Design and preliminary results of a shunt voltage regulator for a HV-CMOS sensor in a 150 nm process

UK Research and Innovation

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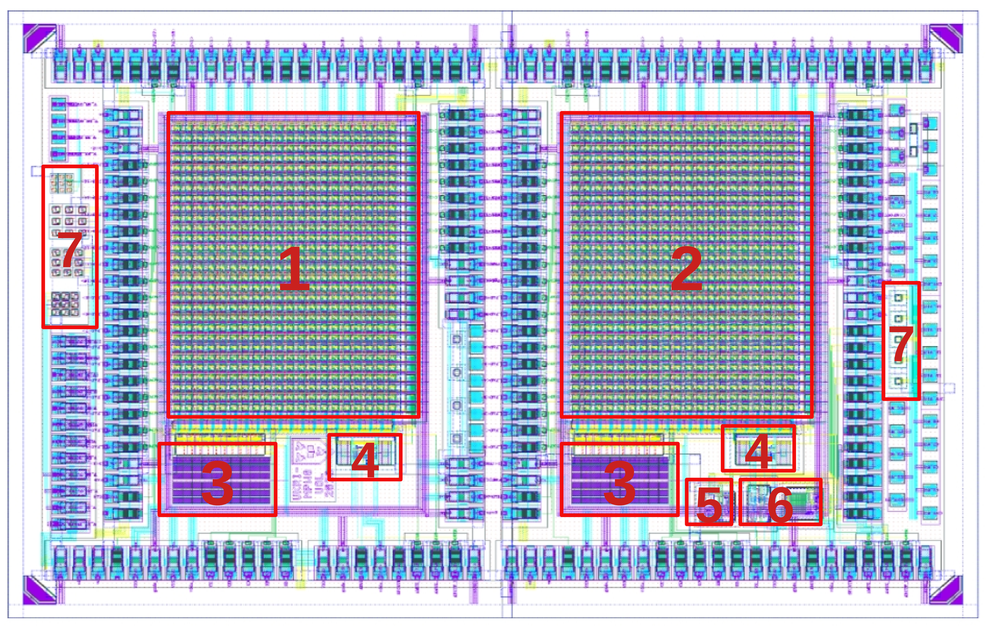
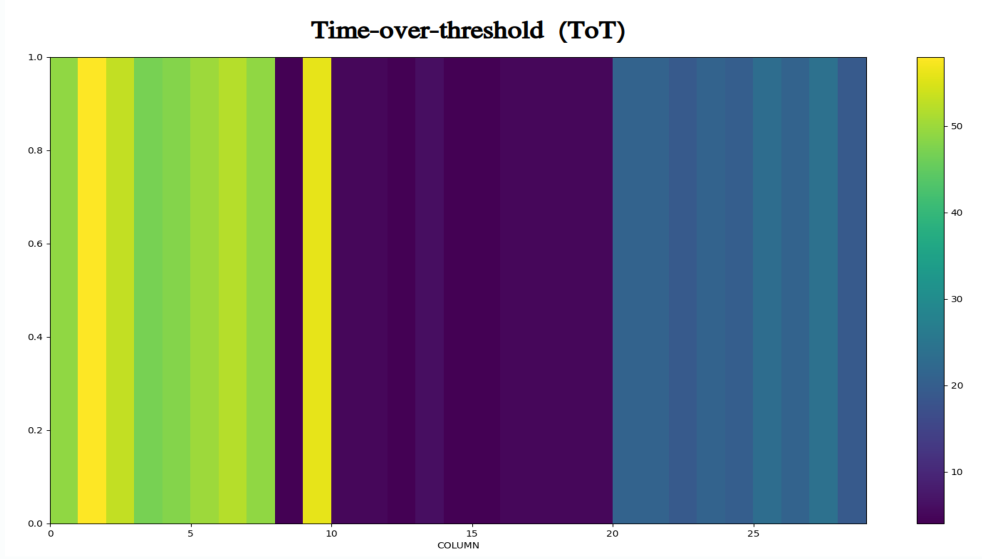
UKRI-MPW0 - Overview and measurement results

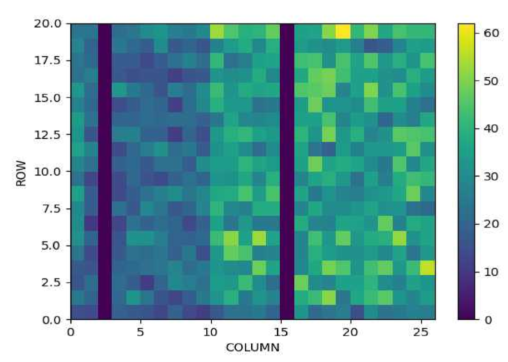
- Depleted Monolithic Active Pixel (DMAPs) ASIC designed and manufactured in the LFoundry 150 nm processs
- Contents
  - **1)** Pixel Matrix 1: 3 pixel flavours with linear transistors only. (20 row × 29 columns)
  - **2)** Pixel Matrix 2: 3 pixel flavours containing 2 ELTs. (20 row × 29 columns)
  - **3)** 2 Bias blocks
  - **4)** 2 Analogue buffers
  - **5)** Voltage regulator
  - **6)** CMOS and BJT Bandgap References (BGRs)
  - **7)** Test structures - Sensor TCT, sensor I-V, linear/circular transistors and Si/SiO2 interface.

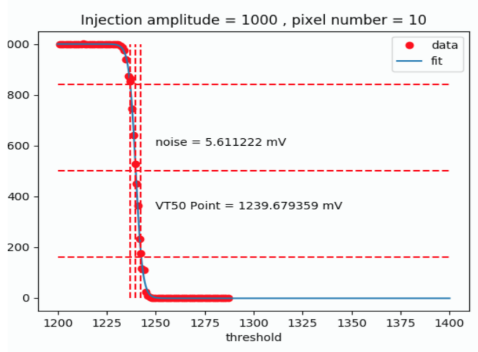


- The active matrix has been characterised in terms of ToT, gain and noise
- The BGRs are independent of the active matrix and have been characterised seperately
- ToT (charge injection) measurements of UKRI-MPW0 matrix 1 show clear distinction between the 3 flavours of pixels implemented in the design



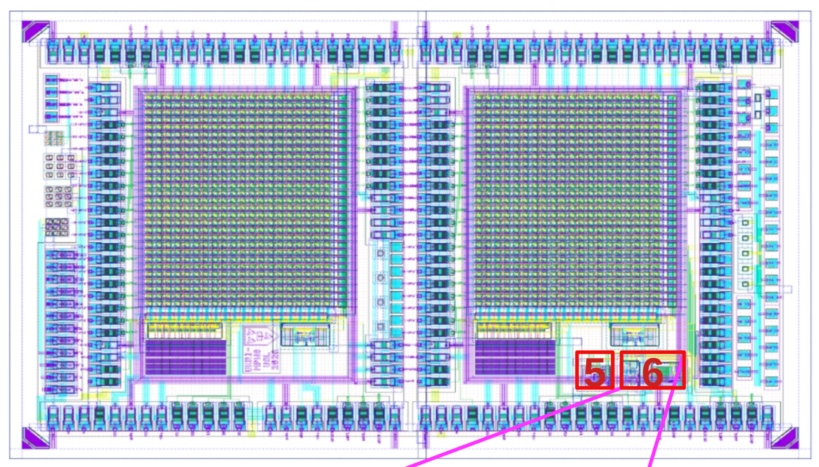
- Hitmap with radioactive source (Sr90) shows gain distribution across pixel matrix as expected for different pixel designs

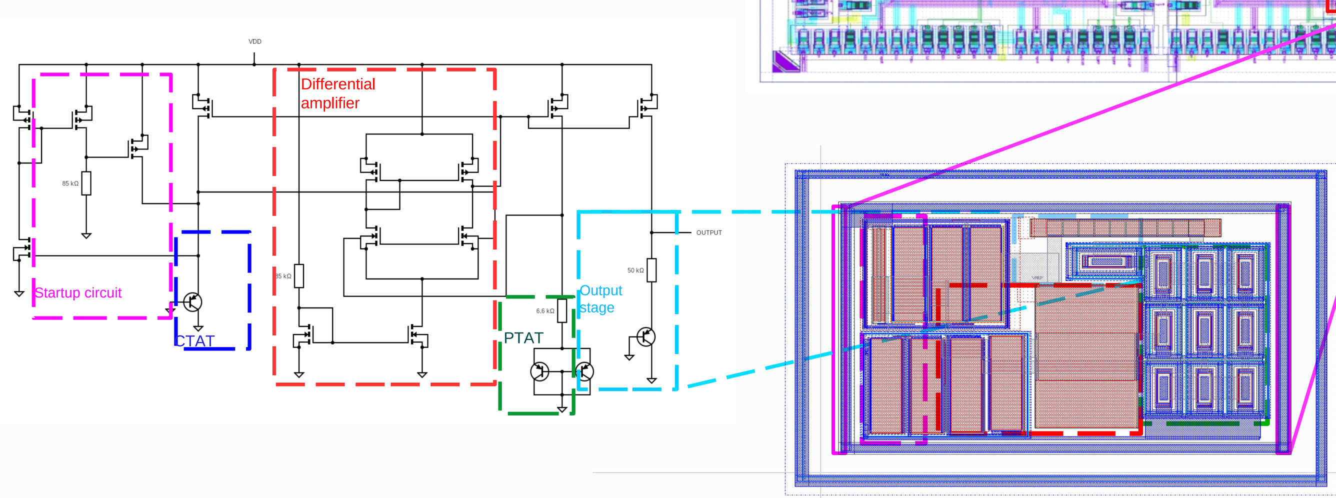




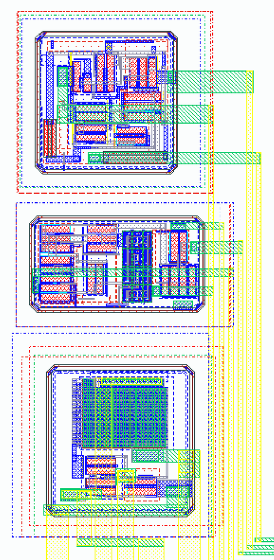
UKRI-MPW0 – BGRs and regulator design

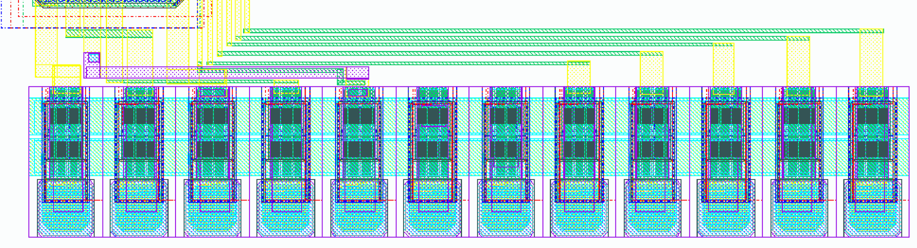
- Circuits designed and manufactured in UKRI-MPW0
  - BJT BGR
  - Fully CMOS BGR
  - Shunt regulator



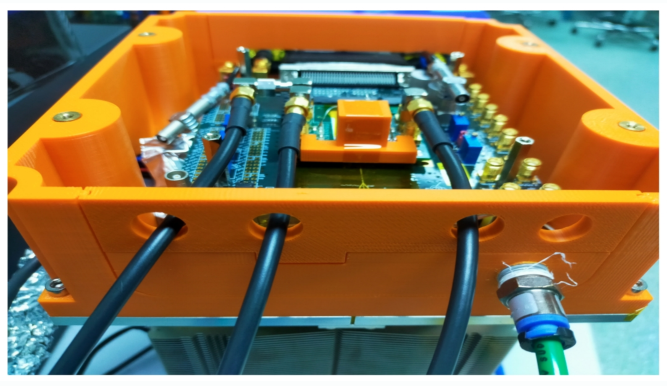


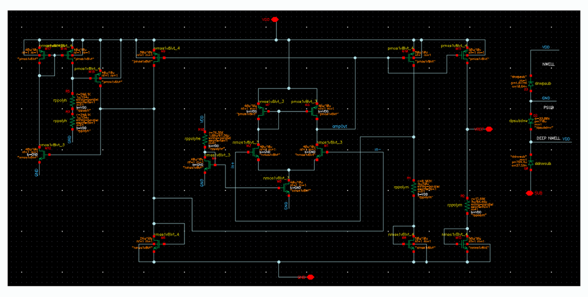
- A practical detector requires a reference against which measurements can be made. A circuit which performs this function is known as a bandgap reference (BGR).
  - A practical detector requires a reference against which measurements can be made.
  - A bandgap reference should provide an output that is stable for changes in input voltage and temperature
  - The circuit should be designed such that positive and negative temperature coefficients cancel each other out providing an output that is independent of ambient temperature
- •A practical detector also requires multiple power supply voltages. Providing these voltages externally requires additional resources (at the module level) in terms of external circuitry module area and bus tape area. For this reason a shunt regulator was included in UKRI-MPW0



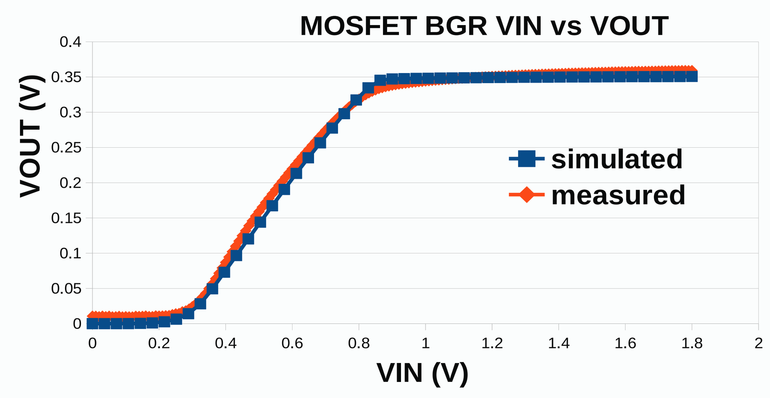


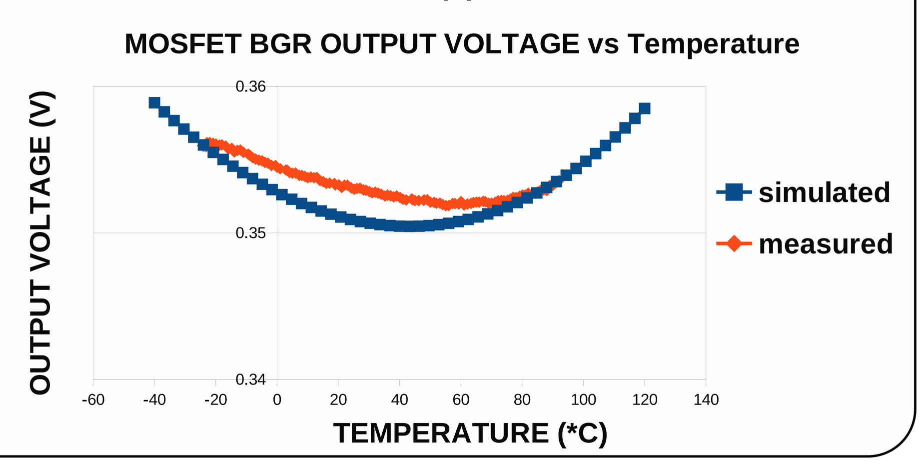
MOSFET BGR performance vs simulation





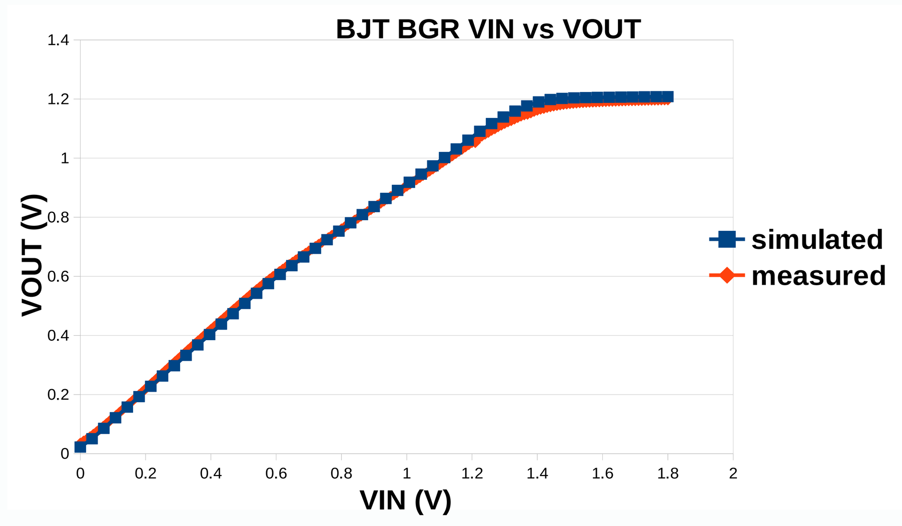
- BGR designs characterised for output voltage with respect to input voltage and temperature.
- The output voltage is fixed to 0.35V
- Peltier/heater PID temperature controlled enclosure used to characterise output over the range -25°C to + 90°C. The output voltage changes by 4.7mV over the entire temperature range
- There is a close agreement between simulation and measurements (<5mV difference)

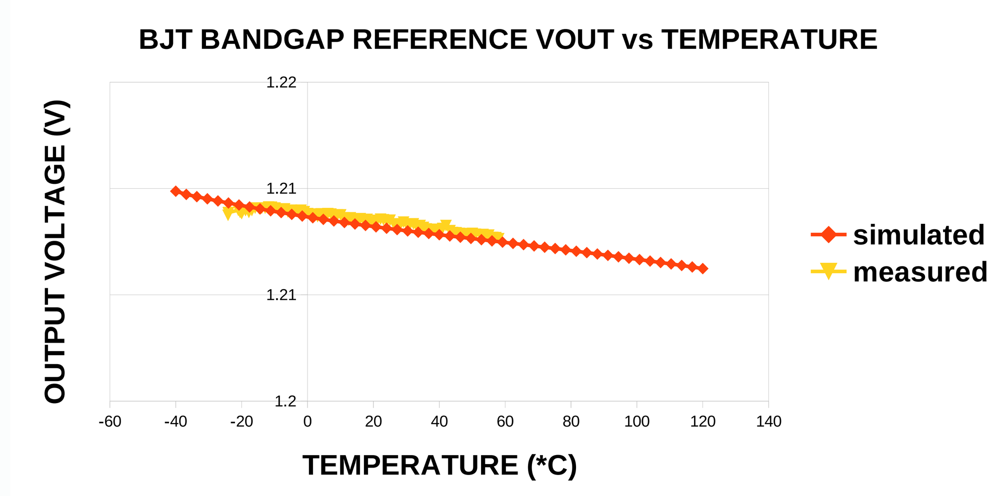




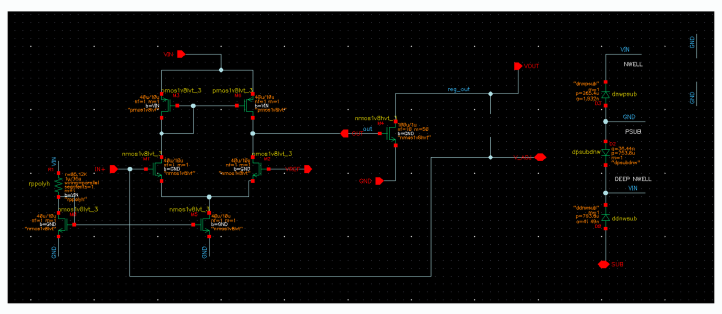
BJT BGR performance vs simulation

- The output voltage is fixed to 1.2 V (close to the theoretical 1.22 eV band gap of silicon at 0 K).
- There is a close agreement between simulation and measurements (<1mV difference). The output voltage changes by 3.7mV over the entire temperature range
- The BJT BGR outperforms the MOSFET BGR in terms of stability in terms of temperature and output voltage stability
- The BJT bandgap may perform worse in terms of radiation tolerance however, as the radiation tolerance of BJTs has never been characterised for this technology, further work Is required to confirm this

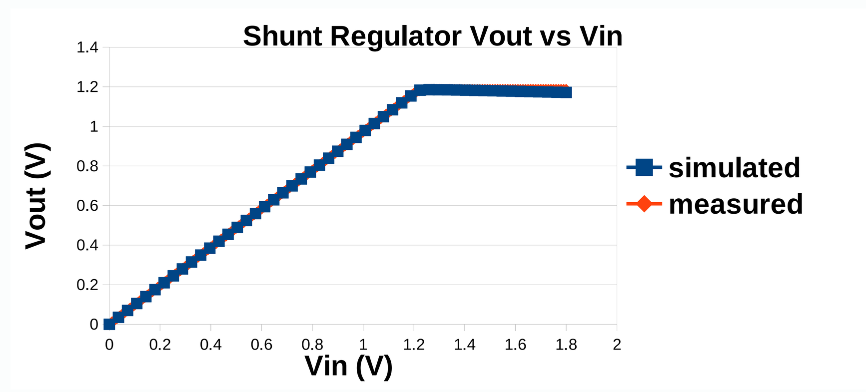


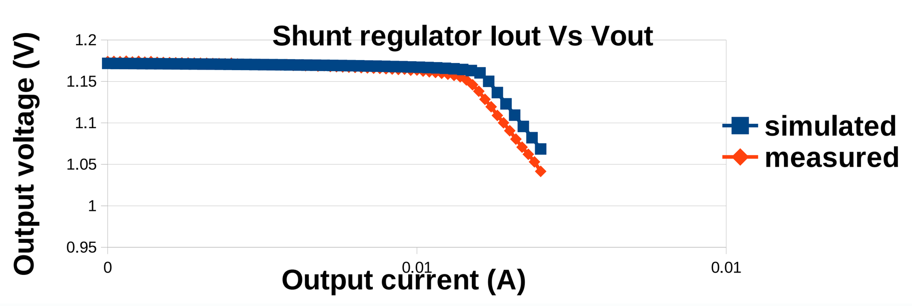


Shunt regulator performance vs simulation and summary



- There is a close agreement between simulation and measurements (<5mV difference between simulated output voltage and measured values)
- The shunt regulator has a variable output voltage and also variable current limit. External resistors allow the regulator output to be tailored to different applications





	Technology	Temperature Range	Vref/Output voltage	Vref Temperature Variation	Supply voltage	Power Consumption
BJT BGR	150 nm HVCMOS from LFoundry	−40 °C to 120 °C	1.2 V	43.75 ppm/°C	1.3 - 1.8 V	106.36 µW
MOSFET BGR	150 nm HVCMOS from LFoundry	−40 °C to 120 °C	350mV	96.32 ppm/°C	0.8 - 1.8 V	146.56 µW
SHUNT REGULATOR	150 nm HVCMOS from LFoundry	−40 °C to 120 °C	Adjustable	Dependant on which reference is used	Dependant on which reference is used	Dependant on which reference is used

Acknowledgements

This work has received funding from UK Research and Innovation (UKRI) under the grant reference MR/S016449/1.

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