4C-07

Very Low Level DC Voltage Measurement Technique by DC-AC Conversion

Yuto Sasaki [a], Kosuke Machida, Riho Aoki, Shogo Katayama, Takayuki Nakatani, Jianlong Wang
Keno Sato, Takashi Ishida, Toshiyuki Okamoto, Tamotsu Ichikawa
Anna Kuwana, Kazumi Hatayama, Haruo Kobayashi

Division of Electronics and Informatics, Gunma University
ROHM Semiconductor

[a] t14304053@gunma-u.ac.jp

1. Objective

Accurate and fast testing
- very small offset voltage of operational amplifier
- with Automatic Test Equipment (ATE)

- Testing Requirements
  - µV-order DC voltage
  - Fast

⬇

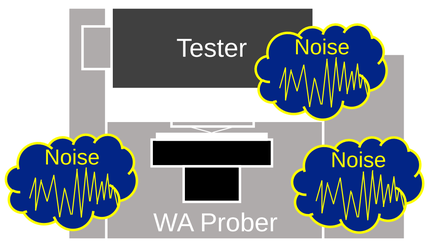
- Proposed Method

FFT-Based DC-AC Conversion

2. Background

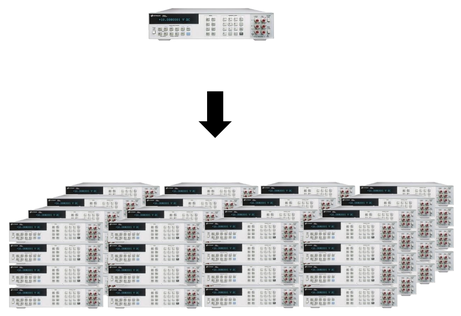
⚠ Problems for µV-order DC Voltage Testing

1. Noise at Test Environment



- DC Noise
- 1/f Noise

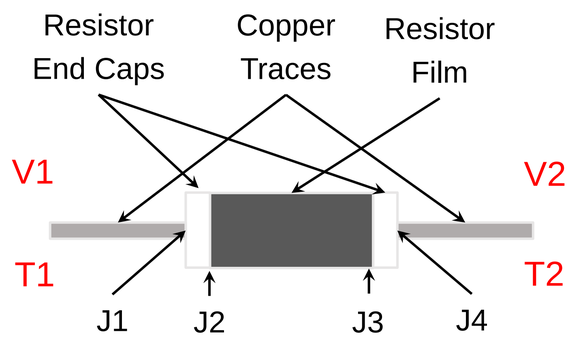
2. Test Time



Multi-Site Test

Multi-meters → expensive

3. Thermo-Electromotive Force (EMF)



$$V_{emf} = V1 - V2 = (T1 - T2) \times 30\mu V$$

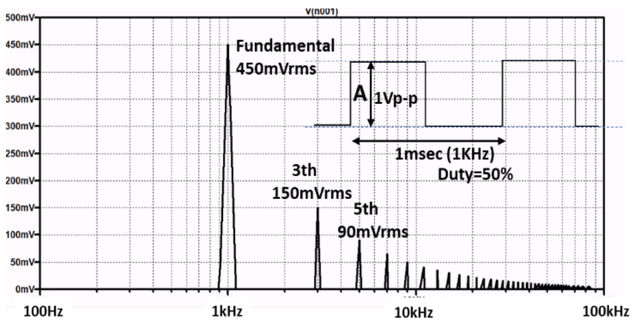
EMF Voltage ← Temperature Difference [/℃]

3. Proposed Method

FFT-Based DC-AC Conversion

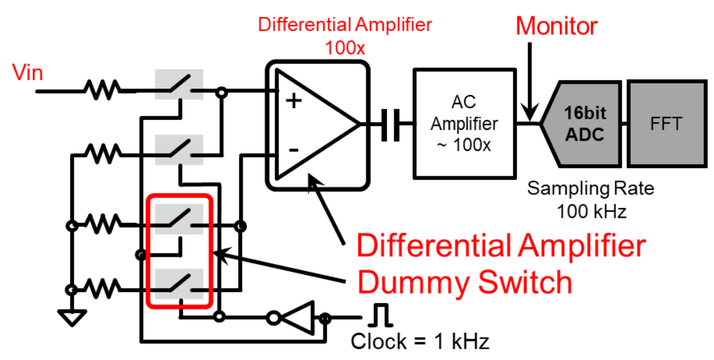
DC Voltage
↓ ← Chopper
AC Square Wave
↓ ← ADC
FFT

$$V(t) = \frac{2A}{\pi}\left(\sin\omega t + \frac{1}{3}\sin 3\omega t + \frac{1}{5}\sin 5\omega t + \cdots\right)$$



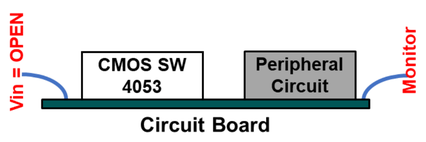
System noises can be ignored

4. DC-AC Conversion Circuit

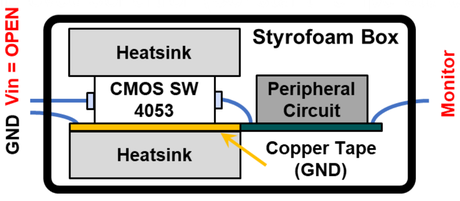


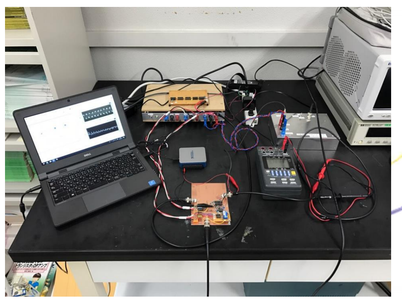
EMF Countermeasure

Exposed in atmosphere

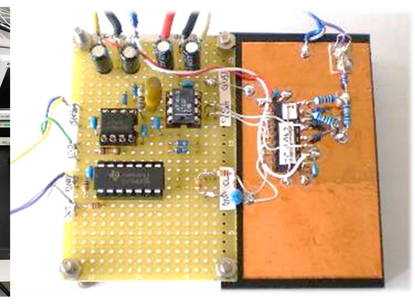


Constant Temperature

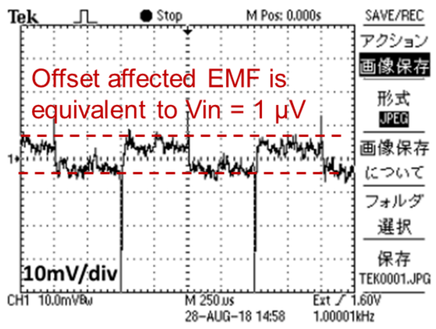


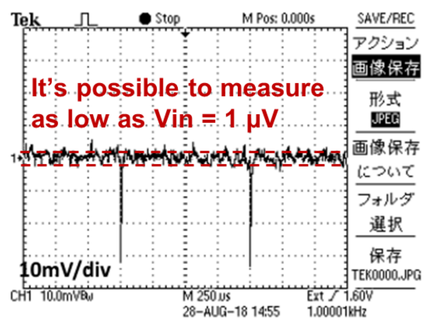


Experiment Environment



DC-AC Conversion





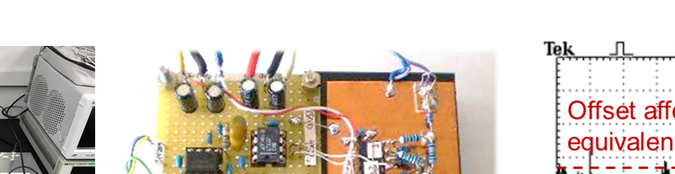
EMF countermeasures → µV-order DC voltage testing is possible

5. Multi-Site Testing

Configuration & Operation

Expected FFT Result

Measured Spectrum



Measurement Result

Sampling Rate : 100kHz, Sample: 10k, Averaging: 100, Frequency Resolution: 10Hz

Multi-site measurement as low as 0.2 µV is possible

6. Conclusion

Solved Problems

1. **Noise at Test Environment**

   Testing is NOT affected by system noises

2. **Test Time Reduction**

   Testing method is applicable to multi-site testing

3. **Electromotive force (EMF) Countermeasure**

   Keep temperature difference less than 0.1 ℃ for µV-order testing

Proposed FFT-based DC-AC conversion is applicable for µV-order DC test using ATE

7. References

[1] James M. Bryant, "Simple Op Amp Measurements" Analog Dialogue, vol. 45, pp. 21-23, 2011
[2] Analog Devices, *Op Amp Applications Handbook*, 2004
[3] Kumen Blake, "Op Amp Precision Design: PCB Layout Techniques" Microchip Technology Inc., Tech. Rep. AN1258, 2009
[4] Bob Dopkin, *Analog Circuit Design*, Linear Technology, 2013