

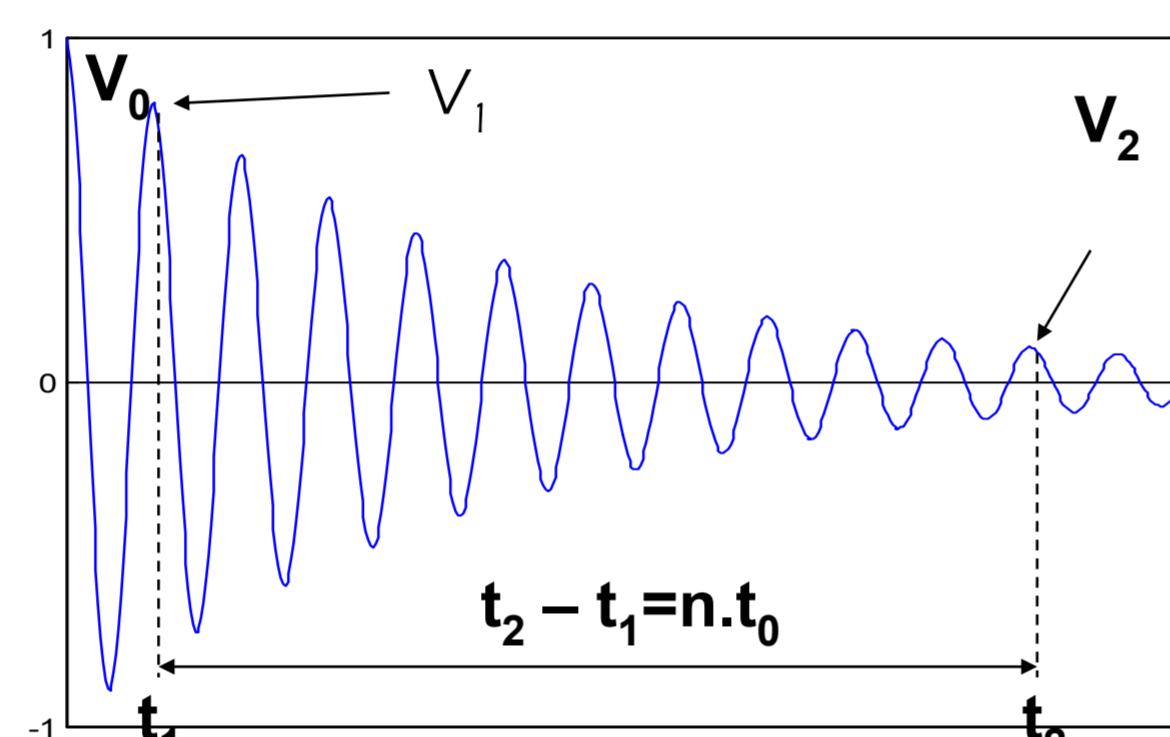
Analysis and Improvement of on-chip architecture for MEMS resonator quality factor measurement

Abstract

In this paper, the performance analysis of our previously proposed architecture for MEMS resonator quality factor measurement is carried out in taking into account the imperfection of each functional block of the architecture. This analysis puts in evidence the impact of the imperfection of each functional block on the measurement precision and predicts the attainable accuracy of this architecture. In order to improve the performance, a modified architecture is proposed, with which the measurement precision can be improved by at least a factor of 2.

1. Principle of time domain measurement

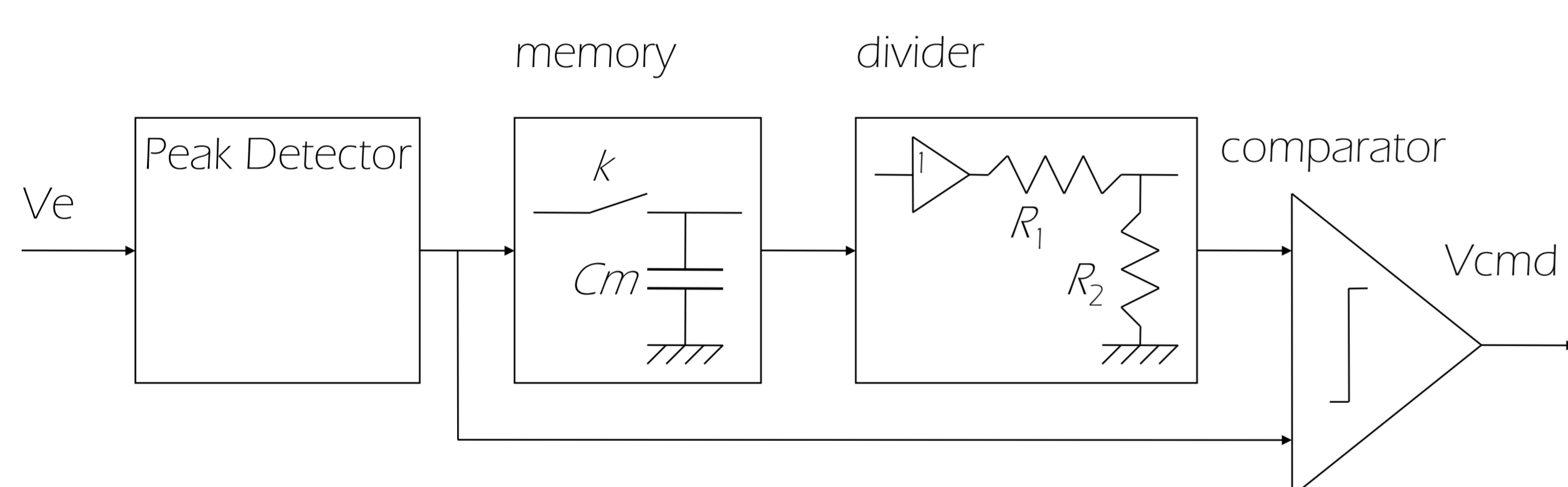
- open loop configuration
- Resonator in damping oscillation
- Period counting between V_1 and V_2
- n is the pseudo period and $k = \frac{V_1}{V_2}$



$$Q = \sqrt{1 + \left[\frac{n \cdot \pi}{\ln(k)} \right]^2} \approx \frac{n \cdot \pi}{\ln(k)}$$

- measurement independent of frequency

2. Proposed architecture



Measurement accuracy:

- SPICE simulation < 7%
- PCB measurement about 20%
- Building block default impact on accuracy?

3. Analytic model of the proposed architecture for relative error calculation

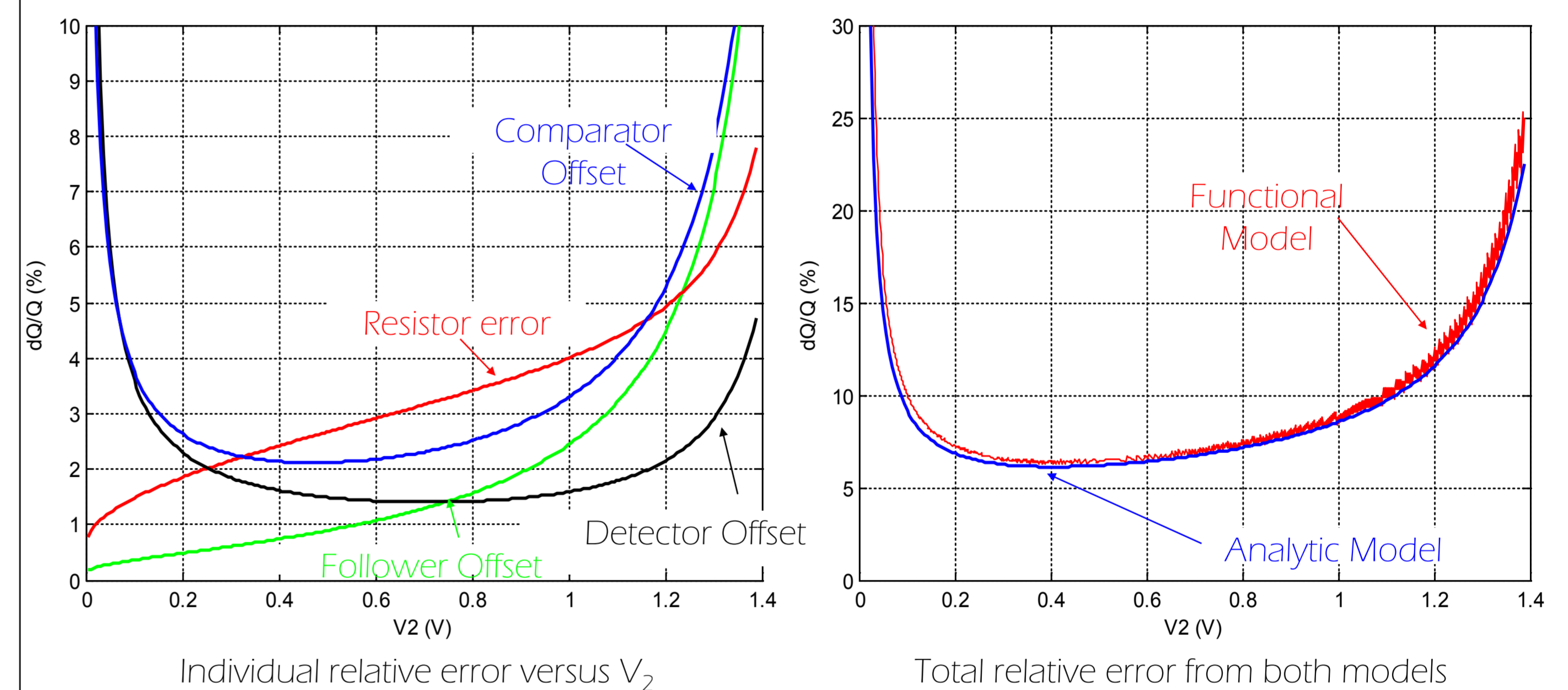
$$\frac{\Delta Q}{Q} = \left[\frac{\ln\left(\frac{R_1}{R_2} + 1\right)}{\ln\left(1 + \frac{V_{off}}{V_0}\right) \frac{1}{R_2} - \frac{V_{oc}}{V_0} - \frac{V_{od}}{V_0}} \right] + 1 + \frac{\pi}{Q \cdot \ln\left(\frac{V_1}{V_2}\right)}$$

where $V_{off} = V_{od} + V_{cj} + V_{of} + V_{cl}$

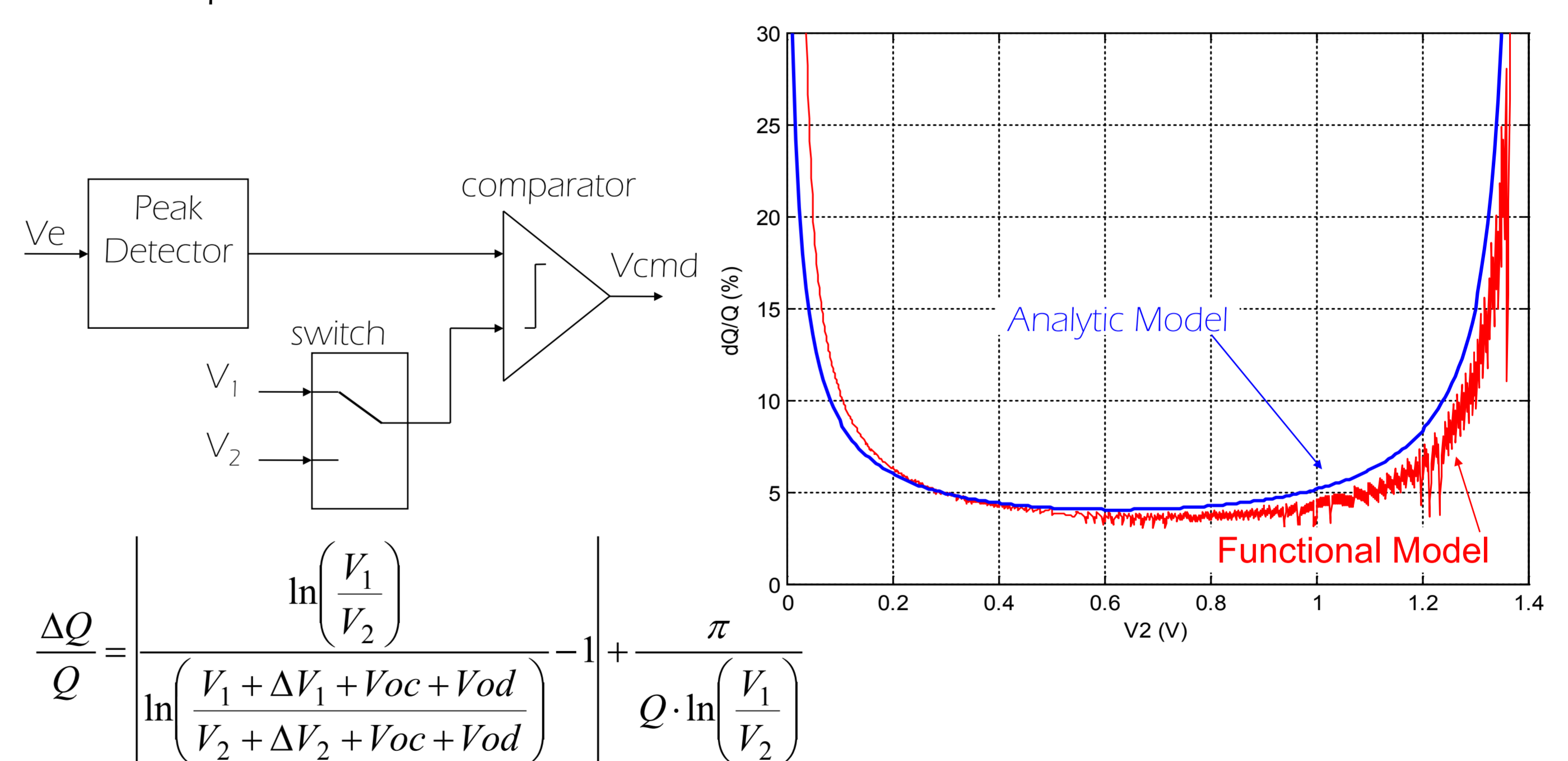
4. Simulation results

Parameters used in simulation

Parameter	Description	Value
V_{od}	Peak Detector Offset	10mV
V_{oc}	Comparator Offset	10mV
V_{os}	Follower Offset	10mV
I_{cl}	Current Leakage	10pA
C_m	Memory Capacitor	10pF
V_{cj}	Charge Injection Offset	100μV
ΔR	Relative Resistor Error	2%
Q	Quality Factor	1000



5. Improved architecture



6. Conclusion

- Analytic model is developed
- Optimum choice for V_2 exists
- Its attainable precision is predicted
- Improved architecture is proposed
- Measurement precision is improved by a factor of 2 with the improved architecture