Synchrophasor System Life Cycle Performance

Mark Adamiak
GE Grid Automation

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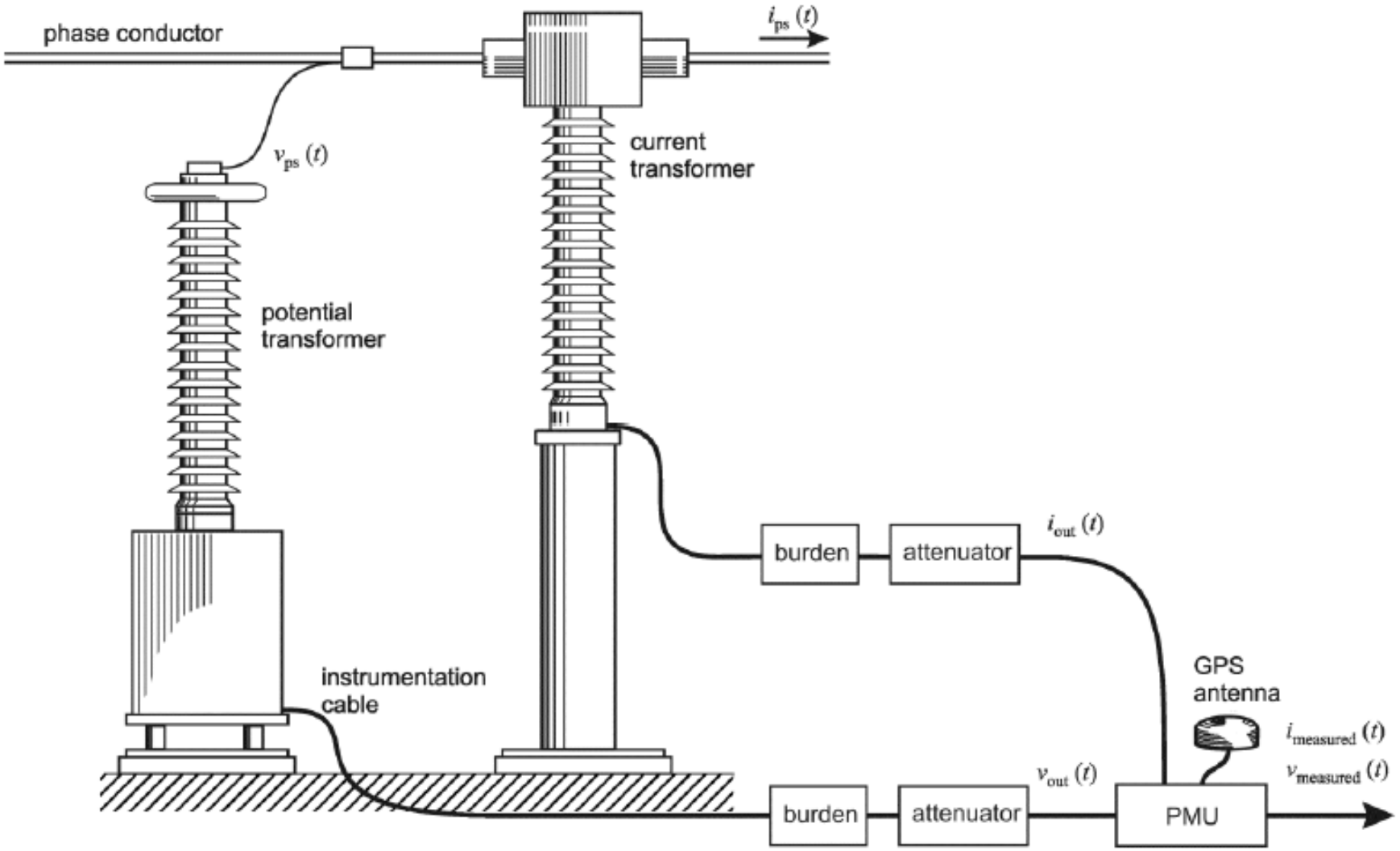
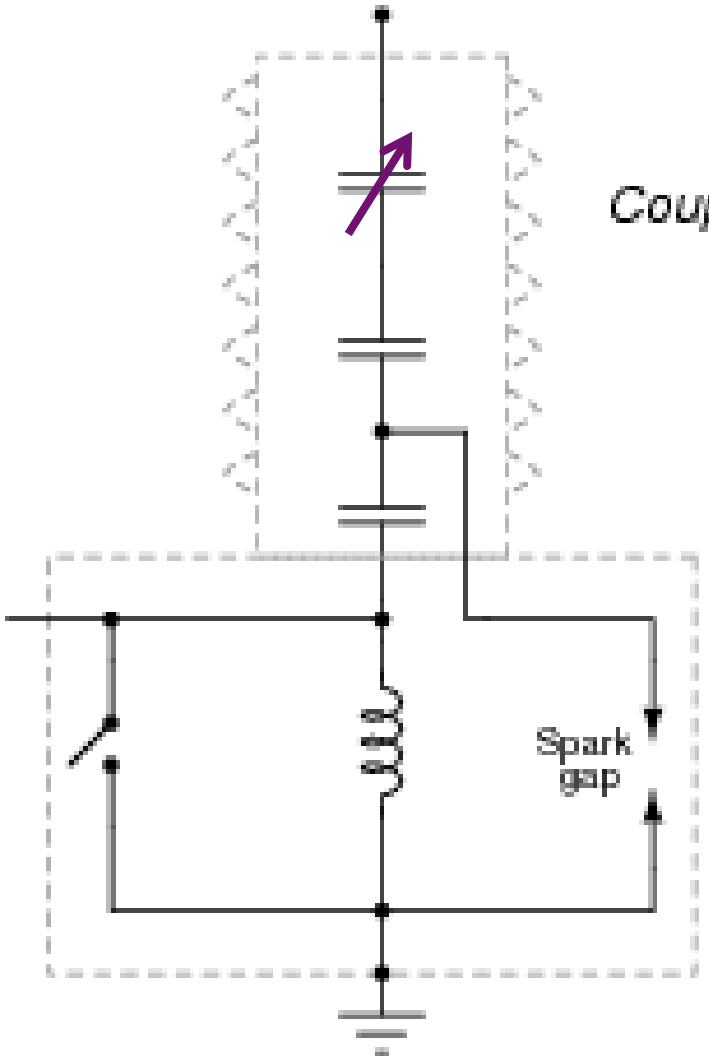
Synchrophasor Measurement



Coupling Capacitor Aging



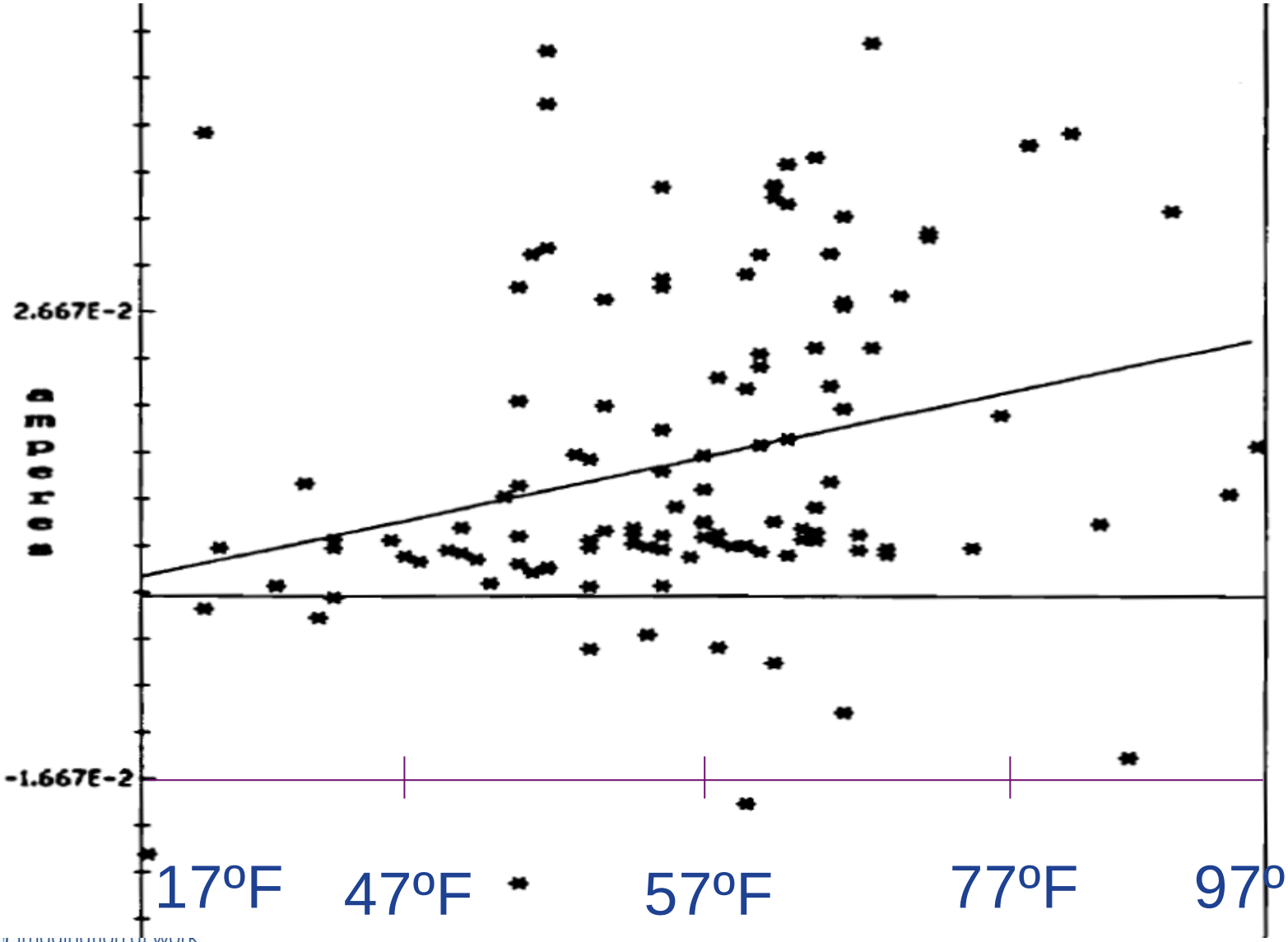
CT/VT Measurement Error Modeling$_2$

- VaTech Thesis – Nitin Vichare
- 1 year monitoring of “metering Class” CT and PT as compared to Relay Class CT and PTs
- Error model developed:

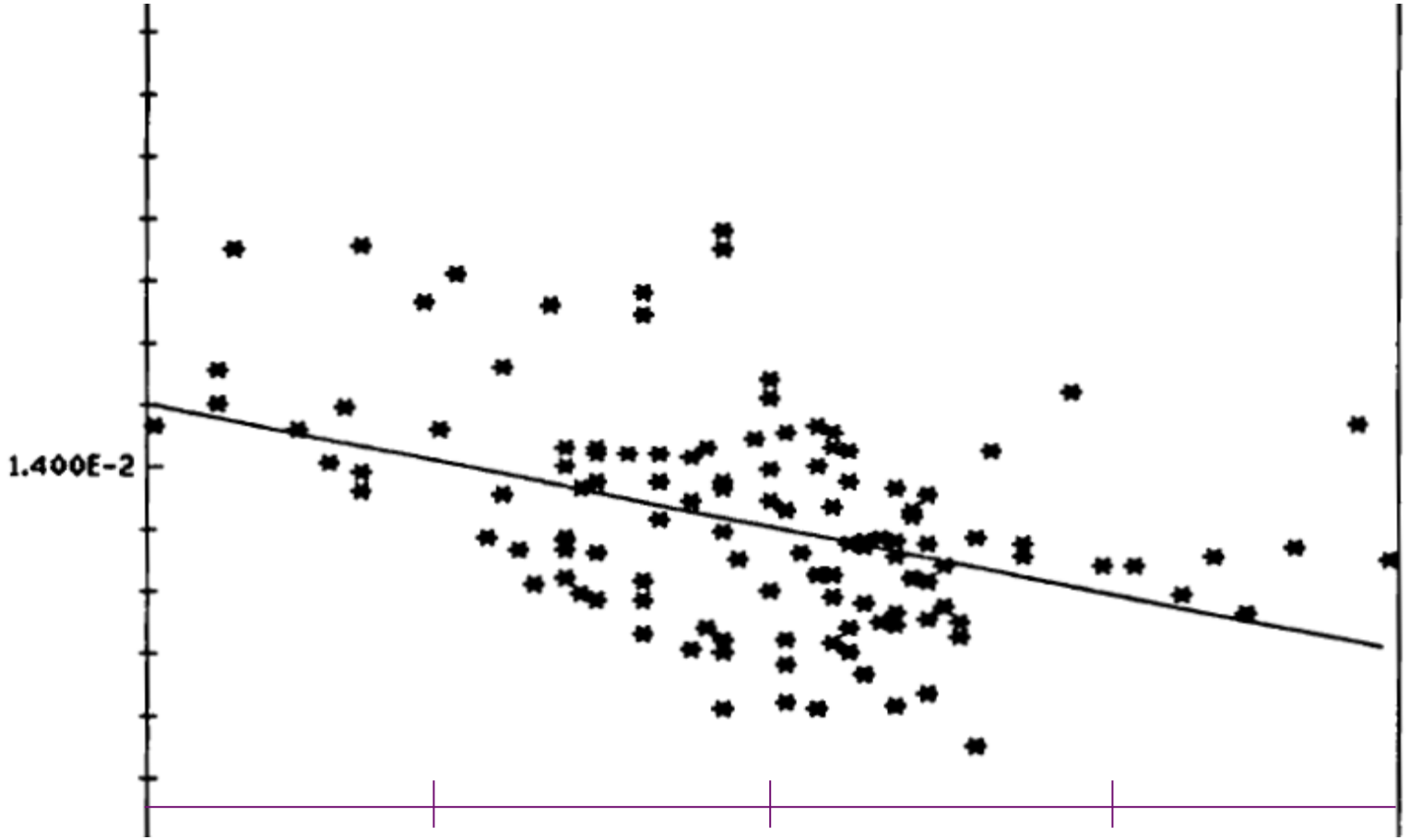
Error = a * (Voltage/Current) + b*Temperature + constant (DC) + ηoise

- Small effect on CCVT (b = .137e-4/ºF)

CT Temperature Variation coefficient



CCVT Temperature Variance



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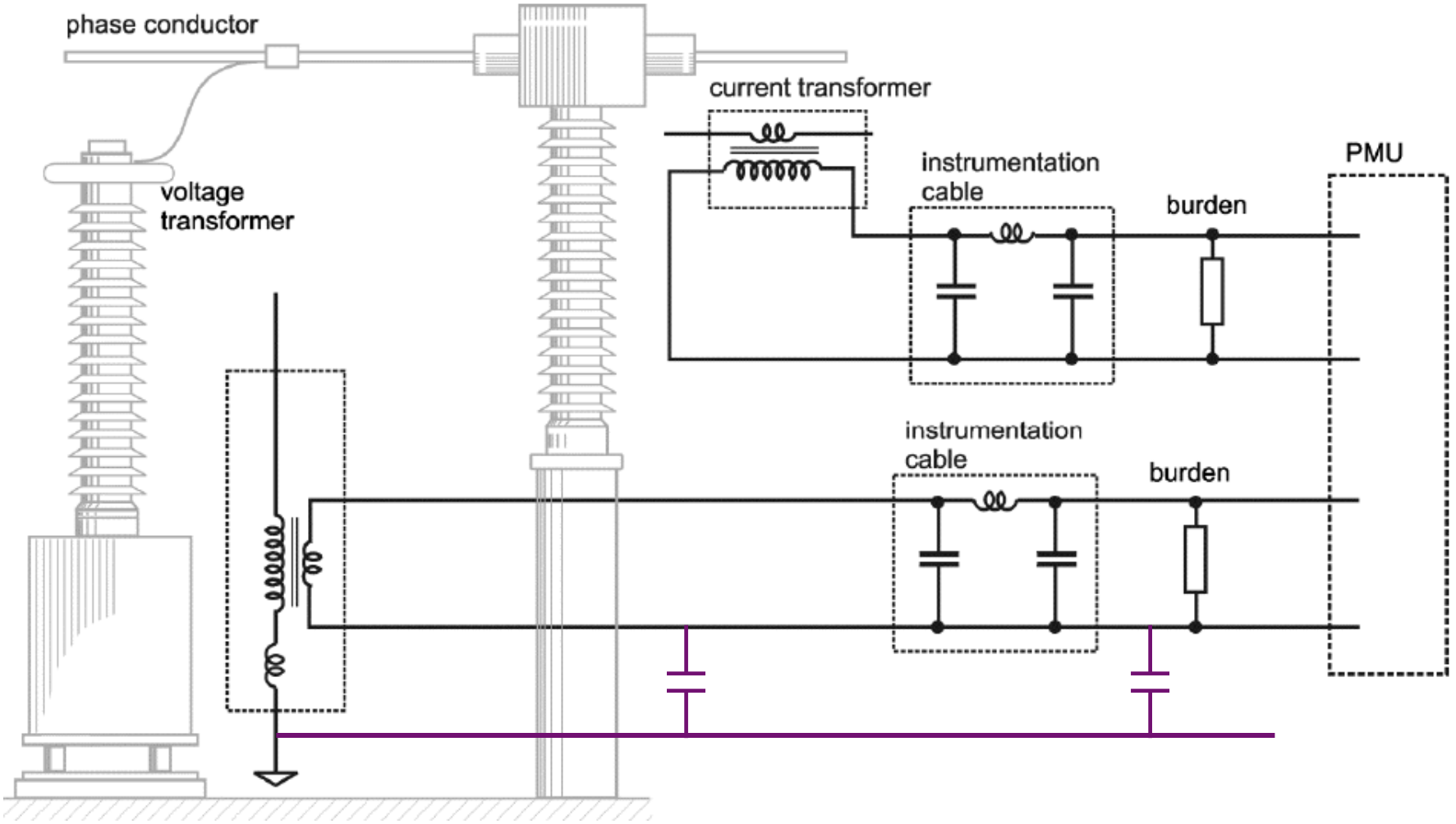
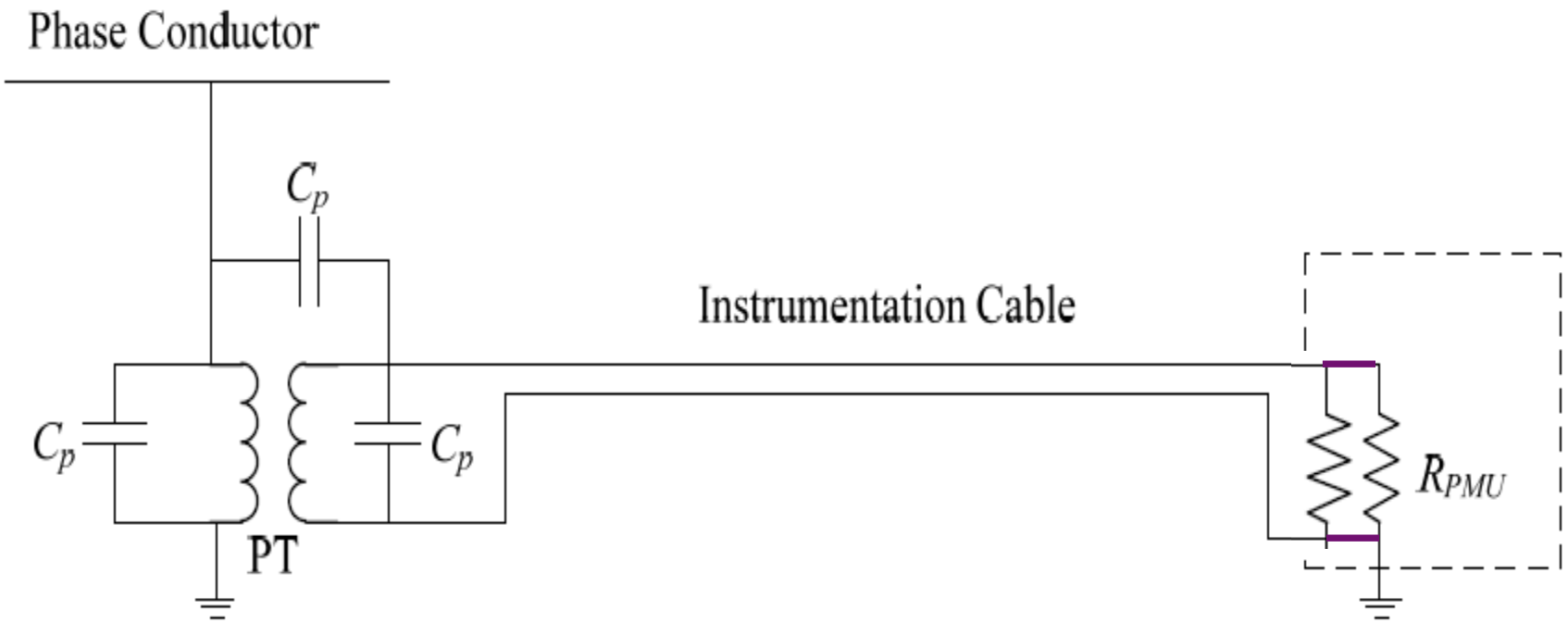
Test Result vs. Temperature

Temperature	Metering VT	Bushing VT
17ºF	1pu	.978pu
96ºF	1pu	.988pu

PMU Cabling Model



Simplified Wiring Model

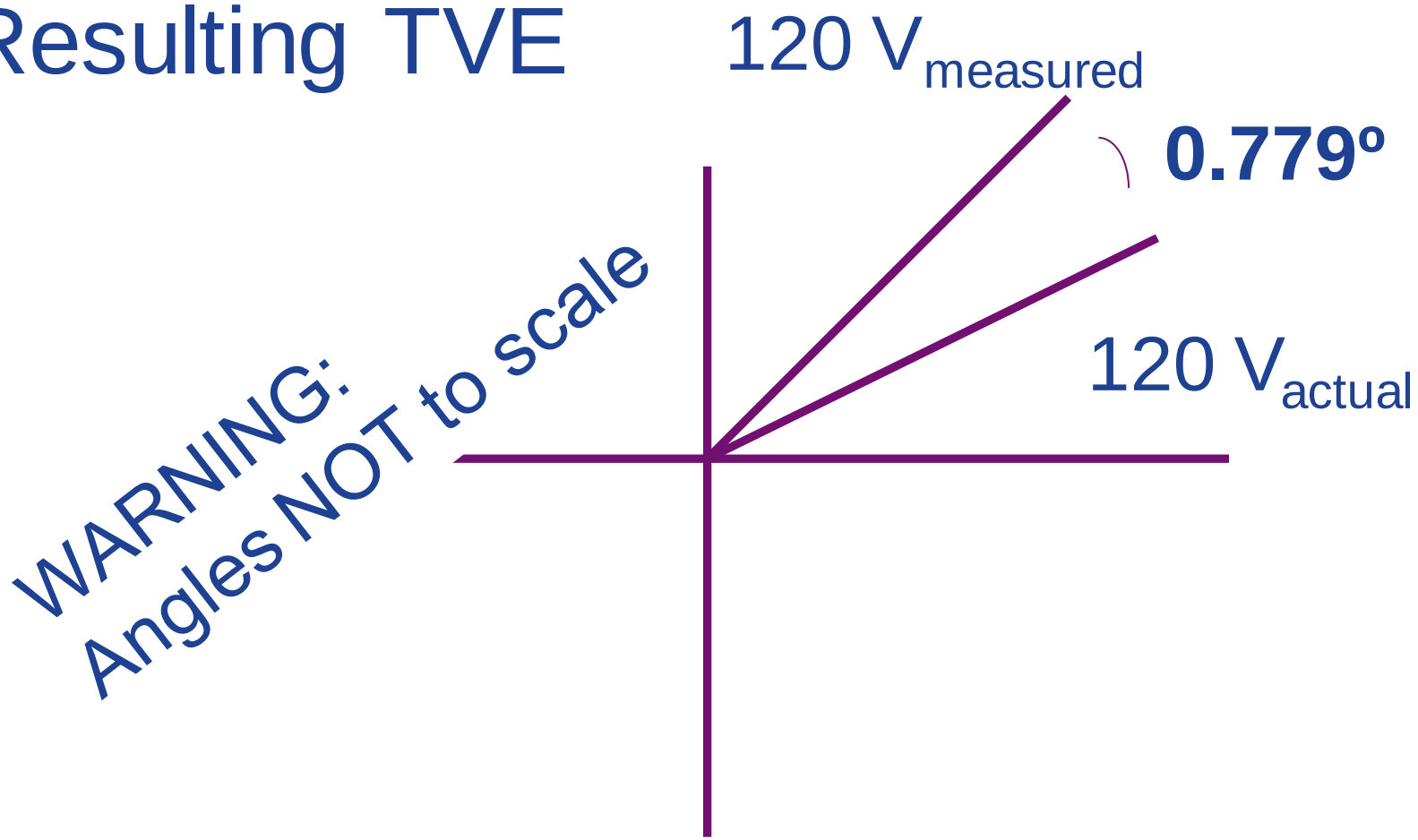


Voltage Phase error (in degrees) for various parasitic capacitances and Line Lengths[1]

	Cable Length		
Cp -Parasitic Capacitance (nf)	**30 m**	**60 m**	**240 m**
25	**0.000º**	**0.185º**	**0.538º**
50	**0.115º**	**0.198º**	**0.614º**
75	**0.196º**	**0.235º**	**0.779º**

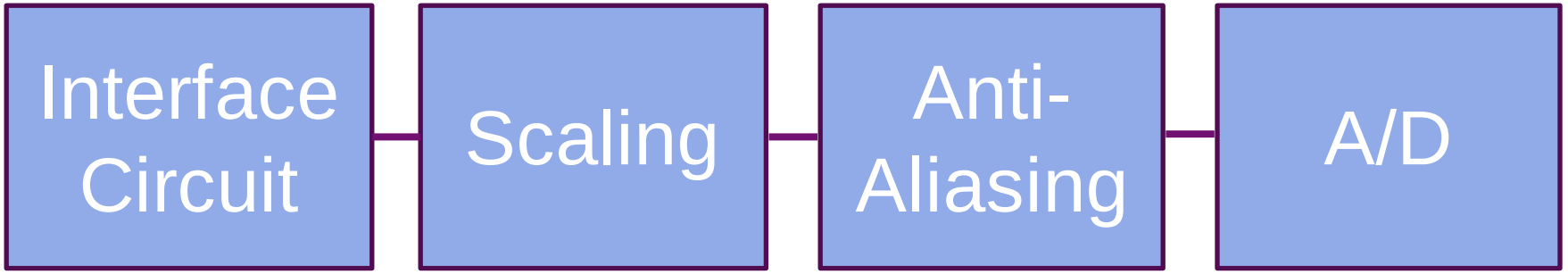
1 – From IEEE C37.242

Resulting TVE

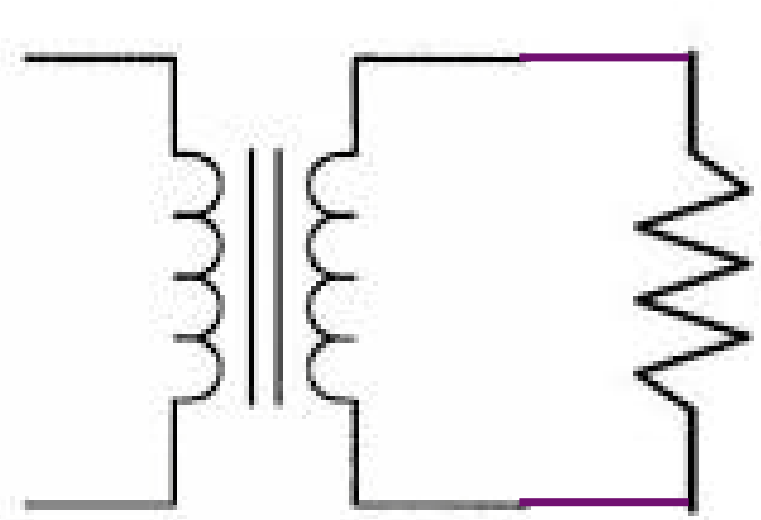


$$TVE = \left| \frac{120\ V_{actual} - 120\ V_{measured}}{120\ V_{actual}} \right| = 1.36\%$$

PMU Analog Data Path

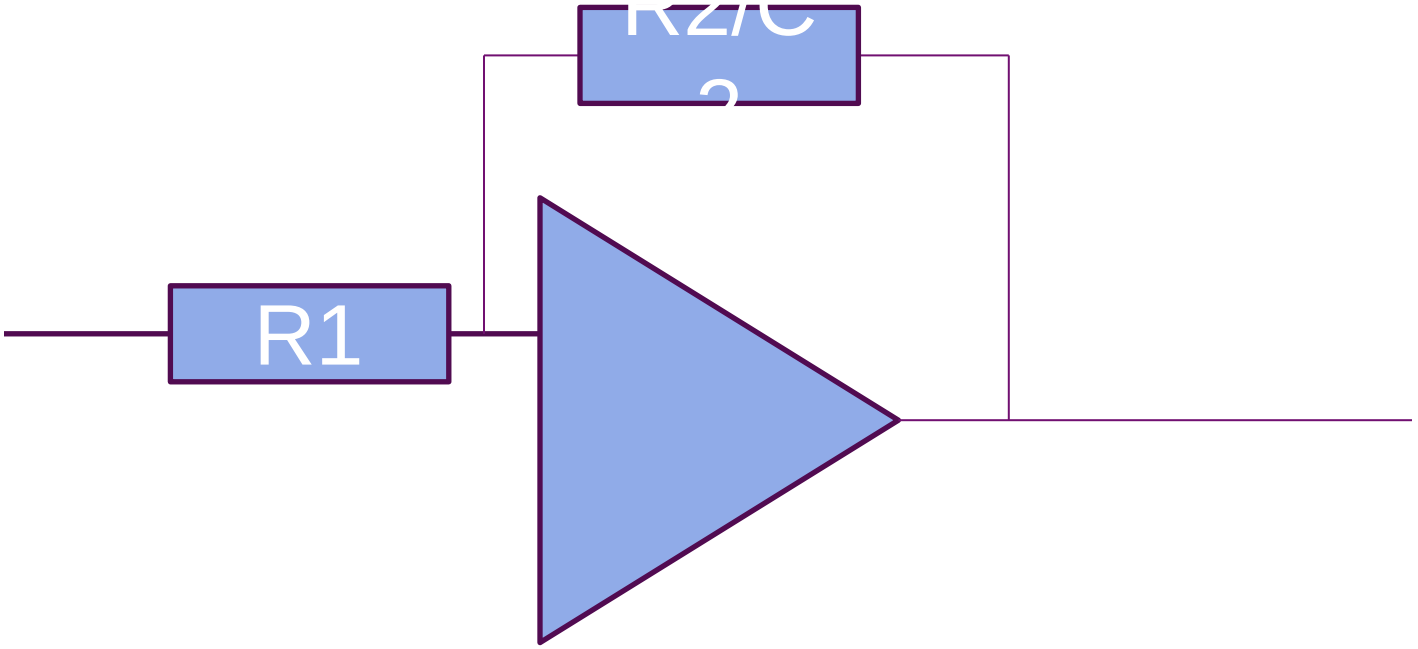


Interface Circuit



Component Accuracy: 0.1%
Typical Component Drift – 25 ppm/ºC

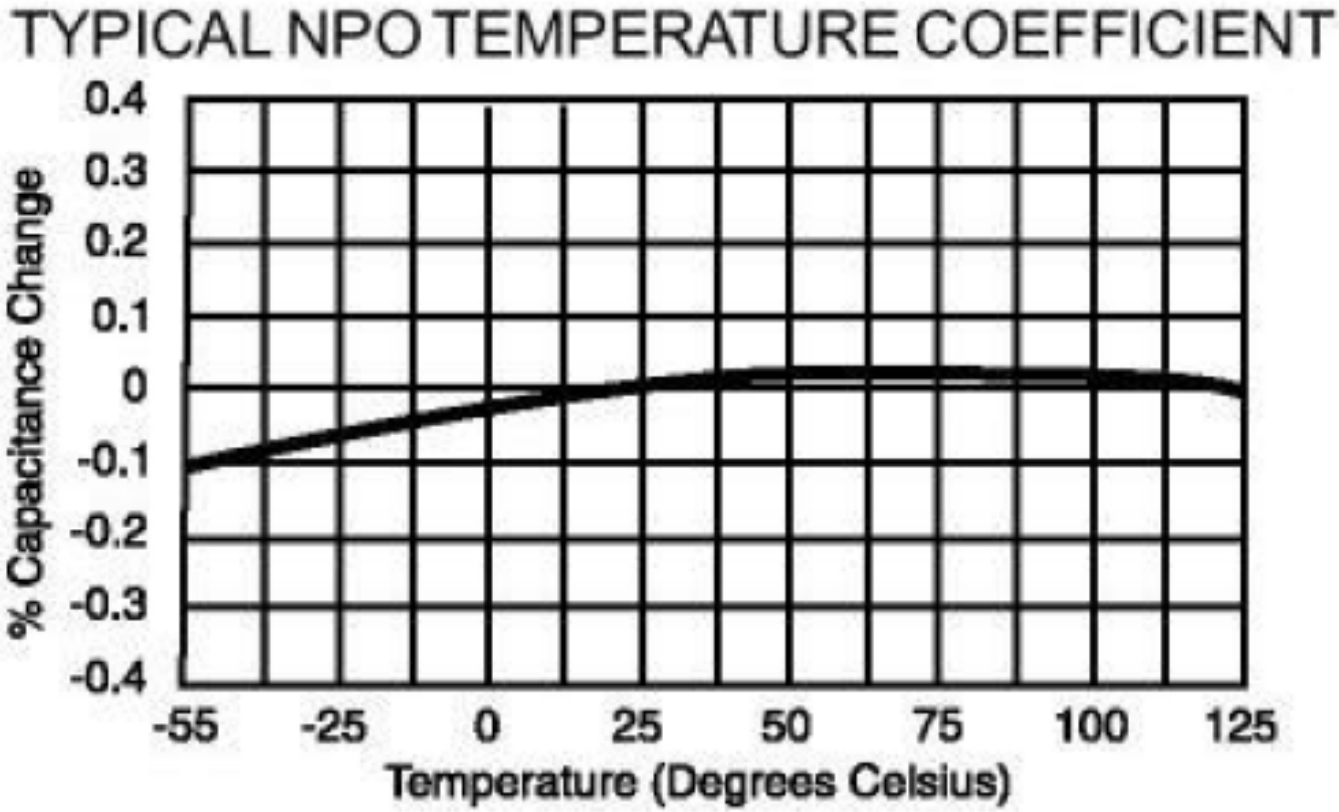
Scaling and Anti Aliasing



- 0.1% Accuracy – Resultant error – 0.2%
- Calibrated during manufacturing
- Temperature drift: 25 ppm

Capacitor Temperature Characteristic

NPO (COG) = 0±30PPM/°C over -55°C ~ +125°C



Ceramic Capacitors:

High-stability; Low Losses; No appreciative aging

Component Accuracy and Drift

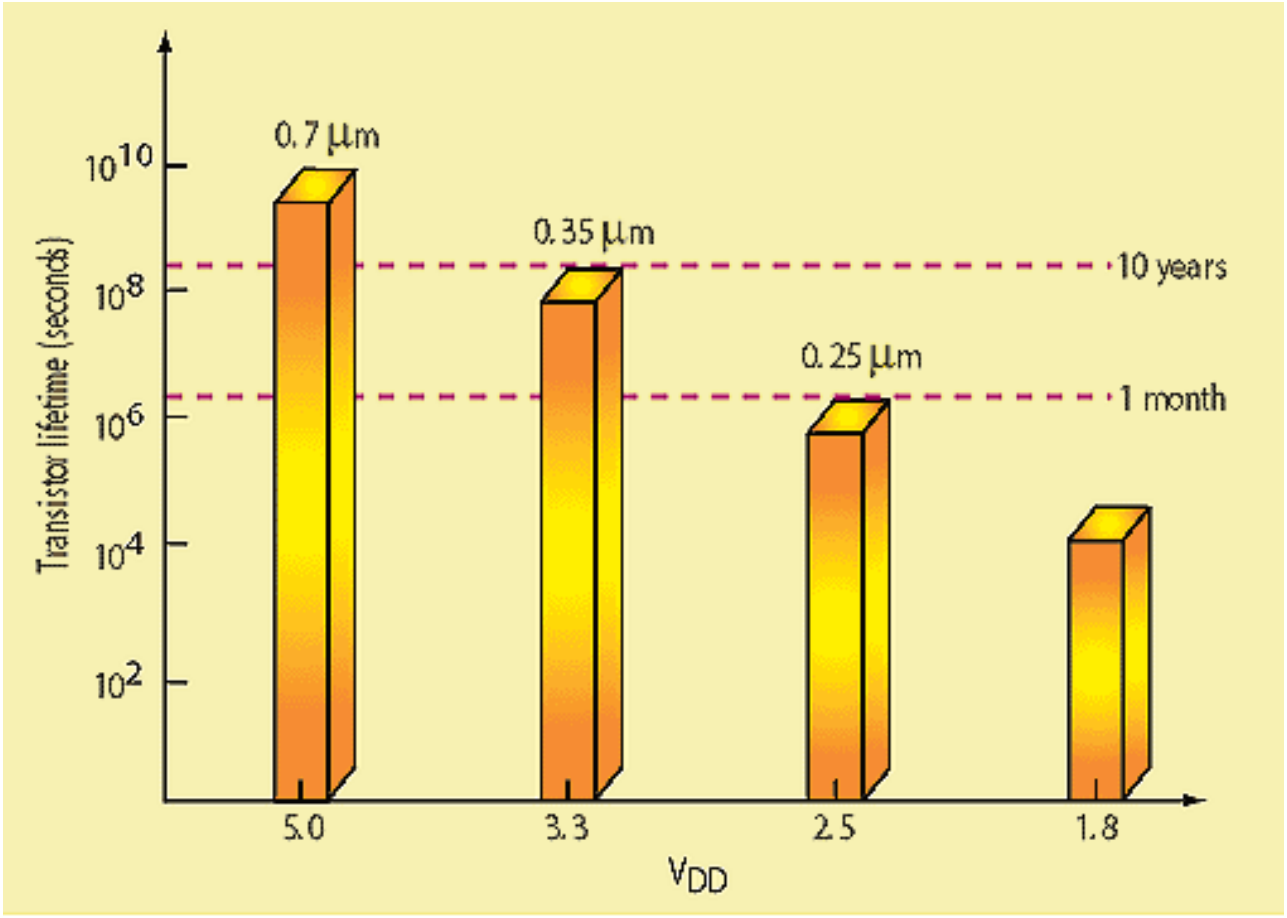
- Typical Resistor Accuracy: 0.1%
- Temperature Coefficient: 25 ppm/ºC
- Anti-Aliasing Filter Error: R1/R2 0.2%
  - Can be calibrated during manufacturing
- Error from 25 ºC to -55 ºC = 80 ºC
  - Given: 1Ω Resistor
  - = 80 * 25 = 2000 ppm = 0.1% Error

Circuit Aging

- Electronic Component Trends:
  - Transistor channel lengths to 0.18 µm
  - Higher operating frequencies
- Result:
  - Electric fields have become more intense…. carriers travel much faster… shatter the surrounding silicon atoms

Circuit Aging happens…..faster than ever before

Component Life vs. Die Size



2. Decreased power-supply voltage doesn't fully offset the lifetime decrease brought about by decreases in device channel lengths.

Summary

- Synchrophasor Systems are affected by many elements
- Observing system changes can help predict changes in performance
- Substation Monitoring can detect value changes

References

1. IEEE Guide for Synchronization, Calibration, Testing, and Installation of Phasor Measurement Units (PMUs) for Power System Protection and Control. IEEE C37.242-2013.

2. Measurement and Modeling of Errors for Relaying Current Transformers and Voltage Transformers; Nitin Vichare; Master's Thesis – Virginia Polytechnic Institute and State University; April 1990.

Update your footer

To update your footer, go to View – Slide Master and change it there.

Use bullets sparingly, if at all

Example with first level text unbulleted

- To use bulleted text default, demote text one or more levels
  - Fill in footer and date information under the “View” menu in the “Header and Footer” area
- Use title to make your main point

Take away boxes should only be used for occasional emphasis, not on every slide

Use bullets sparingly, if at all

- Example with first level text bulleted
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“This is a powerful way to present a meaningful quote with an image” Attribution Position

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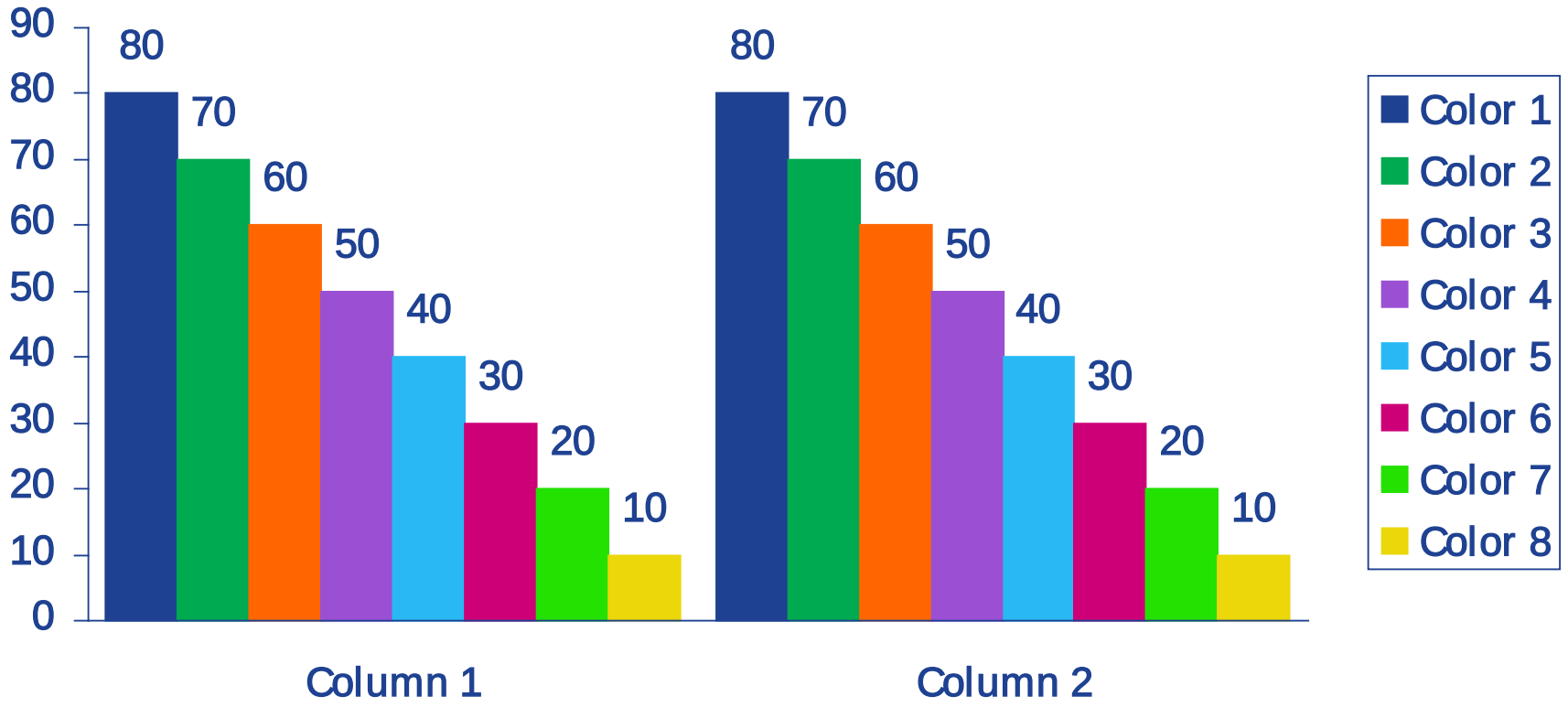
Example of charts

Subtitle – 20 points

These graph colors are for use when there is a great deal of data.

($ in billions – 18 points)



Take away box – 20 points – keep text simple

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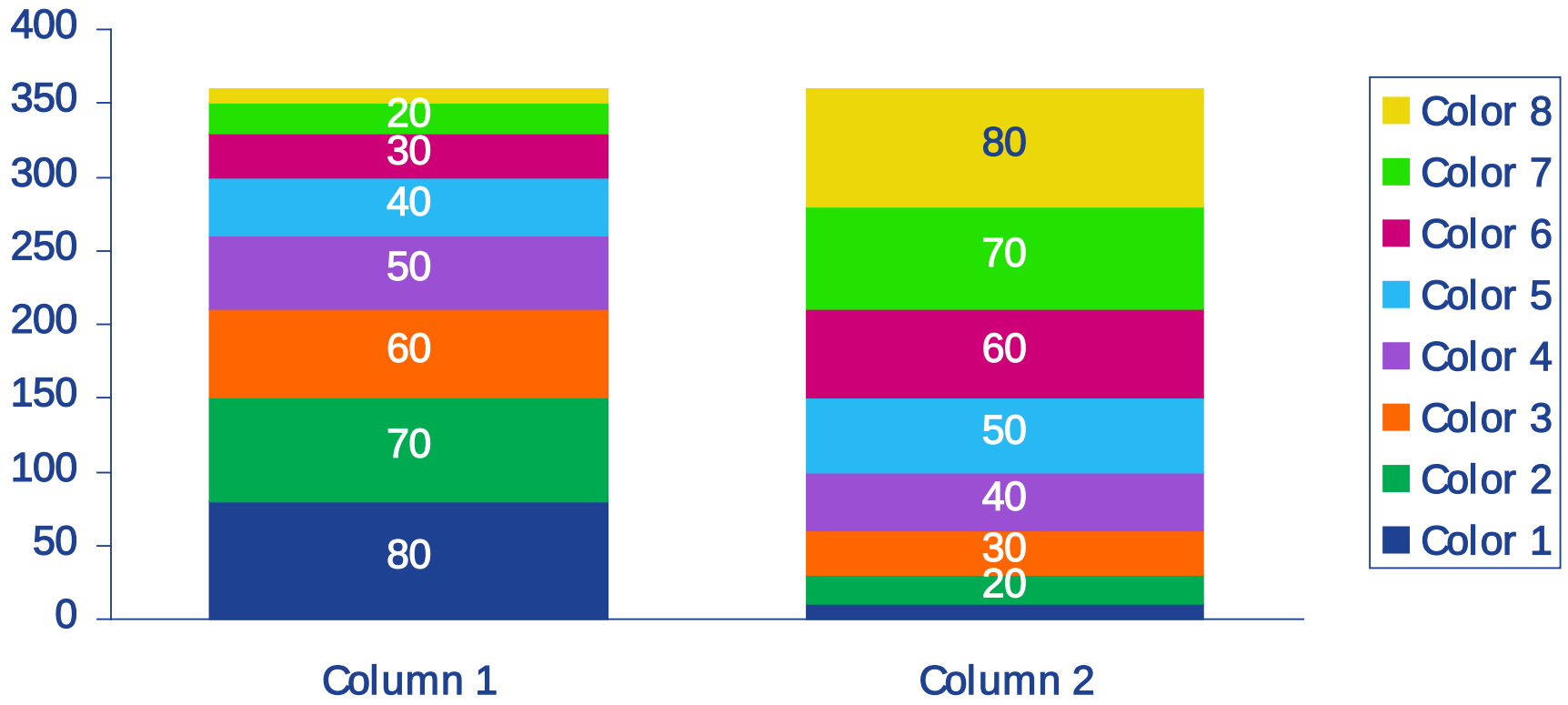

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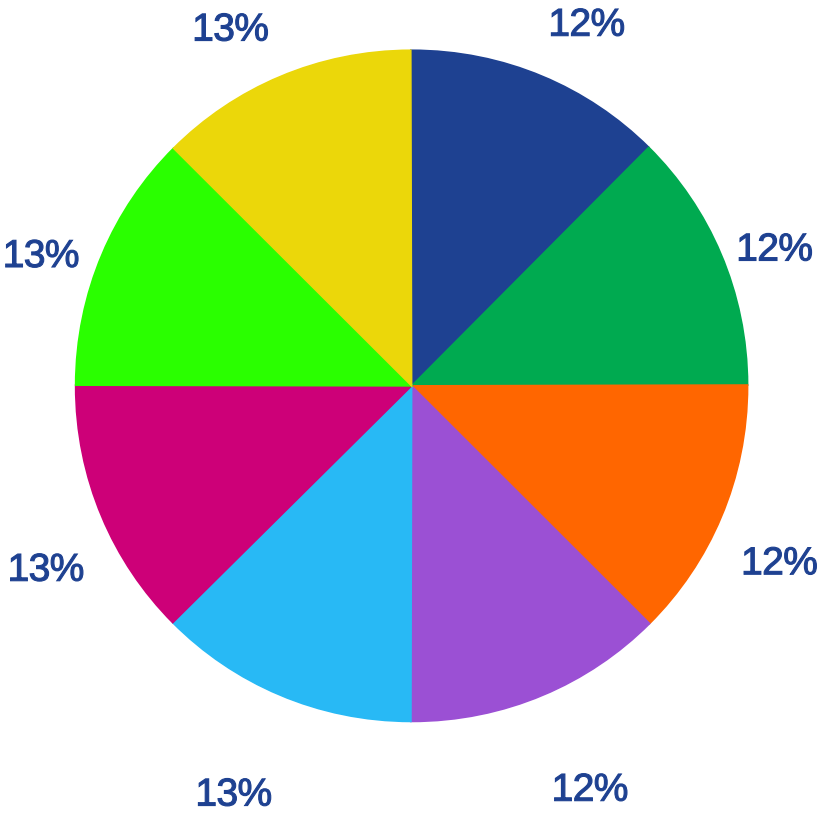

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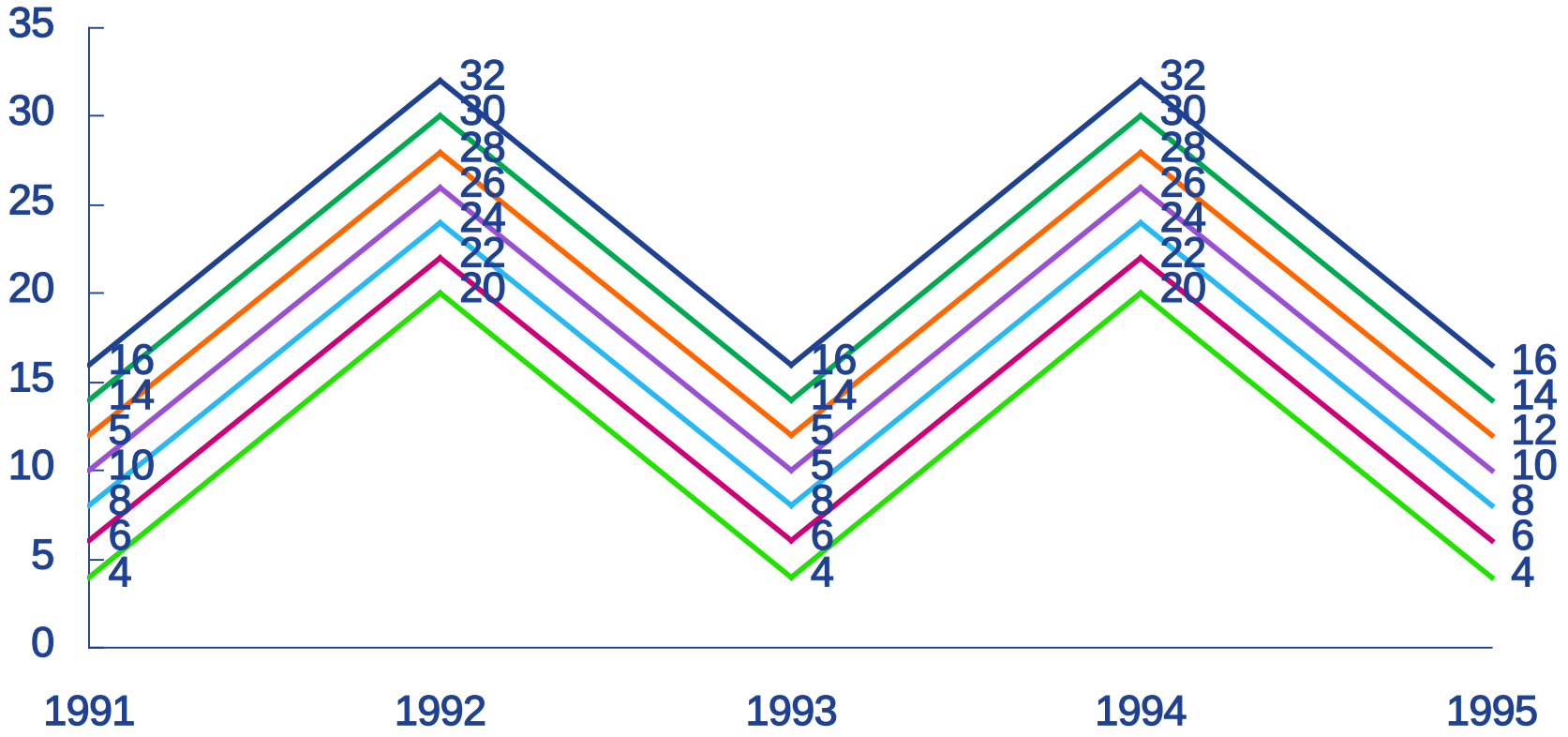

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