Analogue measurements with Emiscope

Distortion-free measurements with Time Resolved Emission

Presented by Frank Zachariasse
NXP Failure Analysis

Developed by Keith Sarault and Gerben Boon
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Outline

- Traditional methods for FA of Analogue circuits
- Why use Emiscope for FA of Analogue circuits ?
- Emiscope : Limitations for analog measurements
- Improved measurement set-up
- Case study : Fault localisation in a Class-D amplifier

Traditional methods for Analogue FA

- Need to trace signals, check which block is failing
  - Microprobing + Oscilloscope
  - Electron Beam tester
- Problems :
  - Need to remove passivation, perhaps make probe pads
  - Time consuming, risk damaging sample
  - Difficult when > 2 metals in analog circuit
  - Power supply tracks block access to the signals
  - Probing can load signals, distort results
- Therefore : Prefer Non-invasive, Fast, Safe method

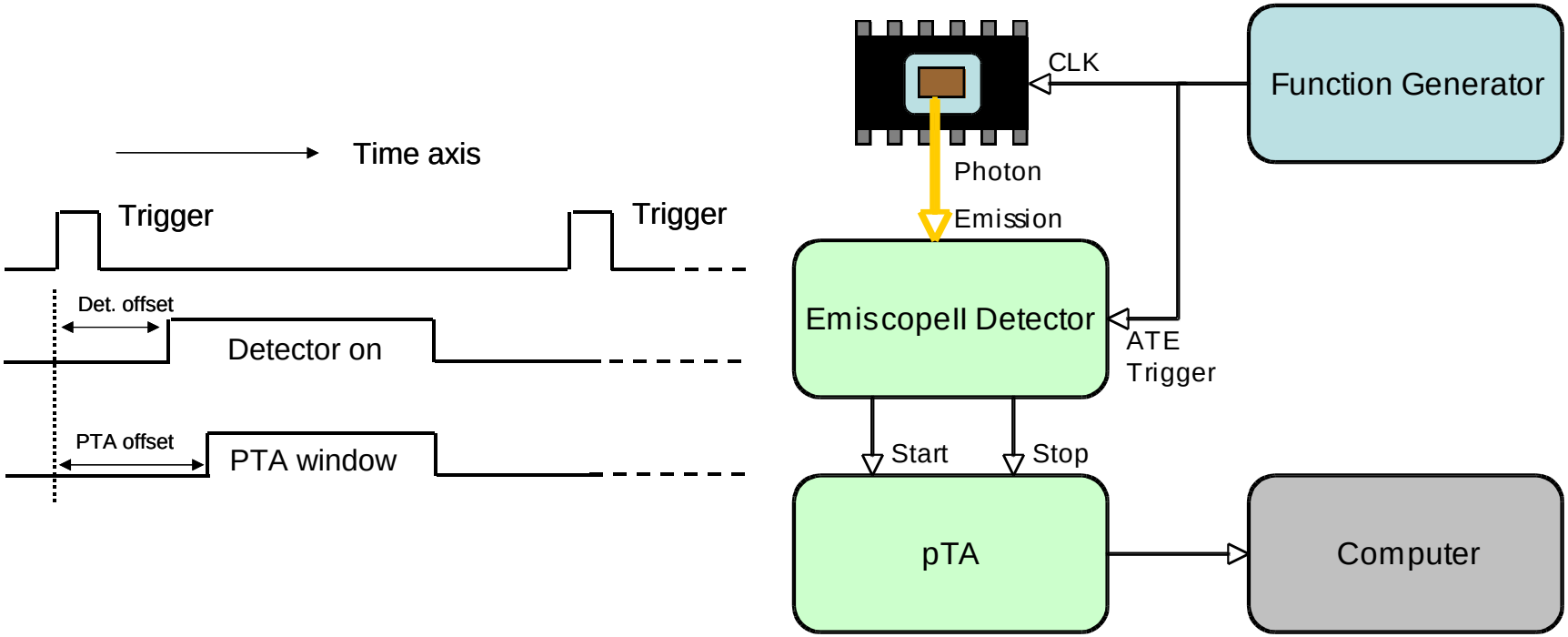
Why use Emiscope ?

- Signals collected by ‘viewing’ only : Not invasive
- Less risk to damage the circuit : no “slipping needles”
- Access to every transistor : All signals can be measured

- Our findings :
  - Traditional method, probing : 4 hours / sample to trace signal
  - Emiscope method : 20 minutes / sample

- **Problem : Non linear distortion of the signal, with normal set-up**

Emiscope – Normal set-up



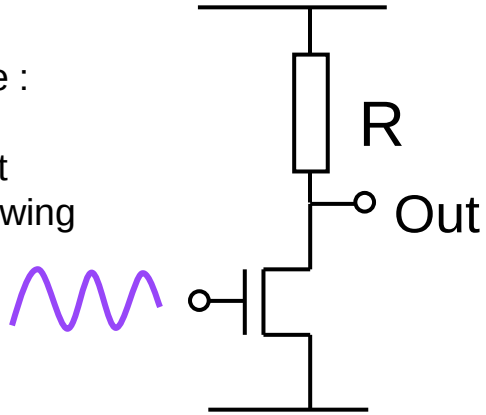
- ATE triggers the Emiscope photon detector
- Same trigger also starts the PTA
- PTA and Photon detector always on at the same time, synchronous

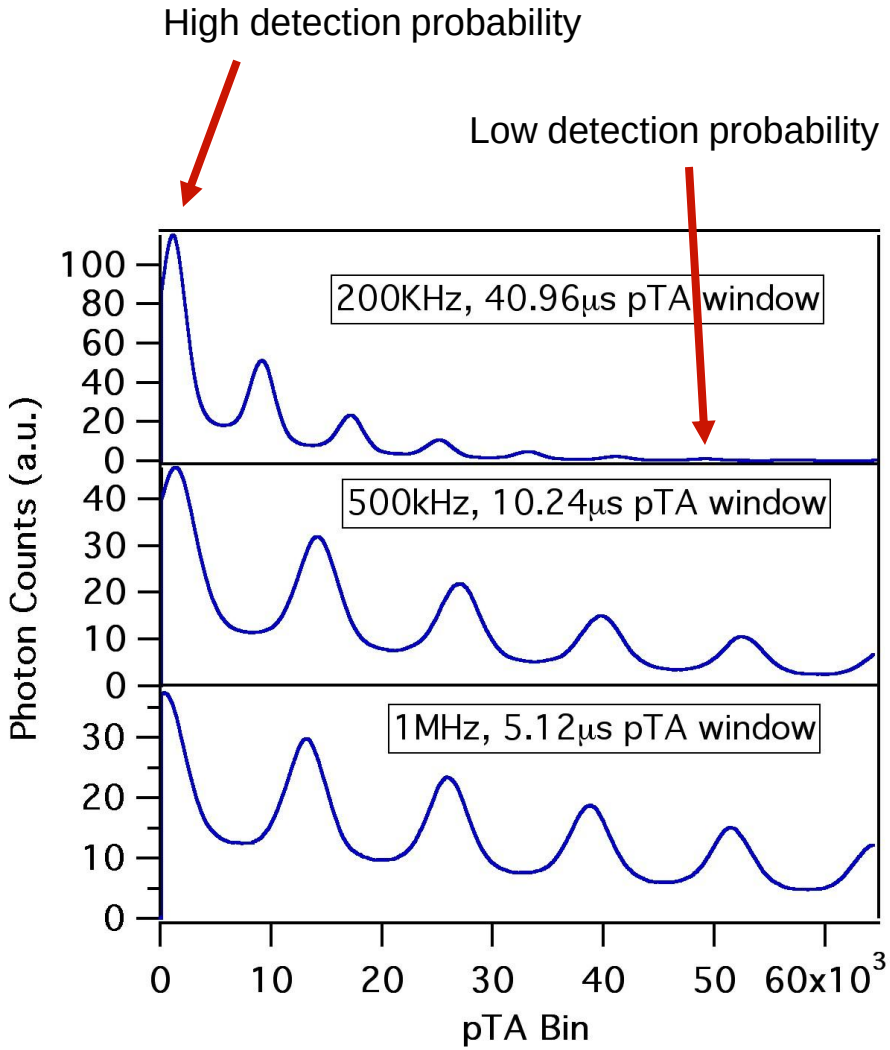
Using normal setup on analog circuit

- Class A amplifier, NMOST
- NMOST, 140 nm technology
- Constant bias current
- Therefore constant emission
- Sine wave signal used as input

Sine Wave :

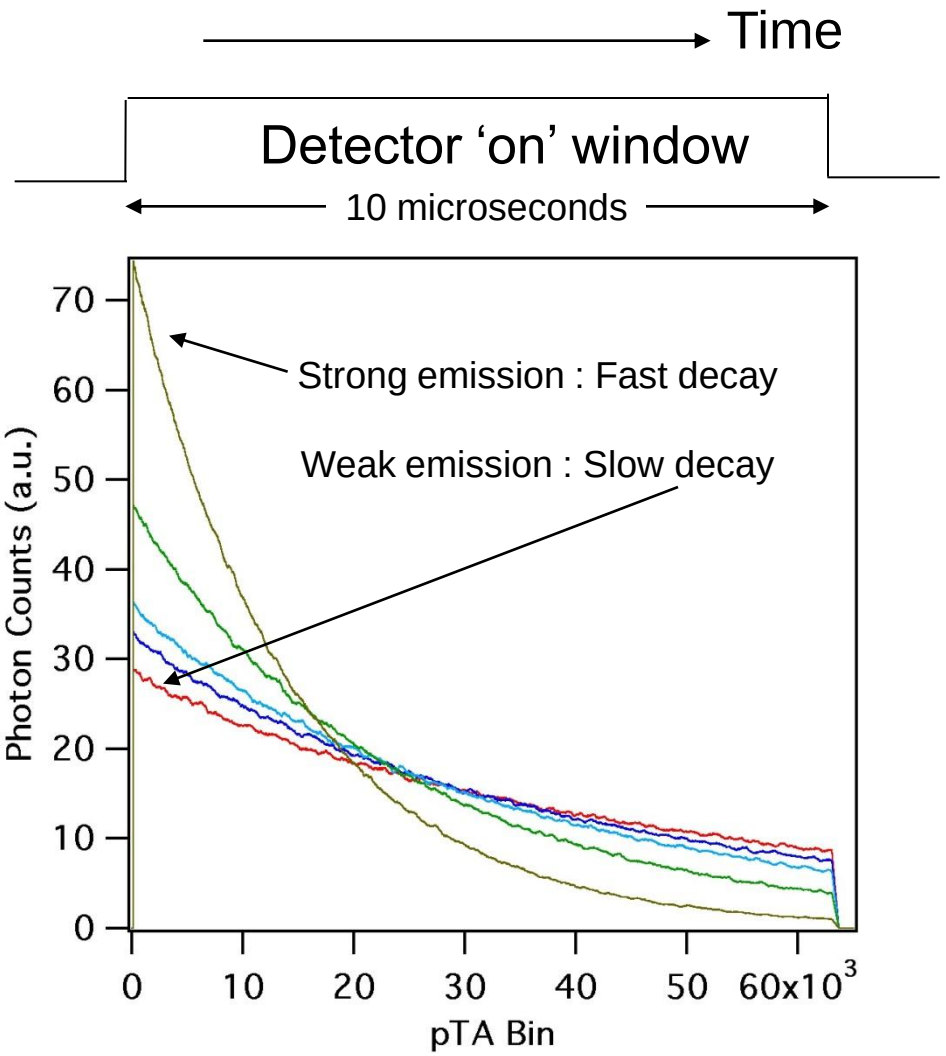
1.3V offset
0.6V p-p swing





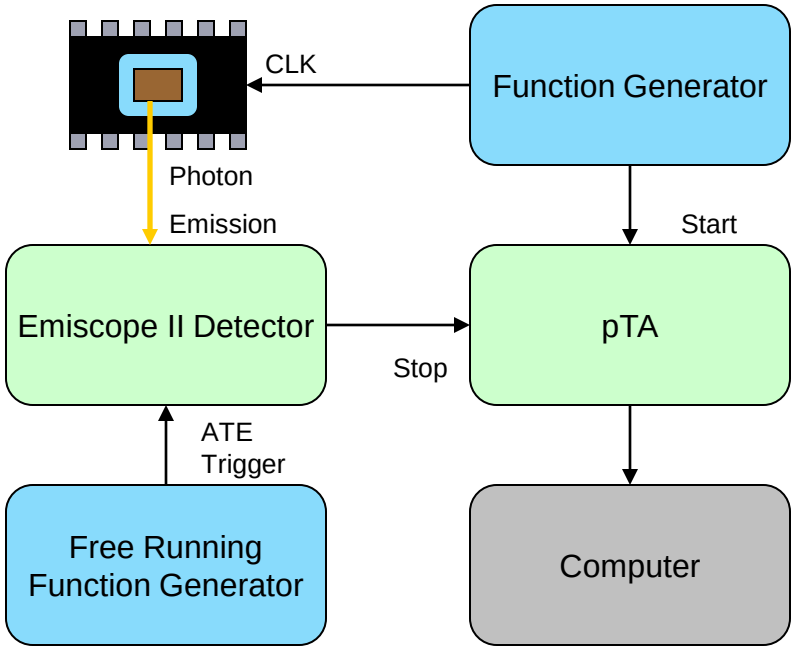
Cause of distortion

- When detector is switched ‘on’ :
  - Only one photon detected
  - After that : Detector ‘dead’
  - Reset detector with new trigger
- Therefore :
  - Early in window :High probability that detector still active
  - Late in window : Detector probably already triggered
- This leads to *non-linear distortion* : Decay depends on signal strength

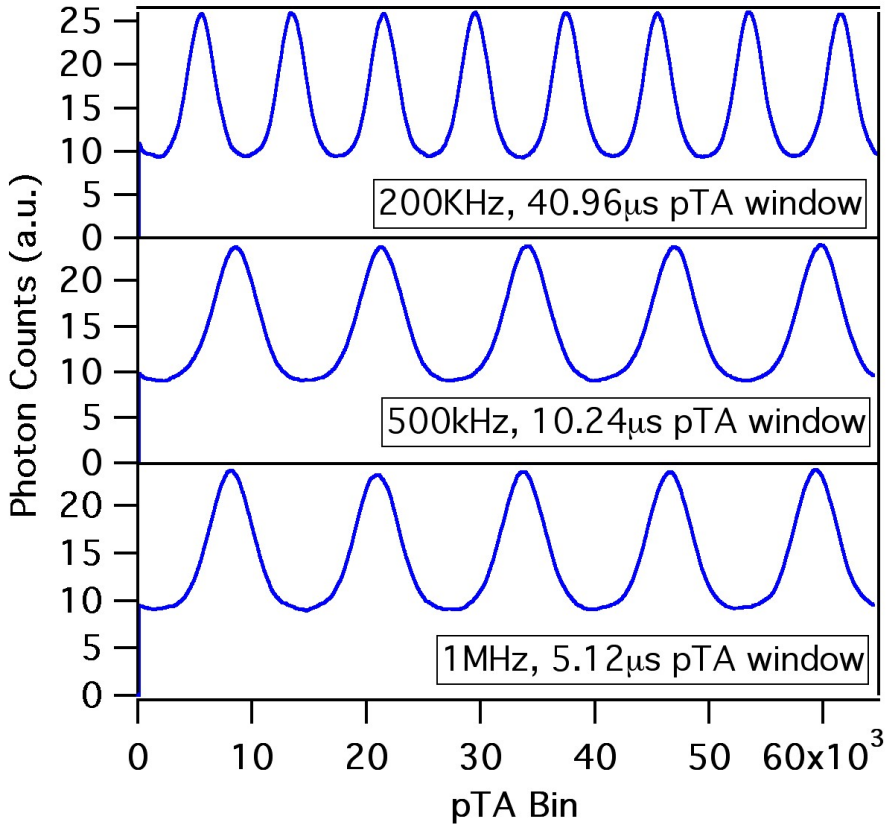


Constant photoemission

Alternative set-up for Analog measurements

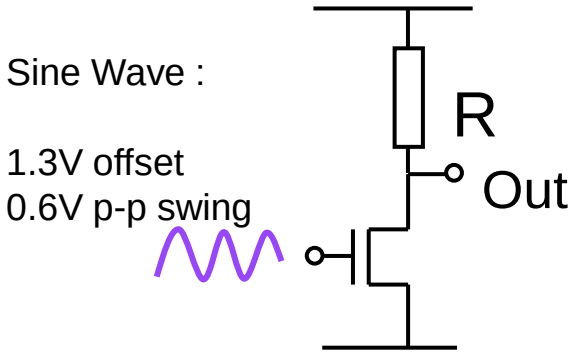


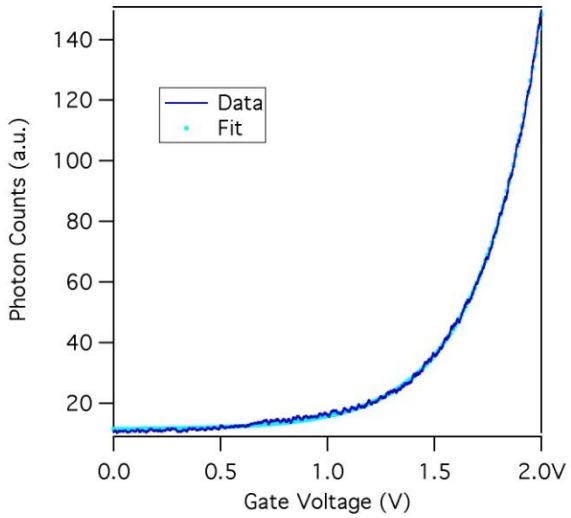
Class “A” amplifier - again



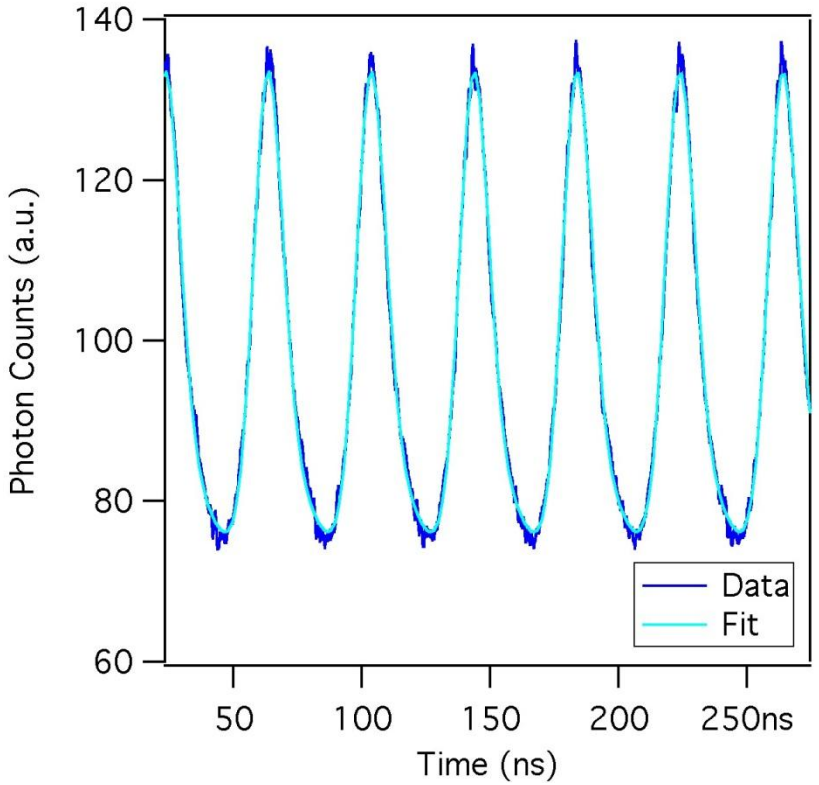
Detector ‘window’ is now ASYNCHRONOUS to pTA window
This gives constant detection probability across the window

Quantitative measurement





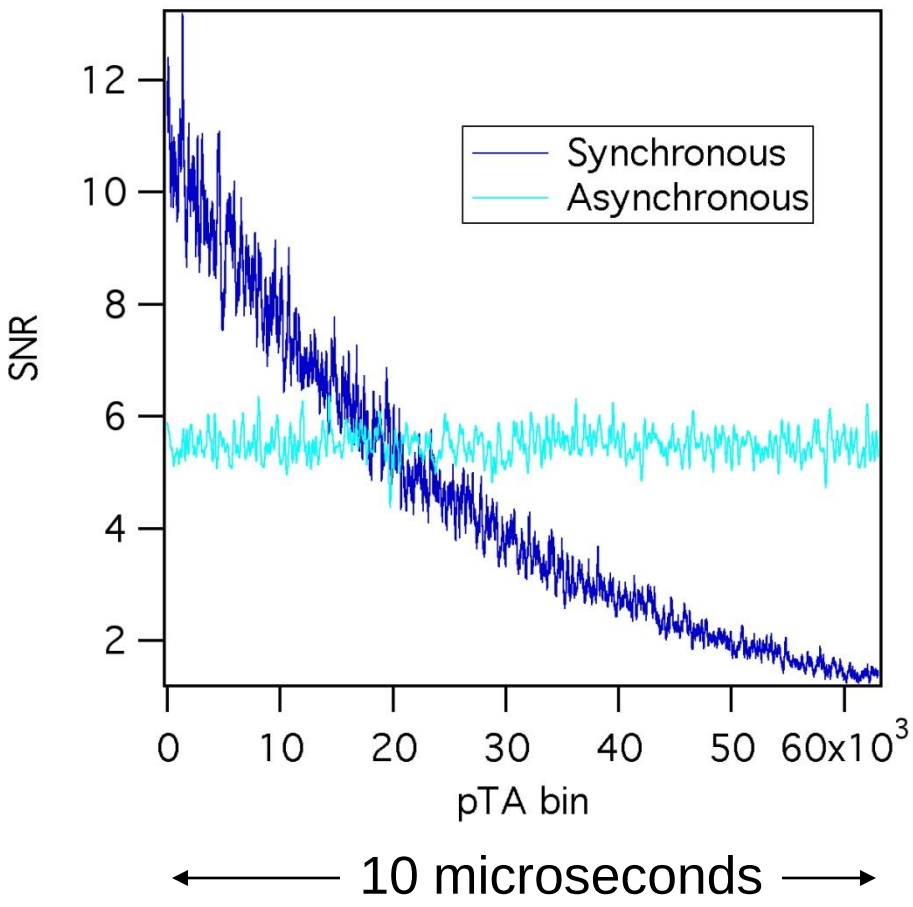
Emission is a non-linear function of Vgs



Correcting sine wave for exponential emission gives a good fit

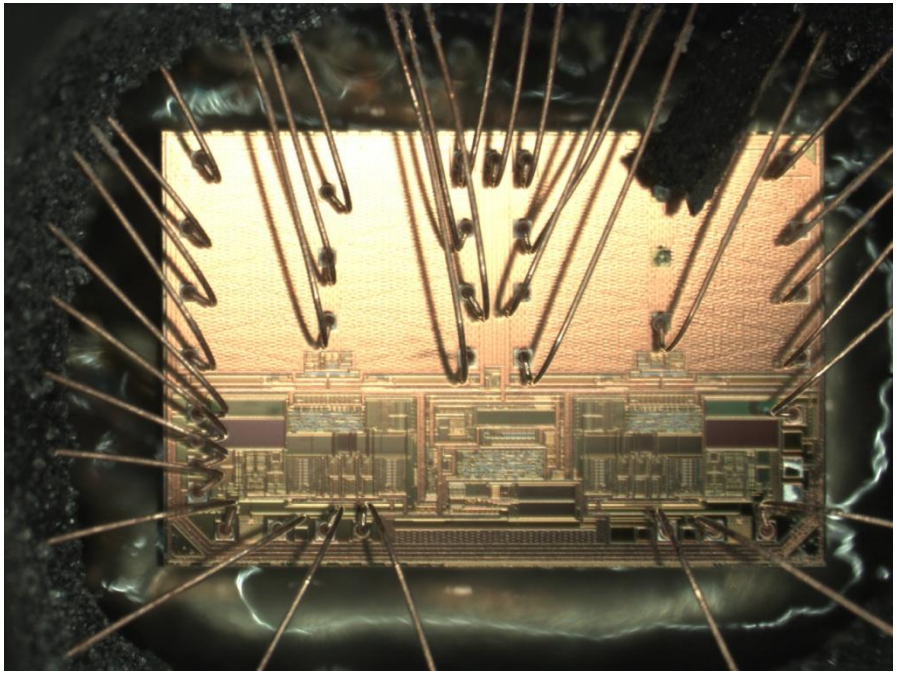
Comparison of Signal:Noise Ratio

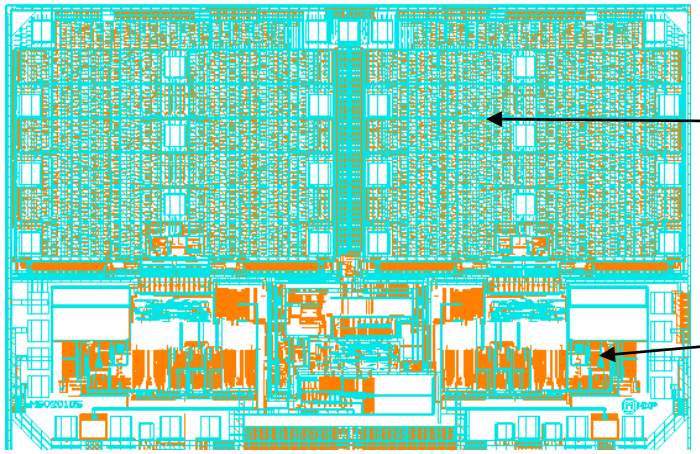
- Asynchronous method has a constant SNR across pTA window
- Normal, synchronous method has SNR that drops off
- You lose some signal at the start of the window
- But, you gain a lot at the end
- Overall, acquisition is much faster



Case study : Qualification failure

- Analogue Class D audio amplifier
- 1 μm “ABCD” technology
  - Bipolar, CMOS, DMOS
  - SOI wafer
- Failed DHTL test, 1000 hours
- 2 audio channels (L & R)
- One channel failed



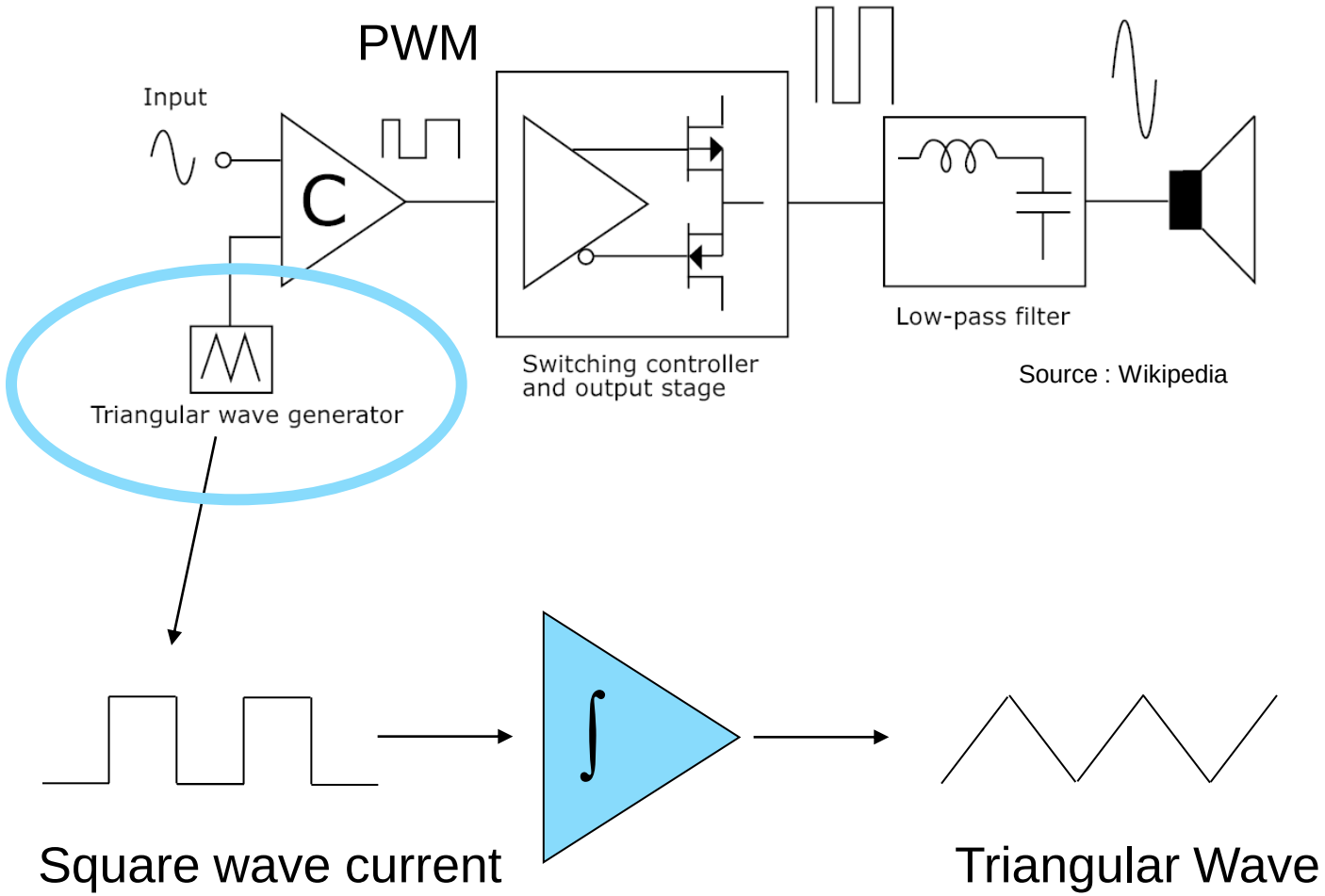


Output driver transistors

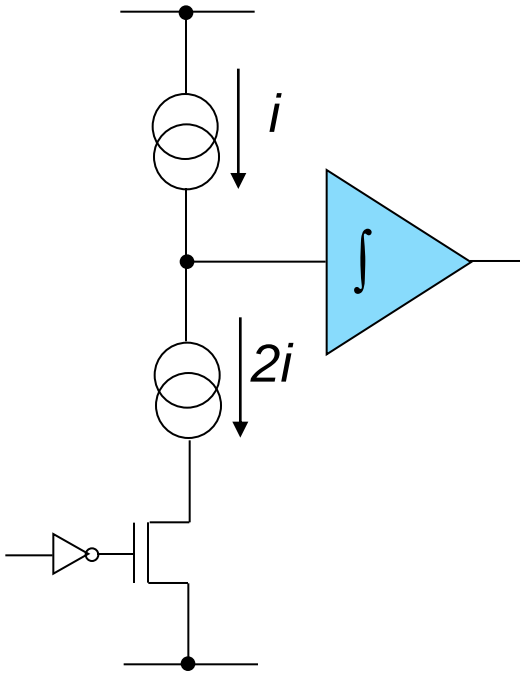
Convert Analog input
To PWM output

Ref 08fa2733

Class D amplifier – Basic principles

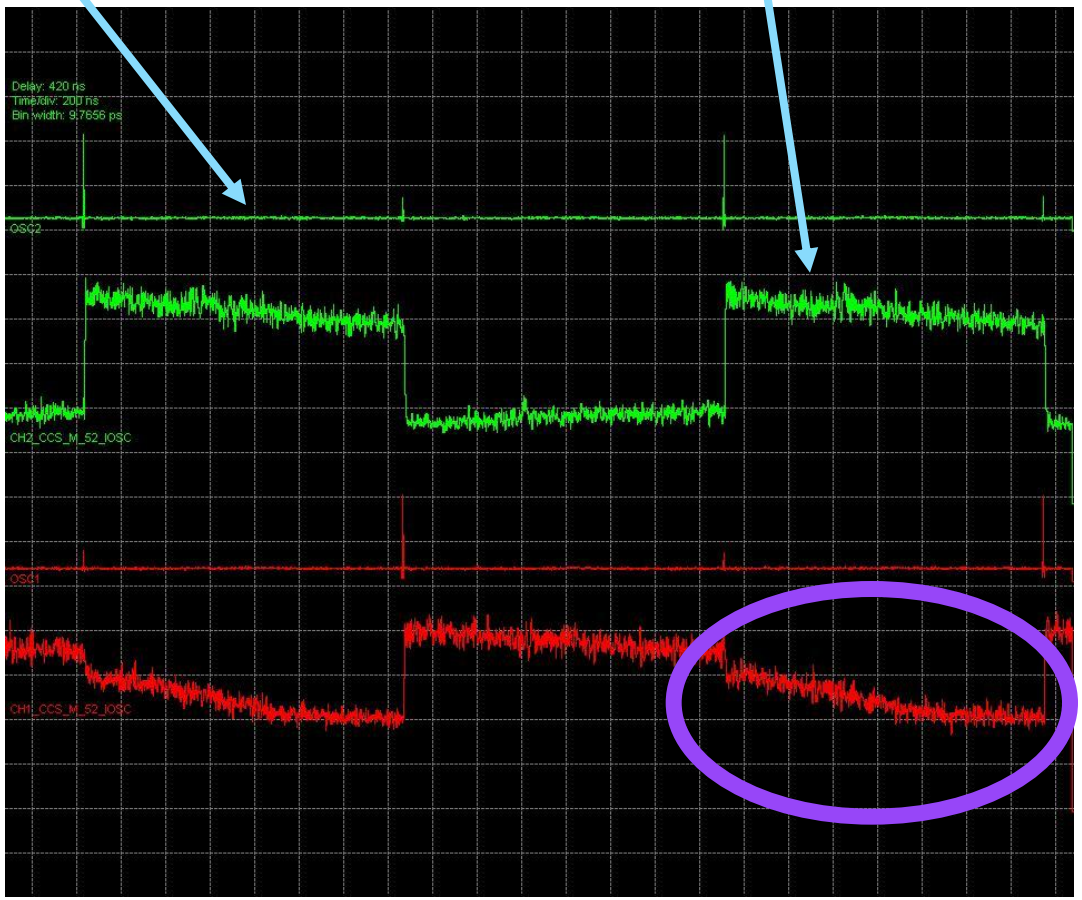


Analog measurement of square wave



Digital driver

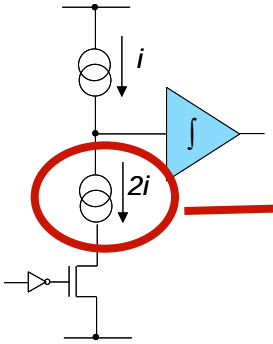
Current square wave

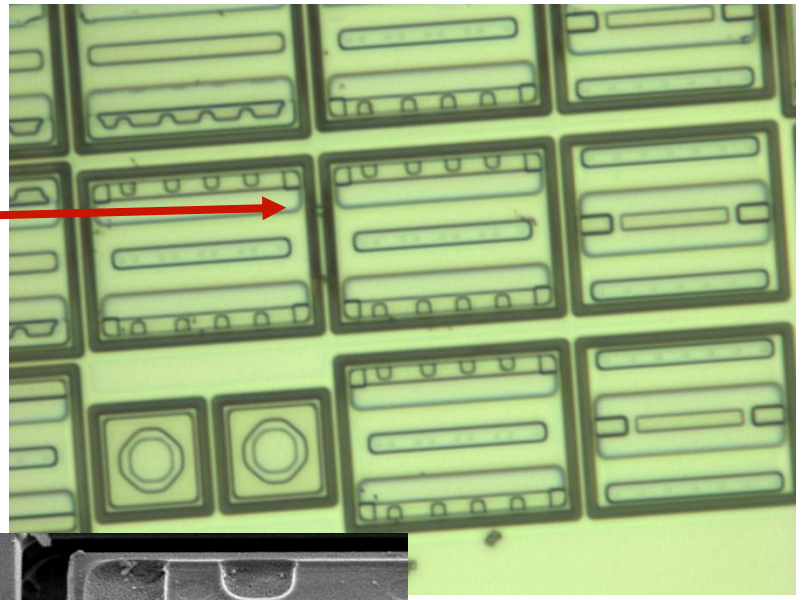


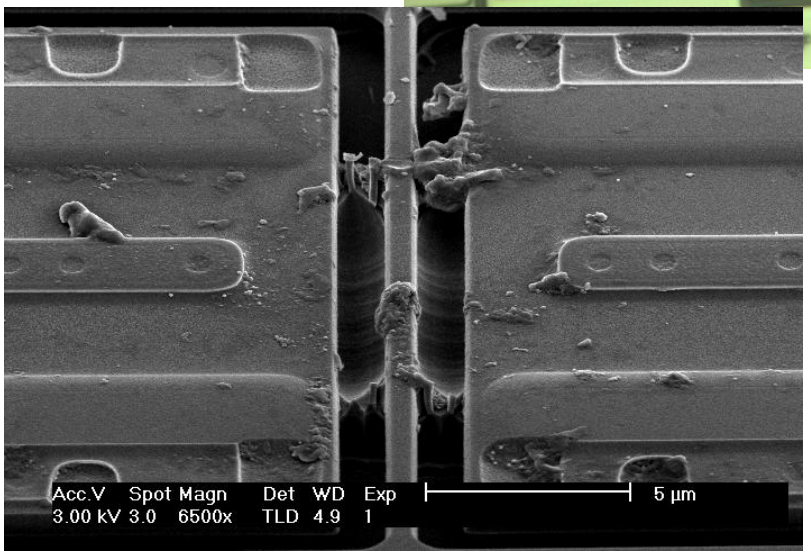
Period : 3 µs

Root Cause - deprocessing

- “Falling” current source had short circuit
- Caused by Polysilicon residue
- Shown by HF strip and SEM inspection







Conclusions

- *How to use Emiscope to measure analog waveforms ?*
  - Make detector window *Asynchronous* to pTA window
  - This eliminates the *sensitivity decay* for analog measurements
  - Also provides *constant Signal:Noise* across the whole measurement
- Main application : Localize failing site by signal tracing
- Compare with ‘known good chip’ to find faulty block
  - Don’t care too much about exact *quantitative* measurement
- Case study demonstrates effectiveness