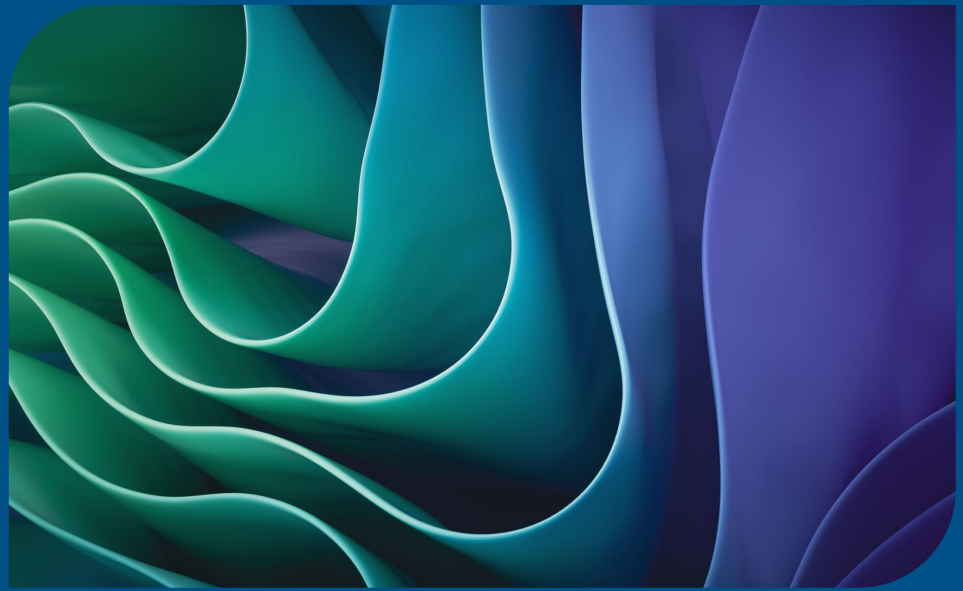
300625

Femto-Amperemeter F.A.M v1.0

Seamless Measurements of DC & Pulsated DC Inputs



S NARASIMHA JAYANTH

1. Problem Statement
2. The Requirements
3. The Solution
4. Simulation Results
5. Conclusion & Future Scope

Problem Statement

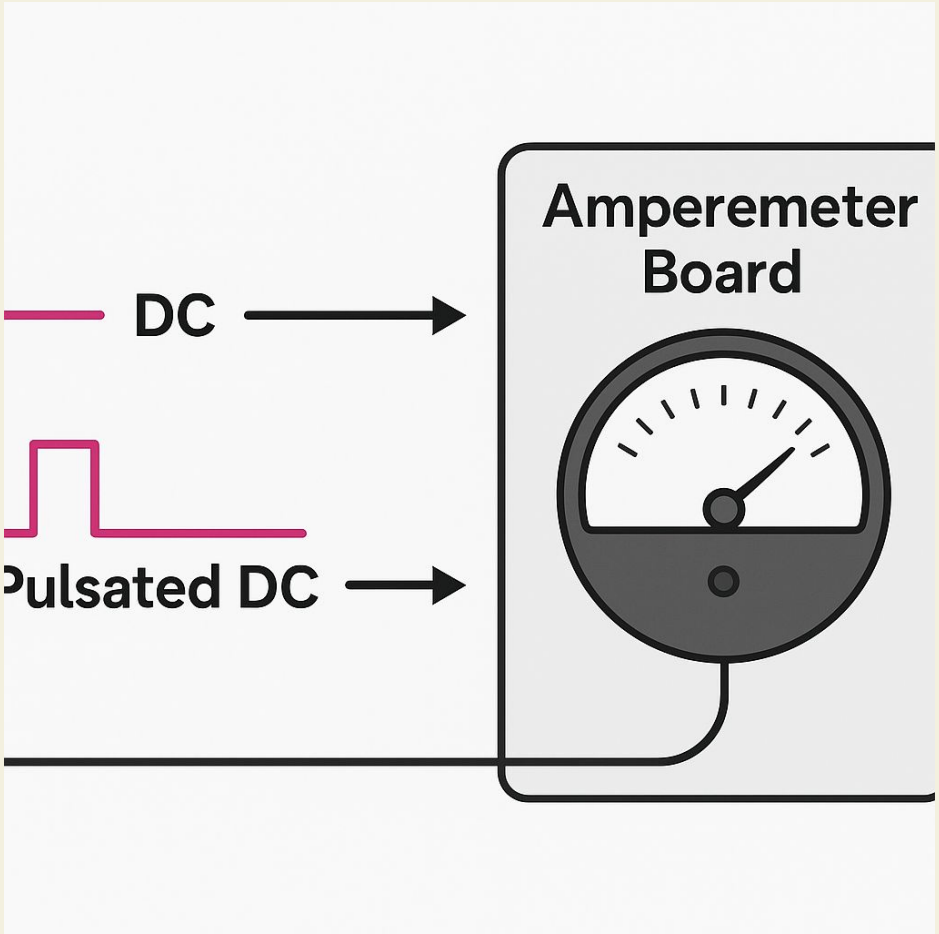
Problems with the X-Design

1. **DC Input measurement Limit:** 1pA
2. **Pulsated DC Measurement Response Time:** 1.8 secs Lag.

The Requirements

The Requirements

1. DC / Pulsated DC Measurement: 5fA to 5mA in the frequency range of 50Hz to 250Hz.
2. Response Time: Instantaneous
3. Cost Effective Solution In The Market

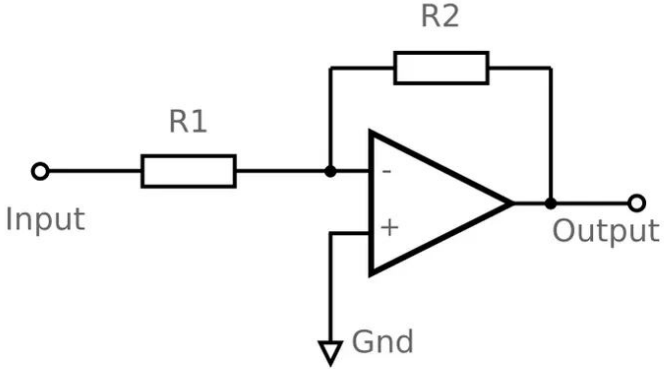


The Solution

Femto-Amperemeter
F.A.M v1.0

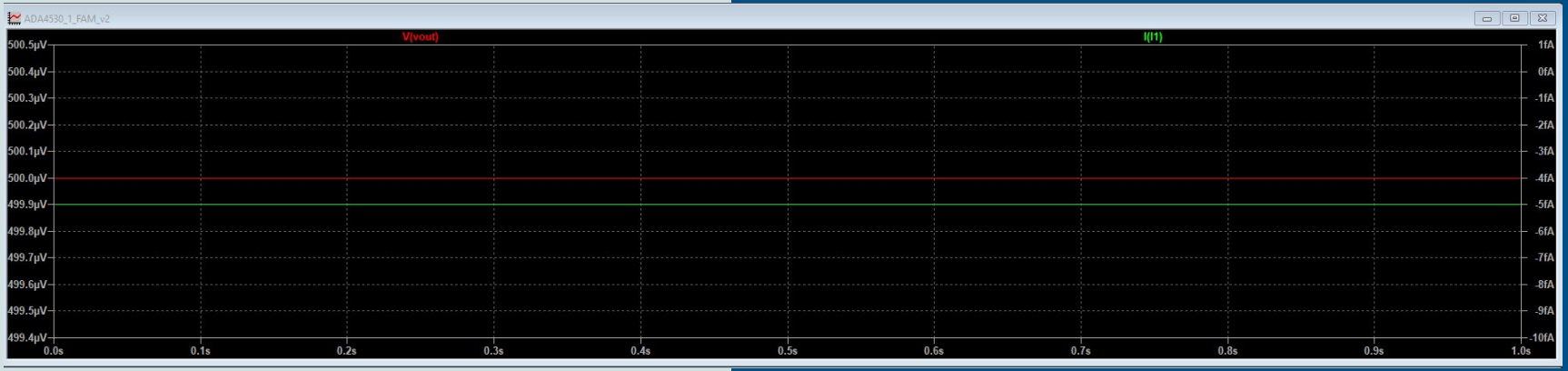
FAM - Ranges for different Modes		
Supply Voltage = +/- 5V	**Rin** = 1G	
Rf (Ohms)	**Cf (F)**	**Range (A)***
1k	0.01p	500nA to 5mA
10M	0.01p	50pA to 500nA
100G	0.01p	5fA to 50pA
* Based on the reading ability from a 18-bit ADC > Inputs are both DC and Pulsated DC between 50Hz to 250Hz		

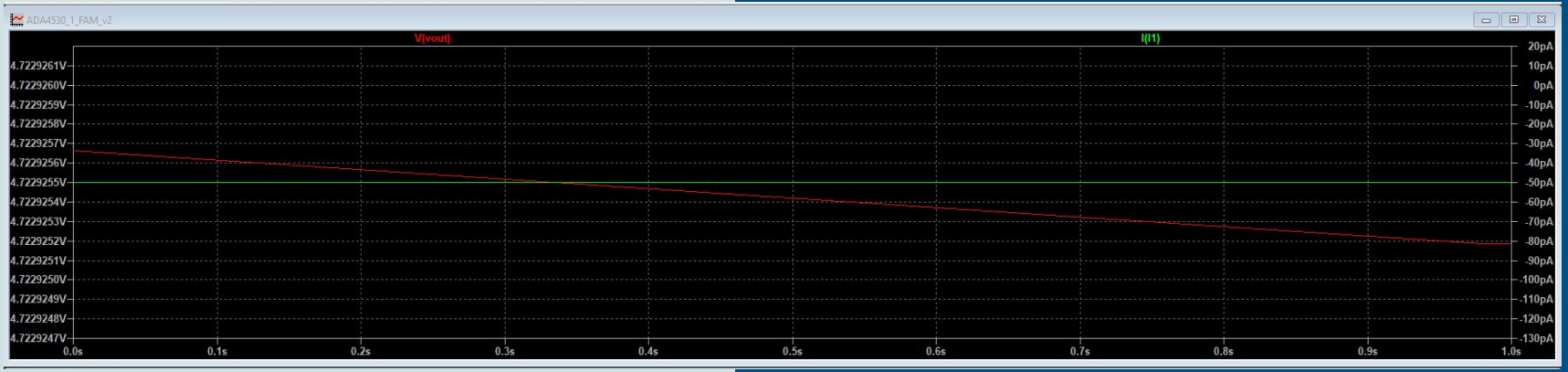
Current Amplifier



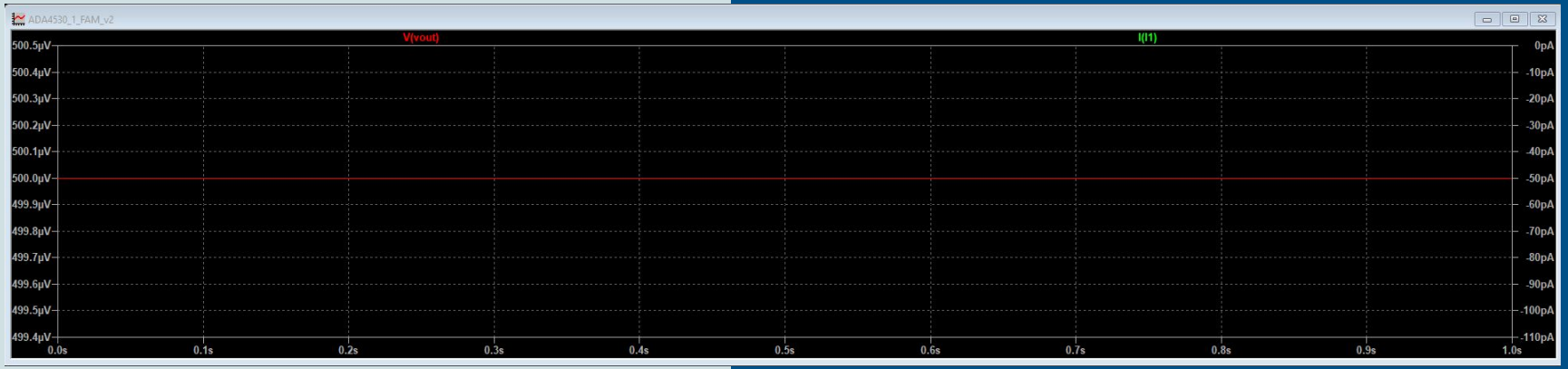
Simulation Results

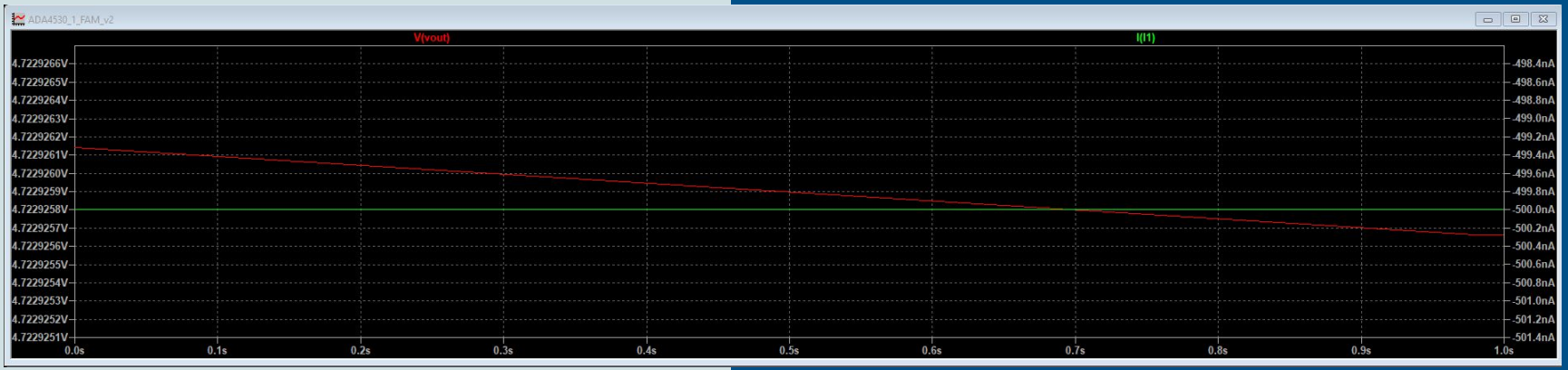
DC: 5fA & 50pA


ADA4530_1_FAM_v2
V(vout)
I(I1)
500.5µV
500.4µV
500.3µV
500.2µV
500.1µV
500.0µV
499.9µV
499.8µV
499.7µV
499.6µV
499.5µV
499.4µV
1fA
0fA
-1fA
-2fA
-3fA
-4fA
-5fA
-6fA
-7fA
-8fA
-9fA
-10fA
0.0s
0.1s
0.2s
0.3s
0.4s
0.5s
0.6s
0.7s
0.8s
0.9s
1.0s

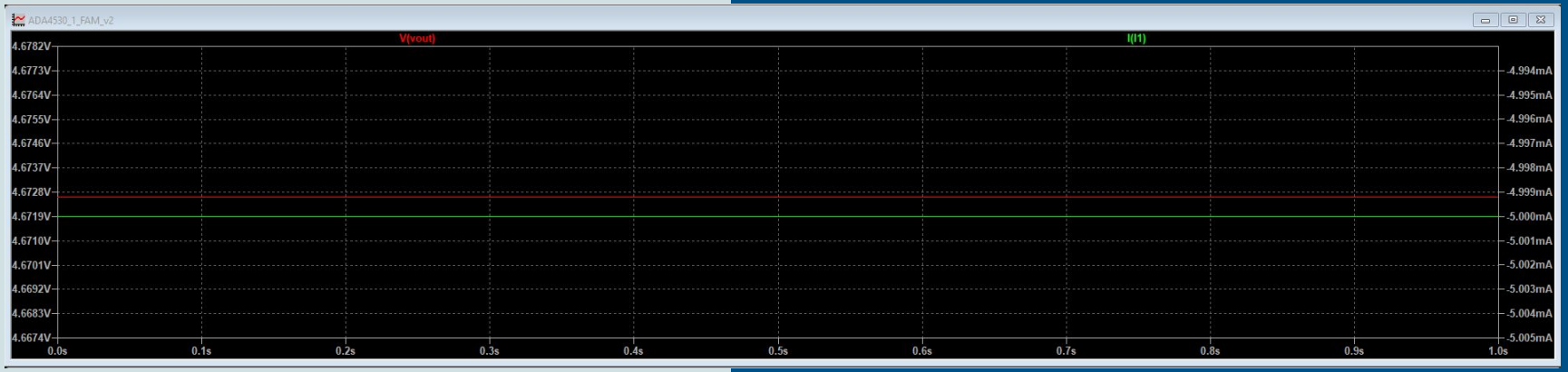

ADA4530_1_FAM_v2
V(vout)
I(I1)
4.7229261V
4.7229260V
4.7229259V
4.7229258V
4.7229257V
4.7229256V
4.7229255V
4.7229254V
4.7229253V
4.7229252V
4.7229251V
4.7229250V
4.7229249V
4.7229248V
4.7229247V
20pA
10pA
0pA
-10pA
-20pA
-30pA
-40pA
-50pA
-60pA
-70pA
-80pA
-90pA
-100pA
-110pA
-120pA
-130pA
0.0s
0.1s
0.2s
0.3s
0.4s
0.5s
0.6s
0.7s
0.8s
0.9s
1.0s

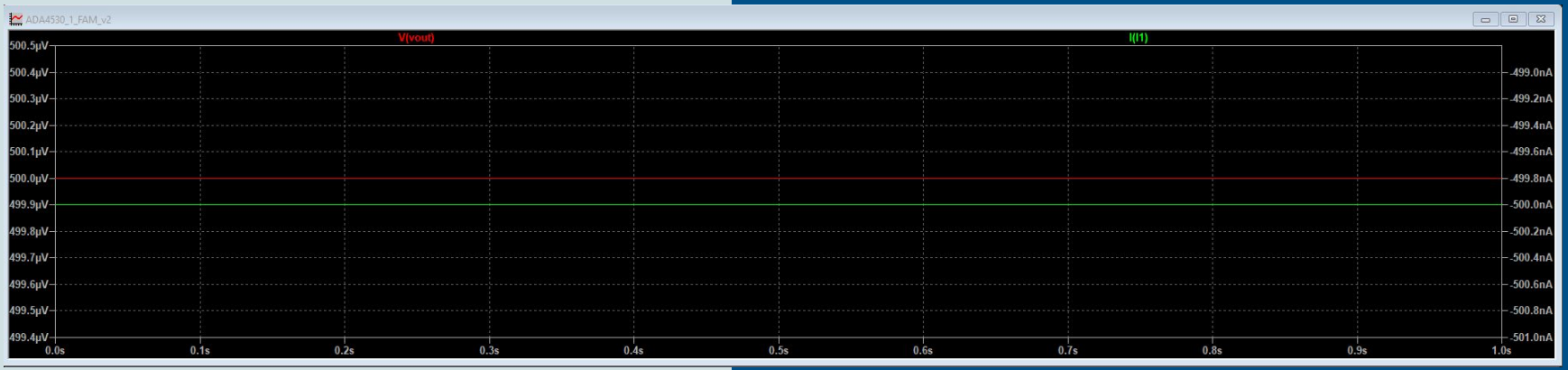
DC: 50pA & 500nA



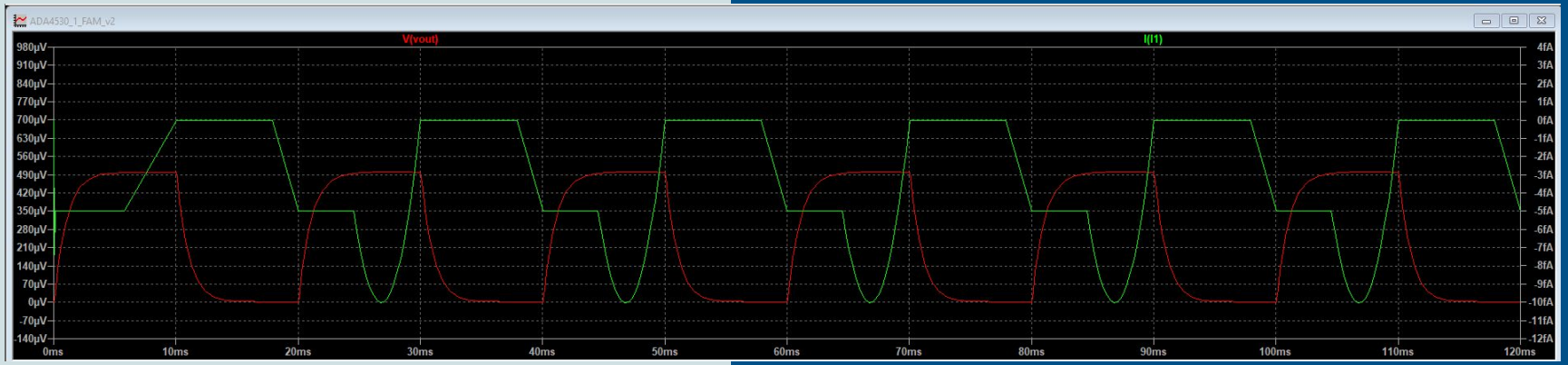


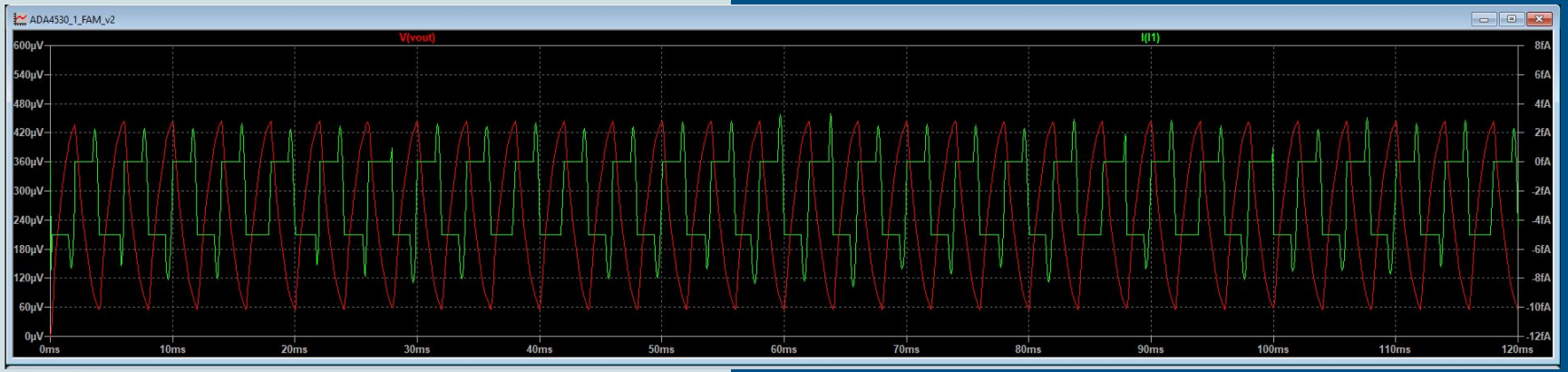
DC: 500nA & 5mA


ADA4530_1_FAM_v2
V(vout)
I(I1)
4.6782V
4.6773V
4.6764V
4.6755V
4.6746V
4.6737V
4.6728V
4.6719V
4.6710V
4.6701V
4.6692V
4.6683V
4.6674V
-4.994mA
-4.995mA
-4.996mA
-4.997mA
-4.998mA
-4.999mA
-5.000mA
-5.001mA
-5.002mA
-5.003mA
-5.004mA
-5.005mA
0.0s
0.1s
0.2s
0.3s
0.4s
0.5s
0.6s
0.7s
0.8s
0.9s
1.0s

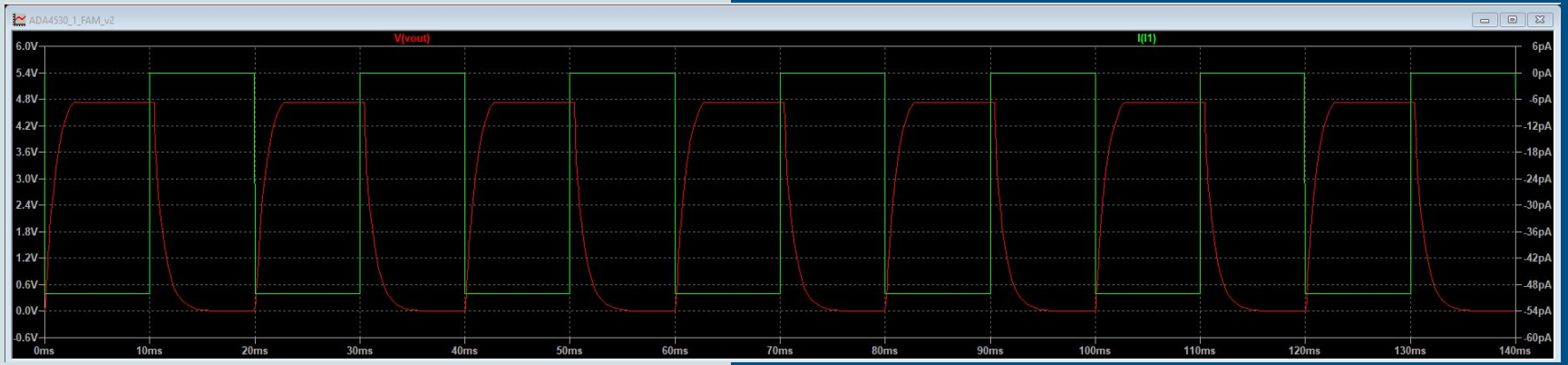

ADA4530_1_FAM_v2
V(vout)
I(I1)
500.5µV
500.4µV
500.3µV
500.2µV
500.1µV
500.0µV
499.9µV
499.8µV
499.7µV
499.6µV
499.5µV
499.4µV
-499.0nA
-499.2nA
-499.4nA
-499.6nA
-499.8nA
-500.0nA
-500.2nA
-500.4nA
-500.6nA
-500.8nA
-501.0nA
0.0s
0.1s
0.2s
0.3s
0.4s
0.5s
0.6s
0.7s
0.8s
0.9s
1.0s

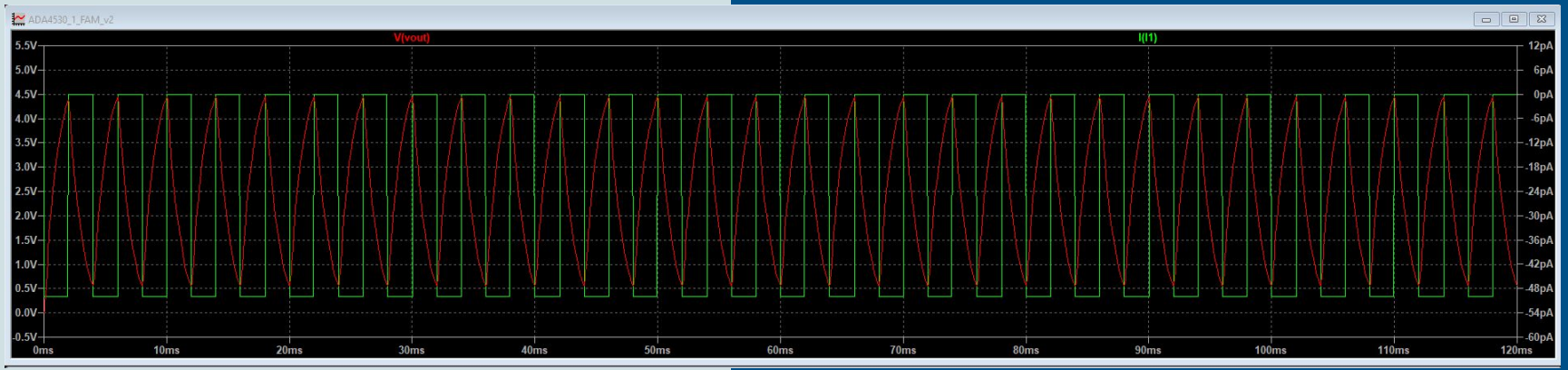
5fA @ 50 &250 Hz


ADA4530_1_FAM_v2
V(vout)
I(I1)
980µV
910µV
840µV
770µV
700µV
630µV
560µV
490µV
420µV
350µV
280µV
210µV
140µV
70µV
0µV
-70µV
-140µV
4fA
3fA
2fA
1fA
0fA
-1fA
-2fA
-3fA
-4fA
-5fA
-6fA
-7fA
-8fA
-9fA
-10fA
-11fA
-12fA
0ms
10ms
20ms
30ms
40ms
50ms
60ms
70ms
80ms
90ms
100ms
110ms
120ms

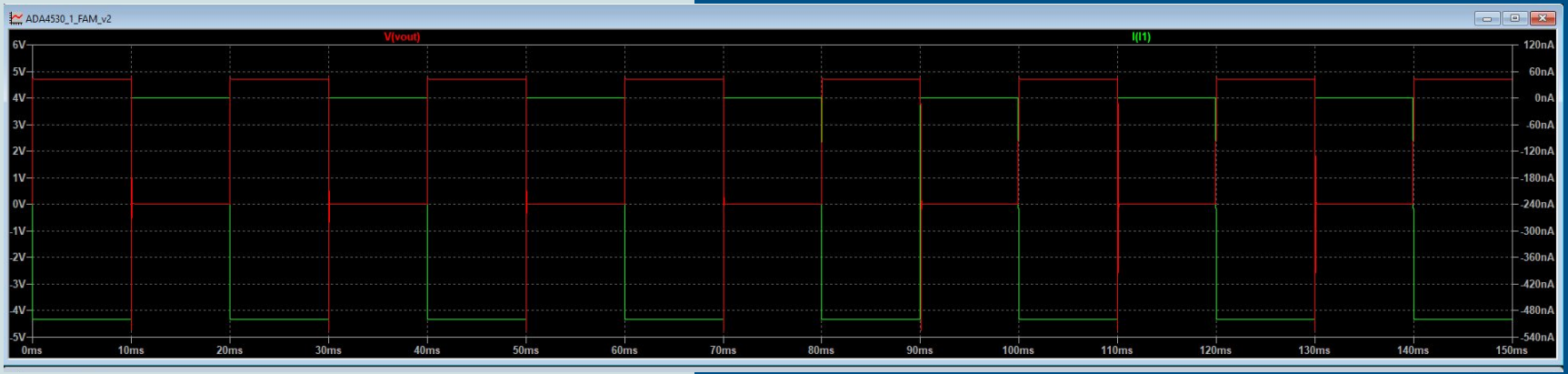

ADA4530_1_FAM_v2
V(vout)
I(I1)
600µV
540µV
480µV
420µV
360µV
300µV
240µV
180µV
120µV
60µV
0µV
8fA
6fA
4fA
2fA
0fA
-2fA
-4fA
-6fA
-8fA
-10fA
-12fA
0ms
10ms
20ms
30ms
40ms
50ms
60ms
70ms
80ms
90ms
100ms
110ms
120ms

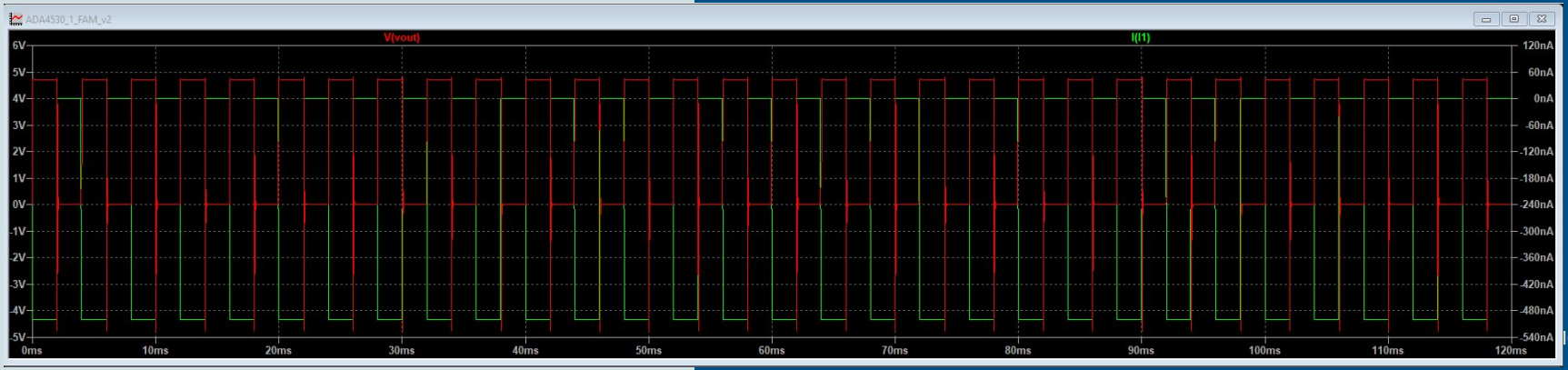
50pA @ 50 &250 Hz





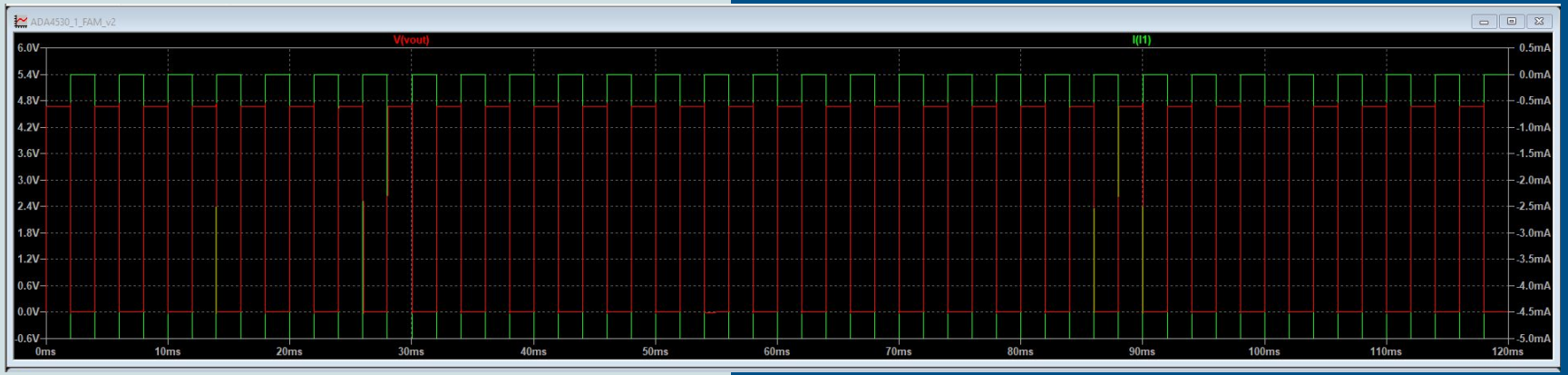
500nA @ 50 &250 Hz





5mA @ 50 &250 Hz


ADA4530_1_FAM_v2
V(vout)
I(I1)
5.6V
4.9V
4.2V
3.5V
2.8V
2.1V
1.4V
0.7V
0.0V
-0.7V
-1.4V
-2.1V
1.4mA
0.7mA
0.0mA
-0.7mA
-1.4mA
-2.1mA
-2.8mA
-3.5mA
-4.2mA
-4.9mA
-5.6mA
-6.3mA
0ms
10ms
20ms
30ms
40ms
50ms
60ms
70ms
80ms
90ms
100ms


ADA4530_1_FAM_v2
V(vout)
I(I1)
6.0V
5.4V
4.8V
4.2V
3.6V
3.0V
2.4V
1.8V
1.2V
0.6V
0.0V
-0.6V
0.5mA
0.0mA
-0.5mA
-1.0mA
-1.5mA
-2.0mA
-2.5mA
-3.0mA
-3.5mA
-4.0mA
-4.5mA
-5.0mA
0ms
10ms
20ms
30ms
40ms
50ms
60ms
70ms
80ms
90ms
100ms
110ms
120ms

Conclusion & Future Scope

Conclusion & Future Scope

1. Both the problems have been solved as the requirements are met meticulously.
2. POC realization is the next step.
3. Components Selection
4. Schematic Design with other modules like ADC & MCU
5. BOM Generation & Justification of Cost-Effectiveness.
6. Gerber realization & PCB made with focus on rules applicable for ultra-low current measurements and Huge Resistances with ultra-low capacitances.

Source

1. ADA4530-1: https://www.digikey.in/en/products/detail/analog-devices-inc/ADA4530-1ARZ-R7/5725985
2. ADA4530-1 EVAL: https://www.digikey.in/en/products/detail/analog-devices-inc/ADA4530-1R-EBZ-TIA/5726244