Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

E. Usenko, INR RAS, Troitsk, Russia
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

**TOF ALICE DETECTOR (LHC CERN)**

- The TOF detector using MRPC strips. The area of the detector is \(~160 \text{ square meters}\).
- The system has total **number of read-out channels** (pads) equal to \(~160,000\).
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

Input stage

- Common gate circuit with very high bandwidth @<0.5ns peaking time

- The input charge is flowing through the output load \((RL \times CL = 1\text{ ns})\), while the input impedance is low

- Input impedance \((1/gmsb)\) is tuned to match the impedance of detector signal transmission lines

- No signal feedback, fully differential DC coupled structure is ideal for high data rates and large signals dynamic range.

\[ v = Z_L i \]

Very fast Diamond signal (over 160ps rise time)

Input stage (half of fully differential circuit)
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

- Fully differential structure from input to output
- Gain of PA stage is 30,
- Gain is obtained by 4 consecutive stages as \( G=6 \), \( BW=500 \text{Mhz} \)
- Last stage is an open-drain differential pair to provide LVDS like outputs
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

NINO channel structure

- Minimum threshold at 5–10fC.
- < 3000 el. Noise @ 6pF Cdet
- Tunable differential input impedance on the range (40–100) Ohm.
- < 9 ps rms front edge time jitter
- Hysteresis value can adjust up to 12%
- Pulse width variable from 0.5ns up to 6ns vs. input charge.
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

- $< 3000$ el. Noise @ 6pF
- $C_{det}$
- $R_{ext}$ is 25 Ohm

- equivalent input charge is 30fC,
- $R_{ext}$ is 25 Ohm,
- additional stretch time value is 12ns
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

Limiting of NINO ASIC for diamond applications

- Input DC offset voltage (equivalent of amplification factor) is a limit of minimum detectable charge over 5-10 fC,
- Input noise level (< 3k el. @ 6pF Cdet) is provide of levels discrimination from ions beams counters,
- Dependence of output pulse width from detectable charge is limiting of maximum data rate over 10e9 particle/s
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

Proposals for using NINO ASIC for diamond applications

Increasing of maximum data rate:

- Using NINO ASIC on standard mode: $Q_{\text{min}} = 5\text{–}10$ fC, output pulse width range from 0.5 ns up to 6 ns, max. data rate over 100 – 400 MHz,

- Using NINO ASIC on inverting mode for realizing maximum data rate 400 – 1200 MHz with $(0.5 \text{–}1)$ ns normalization output pulse width,

- Using constant fraction method for normalization input charges by value (on inverting NINO mode) for providing maximum data rate up to 1200 GHz.

- Using ultra fast 1.2 GHz prescalers with divide ratio 10 are connecting to itch NINO outputs directly for realizing full data rate and reducing limitation for transport cable.
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

Proposals for using NINO ASIC for diamond applications

Increasing of input sensitivity:

- Using NINO ASIC on standard mode: 
  \[ Q_{\text{min}} = 5 - 10 \text{ fC}, \]

- Using additional external ultra fast @ low noise preamplifier (such as ATF–54143, Ajilent HEMT or GALI–S66) with amplification factor \( A_v > 10 \) and \( < 1500 \)
  \[ \text{el} @ \text{Cdet} = 0 \text{ pF noise}, > 1 \text{ GHz} \]
  bandwidth should provide \( 1 \text{fC} \) of estimation minimum detectable charge.

Note: For saving differential front end structure should use two preamplifiers per NINO channel.
Using NINO, an ultra-fast, low-power, front-end amplifier discriminator for Diamond detectors.

- IBM 0.25 um Si CMOS technology
- 8 channels, 2x4 mm$^2$ chip
- Channel power is 27mW
- +2.5V supply voltage only
- Delay time 1ns
- Easy operating and controlling

The NINO ASIC bonded to the PCB

The NINOTAPP final package

8/31/2005 E.Usenko