**Tunneling AFM (TUNA) & Conductive AFM (CAFM) Exam**

# General

## Module(s)

1) What are the similarities and differences between TUNA and CAFM? Can the PF-TUNA module be used for both types of experiments?

2) What are the differences among the PF-TUNA, Extended TUNA, and CAFM modules?

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3) How is the module (PF-TUNA, Extended TUNA, or CAFM) attached to the AFM? What precautions should you take when handling and connecting the module?

4) What is the magnitude of the PF-TUNA test resistor? Briefly describe how it can be used to test the module's response. (Note that there is a similar, but slightly different, test resistor and method for the Extended TUNA/TUNA 2 module.)

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## Probe Holder

5) Does TUNA require a special (non-standard) probe holder? Why or why not? If so, draw a diagram indicating its key features, including how it is attached to the module. Do you have to do anything in software? How much does the probe holder cost?

6) A picture of the probe holder mounting block is shown below. Which of the 3 probe loading stations should be used with the PF-TUNA probe holder and why? Why is it important to check to ensure all 4 metal pins are present and straight (i.e., not bent) prior to *gently* placing the probe holder on the appropriate loading station (i.e., not forcing it onto the pins)?

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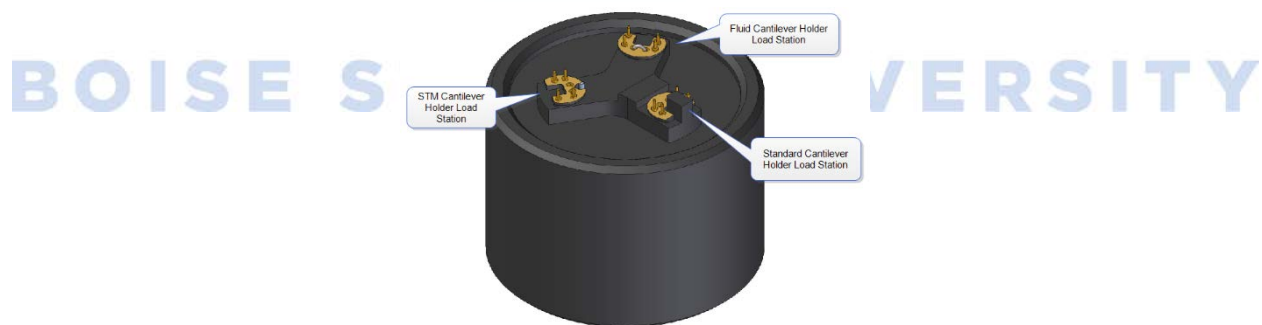
## Probes

7) Probe choice is key for successful TUNA/CAFM measurements.

    a. What is the fundamental requirement for a good TUNA/CAFM probe?

    b. What are the relative advantages and disadvantages of metal coated versus doped diamond probes for TUNA/CAFM measurements?

    c. What precautions must be observed when using a metal coated probe?

    d. Name at least 5 probes that can be used for TUNA/CAFM.

## Samples

8) What are the sample mounting requirements for TUNA/CAFM? How can you confirm that your sample is correctly mounted?

9) What could happen if you used a metal sample? How can you prevent this? Draw a diagram showing the layout.
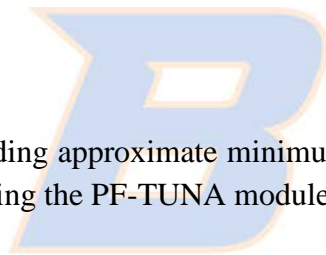
## PF-TUNA

### Hardware

10) To which hole on the PF-TUNA module should the signal wire from the probe holder be connected? Is the ground wire necessary?
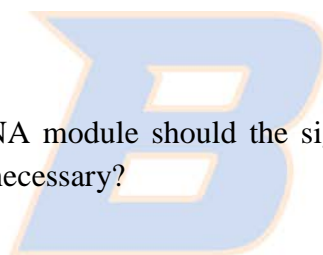
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11) The PF-TUNA module has variable gain settings, including a manual Hi/Lo Gain switch.
   a. How many gain settings does the module have, and what are they?

b.  Where is the manual gain switch located? How are the individual gain settings selected?

c.  What are the approximate minimum and maximum currents that can be measured using the PF-TUNA module? Note any assumptions you make to arrive at your answer.

d.  What are the corresponding approximate minimum and maximum sample resistances that can be measured using the PF-TUNA module?

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## Software

12) Draw a force curve diagram indicating how Peak Current, Contact Current, and TUNA Current are measured in PF-TUNA.

 

 

a. Which of these measured currents are impacted by PF Amplitude? Explain your reasoning, including what the effect of *decreasing* the amplitude would be.

 

b. Which of these measured currents are impacted by PF Setpoint? Explain your reasoning, including what the effect of *increasing* the setpoint would be.

 

c. Will the measured "Peak Current" necessarily be the maximum current during the PF Tapping cycle? Why or why not?

13) Should you enable TUNA feedback when mapping out the conductivity of a surface using PF-TUNA? Why or why not?

14) What is the measurable current range for a sensitivity setting of 10 nA/V?

15) Suppose you apply a 1 V bias to a sample with a through-sample resistance of 1 GΩ.
    a. What current would you expect to measure?

    b. What would be the best sensitivity setting to use/select and why?

    c. How might you adjust the bias voltage to optimize measurement sensitivity?

    d. What would be the effect of reversing the polarity of the bias voltage?

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   e.   Why might your measured current be less than calculated/expected? What does this imply regarding using PF-TUNA to make quantitative (as opposed to qualitative or relative) measurements of sample resistance/conductivity?

## Miscellaneous

16) What kind of RT (Real Time) and OL (Off Line) fit should you select in NanoScope for the various current channels available in PF-TUNA?

17) Can the PF-TUNA module be used to conduct contact TUNA/CAFM measurements? If so, what "Experiment" would you select in software? What probe would you use and why?

18) Which of the following are NOT advantages of PF-TUNA relative to contact TUNA?
   a.   Better able to image soft materials with minimal sample damage
   b.   Better/increased sample contact/force
   c.   Improved imaging resolution and tip lifetime
   d.   Simultaneous quantitative nanomechanical and nanoelectrical properties
   e.   Better current signal