A fast LED driver prototype for HCAL calibration

CALICE meeting at ANL, USA

Proposal for calibration system

- Fast LED driver is a key part of calibration system
- A tunable calibration light in the range 0 to 100MIP
- Simplification of the optical system: one LED -> one side emitting fibre, one row of scintillator tiles
- See Jara's talk **Comments on optical system II**

LED driver strategy not only for SiPM calibration

- At AHCAL prototype (uses SiPM), we used CMB, calibration system with UV-LED 400nm driven by very fast rectangular pulses (1ns rise/fall time).
- Steep Rectangular waveform satisfied the needs to vary pulse-width, BUT creates lots of harmonics → electromagnetic **crosstalk**!
- We have found **fixed** pulse-width to about 6ns, we can go to use narrow band ->smooth waveform ≈ **less RF interference = Quasi Resonant LED driver (single pulse)**

Quasi-Resonant LED driver

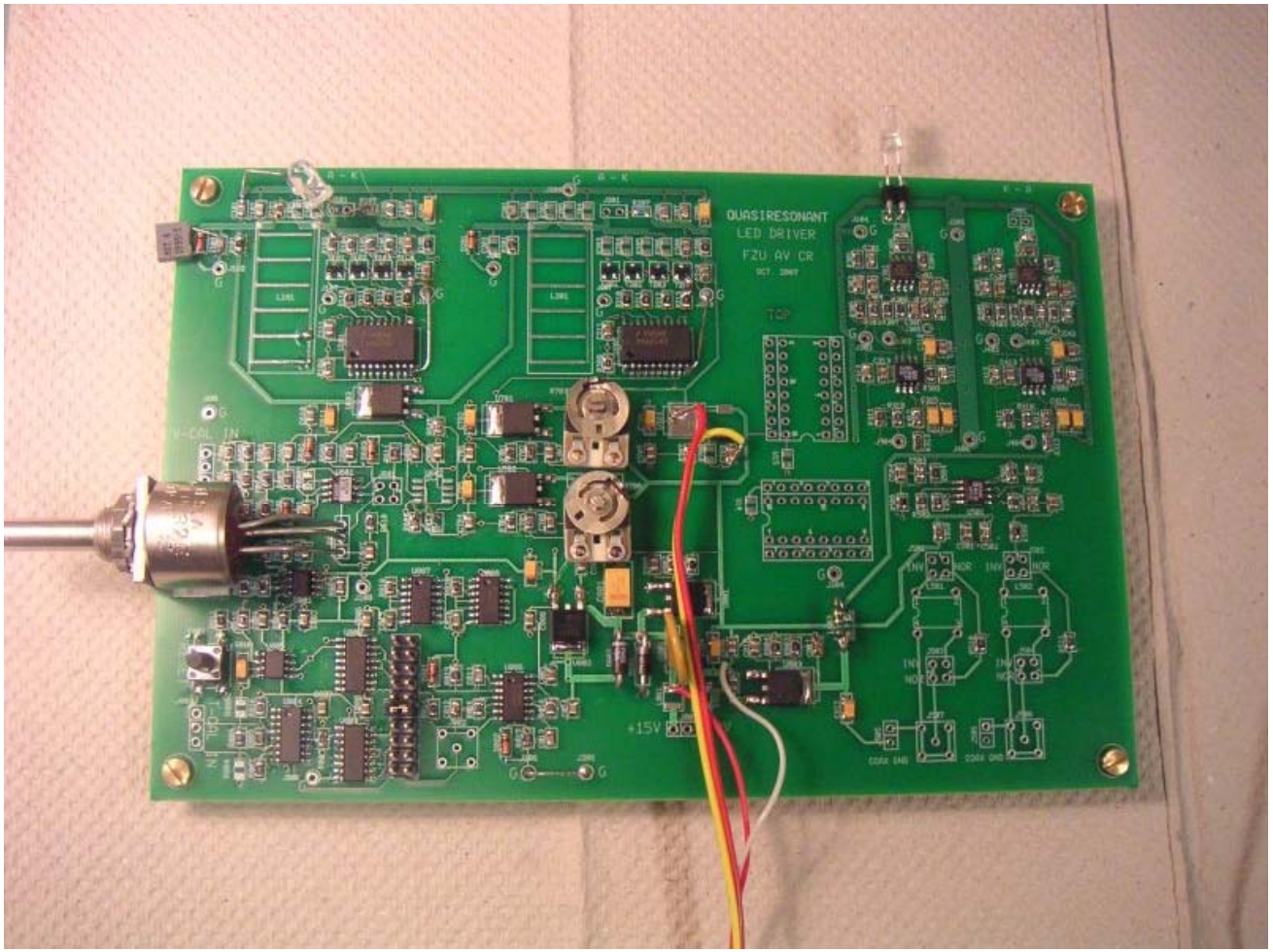
LC circuit, heavily dumped

- **Simulation pulse-width 5ns with 33nH inductance**

- **Prototyping**
- **Used my lovely single side copper foil PCB**
- **We need more work on components**
- **optimization** to recent **LED**

- **2CH board**
- **primary tested**
- **With printed Cu inductor 2ns pulse-width**

2CH QRLED board



Consists of:

Double sided PCB

2 QRLED driver

2PIN photodiode preamp

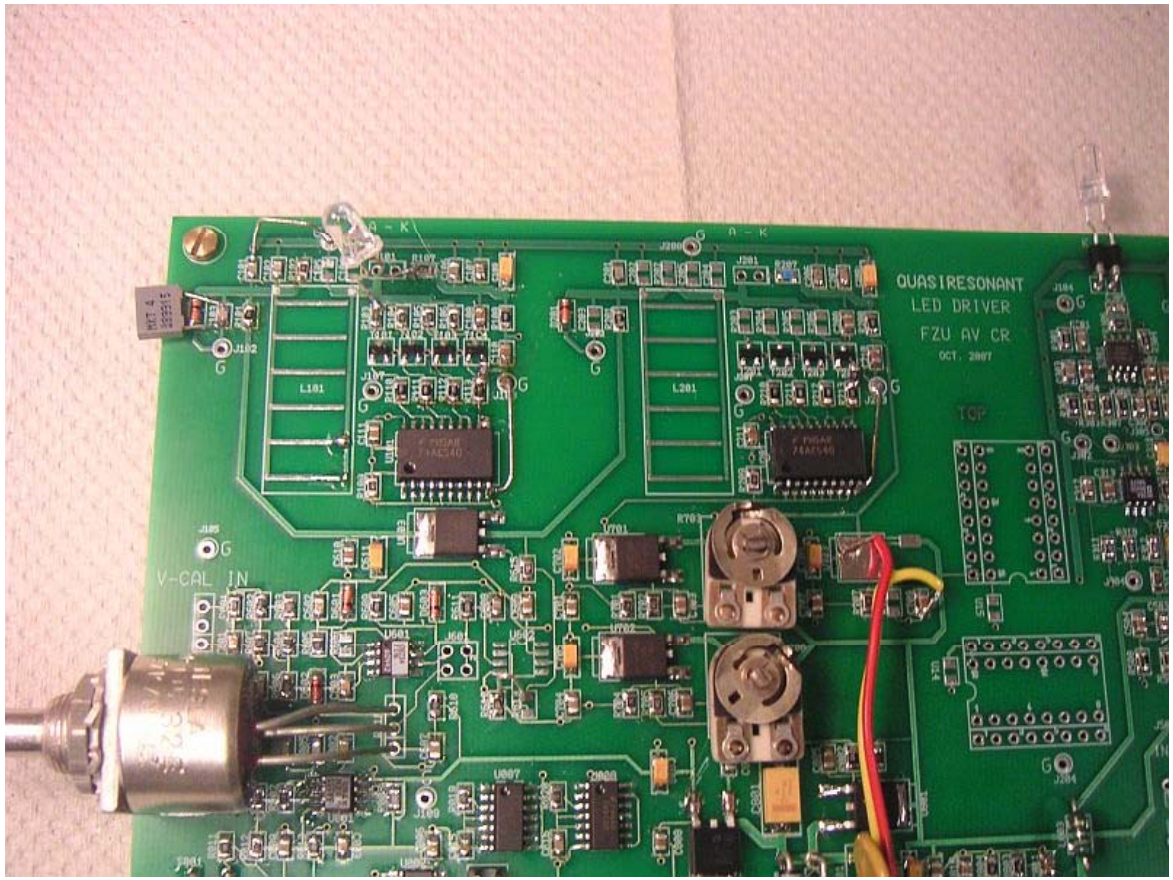
Rate generator 1Hz to 10kHz

Voltage regulators

Amplitude control

V-calib and T-calib interface

2CH QRLED board

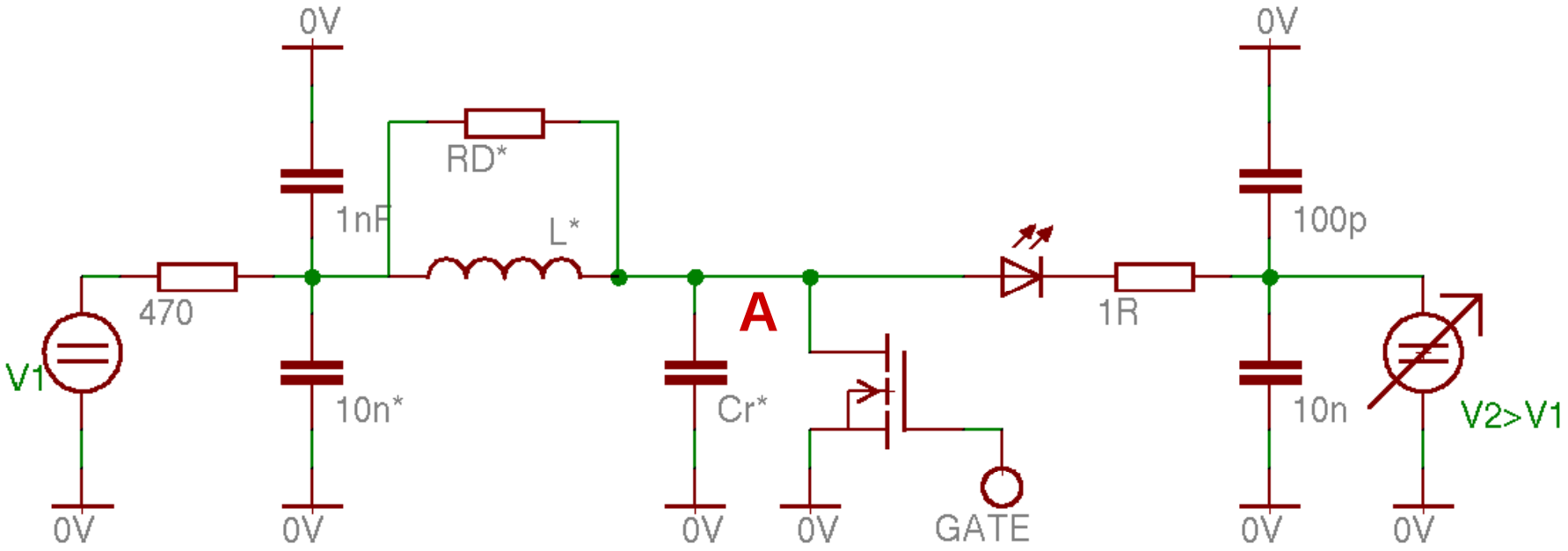


There is a detail of two QRLED driver

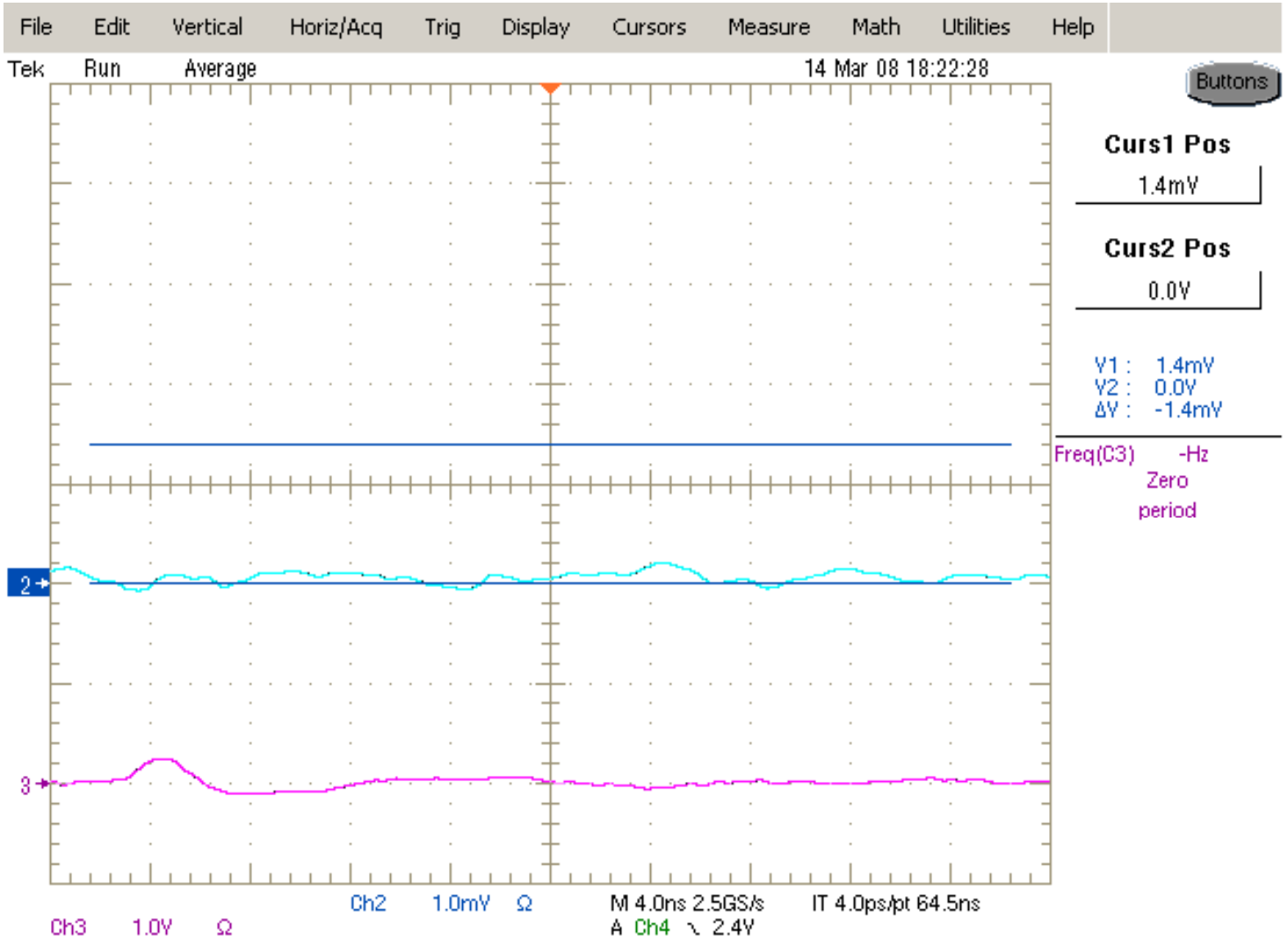
Printed inductors with taps, left is connected by tin joint

Two trimmers equalize delays between CH A and B

Principal schema of QRLed driver



PIN PD response to UVLED



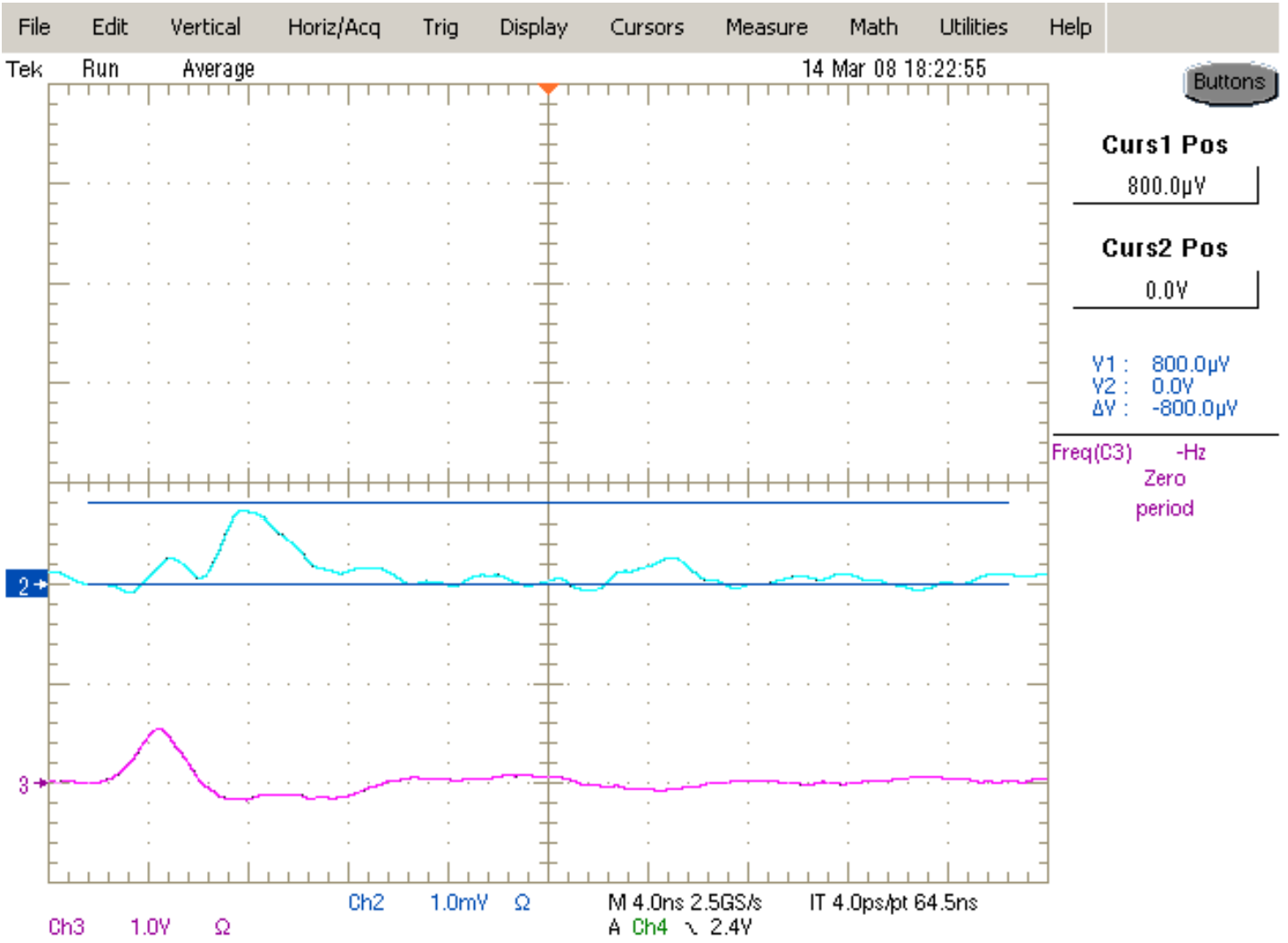
PIN

LED current
1V => 1A

PIN PD response to UVLED

PIN

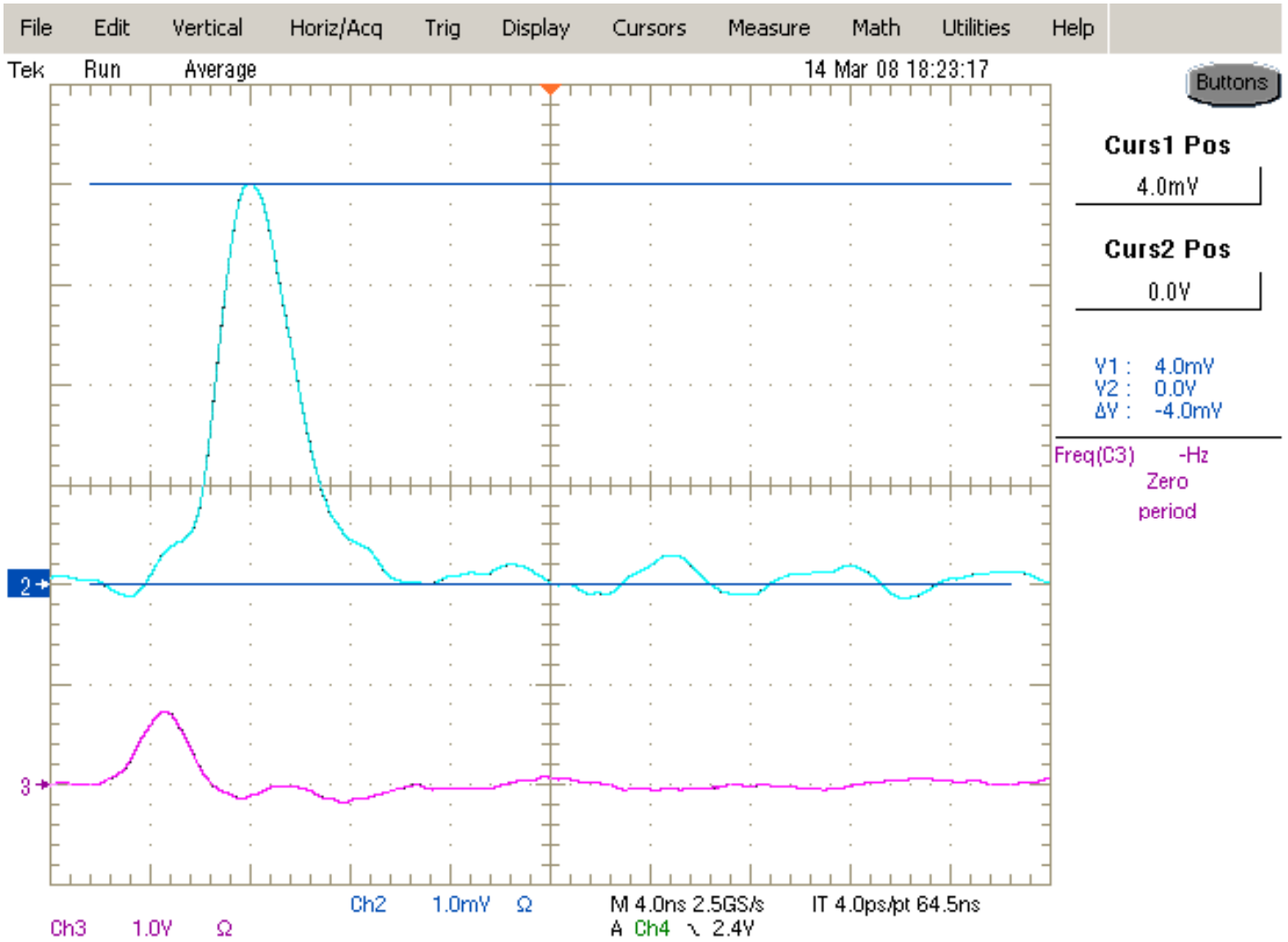
LED current
1V => 1A

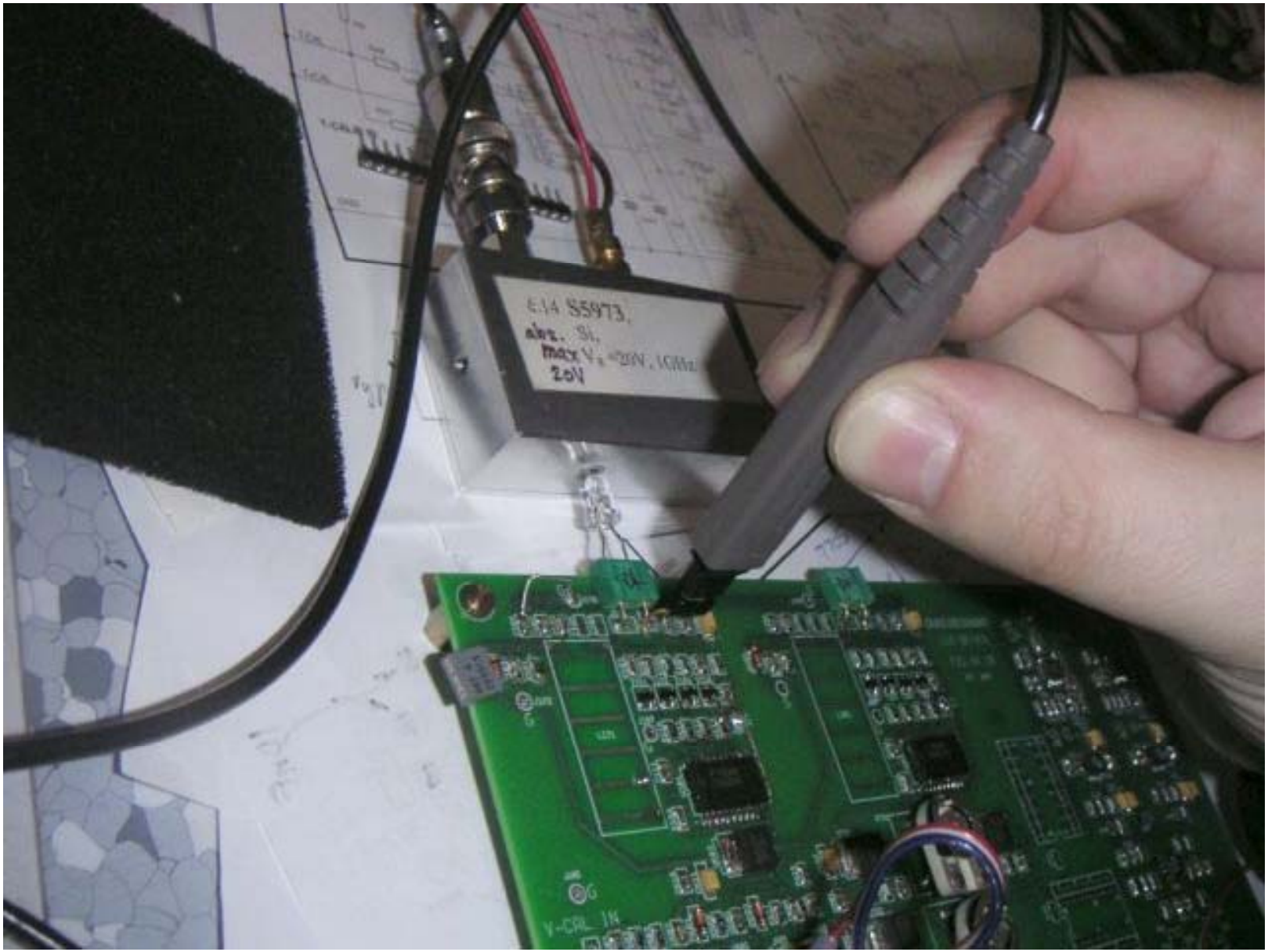


PIN PD response to UVLED

PIN

LED current
1V => 1A



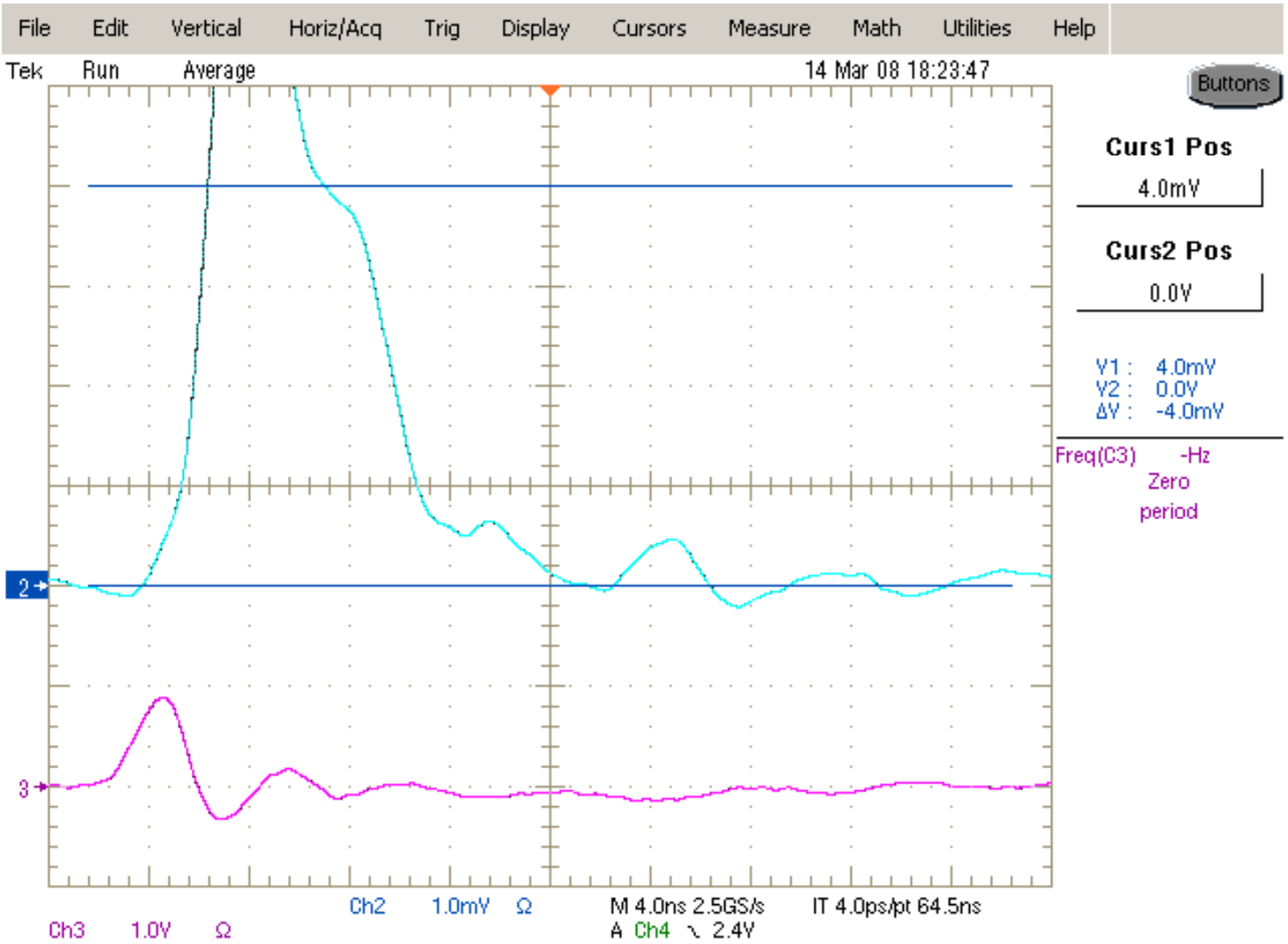

E14 85973.
max V+ =20V, 10Mz
20V

Further increase of the LED amplitude

We see a change of the shape

PIN 1mV/div

LED current
1V => 1A

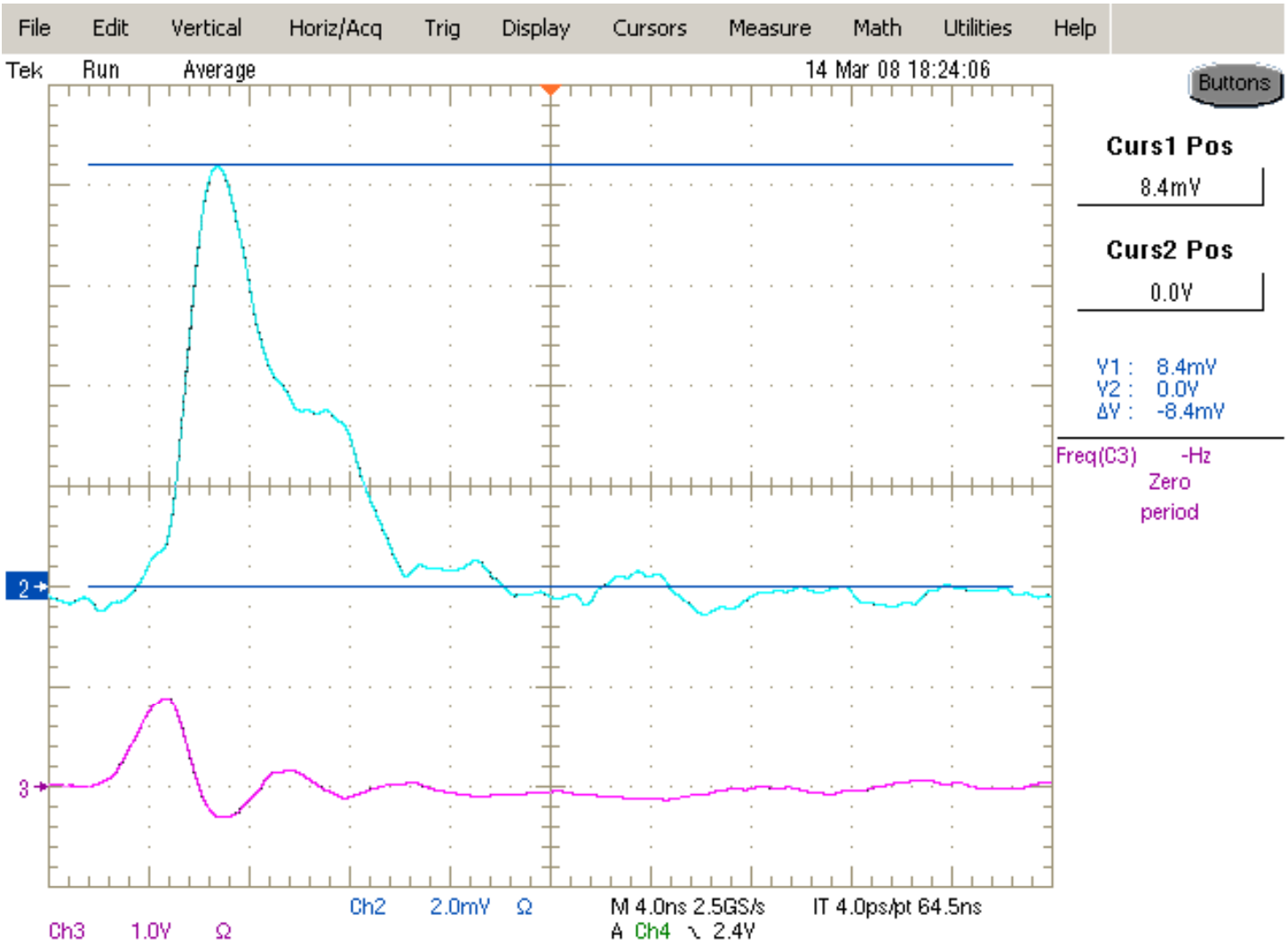


Further increase of the LED amplitude

We see a change of the shape

PIN 2mV/div

LED current
1V => 1A

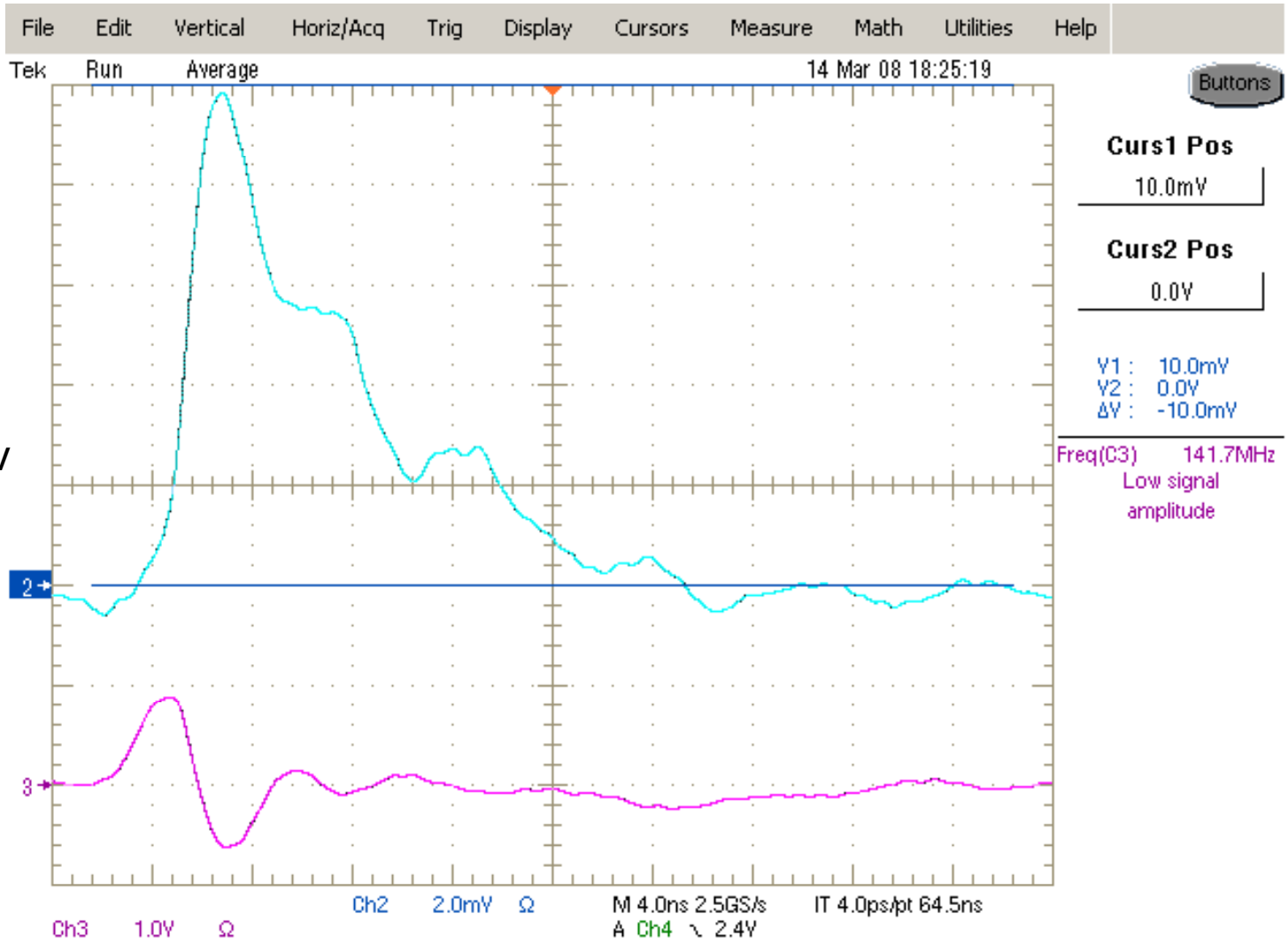


Maximum amplitude of the LED

We see a change of the shape

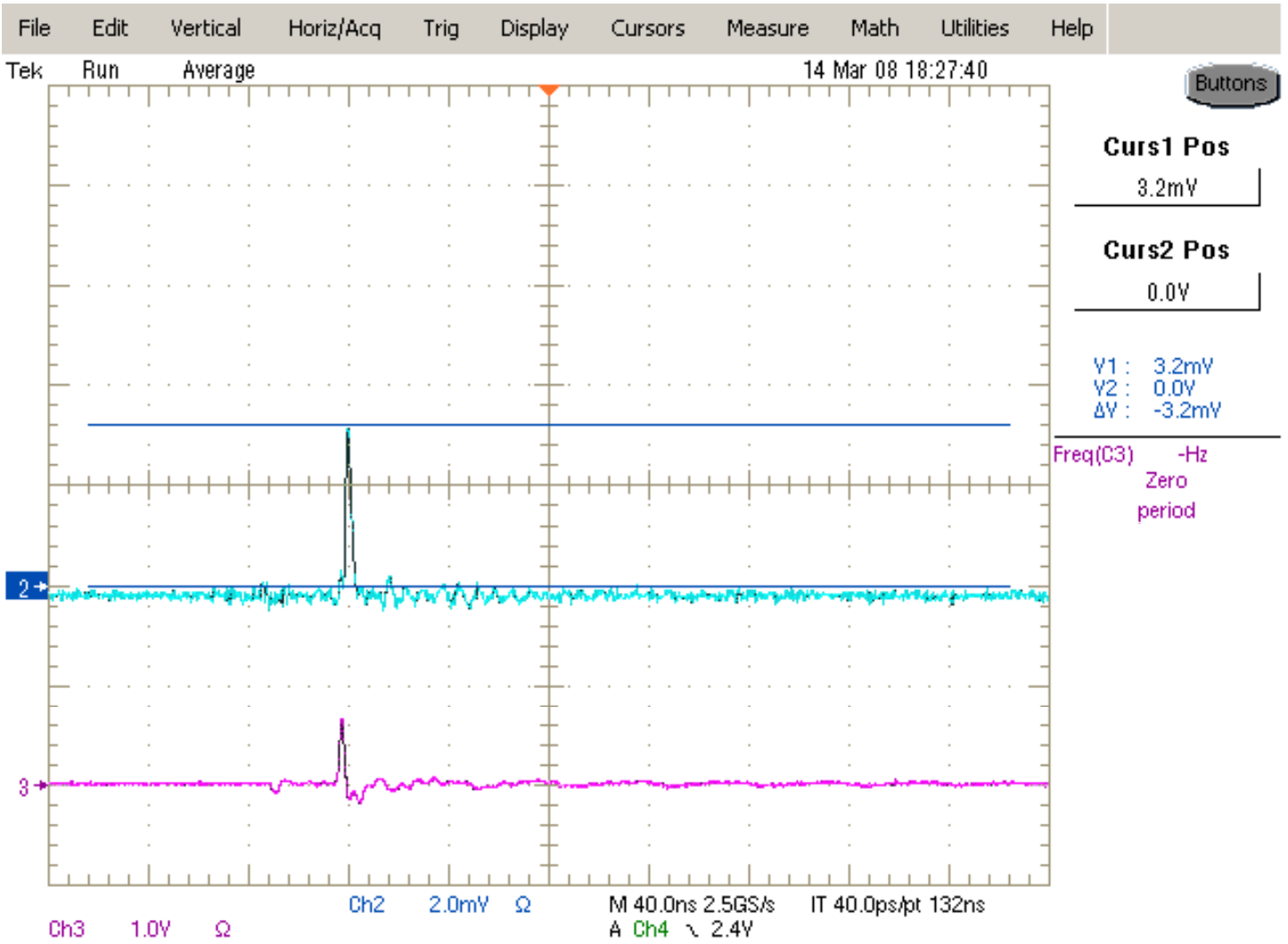
PIN 2mV/div

LED current
1V => 1A



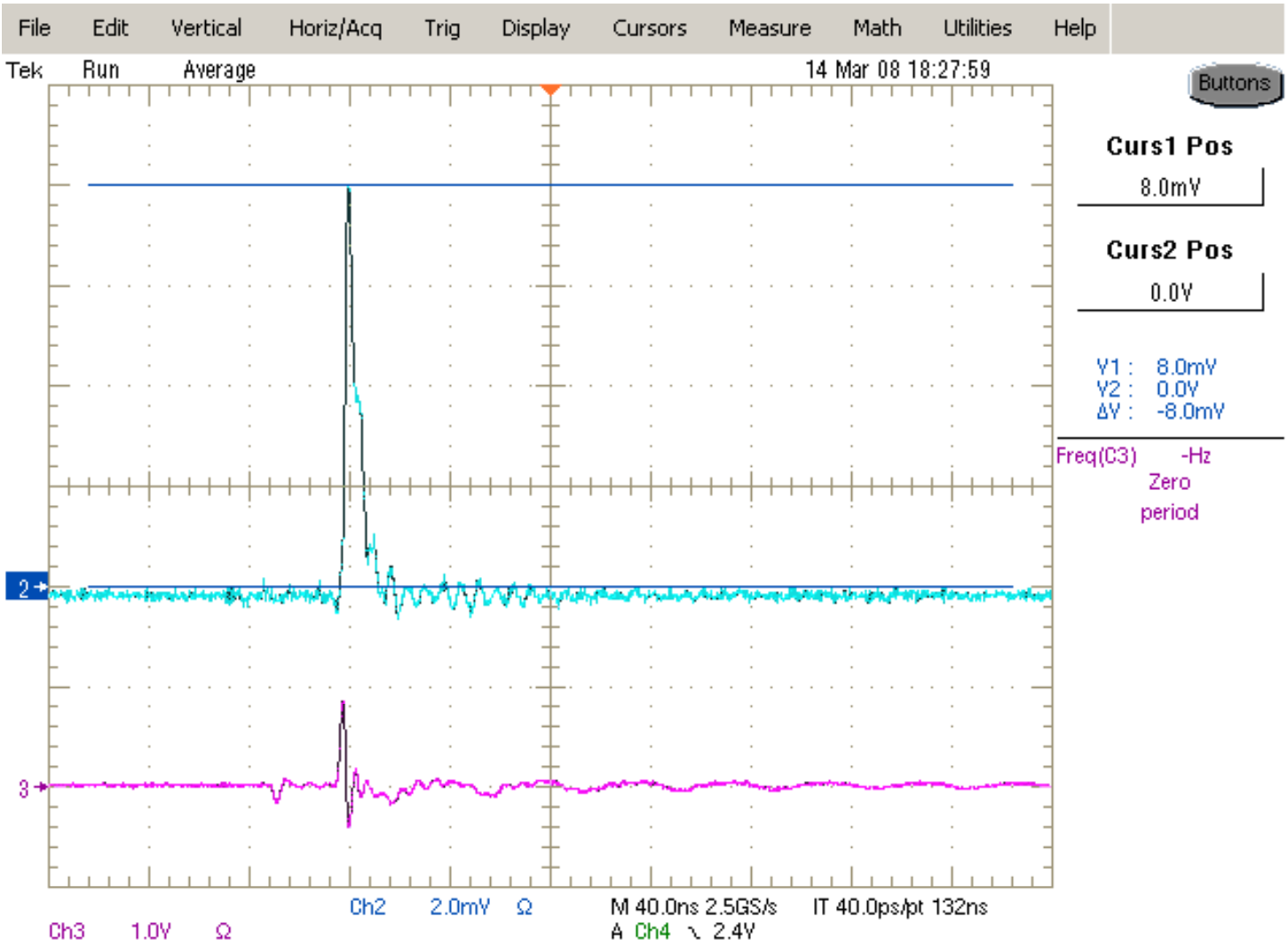
In wider time scale, increase of the amplitude

PIN
2mV/div



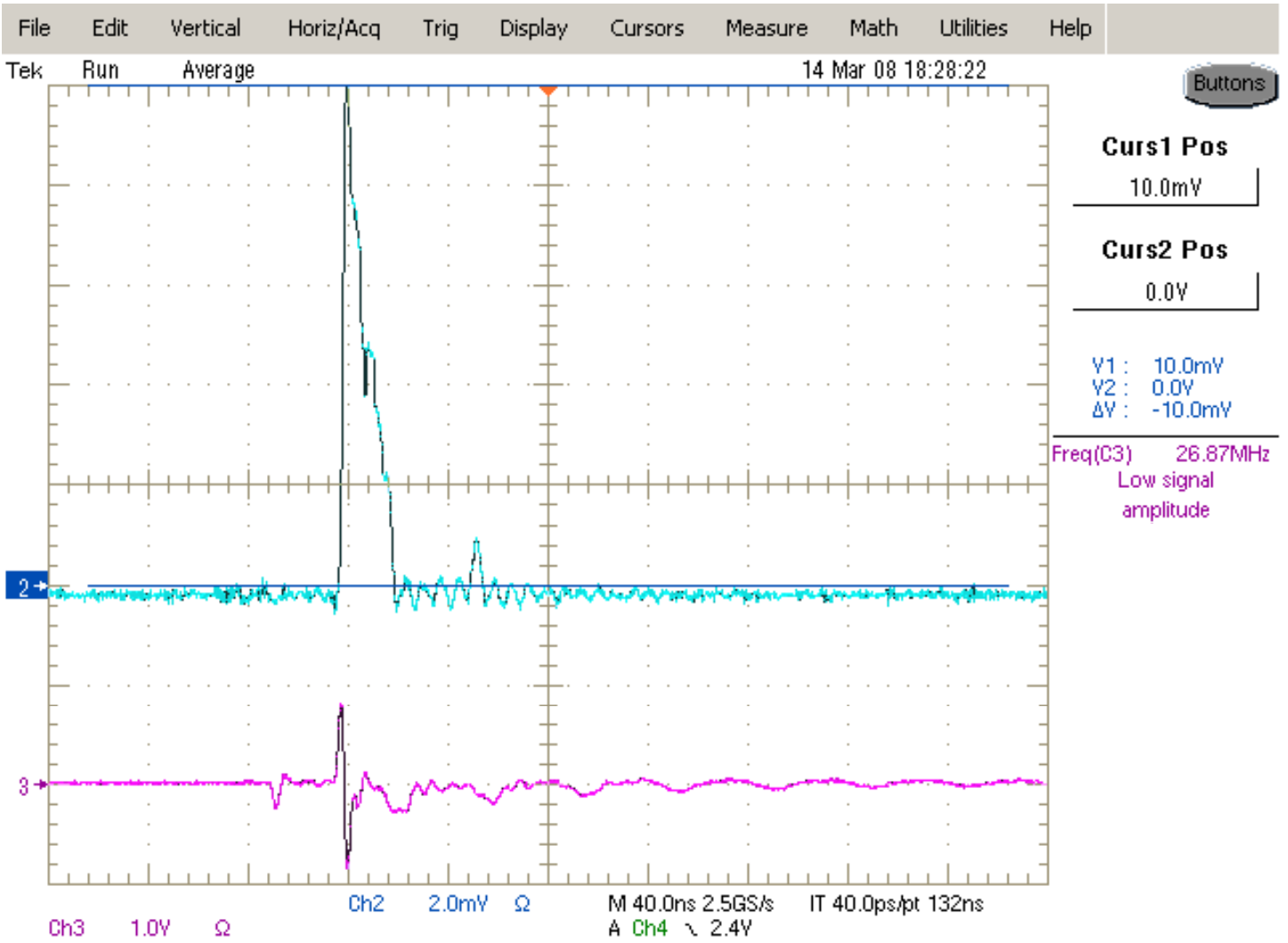
In wider time scale

PIN



In wider time scale

PIN

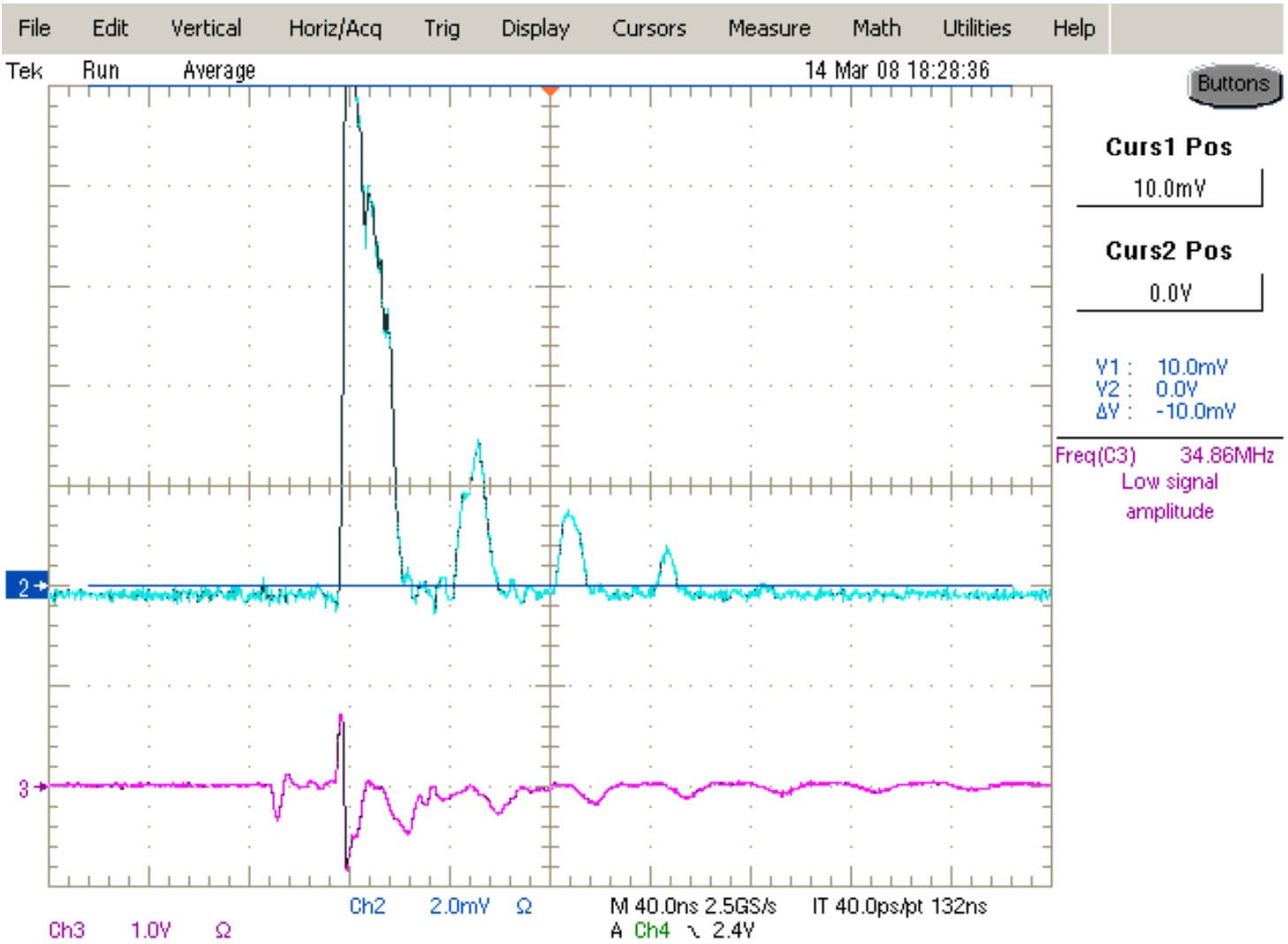


Highest amplitude -> funny distortion

PIN

At this amplitude LED is shining visible ☺

LED current 1V => 1A

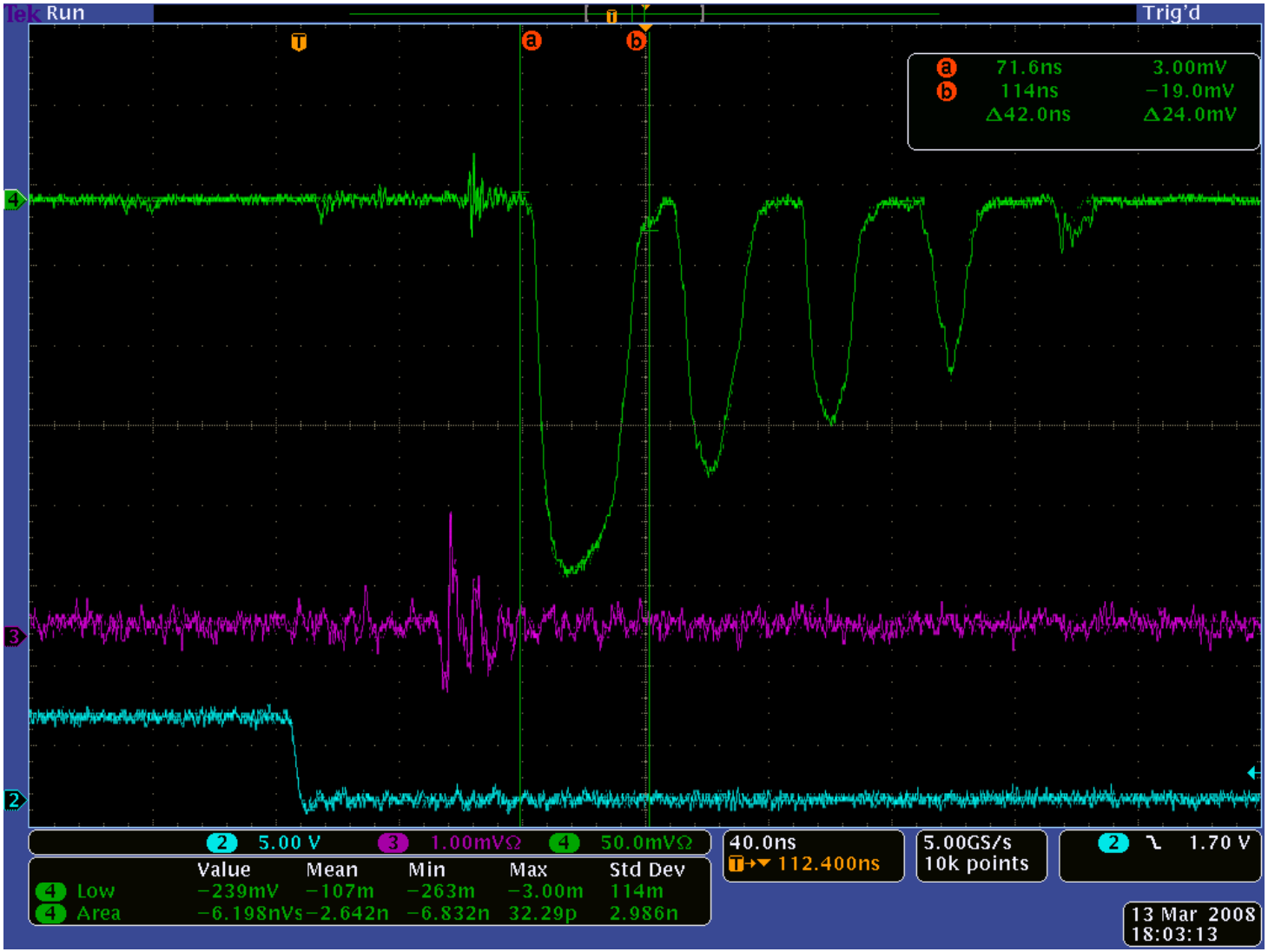


A response to Slower PMT LED is over full power

PMT

LED voltage at cathode

sync

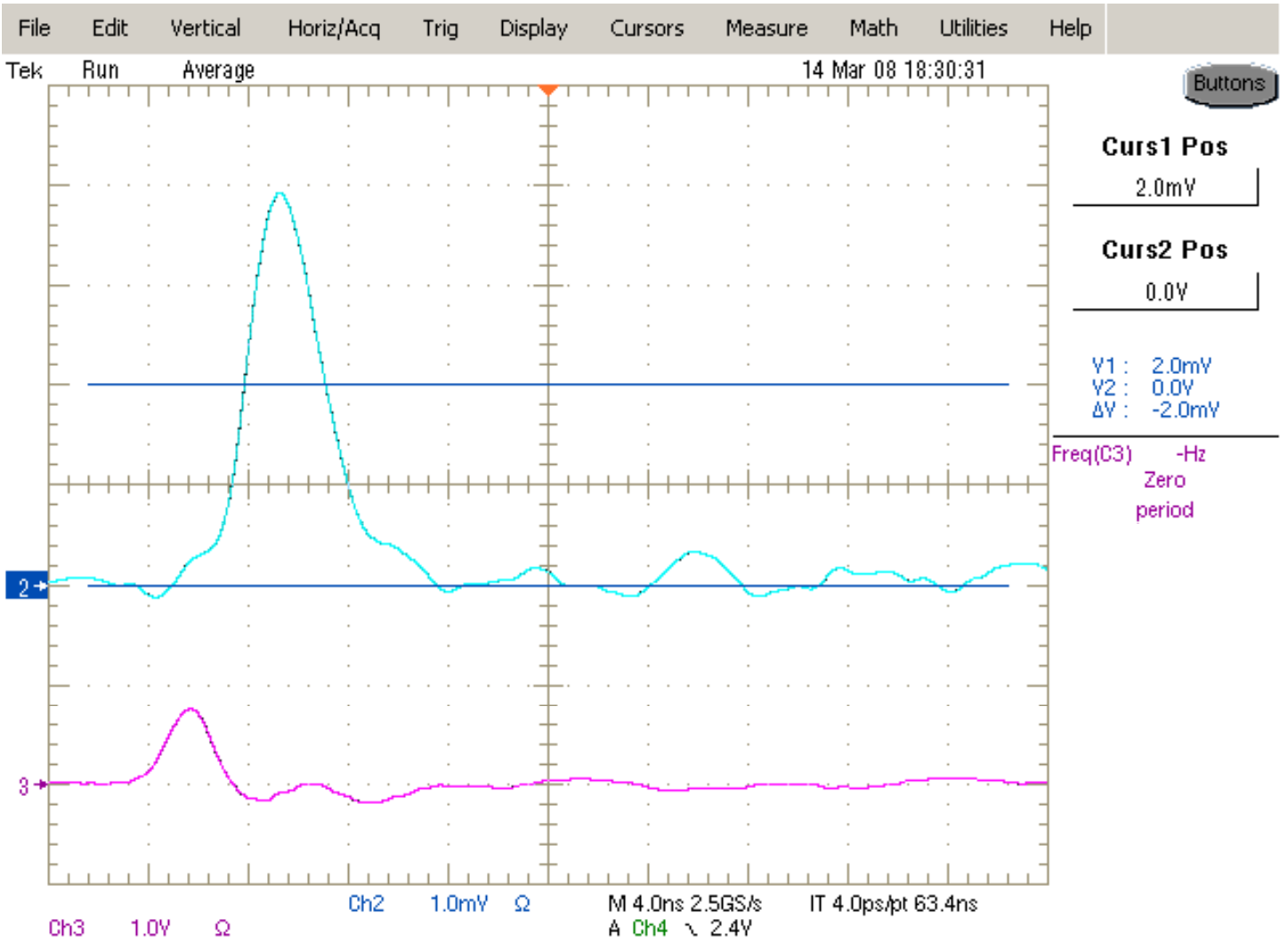


PIN crosstalk test

PIN

Reference amplitude

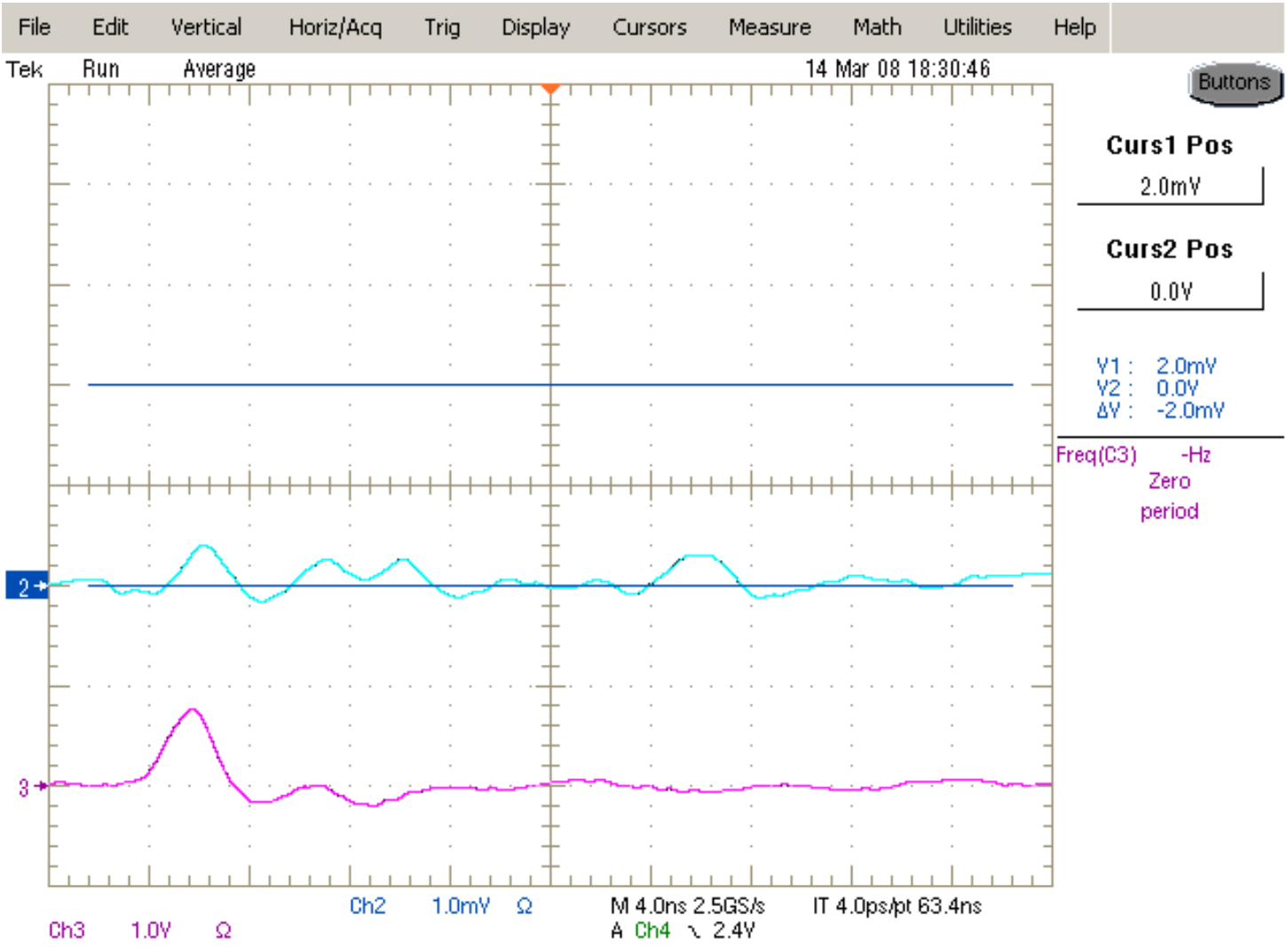
LED current 1V => 1A



Optically shielded, same LED amplitude

Electrical crosstalk to PIN

NO crosstalk



Different LEDs

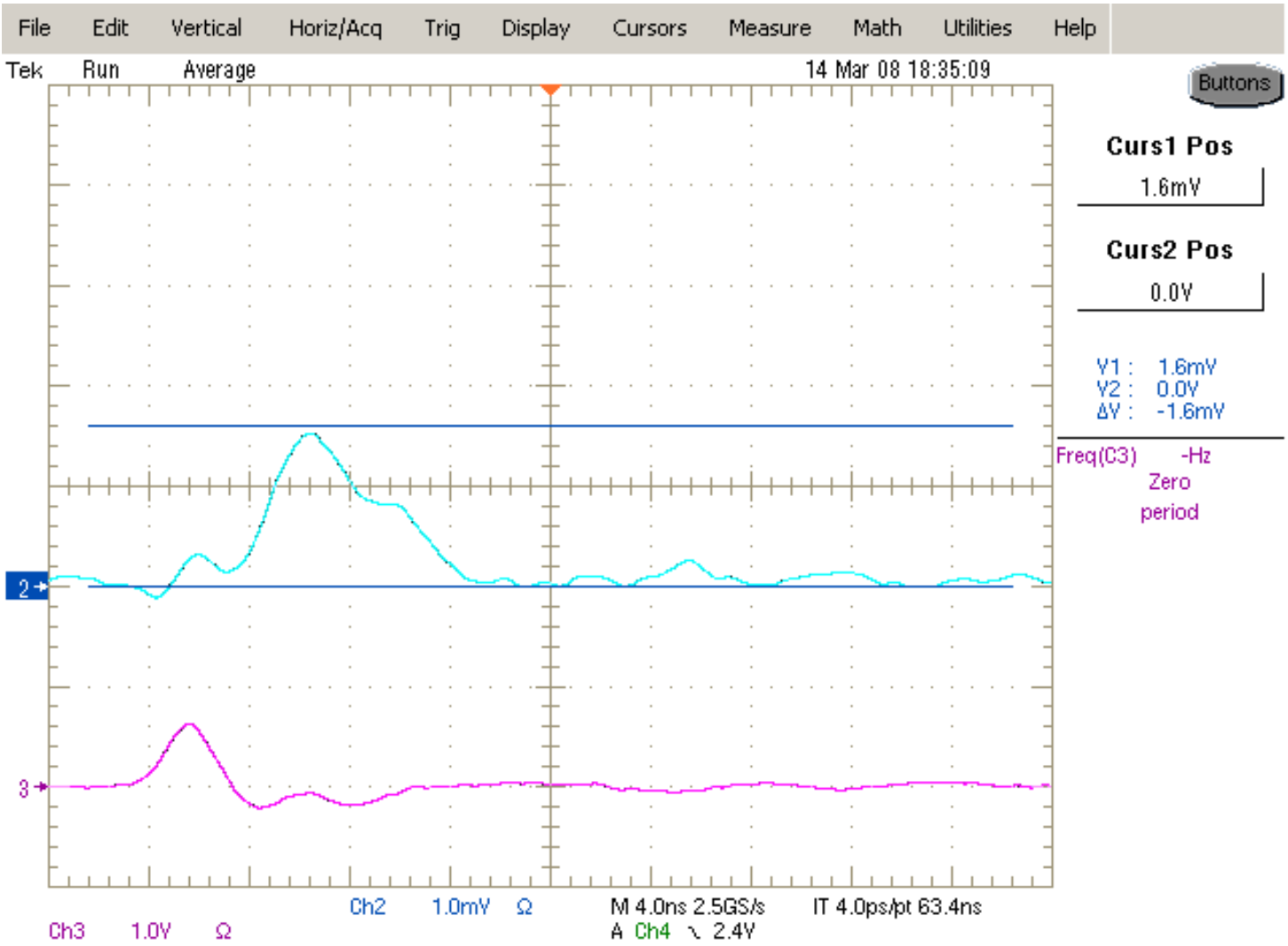
- More different LEDs will be tested
- “PPT UVLEDs” 400nm are very fast!
- One **blue** pioneer has been tested
- Each type of the LED needs a bit of matching of 2 components at QRled driver

Another Blue LED, too slow!

2ns -> 10ns

PIN

LED current
1V => 1A

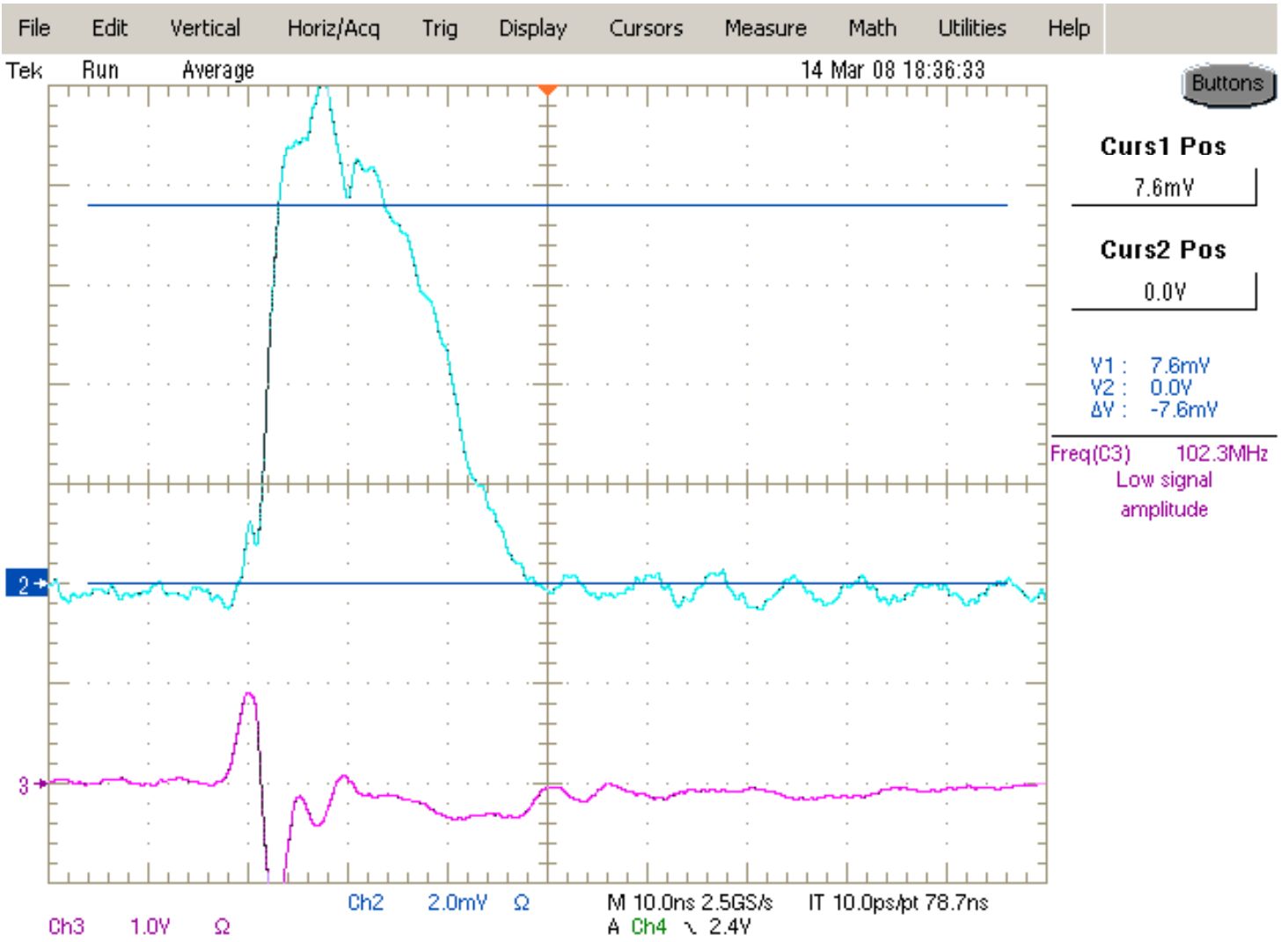


Another Blue LED, too slow!

2ns -> 20ns
Electrical optical

PIN

LED current
1V => 1A

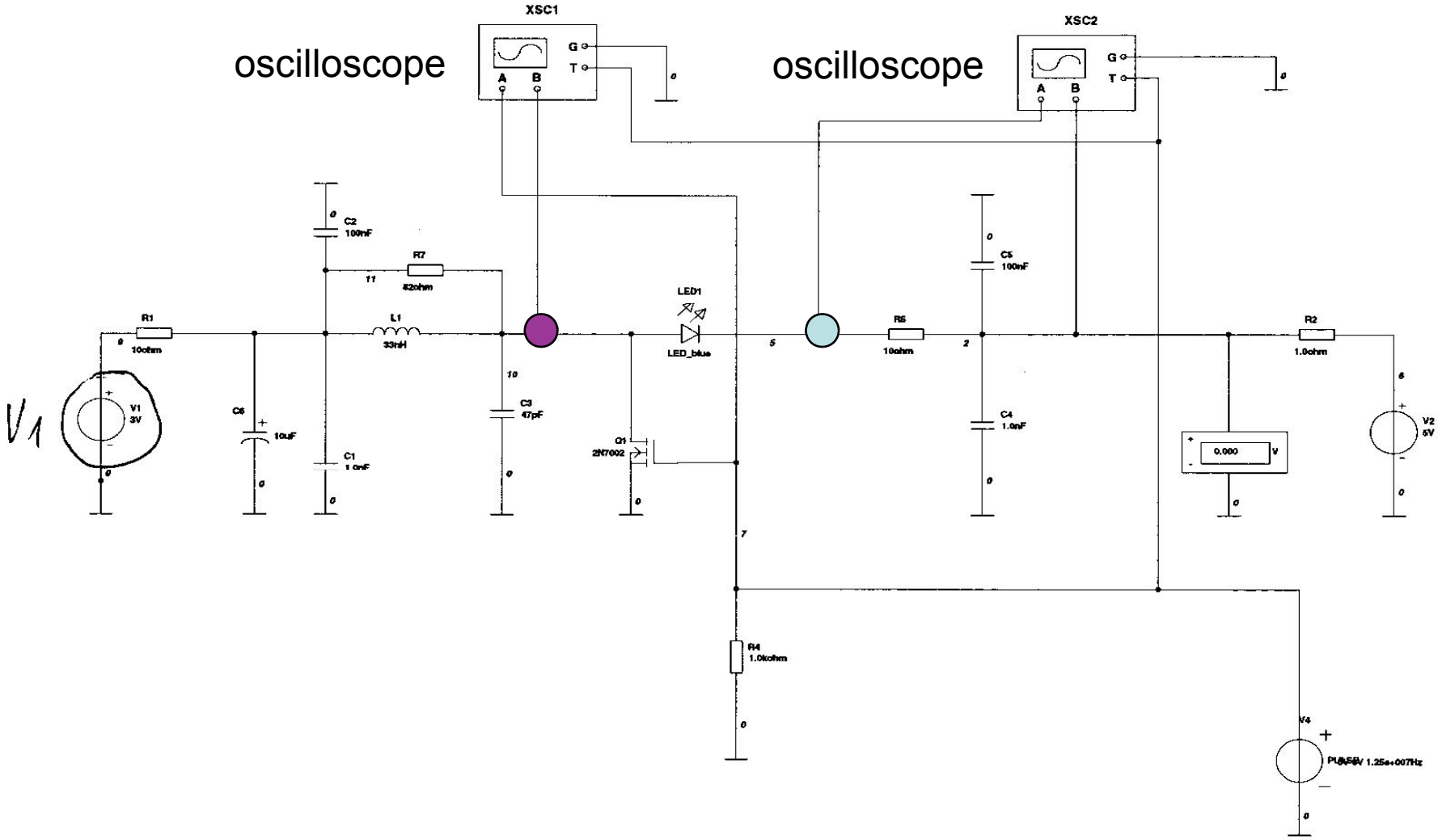


Conclusion

- QR LED driver is very promising technique to reduce Electro-Magnetic-Interferences
- 2 PCBs of the two-channel QR LED driver are ready to further test
- March – linearity test
- April – more assembled PCBs to test
- May – designing of multichannel system with light transfer in side-emitting fibers, first approach to mechanical integration to a new detector design

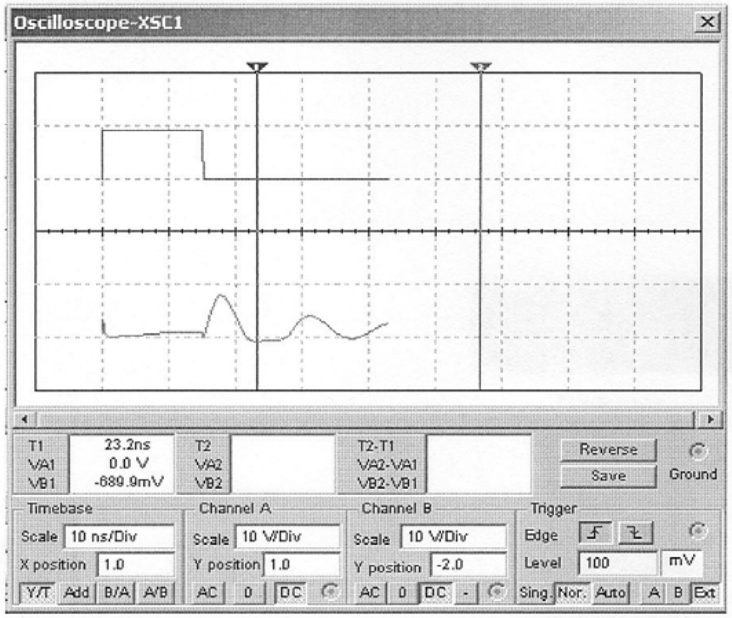
Backup slides

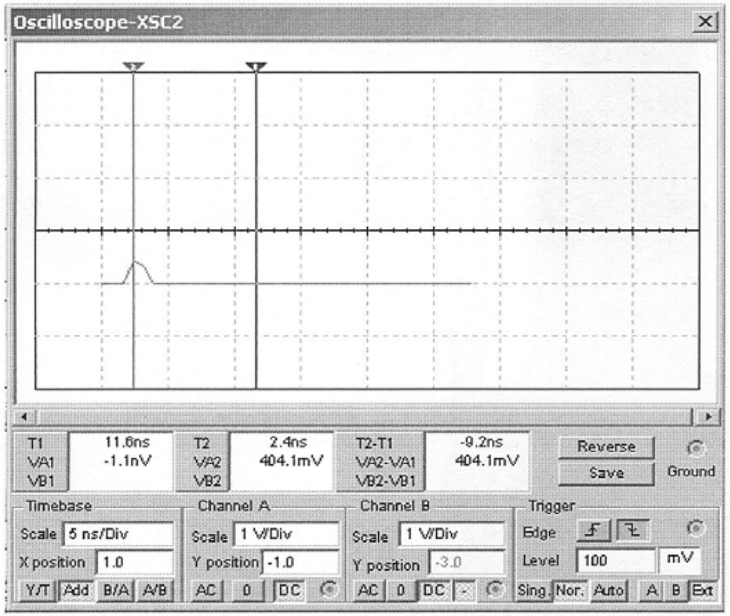
QR LED driver **Simulation**



Simulation at 1.5V amplitude

- XSC1:
- Upper trace - sync pulse
- Lower trace – voltage at LED hot end

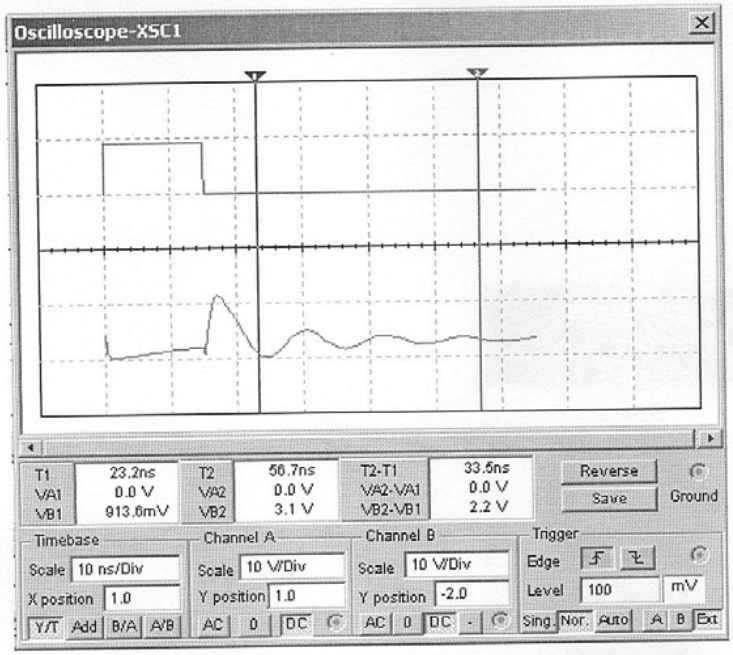




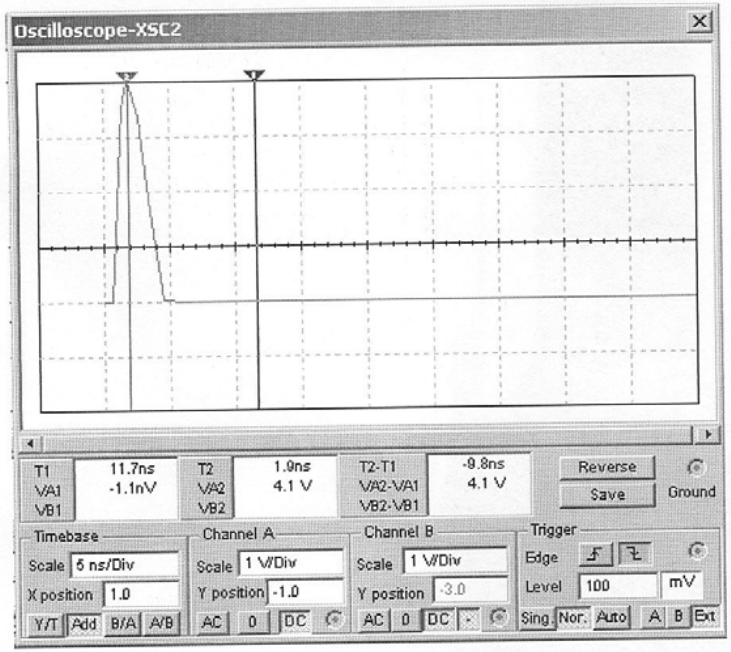
- XSC2: Lower trace LED current

Simulation at 3V

- XSC1:
- Upper trace - sync pulse
- Lower trace – voltage at LED hot end



$V_1 = 3V$

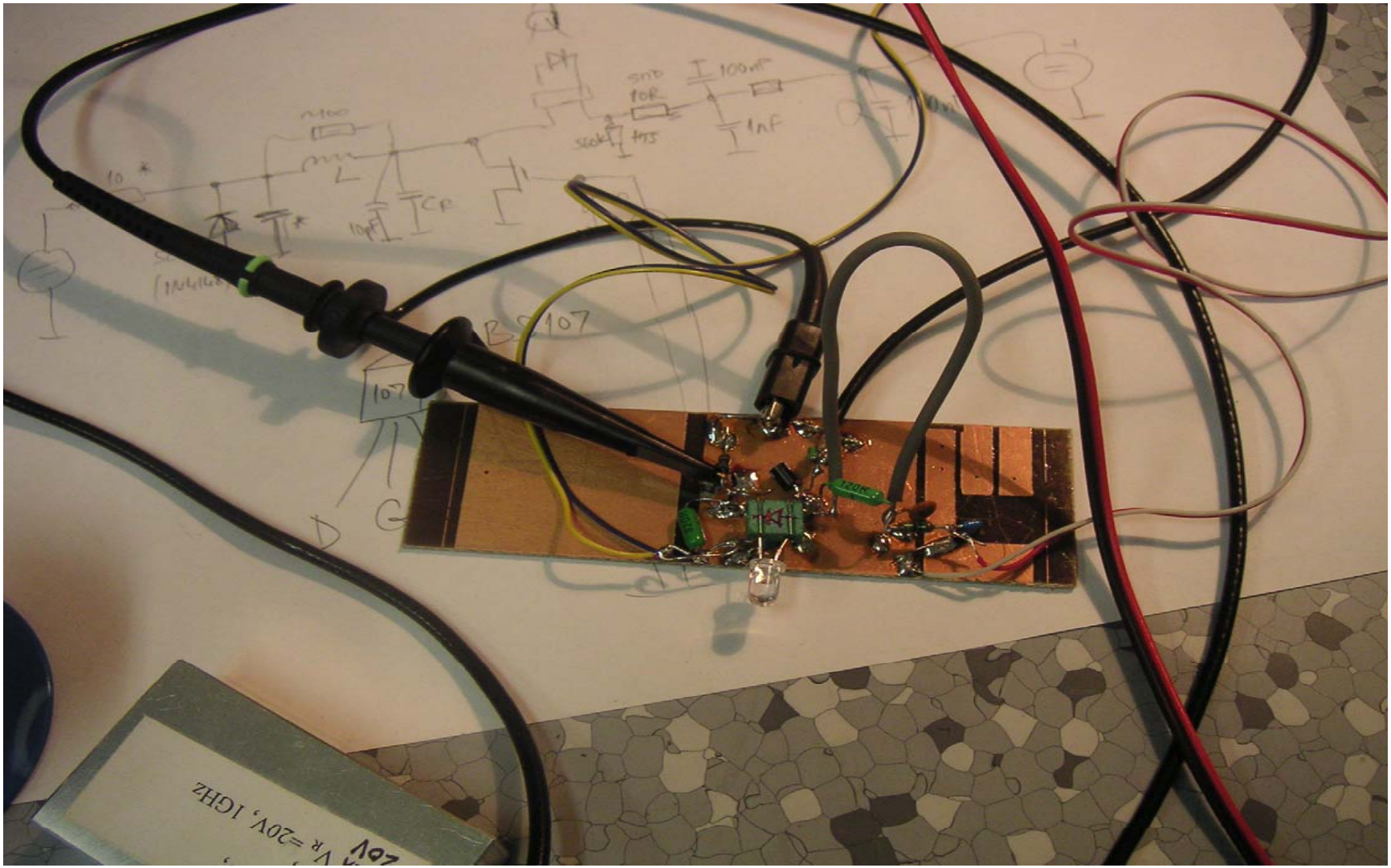


- XSC2: Lower trace LED current

Tests shows more power on LED

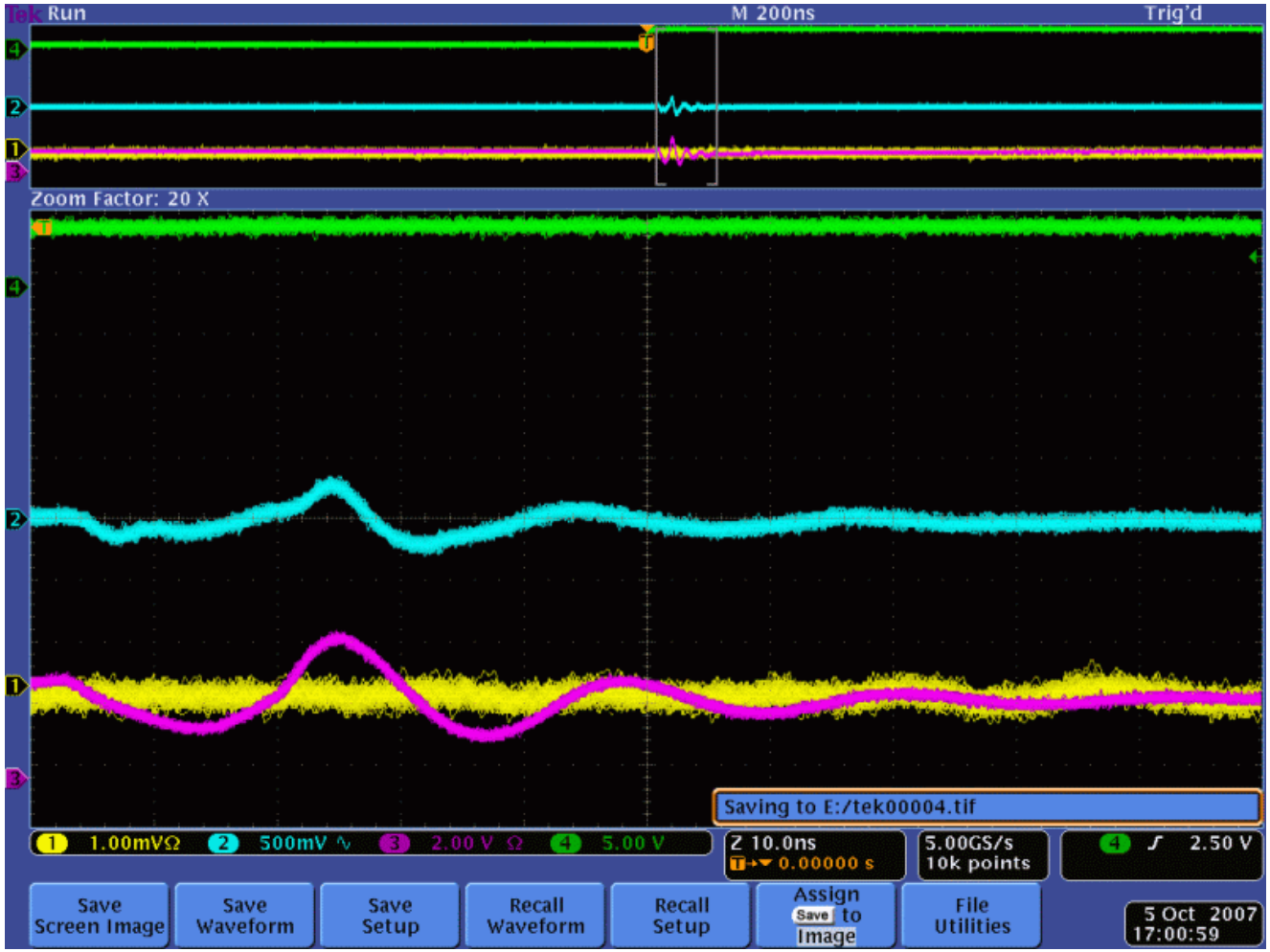
- We see response of PIN photodiode at oscilloscope
- Amplitude up to 2mVpeak @ 50 Ω

Prototype of QR LED driver



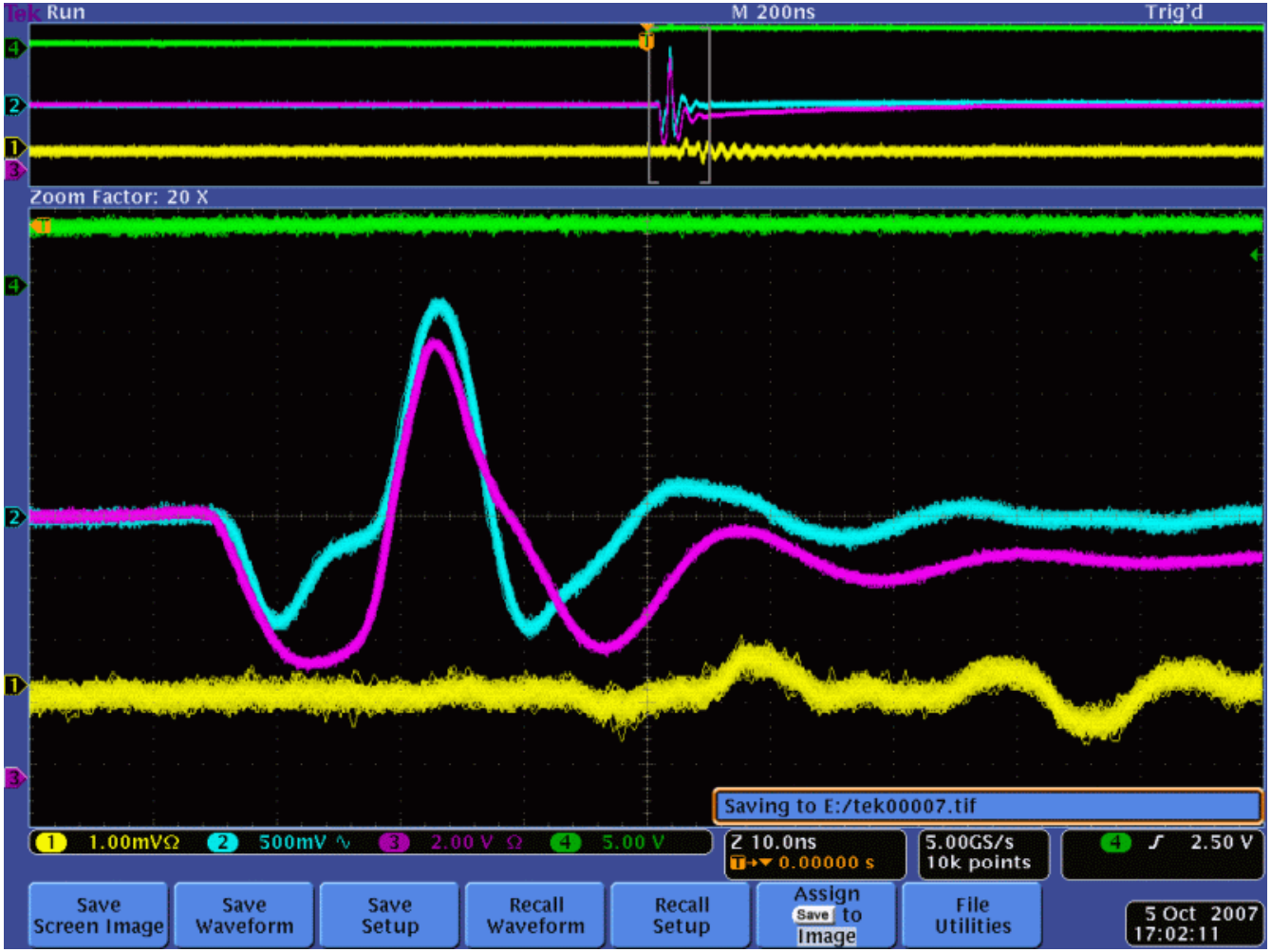
Response to low amplitude at prototype

- **LED current (cyan) (voltage @ 10Ohm)**
- **PIN response (yellow)**
- **LED anode (violet)**



Response to middle amplitude at prototype

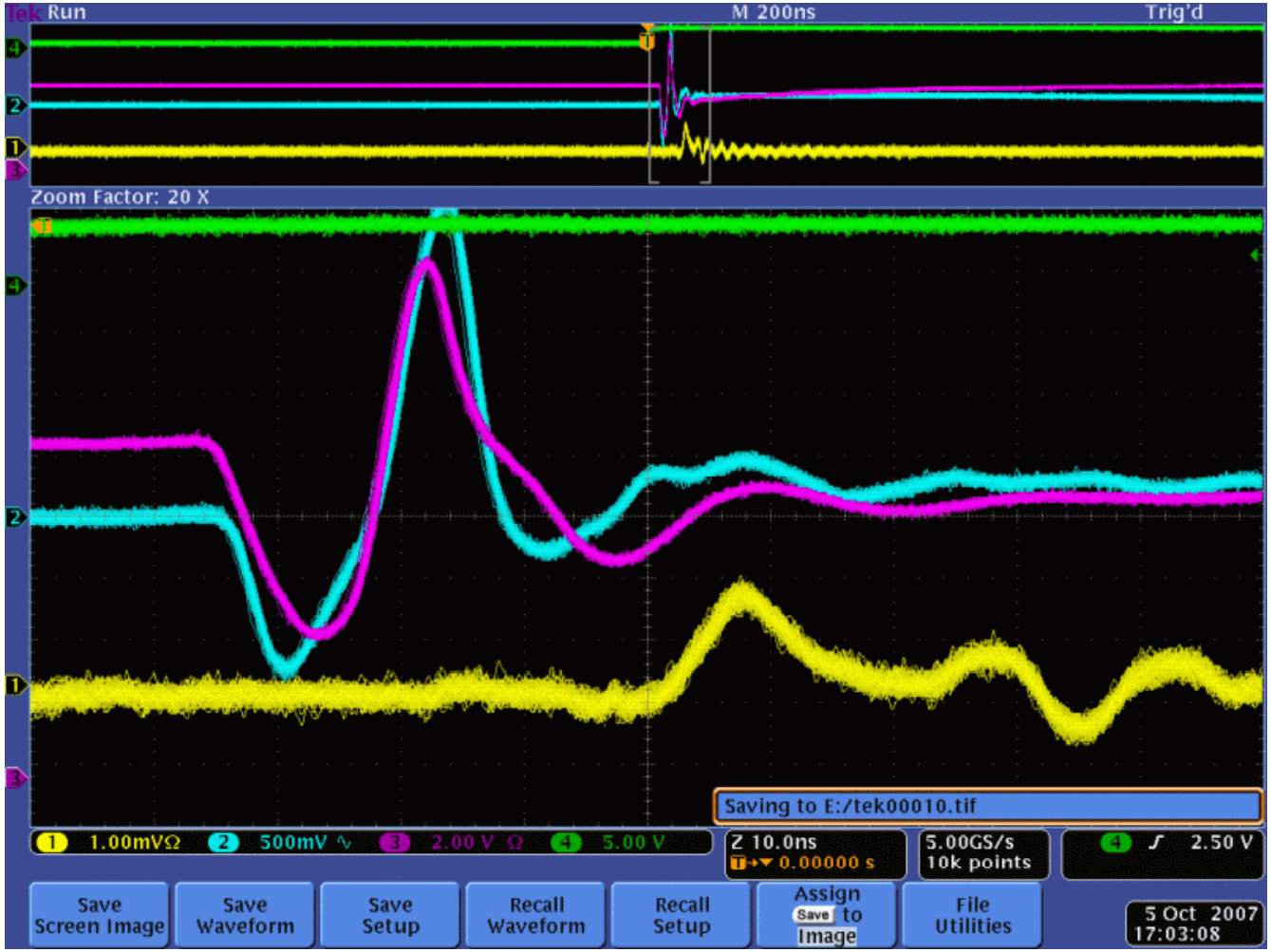
Pulse width
~ 6ns



Response to high amplitude at prototype

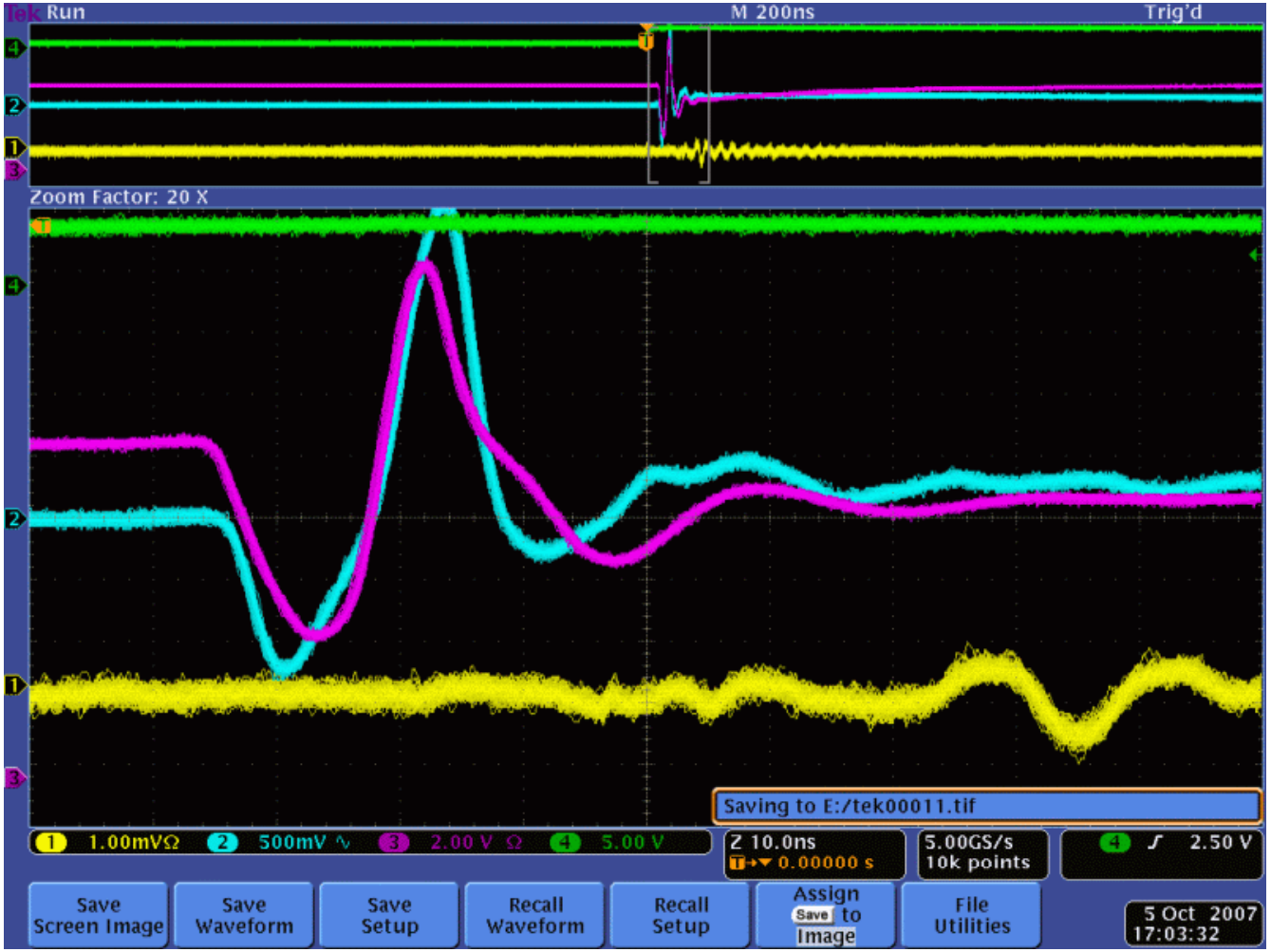
Pulse width
~ 6ns

- **200mA** current at LED

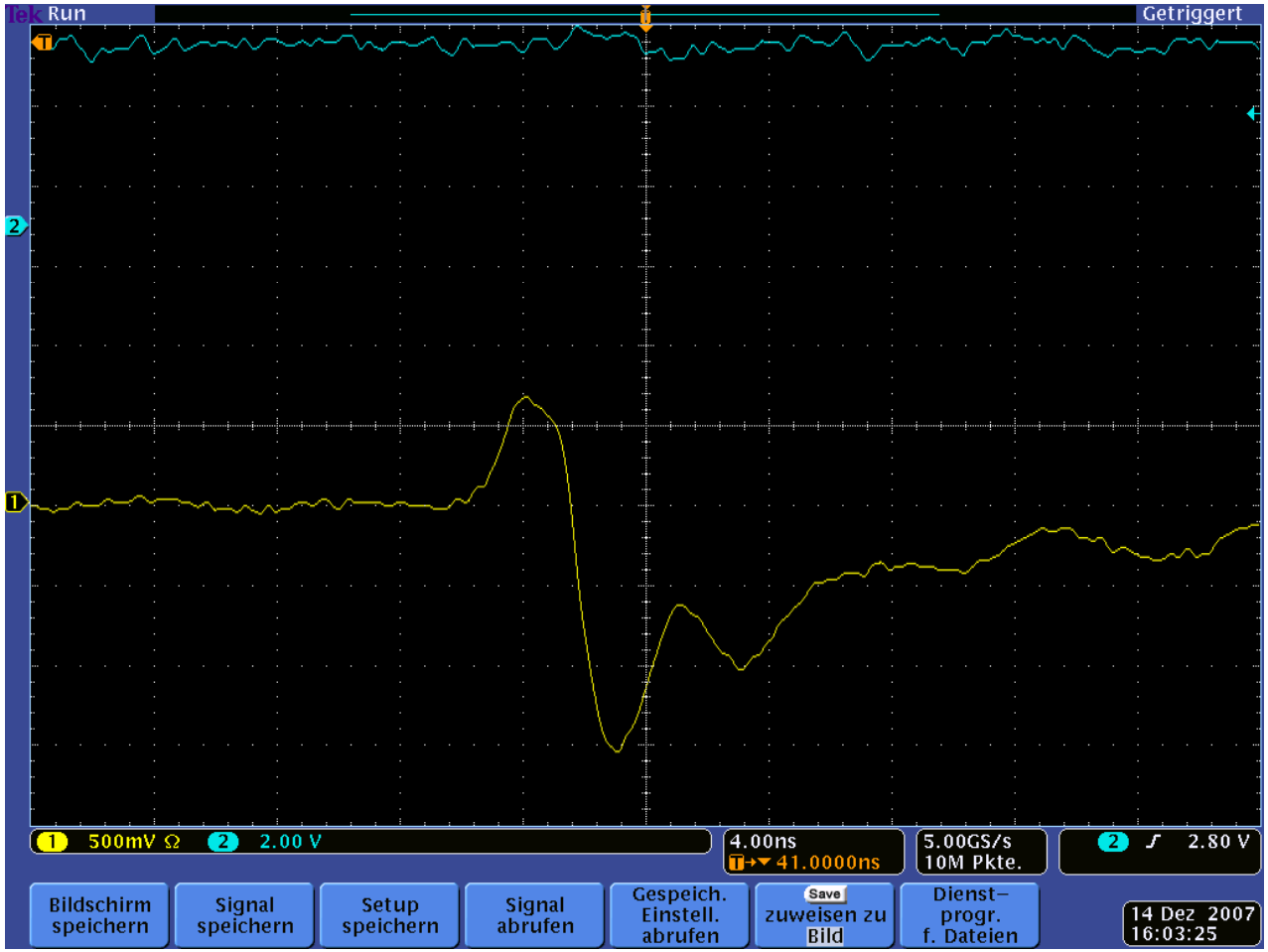


Response to high amplitude at prototype

- The Light from LED was optically blocked to PIN.



LED Current

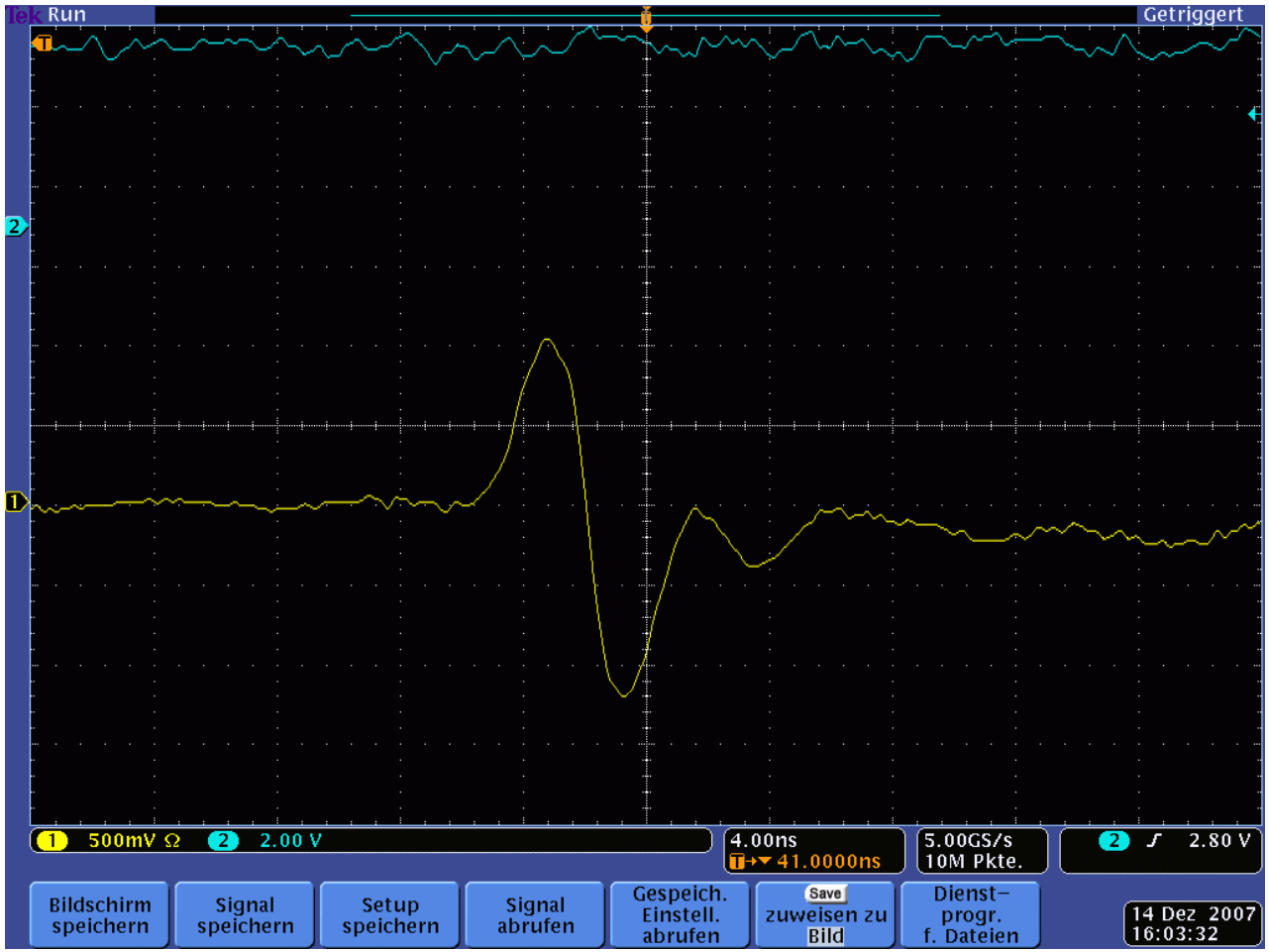


View of the LED pulse for a small amplitude (0.6 A)

Measured with 1GHz voltage differential probe and 1GHz scope TDS4104 at 1Ω smd resistor

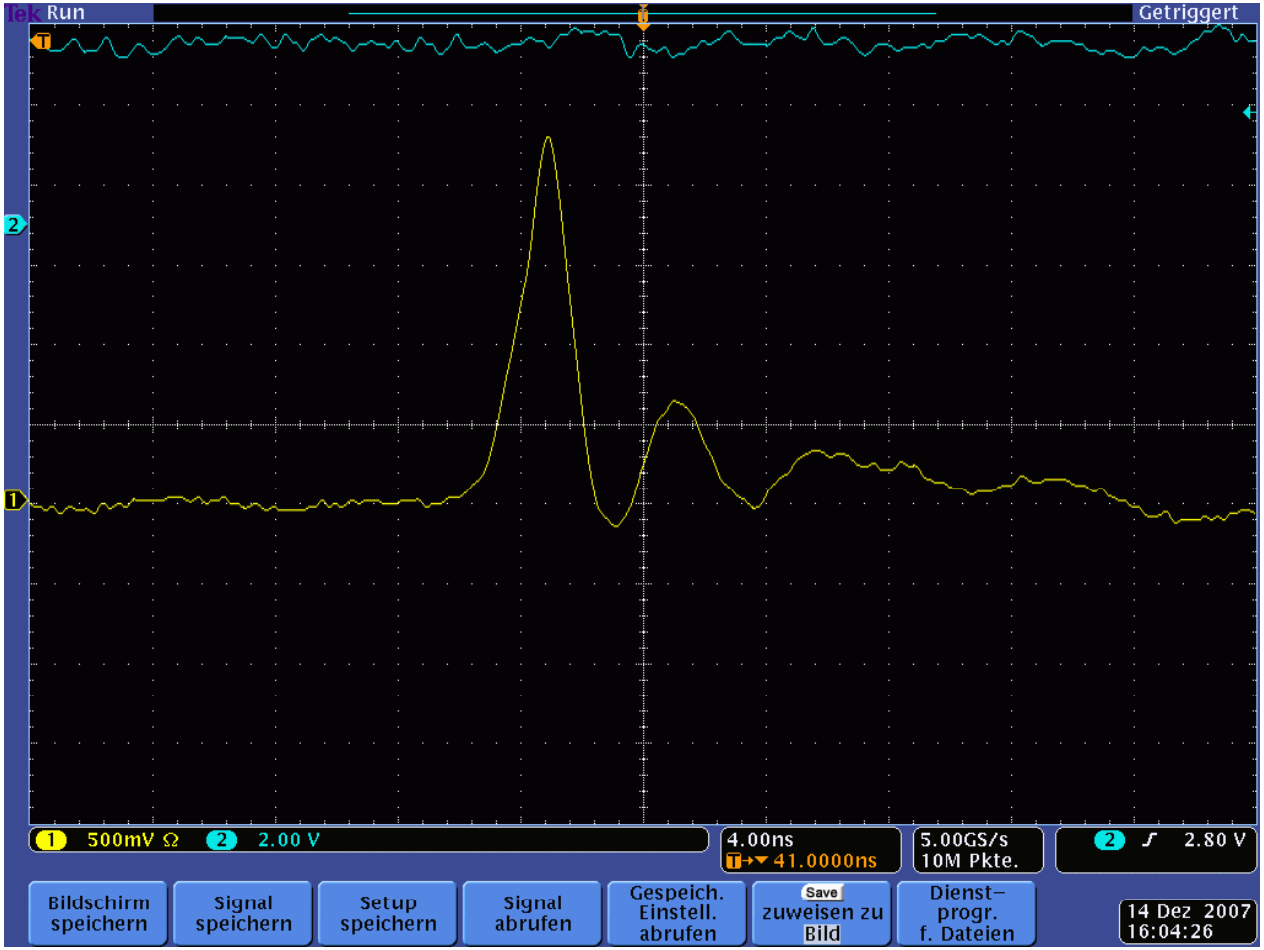
4ns/div 0.5A/div

LED current



- View of the LED pulse for a middle amplitude (1.0 A)
- Measured with 1GHz voltage differential probe and 1GHz scope TDS4104 at 1Ω smd resistor
- 4ns/div 0.5A/div

LED current



- View of the LED current pulse for the highest amplitude (2.3 A)
- Measured with 1GHz voltage differential probe and 1GHz scope TDS4104 at 1Ω smd resistor
- 4ns/div 0.5A/div