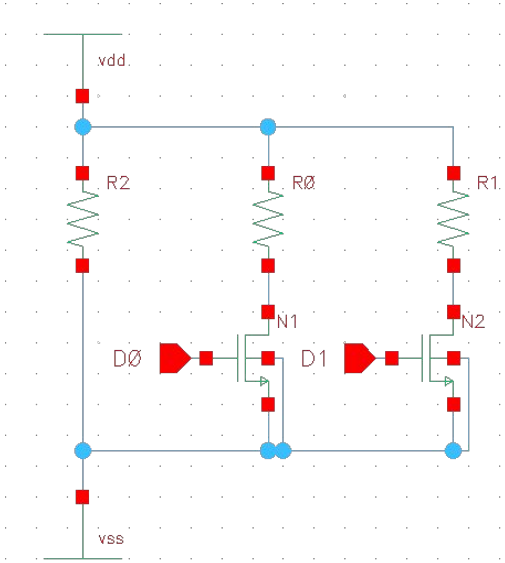


Shortcomings:

- All current is driven through the mosfets.
- Highly temperature dependent
- Resistor and mosfets have different temperature coefficients which don’t cancel out in voltage divider equation.

Current Solutions on the Market Continued

Parallel Structure



Shortcomings:

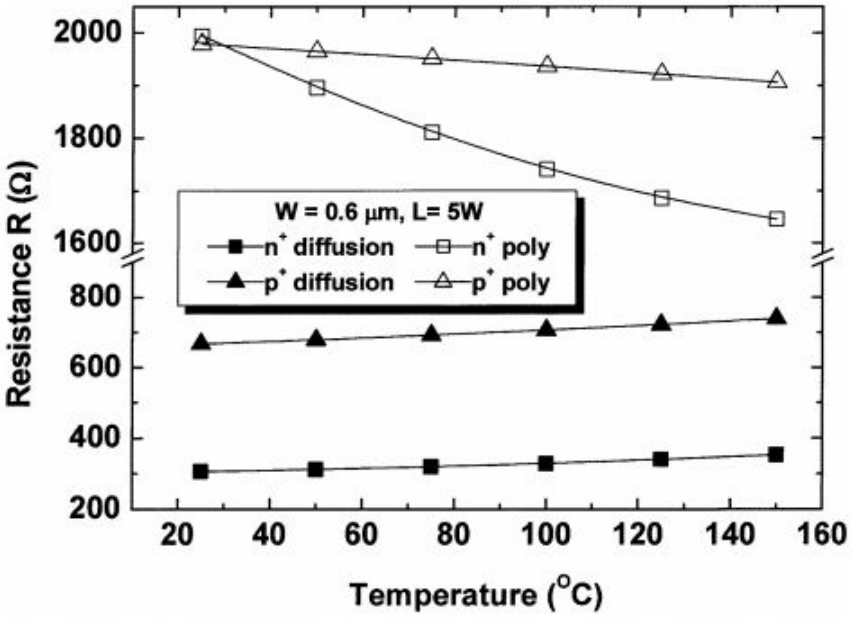
- Resistor area grows dramatically
- Area of total circuit is too large for practical applications.

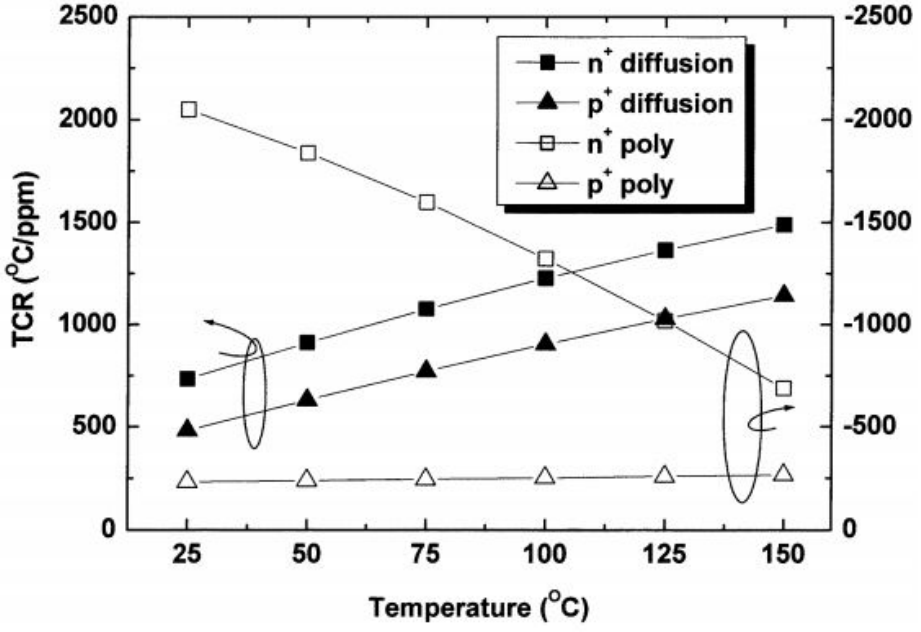
Project Goals

- Conduct additional research targeted towards resistor structures.
- Refine simulation environment to improve precision of data.
- Expand on selected resistor structure schematics.
  - Refine existing schematics
  - Scale up designs to simulate more realistic scenarios
- Conduct more in-depth evaluations of resistor structures.
  - Consider scalability of designs
  - Consider TCR management of all logic states
- Repeatedly trimmable
- ±1% resolution
- Low temperature dependencies

TCR limitations

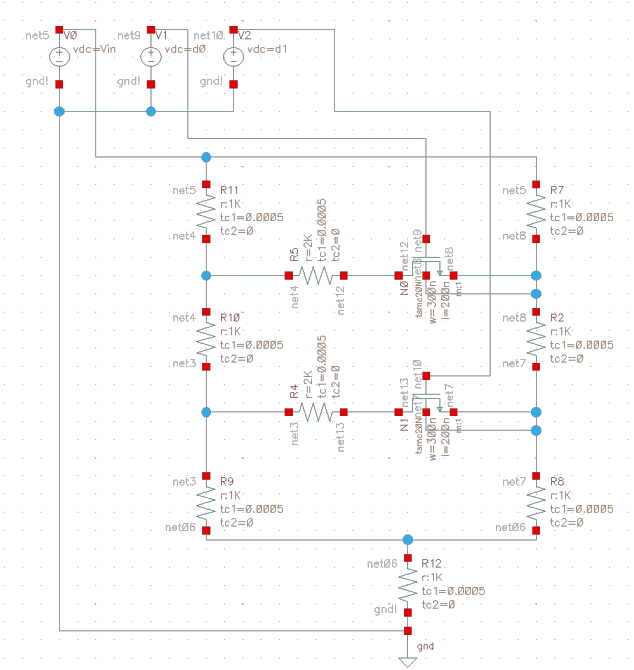
Understanding resistivity of integrated resistors:





Proposed Solution

Ladder Structure

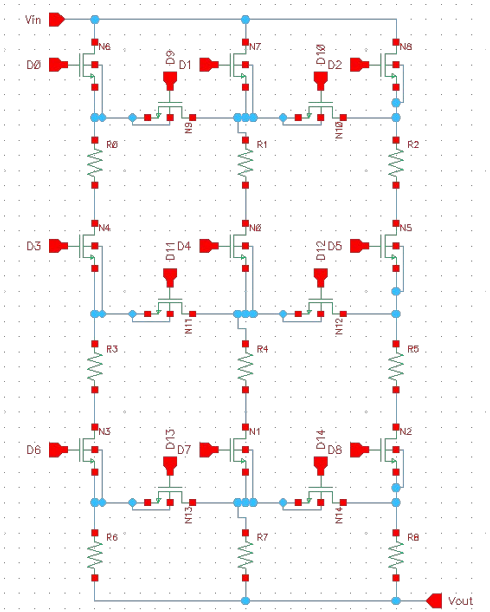


Theory:

- Combination of Series and parallel structure.

Proposed Solution

Matrix Structure



Theory:

- Most adaptable and configurable
- Possibly is a larger area due to a lot of switches
- Resistors could be all one size

Technical Challenges

- Mitigating temperature effects when designing the circuit structure
  - Limit amount of current through the switches
  - Maintain a somewhat small form factor
- Simulation issues with setting up proper settings
  - Reltol, abstol, simulation arithmetic rounding rules
- Determining a good TCR value for comparing structures between one another
  - 500 ppm/°C

Questions?