

Development of a DC Charge Calibration Setup At CSIR-NPL For Pico- To Micro-coulomb Range

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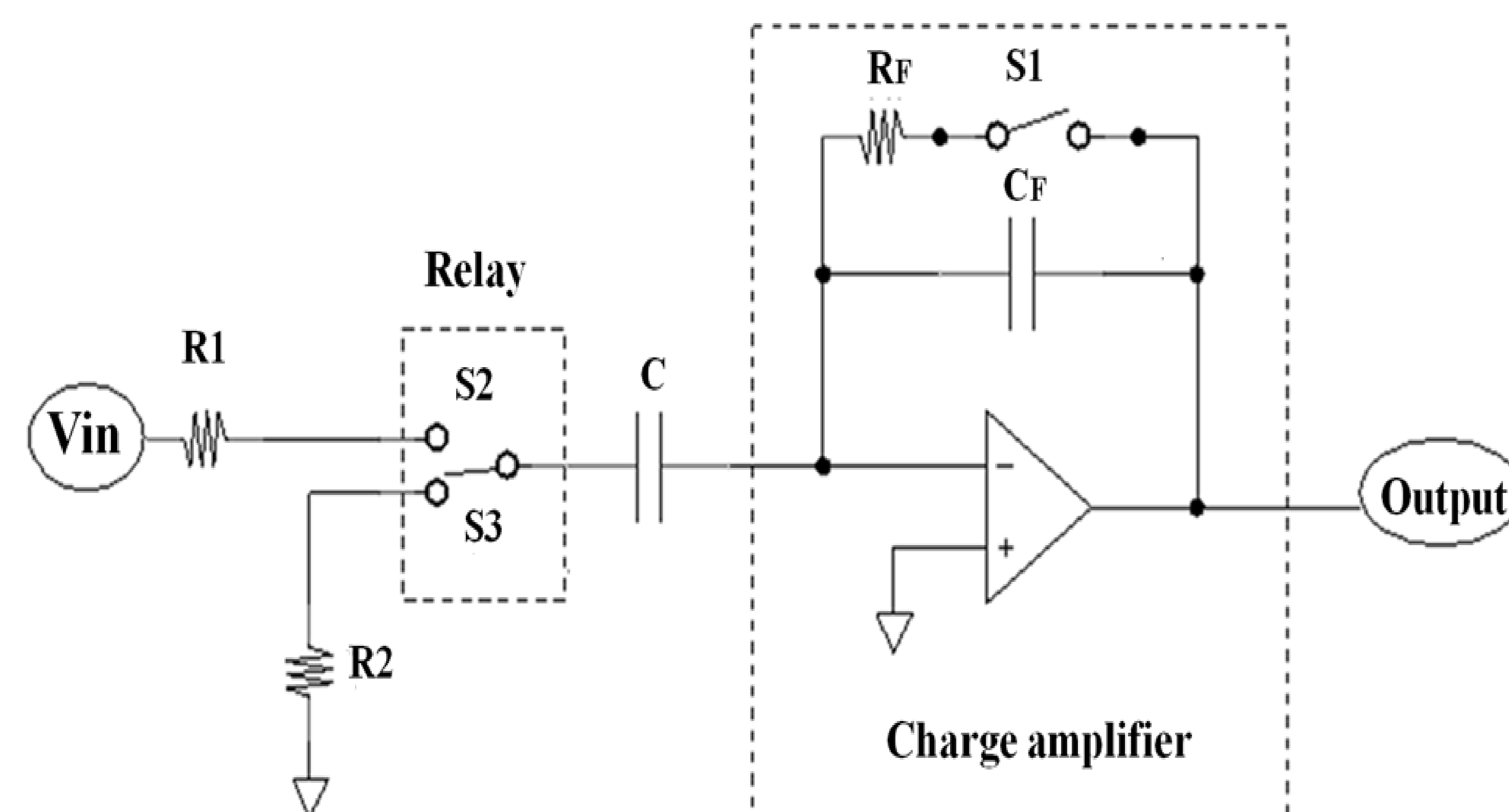
Objective

To develop a set up for the DC charge calibration of charge measuring instruments using the capacitance charging method $Q = C \times V$.

Design Aspects

- Measurement Range: 1 μC to 100 pC.
- Charge generation using solid dielectric capacitors. The capacitance values determined to mHz frequencies.
- Fully automated with custom software made in NI LabView
- Calibration results not affected by parasitic capacitances in the setup

Schematic Circuit Diagram



Sequence of Operation of Charge measurement setup

Operation	S1	S2	S3
Charging mode	Close	Close	Open
Zero reading	Open	Close	Open
Measure mode	Open	Open	Close

DC Capacitance Estimation

- Polypropylene capacitors from 100 pF to 100 nF are used in this measurement.
- Capacitance is measured by a calibrated ultra precision capacitance bridge (AH2700A) from 10 kHz to 50 Hz at temperature $(25 \pm 0.2)^\circ\text{C}$.
- We devised a method to extrapolate the measured capacitance – frequency profile down to mHz frequencies to know the DC value of the capacitance.

DC Charge Measurement Results

Voltage applied (V)	Capacitance value at 1 kHz frequency (pF)	DC value of Capacitance (pF)	Applied charge $Q = C \times V$ (nC)	Measured by Charge Amplifier (nC)	Calibration correction to charge amplifier reading (%)	Uncertainty ($\mu\text{C}/\text{C}$)
9.999998	99726.5	99808.9	998.088	996.056	-0.20	27
9.999998	9910.85	9921.80	99.2179	99.0953	-0.12	33
9.999998	991.439	992.615	9.92614	9.90493	-0.21	38
9.999998	99.2780	99.3767	0.993766	0.991797	-0.20	376
4.999995	99.2780	99.3767	0.496883	0.495774	-0.22	396
0.9999985	99.2780	99.3767	0.0993765	0.0993477	-0.03	1583

Summary

- The DC charge calibration setup developed at CSIR-NPL using solid dielectric capacitors.
- The accuracy of the measurements has been improved using DC value of the capacitors to get the applied charge.
- Measurement Uncertainty: 0.001% to 0.2% in the range of 1 μC to 100 pC.
- Work is progressing to extend the measurement range down to 10 pC and to further reduce the uncertainties of measurement.

Acknowledgement

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References

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