APV25 S1 Low $T_0$ Measurements

Outline:
- Recap of July 2001 Results
- Testing Setup
- Transistor Parameters
- ADC Input
- Low Gain Results
- High Gain Results
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Recap of July 2001 Results

- Following trends occur for a drop in temperature:
  - Baseline increases ➞ lower baseline by increasing VPSP
  - Gain increases
  - Noise decreases
  - Pulse shape changes ➞ tune by changing ISHA and VFS
  - Calibrate pulse changes
  - Current consumption increases
    ➞ lower consumption by decreasing bias register settings for chip currents (IPRE, IPCASC, IPSF, ISHA, ISSF, IPSP, IMUXIN)

- Dependence of noise on temperature:
  - Expected 16% decrease in noise for a 54°C drop in temperature.
  - Results showed 8% decrease in noise.

- Junction temperature unknown.
Testing Setup

- APV25 Chip placed in Environmental Chamber.
- Testing range:
  \[-30^\circ C \leq T_{\text{chamber}} \leq 40^\circ C,\]
  \[-13^\circ C \leq T_{\text{chip}} \leq 58^\circ C.\]
- Pulse shape tuning in Peak mode determines values of ISHA and VFS to be used for each step in temperature.
- VPSP changed to obtain a constant baseline corresponding to roughly ¼ of the full APV output frame.

\[\Delta T\] between two methods = 10\(^\circ\)C
Transistor Parameters

- Threshold voltage, 1 mV/K variation

- Mobility………………
  \[ \mu_n(T) = \mu_n(T_{\text{nom}}) \left( \frac{T}{T_{\text{nom}}} \right)^X \]

- Transconductance….  \[ g_m \propto \mu_n(T) \]

- Noise…………………
  \[ S_V \propto \sqrt{\frac{T}{g_m}} \]
  \[ S_V(T) = S_V(T_{\text{nom}}) \sqrt{T^{1-X}} \times T_{\text{nom}}^{x-1} \]

- \( X = -0.86 \) from \( g_m \) vs \( T^0 \) data.
ADC Input

- The ADC input range is 0 → 2V.
- The output from the APV is ~ 500mV. It is further amplified before being digitised by the ADC.

Two possibilities:

Low Gain: ~4
- Whole output from APV is digitised, digital header + analogue signal.
- Noise level is around 1 ADC unit in Peak mode and 1.7 ADC units in Decon mode.
  ⇒ digitisation noise is significant and has to be subtracted in quadrature from total noise.

High Gain: ~17
- Only analogue signal from APV output frame is fully digitised.
- Saturation affects the first few channels in the analogue signal.
- Noise level is around 3.5 ADC units in Peak mode and 6 ADC units in Decon mode.
  ⇒ digitisation noise is no longer significant.
**Digitisation Noise**

- Noise associated with source used in digitisation noise measurement ⇒ ADC response is broadened.

\[
\sigma = \frac{\Delta}{\sqrt{6}} = 0.41\Delta
\]

\[
0.29\Delta \leq \sigma_{\text{real}} \leq 0.41\Delta
\]
Low Gain Results

- **Deconvolution Mode**
  - Prediction: $\Delta T = 70^{\circ}C$
  - $\Delta S_v = 20\%$
  - Results: $\Delta S_v = 15\%$
  
- **Peak Mode**
  - $\Delta S_v = 14\%$
High Gain Results

- **Deconvolution Mode**
  - Prediction: $\Delta S_V = 20\%$
  - Results: $\Delta S_V = 19.5\%$

- **Peak Mode**
  - Results: $\Delta S_V = 12.2\%$
Comments

- $T_{\text{junction}} > T_{\text{chip}}$  
  $\Rightarrow$ taking this into account would lead to closer match between predictions and results.

- Deconvolution and peak mode data show some differences, $\Delta S_v(\text{peak}) < \Delta S_v(\text{decon})$  
  $\Rightarrow$ Need more data to confirm this.

- APV25 operated at low temperature  
  $\Rightarrow$ Lower noise.

- Bias register settings have to be carefully chosen, especially ISHA and VFS which determine the pulse shape and VPSP which determines the analogue signal baseline.