Status of the test bench at NTU

Jing-Ge Shiu
Belle II meeting/ECAL, 2009 July

- Test bench setup

- First measurements

- Next steps to go

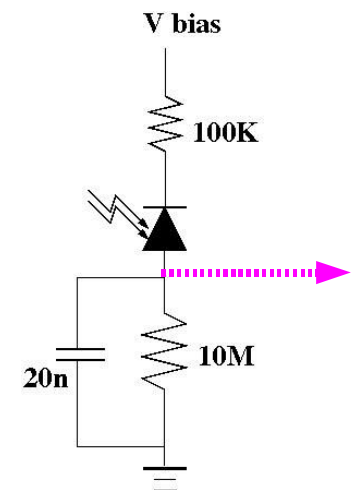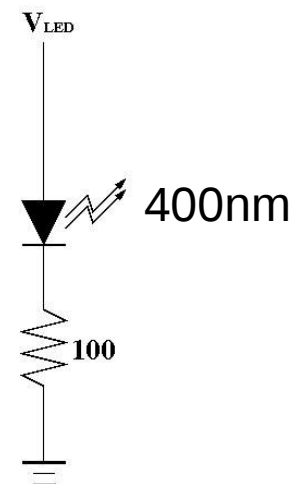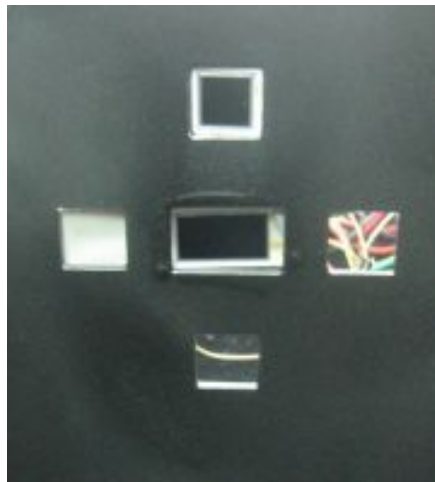- Manpower and equipments

- Summary

Test bench setup

NTU started to build a test bench after last meeting

Light-tight box (Chris Hsu)

1 APD

1 PIN

V_{LED}

400nm

100

V bias

100K

10M

20n

Test bench setup (con't)

Agilent 34970A DAQ system + HV/LV + labview:
an automatic "voltage-setting and output-
measurement" system.
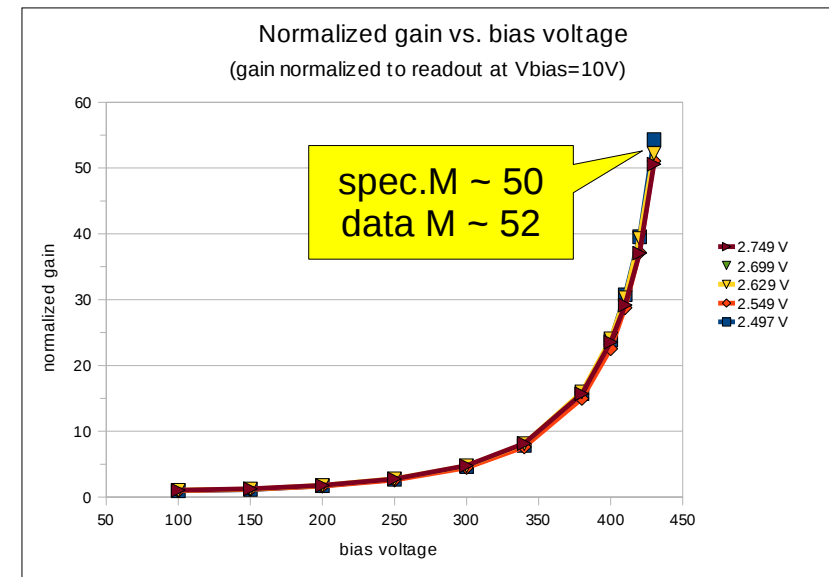--> work is ongoing (Kali Duh)
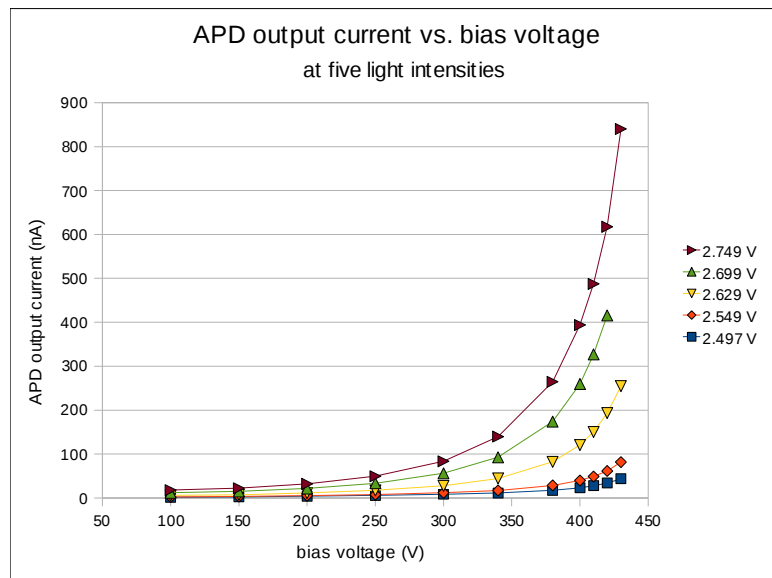

First measurement results

- ◆ No particular goal, just try to check if the system can work
- ◆ Playing with the system and DUT as a learning process
- ◆ APD
  - ➔ gain normalized to APD output at bias voltage = 10V
  - ➔ dark current
  - ➔ readout/gain versus light intensity
  - ➔ readout/gain versus temperature
  - ➔ intrinsic capacitance effect
- ◆ HAPD unit (Amy Wu)

➔ **dark current** no sizable different at 5 conditions (room light on/off, window shield open/shut):

--> light-tight is good

dark current vs. bias voltage
at 5 different external conditions

spec 10-100nA
data 32 nA
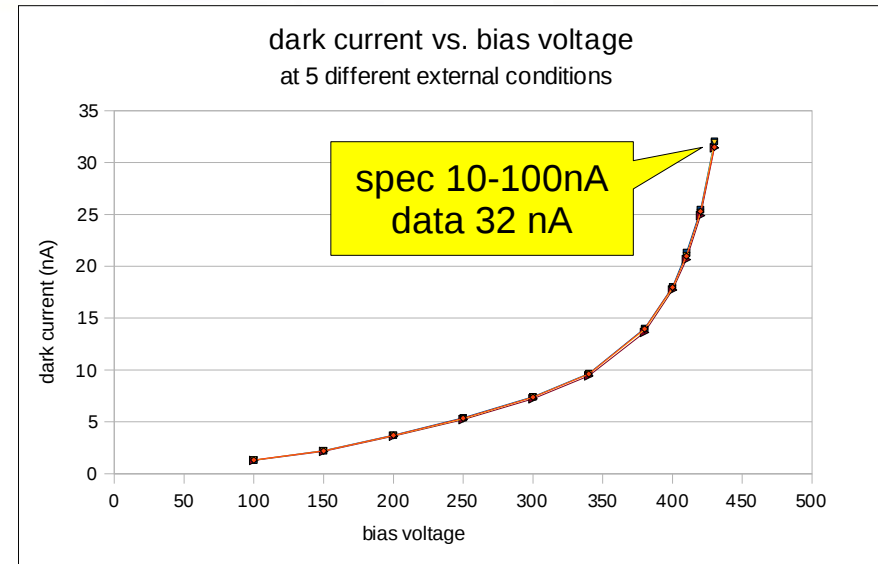
➔ gain at different light intensity:
--> load effect from 10M ohm probably negligible (?!)

APD output current vs. bias voltage
at five light intensities

- 2.749 V
- 2.699 V
- 2.629 V
- 2.549 V
- 2.497 V

Normalized gain vs. bias voltage
(gain normalized to readout at Vbias=10V)
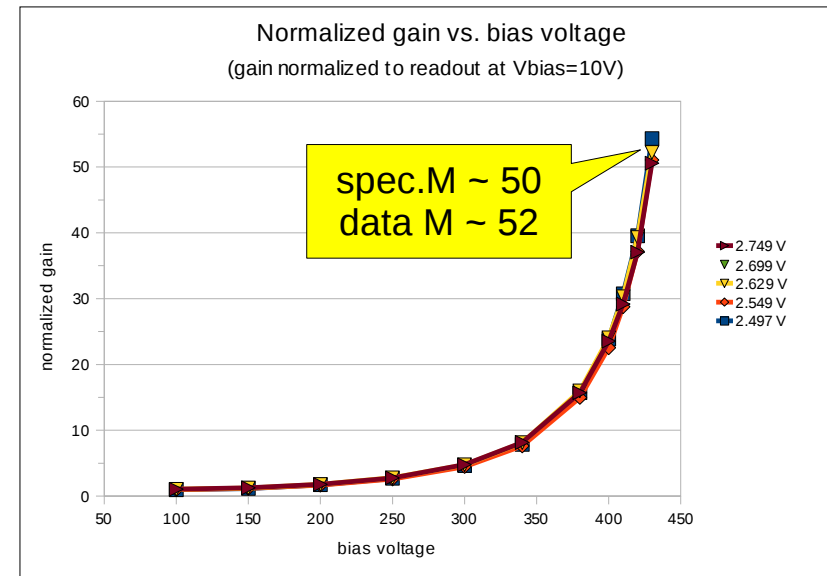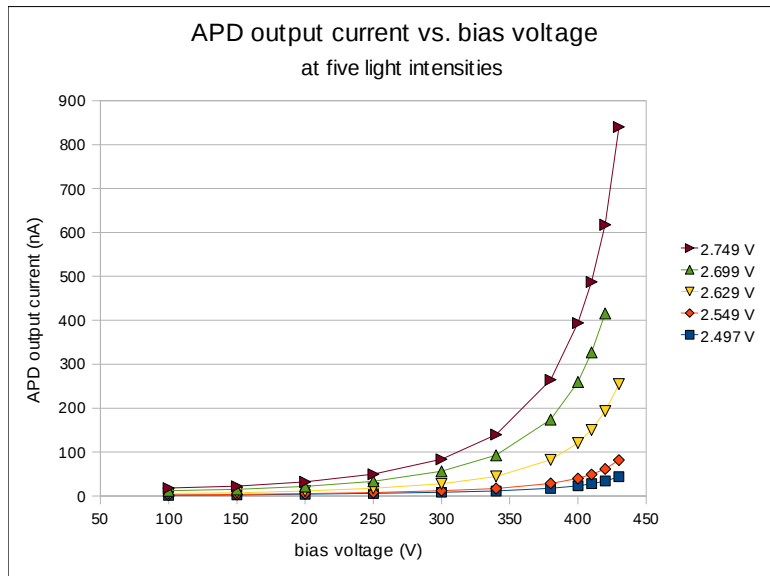
spec.M ~ 50
data M ~ 52

- 2.749 V
- 2.699 V
- 2.629 V
- 2.549 V
- 2.497 V

➜ **dark current** no sizable different at 5 conditions (room light on/off, window shield open/shut):

--> light-tight is good

dark current vs. bias voltage
at 5 different external conditions
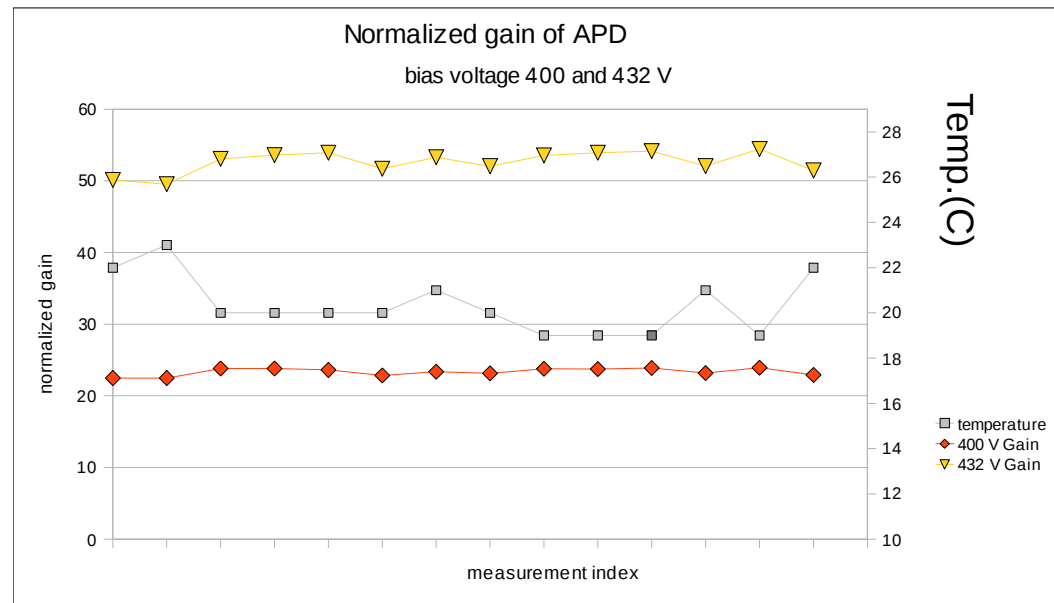
spec10-100nA
data 32 nA

dark current (nA)
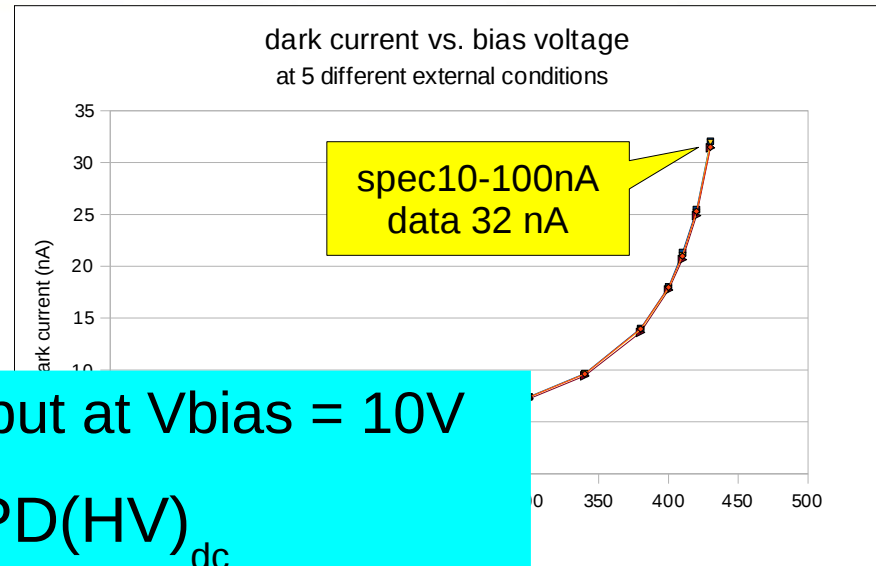
Gain: normalized to output at Vbias = 10V

$$\frac{APD(HV) - APD(HV)_{dc}}{APD(10V) - APD(10V)_{dc}}$$

➜ gain

--> load effect from 10M ohm probably negligible (?!)

APD output current vs. bias voltage
at five light intensities

APD output current (nA)

- 2.749 V
- 2.699 V
- 2.629 V
- 2.549 V
- 2.497 V

bias voltage (V)

Normalized gain vs. bias voltage
(gain normalized to readout at Vbias=10V)

normalized gain

spec.M ~ 50
data M ~ 52

- 2.749 V
- 2.699 V
- 2.629 V
- 2.549 V
- 2.497 V

bias voltage

➔ gain measured over about 1 week span: (Chris)

Normalized gain of APD

bias voltage 400 and 432 V

➔ gain from temperature scan:
drops ~6% while temp. increases ~ 3 °C
 (@ 20°C operation point)

--> ambient temp. stability is important

Consistent, qualitatively, with observation at FJU

normalized gain vs. temperature

bias voltage 400V
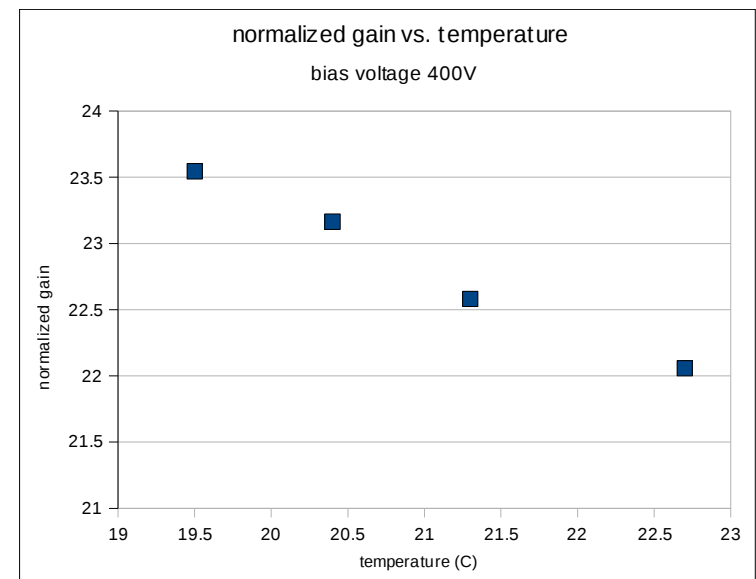
➔ Study the APD capacitance:
  ✔ pulse LED by short square wave
  ✔ 20nF parallel capacitor removed
  ✔ ignore the probe capacitance effect
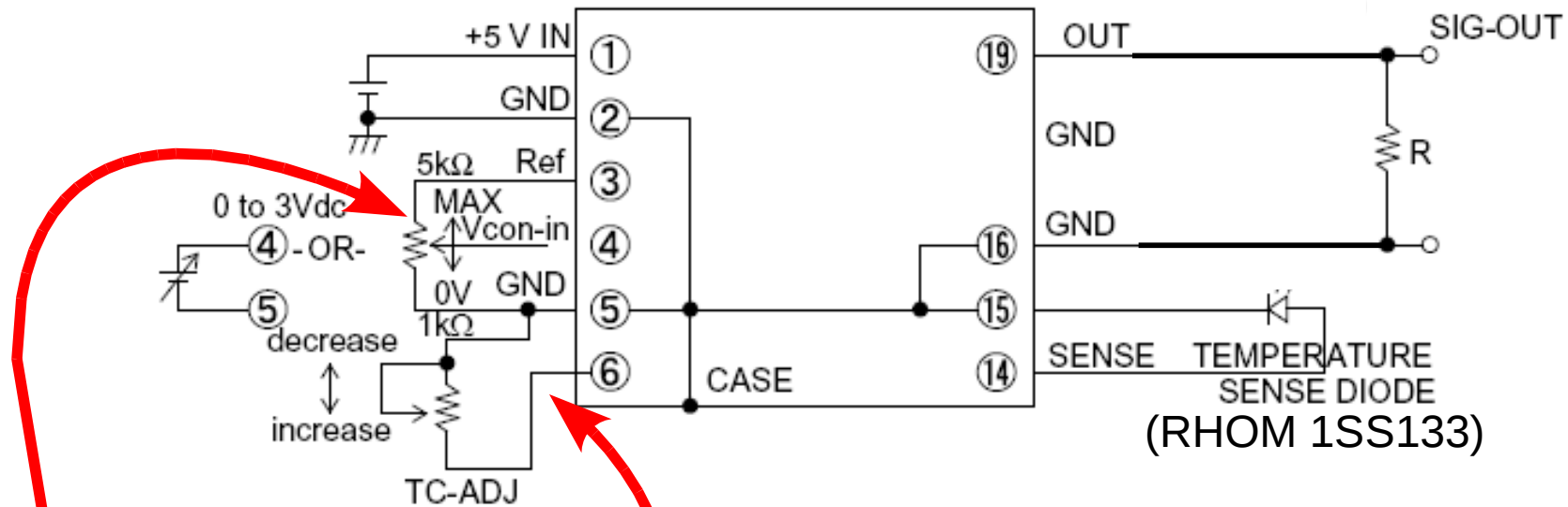 ✔ estimate the APD capacitance from time constant

APD capacitance vs. bias voltage

spec. ~270 pF
data ~130 pF
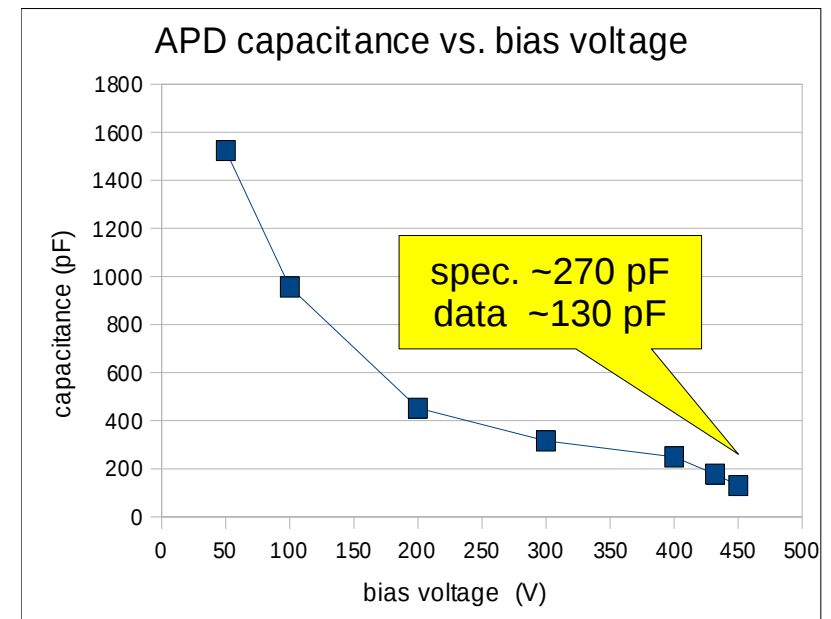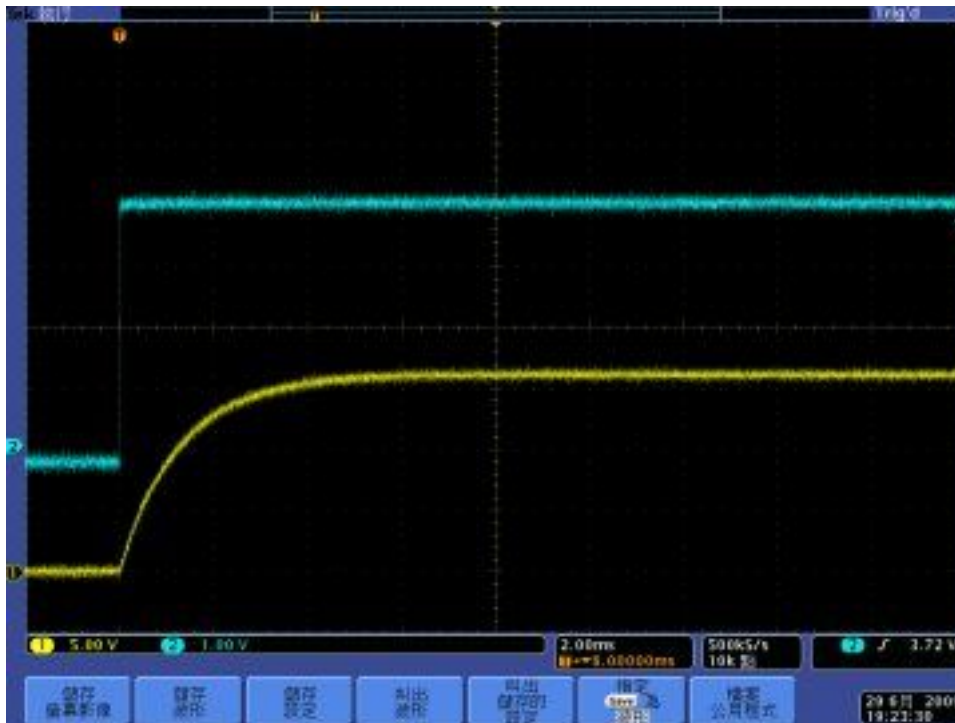
rising time up to ms level
---> current circuit only suitable for "DC-mode" signal.

◆HAPD unit

■ CONNECTION DIAGRAM

(RHOM 1SS133)

(Thanks to KM_san)

- Output control
  :the resistance between pin 3 & pin 4 (R_output)

- temp compensation control
  : the resistance between pin 5 & pin 6(R_temp)

- Connect pin 16 & 19 with a 1.0092 MΩ resistance

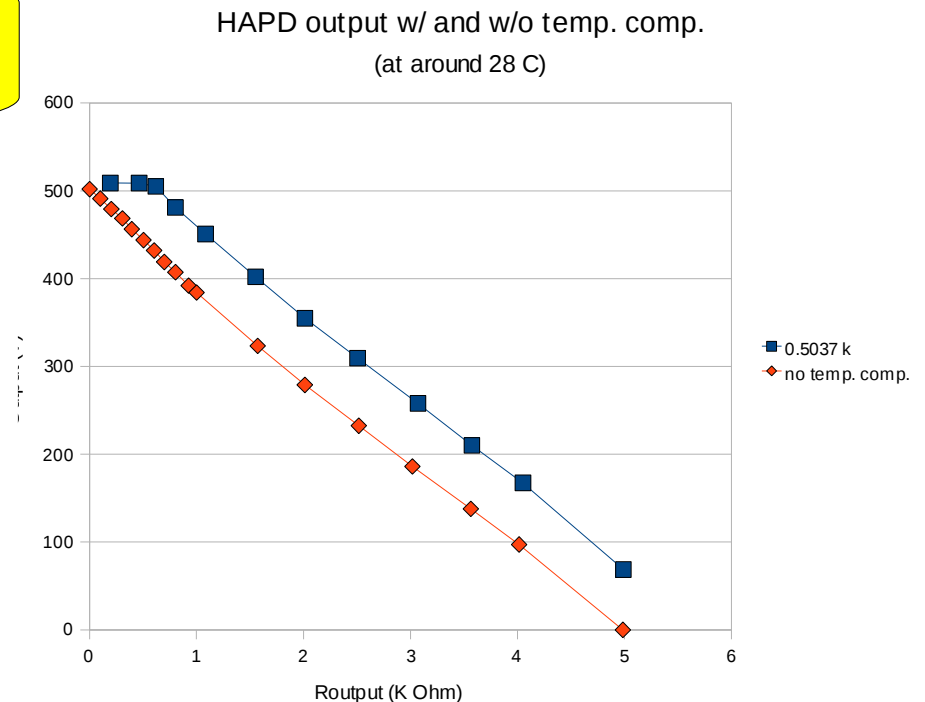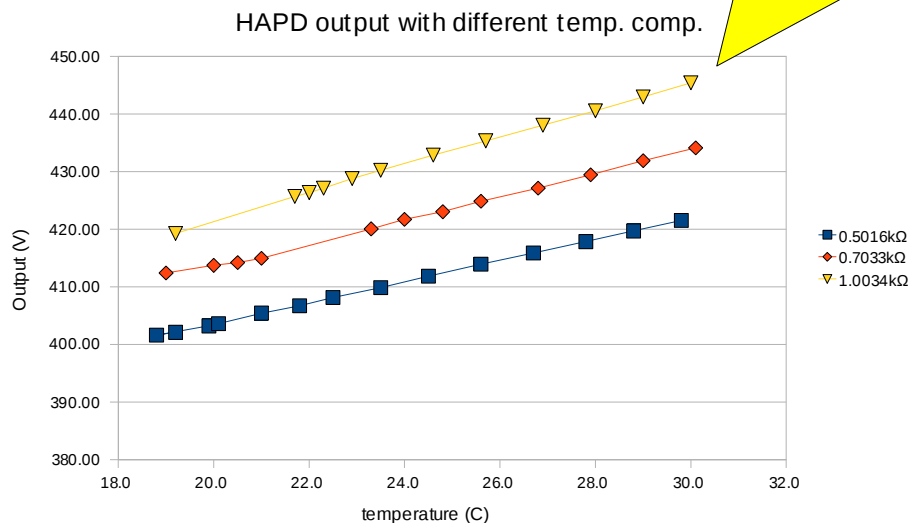- While doing temp. effect test, only the sense diode put into an oven, the HAPD left at room temp.

◆ HAPD unit study (Amy Wu)

➔ output stability
Vp-p within spec.

➔ output change due to input fluctuation
less than 0.1V, while ΔVin ~ 0.8V

➔ temp. compensation linearity vs. temp.

➔ temp. compensation linearity vs. output voltage

spec. max. 2.5 V/°C
data ~2.4 V/°C

HAPD output with different temp. comp.

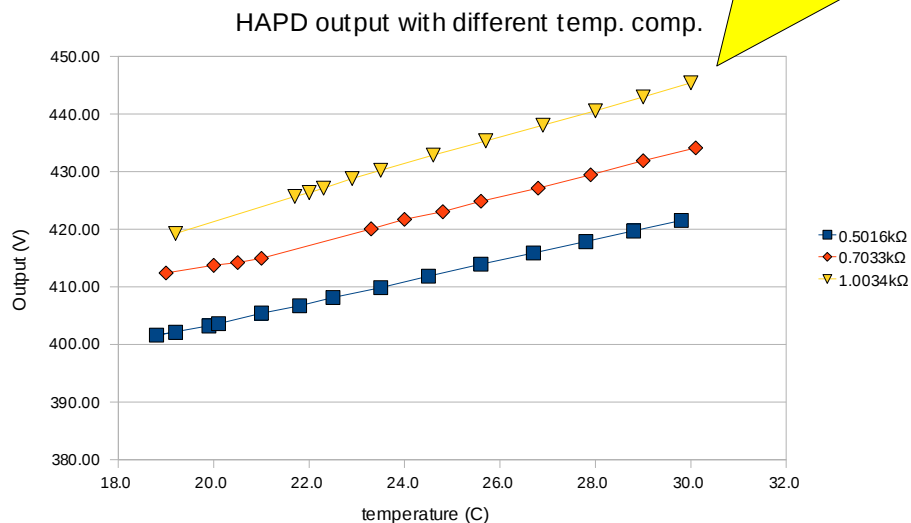HAPD output w/ and w/o temp. comp.
(at around 28 C)

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➔ temp. compensation linearity vs. temp.

➔ temp. compensation linearity vs. output voltage

1SS133

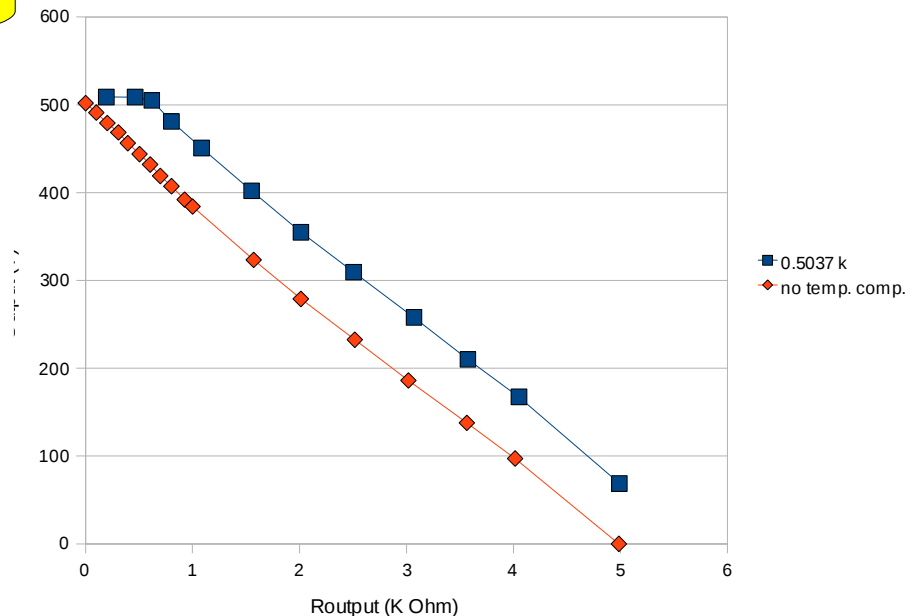oven

spec. max. 2.5 V/°C
data ~2.4 V/°C

HAPD output with different temp. comp.

Output (V) vs temperature (C)
- 0.5016kΩ
- 0.7033kΩ
- 1.0034kΩ

HAPD output w/ and w/o temp. comp.
(at around 28 C)

Routput (K Ohm)
- 0.5037 k
- no temp. comp.

Next steps to go

✔ finish the automatic measurement setup

✔ setup a temperature controlled chamber (or water cooling system)

✔ continue the APD gain measurement and HAPD study

• what is the temp. effect on the HAPD itself?

• set proper HAPD temp. comp. factor for the APD.

✔ change the readout circuit to use Oamp

• existing readout preamp. (or schematics) available?

✔ use radiation source for light source

• need a crystal

✔ prepare for any further contribution to ECAL R&D

Manpower and equipments

➔ currently, 1 Ph.D., 1 Ph.D. student (P. Chen), 3 Master students
➔ equipments:

    light-tight box,

    Agilent DAQ set, DMM,

    LV/HV power supply (computer controllable),

    temp./humi. programmable chamber,

    portable DAQ system (new), ...

➔ previous experiences:

    Belle EFC/SVD2,

    CMS preshower system mother board production/QC,

    Nutel (NTU-made mt. based ET ν experiment), ...

➔ contribution proposal: ???(R&D, production/QC, simulation)???
➔ budget condition for NTU Belle II project (Minzu, Paoti)

Summary

◆ NTU has built a test bench for APD test

◆ preliminary test measurements for system check done

◆ next step is to improve the test system

➔ HAPD

➔ temperature control

➔ automatic measurement system

◆ NTU is ready to join any APD/PP test and R&D, and is willing to do other contribution too.