Status of the development of miniHV at Nikhef

Small HV modules dedicated to gaseous detectors for laboratory use

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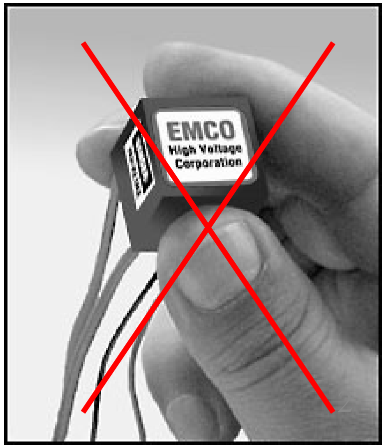
Why developing HV power supplies?

- Getting a HV supply that is **dedicated for gaseous detectors**
  - Fast trip in nA region
  - Accurate current measurement in nA region
  - Small unit, not too expensive
  - Fast remote control
  - Gently ramping to target voltage

- In addition, for large scale HEP experiments, one would like having these units close to the detectors in the hot region
  - Non-magnetic
  - Minimal mass
  - Radhard
  - Low noise emittance



Aiming for two designs

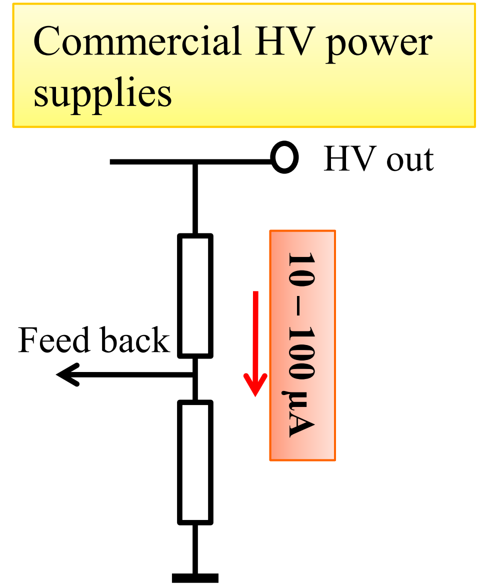
1. **MiniHV** for use in the lab, testbeams etc
   - Practical in use, relatively small, not completely antimagnetic
     - But **NO** inductors, transformers

2. **MicroHV** for use near the detectors in a big experiment
   - Very low mass, non-magnetic, radhard (until 1000 Mrad/ 10^7 Gy)

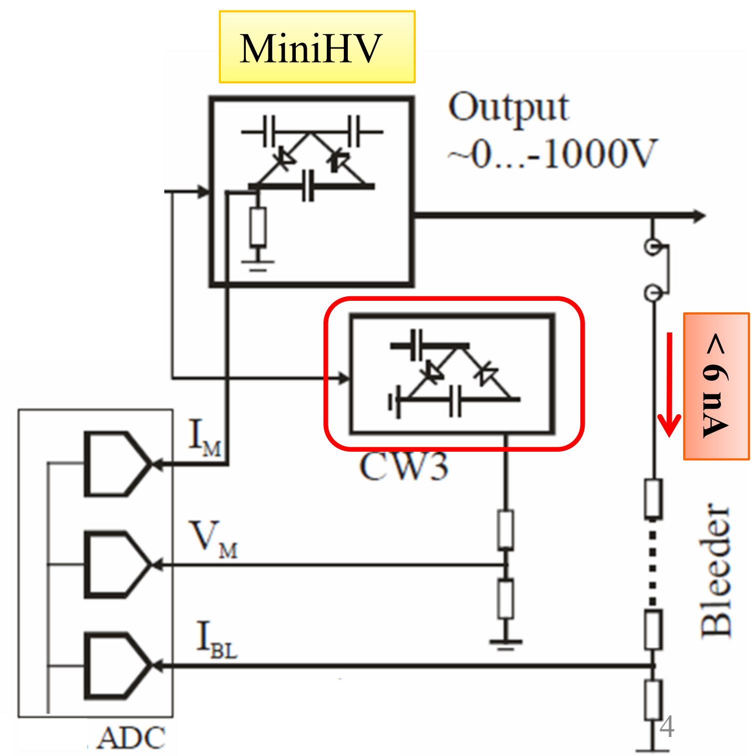
- Presently we are developing **miniHV**

Philosophy of Nikhef miniHV

- Generally HV power supplies make use of feedback by voltage divider circuit
  - => quiescent current of 10 – 100 µA

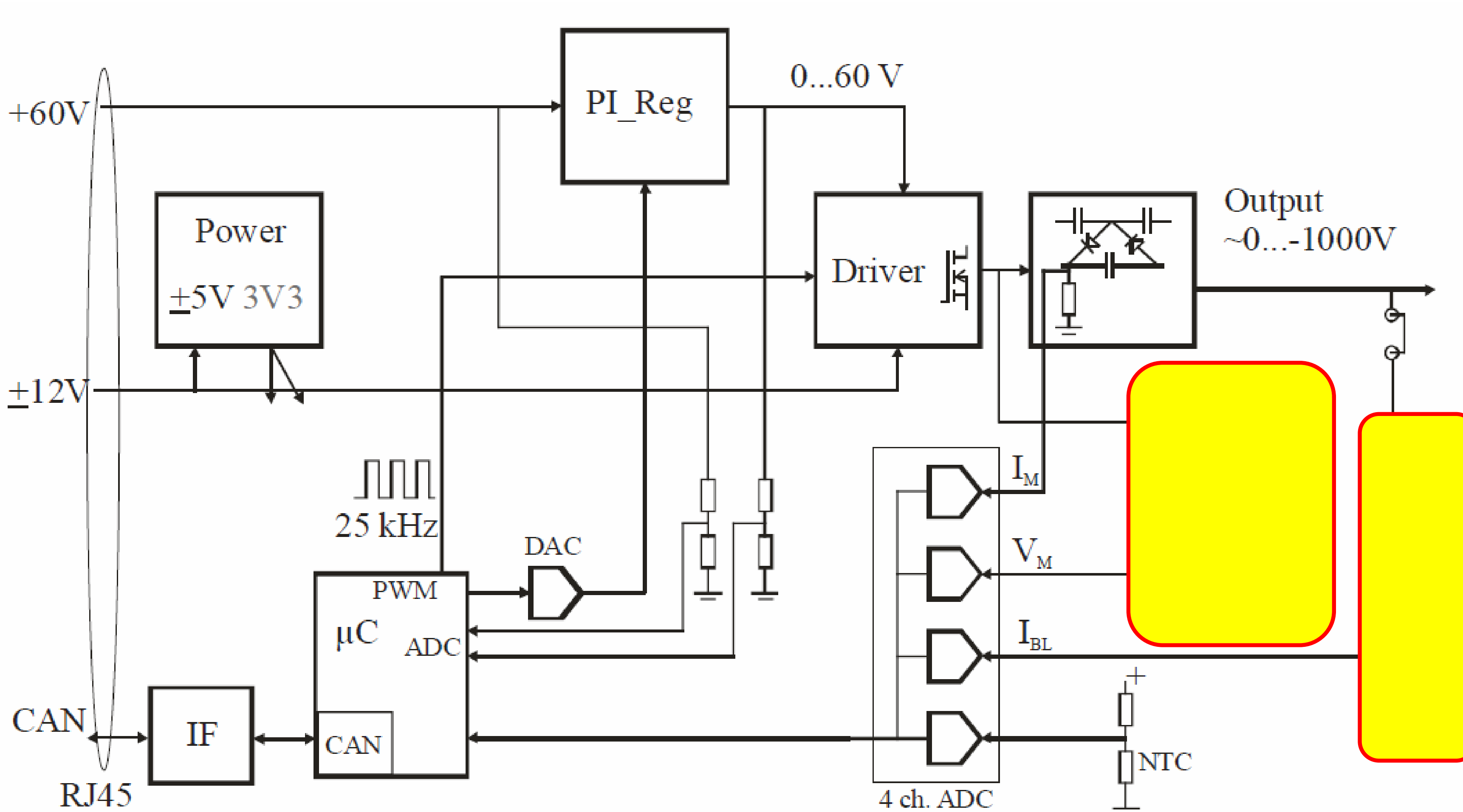


- With Nikhef miniHV no feedback by voltage divider
  - But **by dummy Cockcroft-Walton cell**
  - Additional compensation from measured output current
- => trip and output current measurement in nA region
- Bleeder circuit using high ohmic resistors (180 GΩ total) for HV signaling
  - => $I_{quiescent} < 6$ nA
  - Used for HV indication by an LED
  - (Not suited for voltage regulation)



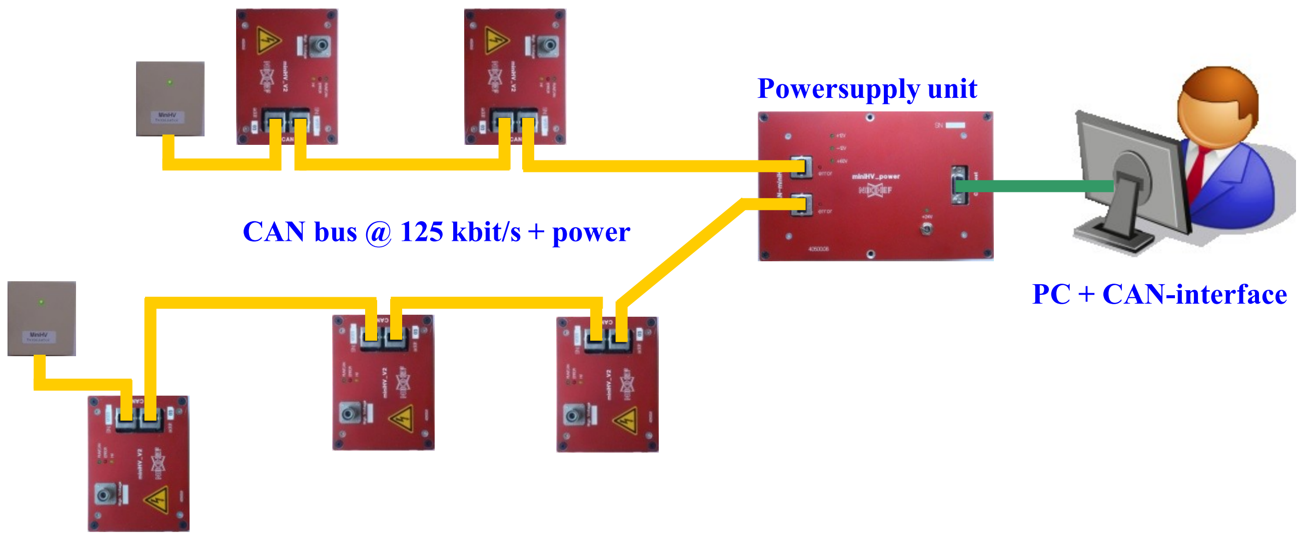
Voltage regulation

- Regulation by analogue input voltage (0 – 60V)
- Voltage feedback
  - Via single Cockroft Walton circuit
  - Current compensation by local microprocessor



Configuration

- Up to 10 HV units connected to single power supply unit
- Only connected by CAN bus
  - Power supply lines incorporated (+/- 12 V; 60 V)
- CAN interface needed (National Instruments or KVASER)
- CAN bus ends in passive terminator

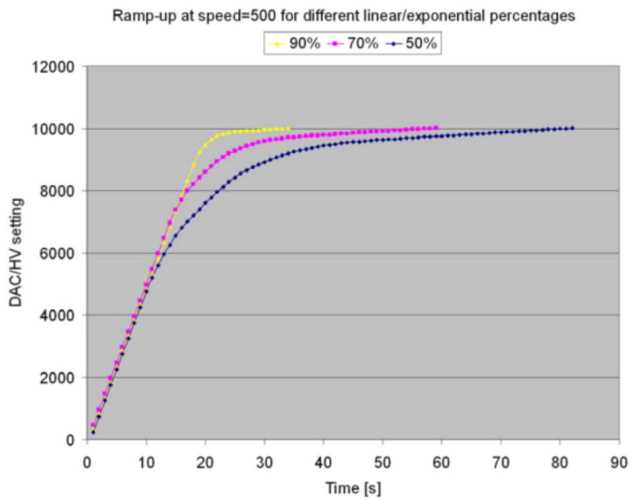


Specs of miniHV, version 2

More or less finalised

Conform CE classification

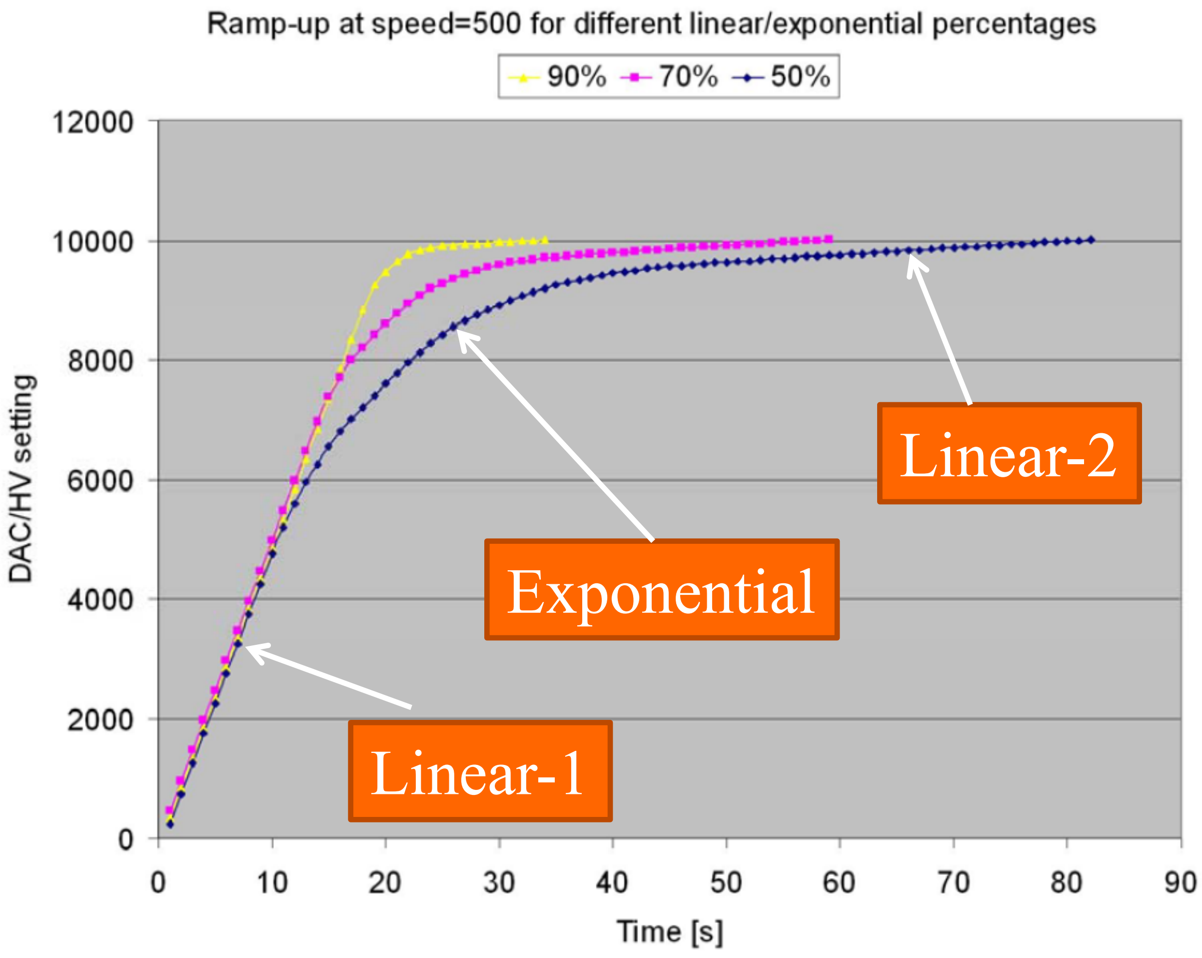
- Output ~ -3 to -1000V @ ≥ 0 - 5 μA
  - Steps of ~ 70 mV
  - Voltage variation from zero to full load: 4 – 6 V
    - **To be improved**
- Standard negative output
  - **Positive** output in principle possible but needs modified Cockcroft Walton PCB
- Ripple ~ 100 mV p-p measured
- Output impedance **without** current compensation ~ 5 MΩ
- LED indication for V_{out} **exceeding -50V**
- **Ramping**
  - Completely controlled by local microprocessor
  - Initially linear, followed by exponential approach to target voltage, fully configurable
- Containing minor magnetic parts from electronics
  - => **expected to operate in magnetic field**
  - Supply box is NOT antimagnetic



Ramping scheme

- Controlled by local processor

- **Linear-1**
  - 0.07 – 4500 V/s
  - Units of 0.07 V/s
- **Exponential**
  - Starting between 0 and 100% of required voltage
  - Units of 1%
- **Linear-2**
  - 0.07 – 4500 V/s
  - Units of 0.07 V/s



Two different trip actions

- **Warning** limit (nA) in 0 – 65 µA
  - Action: warning message is sent
- **Trip** limit (nA) in 0 – 65 µA
  - Actual trip only after **certain number** of overcurrent events (0 – 255)
  - => **reaction time** depends on frequency of the control loop of the local processor
    - Example: 2 Hz => 0.5 – 128 s
  - Action: **HV supply current is set to zero**

(no active pull down to zero, the pull down current has to be provided by the detector itself)

Manufacturer-Specific Profile Area

Index (hex)	Sub Index	Description	Data/ Object	Attr	Default	Comment
2001		High-Voltage control loop parameters	Record			
	0	Number of entries	U8	RO	7	
	1	Control loop enabled	Bool	RW	0	= 1 at power-up if module is calibrated
*	2	Control loop interval	U8	RW	50	In units of 10 ms, must be > 10
*	3	Output current warning limit	U16	RW	0	In nA (0 = not enabled)
*	4	Output current trip limit	U16	RW	0	In nA (0 = not enabled)
*	5	Current limit count	U8	RW	1	If number of consecutive samples exceeding the limit reaches this count action is taken (e.g. Emergency message, trip), must be > 0
*	6	Constant p in logarithmic factor for current compensation	U8	RW	20	Factor is $^{e}\log(1+I_{adc}/p)$ [V]
	7	Constant q	U8	RW	0	*Currently not used*

CANopen Object Dictionary prepared

Software for

miniHV

a high-voltage powersupply module
with CANopen interface

user manual & reference
version 1.0

NIKHEF

Henk Boterenbrood
NIKHEF, Amsterdam
17 February 2011

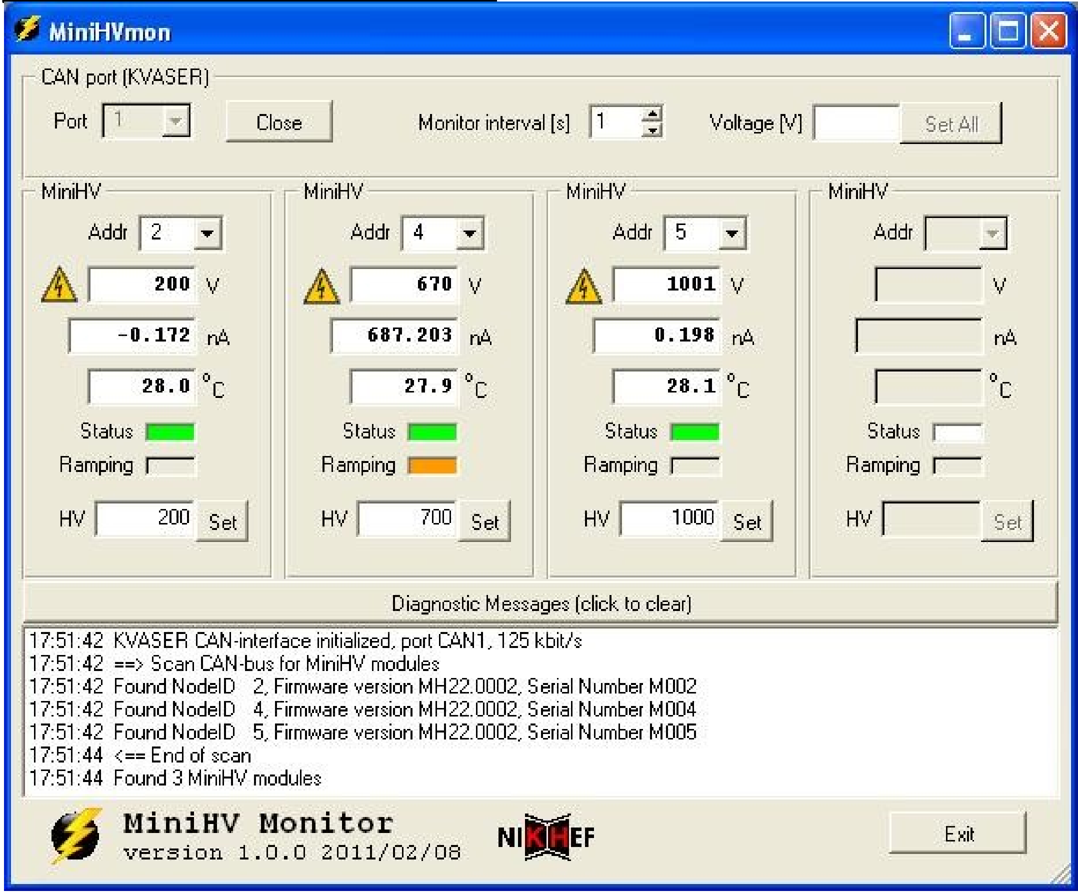
Manufacturer-Specific Profile Area

Index (hex)	Sub Index	Description	Data/ Object	Attr	Default	Comment
2000		High-Voltage parameters	Record			
	0	Number of entries	U8	RO	13	
	1	Set output voltage [V]	U16	RW	0	Maximum possible is set in Object 2000, sub 8
	2	Set output voltage [V] directly	U16	RW	0	No ramping done if setting is lower than current setting (e.g. for fast HV switch-off)
	3	Output voltage [V]	U16	RO	0	Vout = $((a/100)*V_{adc} + b - c*I_{adc} - {}^{e}\log(1+I_{adc}/p))/1000$
	4	Output current [pA]	I32	RO	0	Iout = $e*I_{adc} + f - I_{bleeder}$
	5	Bleeder voltage [V]	U16	RO	0	High-voltage output according to bleeder resistance and current, Objects 2000, sub 6 and 2010, sub 8
	6	Bleeder current [pA]	U16	RO	0	
*	7	Ramp speed [mV/s]	U32	RW	0	If != 0 ramp speed is taken into account; in mV per second, assuming Vout = (m/100)*DAC + n Equivalent to Object 2500, sub 2
*	8	Maximum allowed output voltage [V]	U16	RW	1020	Maximum high-voltage output allowed (must be ≤ fullscale in OD 2020)
	9	HV voltage calibrated	Bool	RO	0	= 1 if voltage output has been calibrated
	10	HV current calibrated	Bool	RO	0	= 1 if current output has been calibrated
*	11	Bleeder resistor installed	Bool	RW	1	
	12	Temperature sensor reading [°mC]	I32	RO		The ADC input connected to the onboard temperature sensor is read out and converted to millidegrees centigrade
*	13	T-sensor data in TPDO	Bool	RW	0	If = 1, DAC value in TPDO1 replaced by temperature

Existing control software

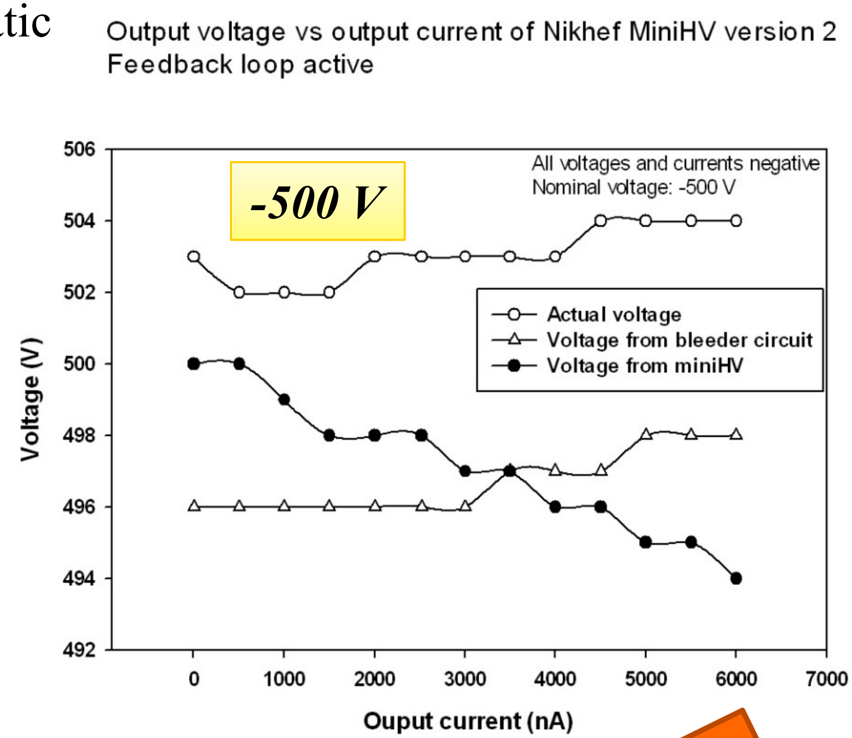
- Full control by CAN bus
  - No manual control or read-out
- Control by stand-alone program
  - MiniHVmon
- LabView control
  - In progress
  - Some communication problems to be solved

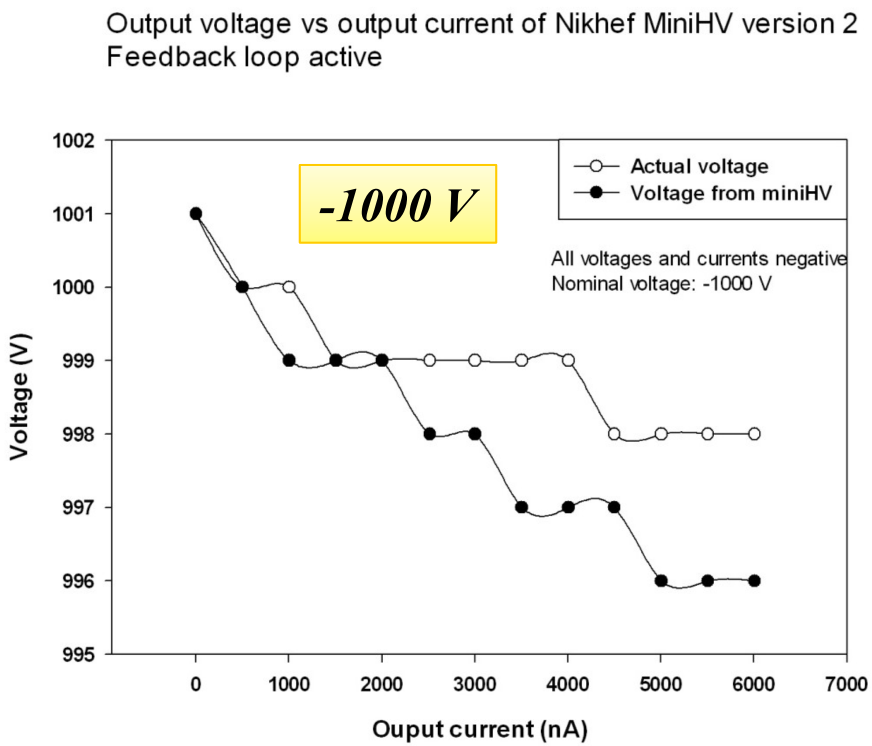
4 channel control panel



Preliminary performance

- Actual voltage measured with electrostatic voltmeter (readout lc 1 V)
- Voltage stability (0 – 5 μA): ~ 5 V



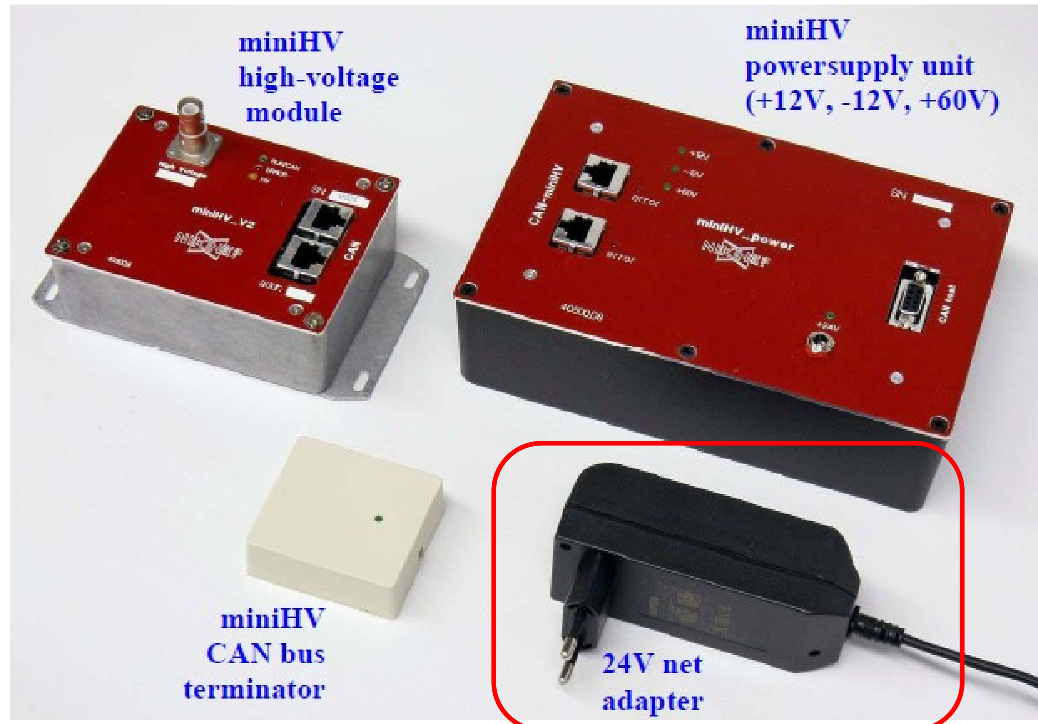


Calibration routines still in development

All voltages and currents negative

Prices, availability

- 5 miniHVs are operational
  - Only for Nikhef use
- 20 miniHVs in preparation
  - Expected to be finished mid May 2011
  - Partly for Nikhef use
  - Price not yet fixed, but ~ € 1200 + 19% VAT (Europe)
- 10 modified power supply units in development (connected to line ground)
  - Expected to be finished July 2011
  - Price not yet fixed, but ~ € 400 + 19% VAT (Europe)
- In addition a CAN interface is needed (National Instruments or KVASER)
  - ~ € 300



Will be exchanged by grounded AC power connection

Send me an email if you're interested

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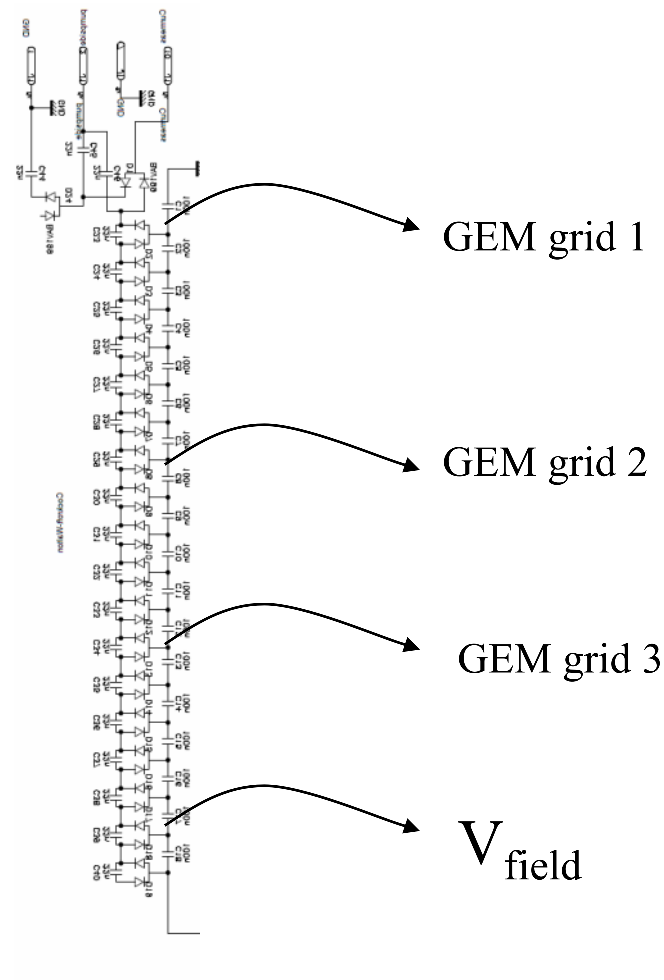
Ideas for other miniHV modules

1. **-2000 V version**
   - **Different CW PCB but same housing**

2. **Single MiniHV** with ~ 7 outputs (-6000 V?) from Cockroft Walton circuit for **triple GEM**
   - Regulating GEM voltages by selecting the desired CW stage
     - steps of ~ 50V
   - But whole chain may be finely tuned

- Advantage
  - Getting rid of voltage divider chains or multiple cascaded HV units
  - Low trip levels possible (nA region)
    - No current from voltage divider chain
  - **Problem**: how to handle possible **pull up currents**



Send me an email if you're interested in one of these ideas F.Hartjes@nikhef.nl

Conclusions

- 5 units Mini HV version 2 (-1000V) now completed and operating well
- 20 units + power supplies available after summer, partly for groups outside Nikhef
  - **But a new series can be started at sufficient interest**
- Positive output possible but needs additinal work (modified cascade board)
- -2 kV version well possible but also new cascade PCB required
  - **Not yet designed, will only be considered at sufficient interest**
- Possible future developments
  - **More outputs and higher voltage (-6 kV)**
    - GEM grids
    - => bit larger housing
  - **Not yet designed, will only be considered at sufficient interest**
- More info about mini HV on web page
  http://www.nikhef.nl/pub/departments/et/high_voltage/index.html