FAST PULSE SOURCE FOR FIELD EMISSION APPLICATIONS

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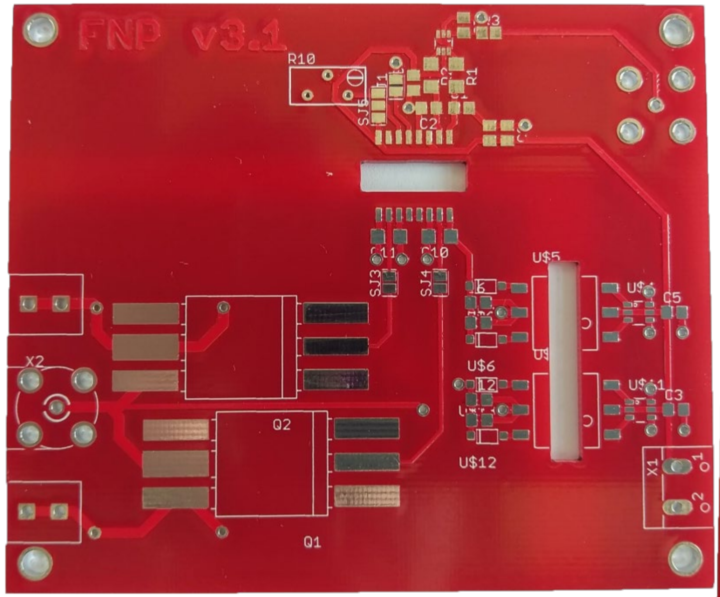
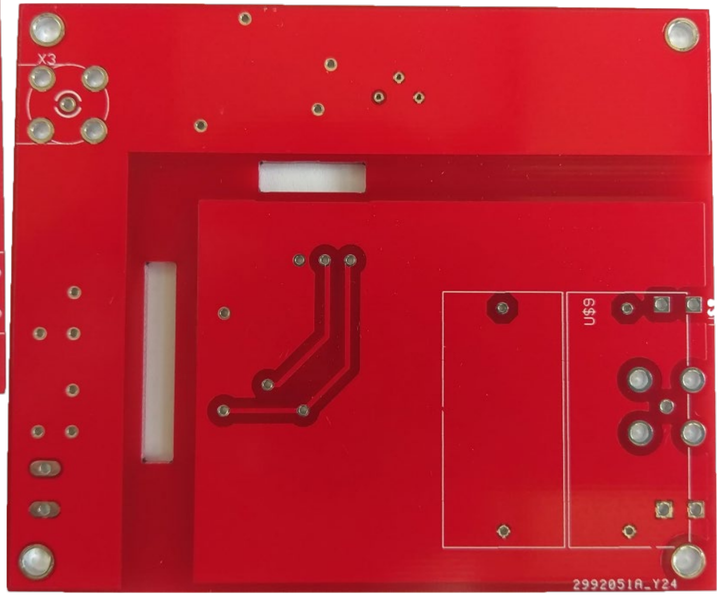
Overview

- **Basics of the electrical circuit**
- **Measurements without load**
  - Test setup
  - Primary side signals
  - Secondary side signal
- **Measurements with load**
  - Test setup
  - Secondary side signals
- **Application measurements (Bayard-Alpert)**
  - Temporal setup, measurements
- **Summary**

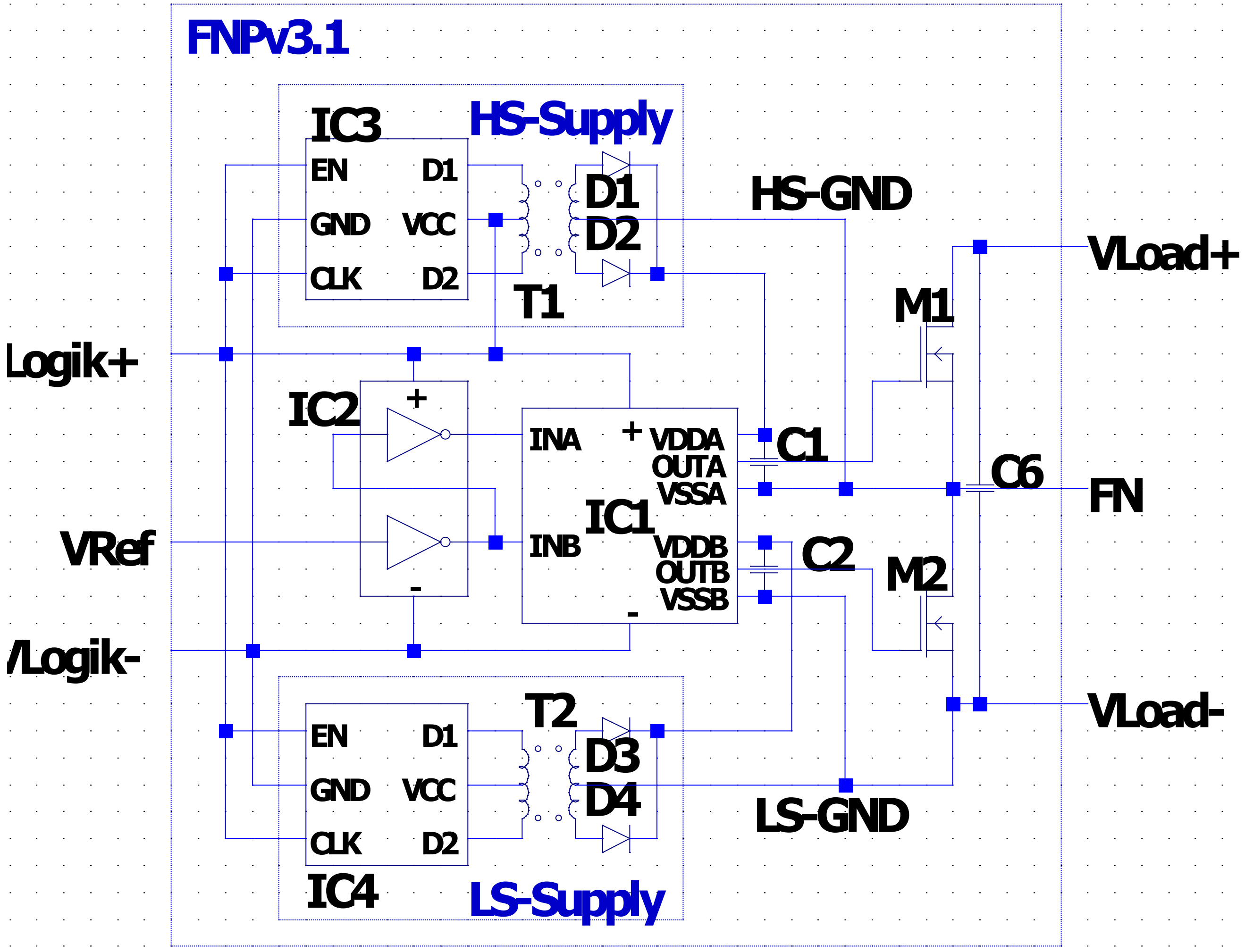


Frontside

Backside

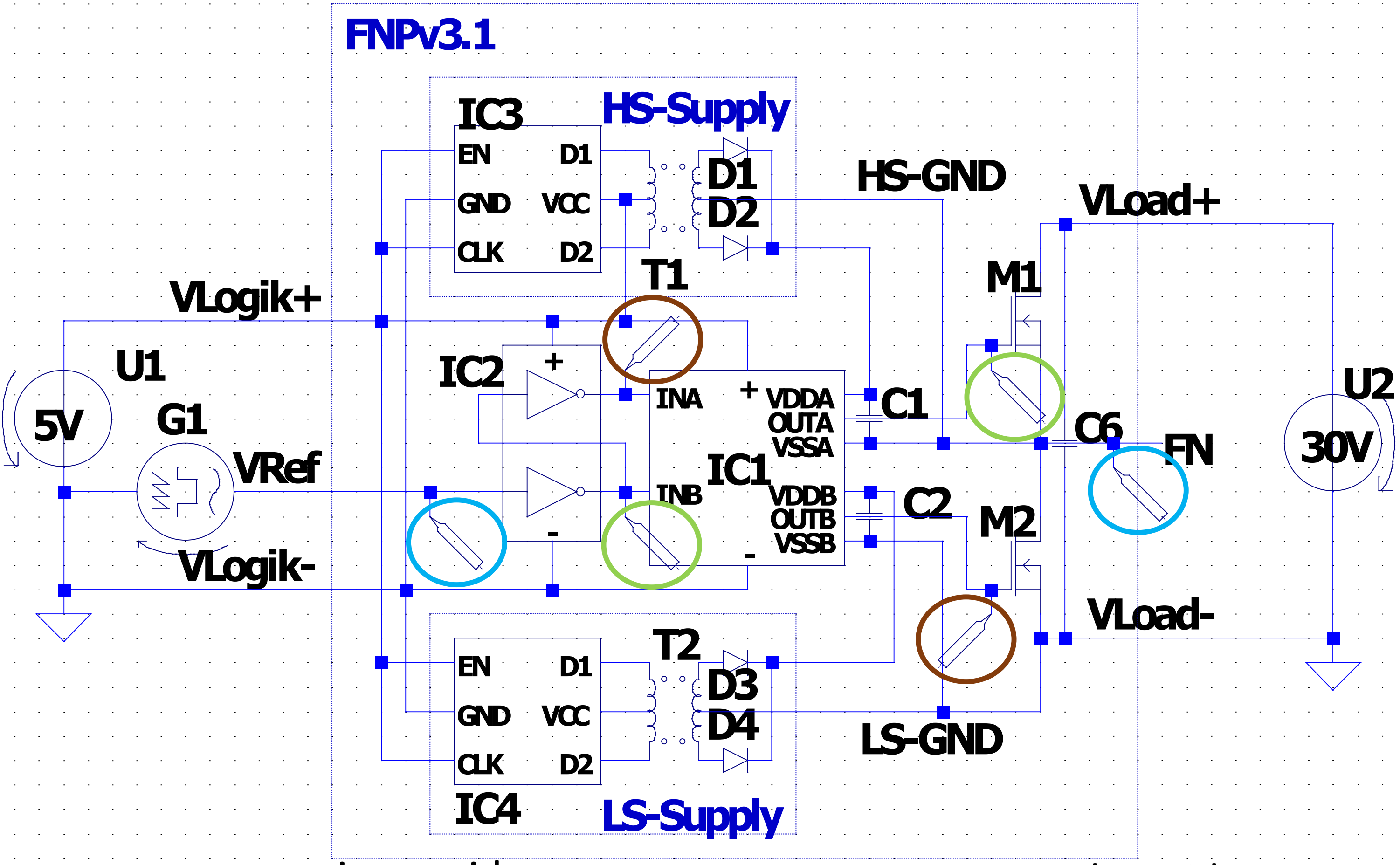


Basics of the electrical circuit



- Supply voltage 5V (V_{Logic})
- Inverter as input-stage
  - Reduced input-amount
  - Provides square waves
  - Signals are temporal aligned
- HS/LS supply by two separate DC/DC-PushPull ciruits
  - Each supply-output can float up to 3kV over 1 minute
  - Enables the circuit to turn on the HS-FET without temporal limitation
- Gatedriver
  - Outputs can float up to 5700V over 1 minute (compared to primary side)
  - Isolation allows potential differences of up to $1500V_{DC}$ between secondary-side channels
- HS/LS MOSFETs
  - V_{DS} up to 1000 V_{DC}
  - Low $R_{DS(on)}$ ($\lessapprox 8\Omega$)

Measurements without load
Test-setup



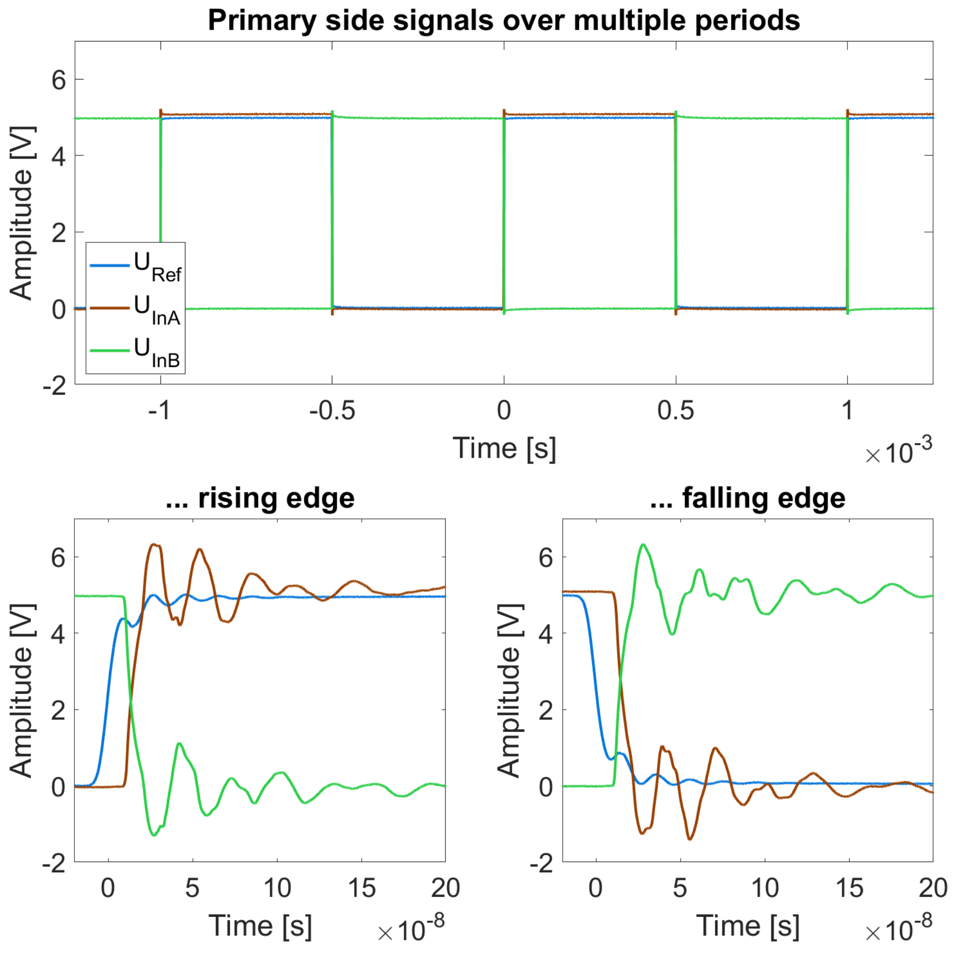
primary side
low voltage/logic

secondary side
load voltage/switching elements

List of testconditions:

- DC Powersupply for V_{logic} ($5V_{DC}$)
- Signal generator for V_{Ref} (5V square-wave)
- DC Powersupply for V_{Load} ($30V_{DC}$)
  - Due to $\tau = R \cdot C \neq f(U)$ it's valid to test the output stage with small load-voltages
- Oscilloscope needle-probes for measuring the time dependent signals

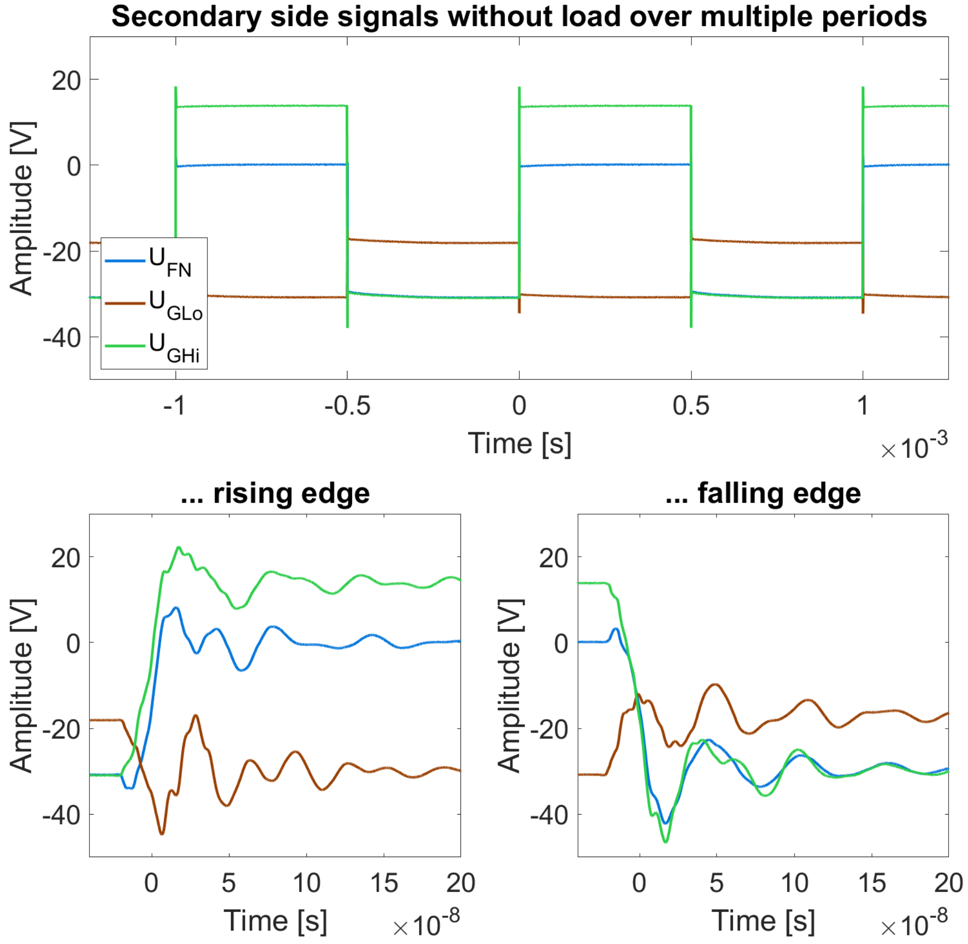
Measurements without load
Primary side signals



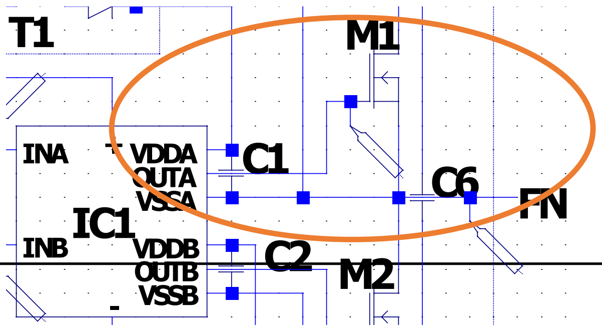
Primary side signals (gatedriver reference)	
Inverterlevel	0V; 5V
U_{Ref} (10-90%)	24.88 ns
U_{Ref} (90-10%)	25.62 ns
U_{GLo} (10-90%)	9.27 ns
U_{GLo} (90-10%)	9.33 ns
U_{GHi} (90-10%)	8.75 ns
U_{GHi} (10-90%)	8.91 ns

➔ Inverter speeds up incoming V_{Ref} signals and provides temporal aligned contrary square waves

Measurements without load
Secondary side signals

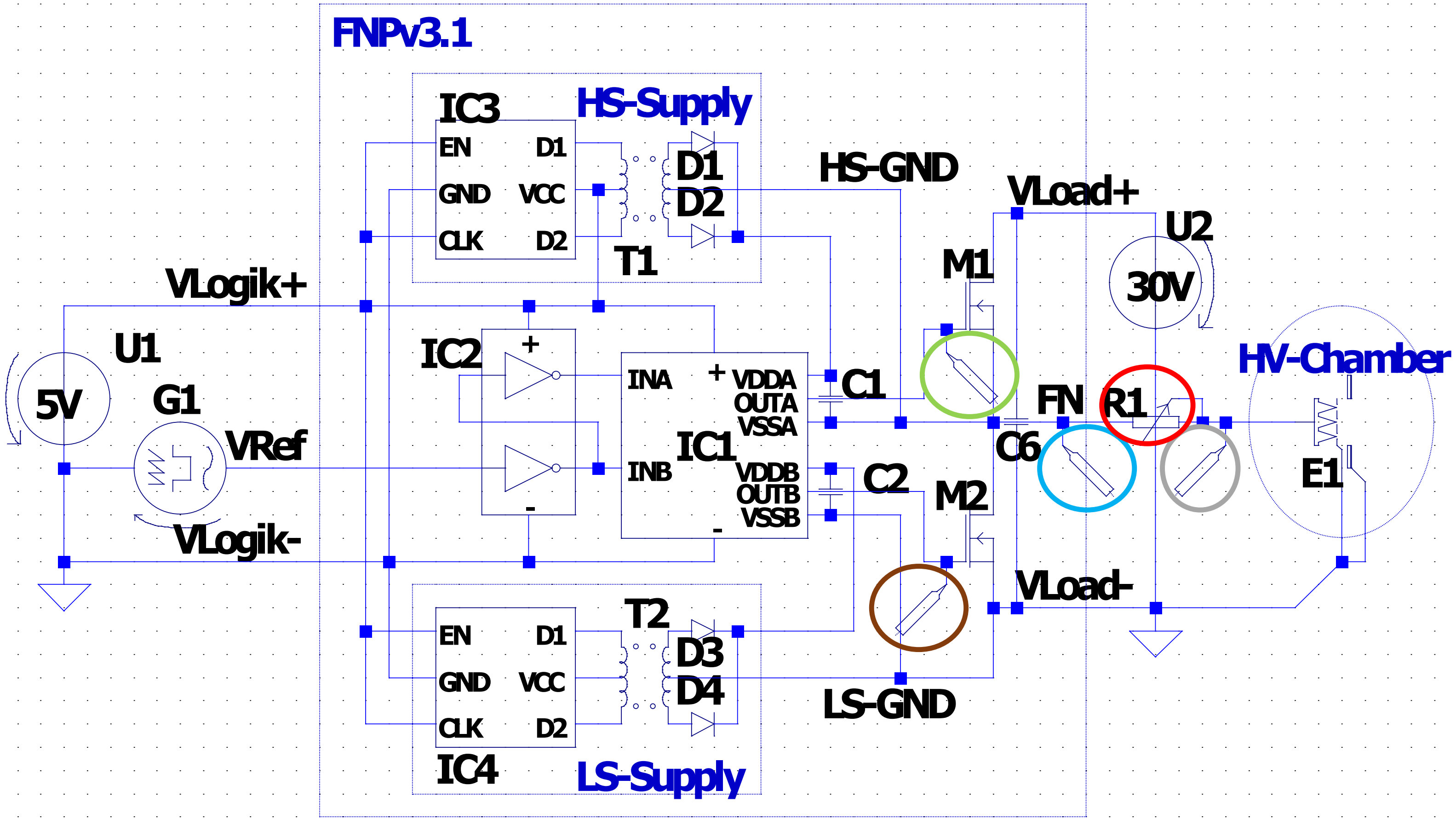


Secondary side signals (gatedriver output)	
Supply-levels	0V; -30V
U_{FN} (10-90%)	10.44 ns
U_{FN} (90-10%)	11.52 ns
U_{GLo} (10-90%)	5.67 ns
U_{GLo} (90-10%)	6.17 ns
U_{GHi} (90-10%)	-
U_{GHi} (10-90%)	-



- ➔ Output can be switched within ≈10ns
- ➔ HS-Gate not easy measureable due to affecting it's own reference potential

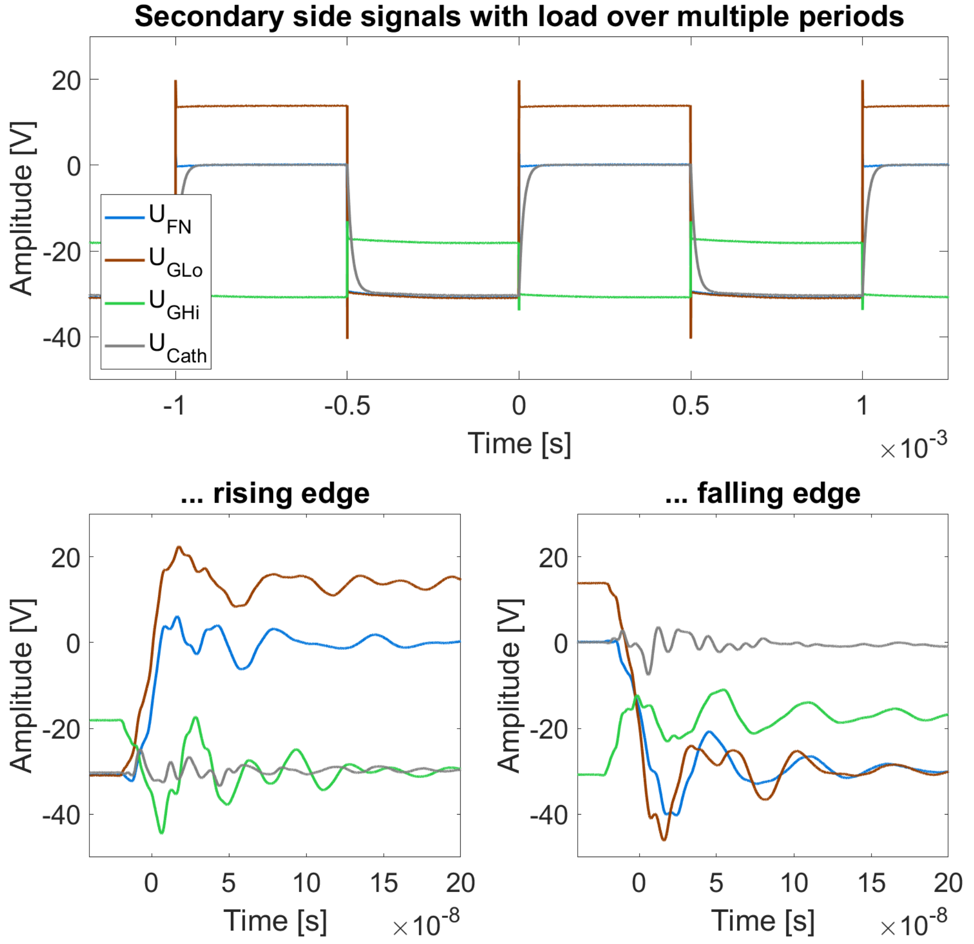
Measurements with load
Test-setup



List of testconditions (gray = not changed):

- DC Powersupply for V_{logic} ($5V_{DC}$)
- Signal generator for V_{Ref} (5V square-wave)
- DC Powersupply for V_{Load} ($30V_{DC}$)
  - Due to $\tau = R \cdot C \neq f(U)$ it's valid to test the output stage with small load-voltages
- Oscilloscope needle-probes for measuring the time dependent signals
- Cathode connected to FN via a potentiometer (damping overshoots)
- 4th needle-probe for cathode-voltage

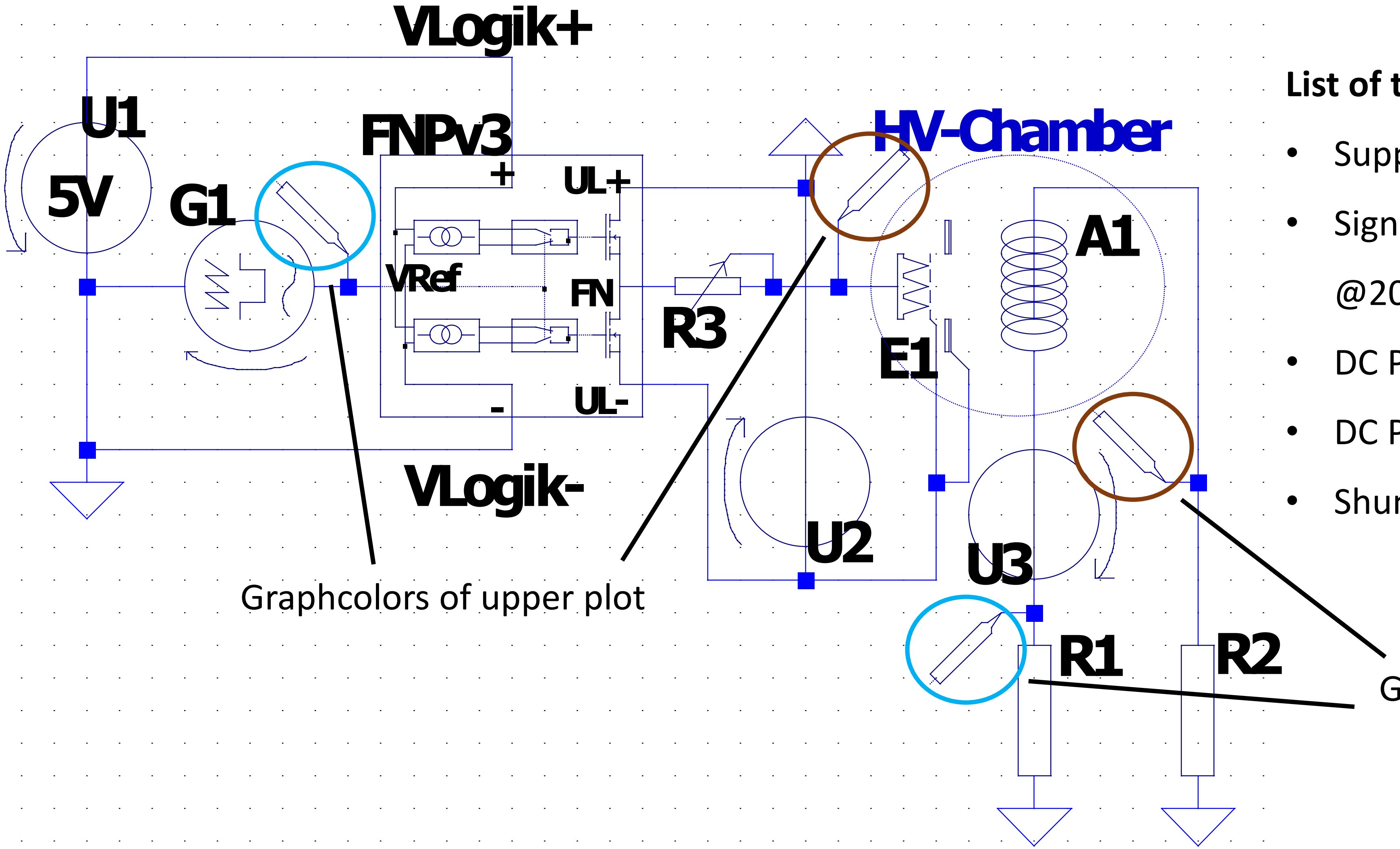
Measurements with load
Secondary side signals



Secondary side signals (gatedriver output)	
Supply-levels	0V; -30V
U_{FN} (10-90%)	13,28 ns
U_{FN} (90-10%)	18,10 ns
U_{GLo} (10-90%)	5,67 ns
U_{GLo} (90-10%)	7,88 ns
U_{GHi} (90-10%)	-
U_{GHi} (10-90%)	-
U_{Cath} (10-90%)	28,22 µs
U_{Cath} (90-10%)	30,80 µs

➔ Connected load (cathode) slows down the switching speed
➔ Series potentiometer damps overshoots (but also slows down speed!)

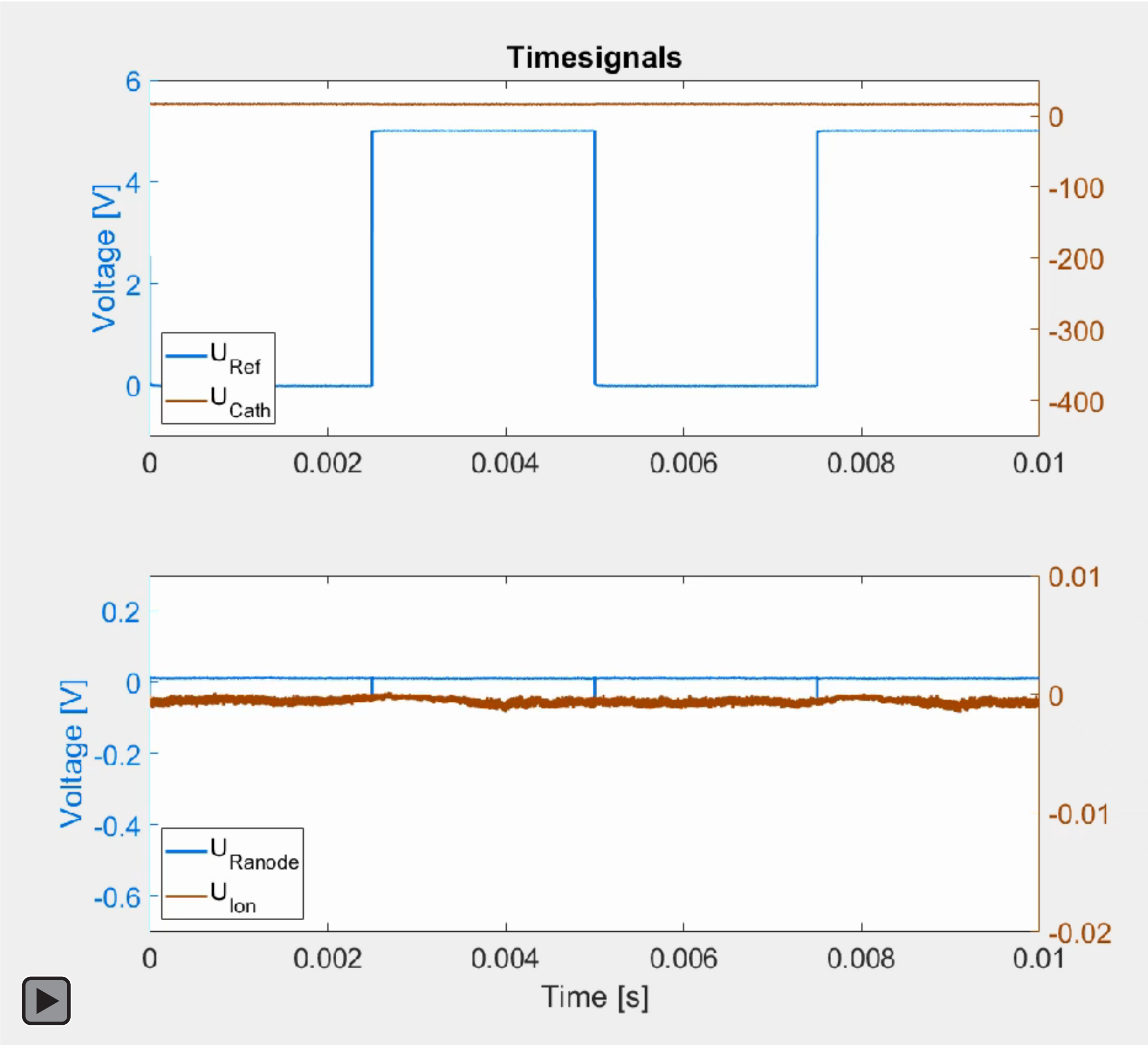
Application measurements (Bayard-Alpert)
Temporal measurement setup



List of testconditions:

- Supply voltage 5V (V_{Logic})
- Signal generator for V_{Ref} (5V square wave @200Hz)
- DC Powersupply for U_{load}/U_2 (0 to -400V_{DC})
- DC Powersupply for U_{RAnode}/U_3 (200V)
- Shunts for current measurement

Application measurements (Bayard-Alpert)
Temporal measurement



- ➔ Pretty unstable behaviour of Ringanode current
- ➔ No signal at ion collector („low“ shunt-value)
- ➔ Shunts slowing down the system ($\tau = R \cdot C$) which falsifies the temporal shape of the electron-burst

- ➔ However pulsed emission currents can be measured
  - → The fast pulse source works

Thanks for your Attention

- **FNPv3.1**
  - Only one V_{Ref} input necessary
  - Load voltages up to 1kV (limitated by chosen MOSFET-devices)
  - Fast pulse edges possible (≈15ns with cathode)
  - Edge times adjustable by a potentiometer
  - No temporal switch limitation of the MOSFET
- **Measurements**
  - Fast pulse source principle works
  - FNP can be used for DC and pulsed operation
  - Pulsed operation forbids the measurement of the cathode- and extraction grid current
- **Next Steps**
  - Find a way to measure the temporal emission signals…