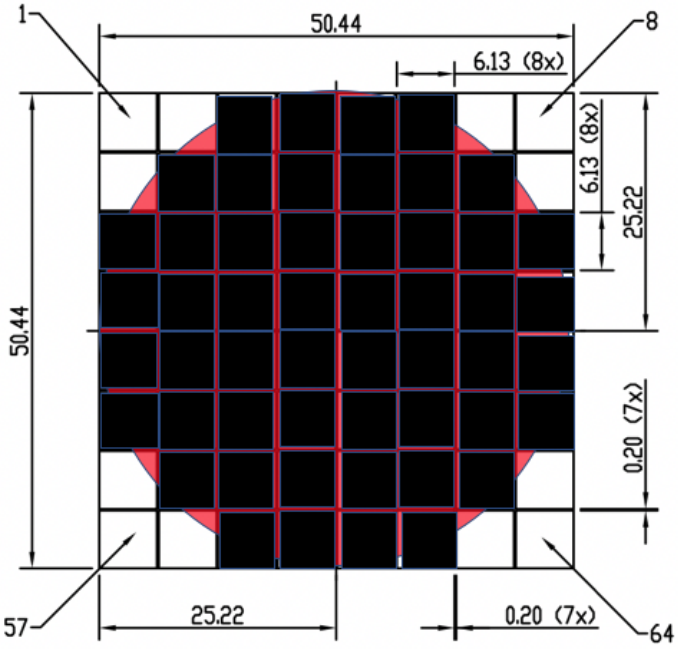
Chemistry 985

Fall, 2o19 Problem Set #4

Distributed: Tues., 5 Nov. 2019 Due: Thurs., 14 Nov. 2019

Show your work! Indicate sources of external data!

1. CCD's etc.:
   The recent iPhone 11 camera incorporates a CCD chip that is listed as being able to record 1080p HD video at 30 frames per second (fps). The charge created in each pixel is measured on an 8 bit scale (values 0-255). Note that 1080p = 1920 x 1080 pixels and is usually known as "Full HD" resolution. What is the minimum data processing rate in bits/second to process the data if the CCD chip relies on a single ADC to convert the data and the time is split equally between exposure and processing.



2. SiPM
   A student would like to test the readout of a new SiPM device and decides to use a 2-inch diameter, 2-inch long right cylindrical NaI(Tl) detector as a reference. The detector is mounted on a SenL J-series SiPM array of 64 devices (called pixels) in an 8x8 array that would almost exactly match the 2-inch diameter, as indicated in the figure above. Note that the student elects to only use 52 devices (black squares)

and not collect the output from the 12 pixels (open squares) in the corners. A ^{137}Cs source is used to test the device since the decay pattern has only one gamma ray. Data Sheet: MICROJ-SERIES-D.PDF

(a) What is the total number of individual APD cells in the 52 pixels? (duh)

(b) The professor suggests that only the four pixels in the corners (without any coverage) be excluded from the measurement and the student should use 60 pixels. What fraction of individual cells in the 60 pixel array will be struck by a photon produced in the NaI(Tl) detector when the light from the interaction of one gamma ray is transmitted to the face of the array with a 90% efficiency? Note that there is dead space between the cells similar to that between channels in a microchannel plate.

3. Neutron Detectors:
The ^{3}He counters in the NERO array are described in Table 1 from their publication in NIM **A618** (2o10) 275. What is the intrinsic efficiency for a Type (a) NERO detector for thermal neutrons, i.e., at 20°C? Thermal neutrons have a K.E. = 0.025 eV, of course. For aficionados, the model numbers in the caption refer to the Reuter-Stokes catalog.

Table 1: Technical specifications of the NERO gas-filled proportional counters. (a) and (b) refer to the ^{3}He detector models RS-P4-0810-104 and RS-P4-0814-207, respectively.

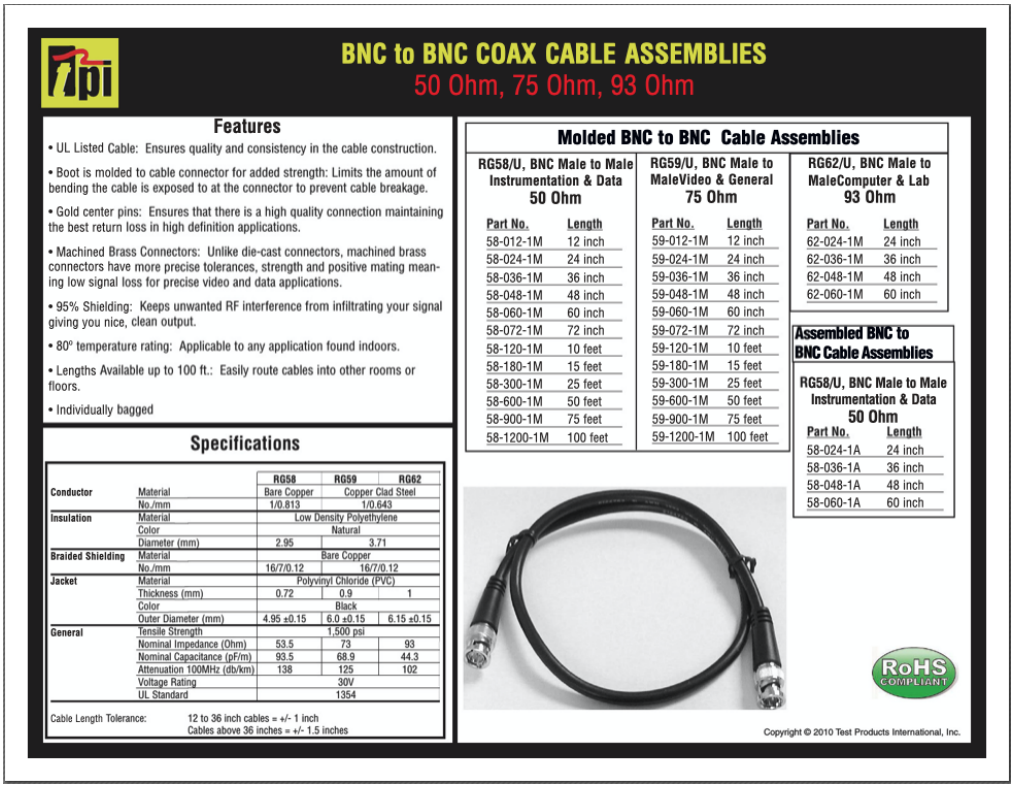
Detector	Active Length (cm)	Radius (cm)	Nominal Pressure (atm)	Gas Composition	High Voltage (+V)
^{3}He (a)	25.0(2)	1.3(2)	10.2	100% ^{3}He	1350
^{3}He (b)	35.6(2)	1.3(2)	4.0	100% ^{3}He	1100
BF_3	50.8(1)	2.5(2)	1.2	>96% ^{10}B	600

- continue -

4. Signals:
   A new graduate student needed to buy some cables to connect a pair of identical detectors to an electronics setup for a time of flight measurement. The figure shown below was copied from a real supplier's website describing the specifications for their cables. After a lot of hand-wringing and sleepless nights, the student ordered two 100 foot long RG58/U cables (part number 58-1200-1M) and hoped for the best. The student was apparently swayed by the Feature: *"Easily route cables into other rooms or floors."* Based on the information in the specs: Data Sheet: DigiKey Cables

   (a) What is the velocity of propagation in these cables?

   (b) What is the uncertainty in ns for a time difference measurement that would come from using two of these random cables without any other sources of uncertainties, Hint: read the specs carefully, The experiment spokesperson grumbled due to the apparent unnecessary time spread. The student, having taken Chem 985, realized that the time difference could be easily measured and was not a variable for the actual delivered cables.



BNC to BNC COAX CABLE ASSEMBLIES
50 Ohm, 75 Ohm, 93 Ohm

Features

- UL Listed Cable: Ensures quality and consistency in the cable construction.
- Boot is molded to cable connector for added strength: Limits the amount of bending the cable is exposed to at the connector to prevent cable breakage.
- Gold center pins: Ensures that there is a high quality connection maintaining the best return loss in high definition applications.
- Machined Brass Connectors: Unlike die-cast connectors, machined brass connectors have more precise tolerances, strength and positive mating meaning low signal loss for precise video and data applications.
- 95% Shielding: Keeps unwanted RF interference from infiltrating your signal giving you nice, clean output.
- 80° temperature rating: Applicable to any application found indoors.
- Lengths Available up to 100 ft.: Easily route cables into other rooms or floors.
- Individually bagged

Specifications

		RG58	RG59	RG62
Conductor	Material	Bare Copper	Copper Clad Steel	
	No./mm	1/0.813	1/0.643	
Insulation	Material	Low Density Polyethylene		
	Color	Natural		
	Diameter (mm)	2.95	3.71	
Braided Shielding	Material	Bare Copper		
	No./mm	16/7/0.12	16/7/0.12	
Jacket	Material	Polyvinyl Chloride (PVC)		
	Thickness (mm)	0.72	0.9	1
	Color	Black		
	Outer Diameter (mm)	4.95 ±0.15	6.0 ±0.15	6.15 ±0.15
General	Tensile Strength	1,500 psi		
	Nominal Impedance (Ohm)	53.5	73	93
	Nominal Capacitance (pF/m)	93.5	68.9	44.3
	Attenuation 100MHz (db/km)	138	125	102
	Voltage Rating	30V		
	UL Standard	1354		

Cable Length Tolerance: 12 to 36 inch cables = +/- 1 inch; Cables above 36 inches = +/- 1.5 inches

Molded BNC to BNC Cable Assemblies

RG58/U, BNC Male to Male Instrumentation & Data 50 Ohm

Part No.	Length
58-012-1M	12 inch
58-024-1M	24 inch
58-036-1M	36 inch
58-048-1M	48 inch
58-060-1M	60 inch
58-072-1M	72 inch
58-120-1M	10 feet
58-180-1M	15 feet
58-300-1M	25 feet
58-600-1M	50 feet
58-900-1M	75 feet
58-1200-1M	100 feet

RG59/U, BNC Male to MaleVideo & General 75 Ohm

Part No.	Length
59-012-1M	12 inch
59-024-1M	24 inch
59-036-1M	36 inch
59-048-1M	48 inch
59-060-1M	60 inch
59-072-1M	72 inch
59-120-1M	10 feet
59-180-1M	15 feet
59-300-1M	25 feet
59-600-1M	50 feet
59-900-1M	75 feet
59-1200-1M	100 feet

RG62/U, BNC Male to MaleComputer & Lab 93 Ohm

Part No.	Length
62-024-1M	24 inch
62-036-1M	36 inch
62-048-1M	48 inch
62-060-1M	60 inch

Assembled BNC to BNC Cable Assemblies

RG58/U, BNC Male to Male Instrumentation & Data 50 Ohm

Part No.	Length
58-024-1A	24 inch
58-036-1A	36 inch
58-048-1A	48 inch
58-060-1A	60 inch

RoHS COMPLIANT