Diode circuits lab report

To measure the characteristics of the straightener and diodes of the sener and to understand the difference between the perfect diode and the real device. To introduce students to the main cleaners and other diode schemes. PRELAB What are the differences between the characteristics of the perfect diode model and the real device? What is the difference between a diode zener and a diode of a standard straightener? Draw a load line section for a diagram with a D.c., forward biased diode and resistor. The site should have a diode voltage on the horizontal axis and current on the vertical axis. Separate both scales with numerical values in volts and mA, respectively. Draw two straight load lines representing two resistors with certain values (1 to 10 kohm). Draw a reasonable diode characteristic curve on the same graph; you'll measure it later in the lab. Separate two operating points corresponding to two resistors. LABORATORY Equipment needed from reserve: Proto-board, analog universal meter, leads. 1. MEASUREMENTS OF I-V DISODE STRAIGHTENER CHARACTERISTICS. a) Measure the I-V characterization of the disode of the straightener or current dependence through the diode on the voltage throughout the diode. For measurements with forward diode displacement, you need a voltmeter and an ammeter; use analog and digital meters. The incandescent lamp in the series with the diode makes a convenient resistor of high power. Don't burn the lamp (stop zooming in when it gets bright)! Cover a wide range of current values, from the share of mA to about 100 mA. The current area as a voltage shift function. Make a preliminary schedule in the lab. b) Apply the reverse slope to the diode a few volts to see how big the reverse current is. Even your digital ammeter may not be able to measure a very small reverse current. Can you identify it by measuring voltage through the high value of the resistor (MH) paired in the series with the diode? Think of which of the two volts to use in this dimension (consider their inner resistance!). 2. SENER DIOD Mera I-V characterization of diode zener with reverse bias. Use the corresponding series resistor (the light bulb can do this) to allow a few dozen mA current after reaching the voltage breakdown. Make a preliminary schedule in the lab. The reverse displacement site is characteristic of diod zener and determine the tension of the breakdown of the zener. 3. DIODE IN CHAINS; LOAD LINE a) Assemble the diagram shown below using a diode that you've just measured. Choose a resistor in multiple kohm ranges. Measure the voltage through it, slowly increasing the power voltage to get the current in a few mA. Measure also voltage throughout the chain (Vs) and through the diode. Fig. 8.1 Diode in chains with resistor a) Repeat a) for lower resistance (100 om) and in the range of a few dozen to 100 mA. Do not exceed the resistor power rating (1/4 w). Make a quick calculation of scattered power (e.g. 100 too much for 100 ohms small resistor!) Make load line graphics for two circuits tested in (a) and (b) using the diode characteristic you measured in 1. Advice: Make sure the current is in the range that you are covered in measuring diode characteristics in section 1. If not, you may need to add a few points to the feature now. You will need it to prepare a section of the load line. 4. DIODE CLAMP CIRCUITS Collect schemes shown on rice. 8.2, and check the output voltage with the Oscilloscope, supplying waves with different amplitudes to enter. Try a sinusoid and triangle or a square wave with a different DC slope. The second circuit, known as a diode limiter, is often used to protect the inputs of sensitive devices such as ammeters or high amplification amplifiers. Choose an R for good clipping performance. Sketch of entrance and output wave forms. Explain how these schemes work (experiments in 4 should help). a) Diode clip scheme Diode restrictive rice scheme. 8.2 REPORT Tabool Results 1 a). Phase I-V is a disstode characteristic for forward bias. At what forward voltage does the straightener diode effectively conduct current? Do your measurements agree with the known theoretical equation of diode current and voltage? Show it on the graph. Hint: A semi-journal graph may be the most informative here, plot it in addition to the standard linear graph. Tabulate the results of the measurement of the fictitious and diod zener. Phase I-V is a dispenser diode characteristic for forward bias using (a) linear graph and b) semi-log graphics. The section of the diode is typical for reverse bias using a linear graph. At what forward voltage does the straightener diode effectively conduct current? What is the value of the voltage of the breakdown of the zener? Include load line sections for two circuits tested in 3 (a) and 3 (b) using diode, which you measured in 1. Answer all the other questions printed in bold letters in this guide. University of California at Berkeley Donald A. Glaser Physics 111A InstrumentAtion Laboratory 3 Semiconductor Diodes Links: Physics 111-Lab Library Reference Site Reprints and other information can be found on the website of the Physics Library 111. Lab 3 Apps: Data Sheets and Operation Curve Tracer. NOTE: You can check and keep portable boards, VB-106 or VB-108, from 111-Lab to yourself (only one, please) This is the first of three laboratories on basic semiconductor You will study semiconductor characteristics and some of their applications, which will lead to the design and construction of a differential amplifier. Note: Keep all your parts with you as for you forever. DON'T RETURN THEM TO THE CUPBOARDS. This lab is studying diodes. You will find a link between tension and tone in the diode, and study of temperature effects, correction, nonlinear phenomena and doubling of frequency. This lab uses liquid nitrogen (LN${2}$), which is very cold: about $77,' 'mathrm'K'$. LN $'mathrm{2}$can cause severe skin and eye burns. Use goggles while working with LN${2}$; Points are provided free of charge at 111-Lab and yours to keep. Shoes with an open new one are not allowed in the laboratory, while LN${2}$is used. Read EH'S cryogenic safety materials. Take cryogenic preparation: Go to and enter 109 in the search box. You may have to choose a UCB and then log in. (Alternatively, you may be able to get into training through , login, then tap the UC Learning Center in the left column, and then when UC Learning Center opens the Click Find course, enter 109 in the search box that opens and click Search. (Another way into this links from and then click Find the course and then search 109) If you can't log in to blu or sumtotal, please show your problem to your instructor or GSI. If they do not see obvoius fix please grab a screenshot or snippet of the problem and upload this along with your name and email through the form: (Please check the box that says: Send me a copy of my replies and then send me an email to your get on winthrop@berkeley.edu) Get LH $ Masters{2} $ from GSI, which will provide it for you in a styrofoam cup. Be careful not to spill the cup. You can't get LN $ imarm{2} $ form of dewar storage yourself. The semiconductor components used from now on in this course can get pretty hot... especially if they are connected incorrectly. They can easily burn you. If you have to touch the components while the power is on, touch them gently first ass their temperature before grabbing them with force. Better yet, turn off the power, and wait a few minutes for the ingredients to cool down. Before you move into the class, complete this list of tasks: Fully read the Lab Notebook Record Book (en) Answer pre-lab questions using links and records Perform any chain calculations to use Matlab or anything that can be done outside the lab to use RStudio (free software). NOTE added: R is now a dead tongue. Instead, study Python. · Plan how to perform Lab tasks. All part specification sheets here Physics111 Library Site Preliminary Laboratory 1. In a few sentences, explain what diodes are and how useful they are. 2. Show that second term in Eq. (1) (-1 in brackets) may be neglected for typical operating parameters: parameters: 2$. 3. Why is there a ripple on top of the DC voltage output on the circuit at 3.11? What is the load line used for? What are the relative benefits of graphic and iterative analysis? This lab is one of the most analyzed and build intensive labs done this semester. Don't leave your analysis section until the last minute. Using a computer for analysis is much easier and faster than doing it manually. Bring a flash drive to the classroom or email yourself data files from the diode of characteristic traces found by the Tracer curve so you'll have access to the data, both at your lab station and at home. Excel is a powerful timer when you graphics similar data sets multiple times. Light-emitting diodes (LEDs) will burn up if you connect them directly to a 5V power source without a current limiting the resistor. Diodes and mon-connections of diodes and transistors are made of semiconductor materials: usually crystalline silicon. Pure silicon has few free electrons and is quite frisky. To increase its conductivity, silicon is usually refined, i.e. deliberately contaminated with other elements. Some dopants, such as phosphorus, arsenic and antimonium, easily give way to one of their electrons now unclean silicon crystal. These donated electrons can move freely through the crystal, and its conductivity increases dramatically. Only a few pre-pant atoms will significantly increase the conductivity of the crystal. For example, a single pre-pant atom per 100 million silicon atoms will increase the conductivity of pure silicon by about 105. Of course, the atoms of the additional, which give the electron, become positively charged. The net charge remains zero. Other dopants, such as boron, indium and aluminum, capture electrons from the surrounding silicon atoms, leaving behind positively charged silicon ions. In turn, these now positive silicon ions are trying to restore their neutrality by grabbing electrons from their neighbors... as a result, there are positive regions floating around the crystal lattice. Such no electrons are called holes. Surprisingly, the holes behave almost exactly like positively charged electrons; they move, react to electric fields and appear to have a mass close to the mass of an electron. A semiconductor with more mobile electrons than holes is called a n semiconductor; Conversely, a doping semiconductor with more time holes than mobile electrons is called a p-type semiconductor. If the only effect of doping was to increase the conductivity of semiconductors, semiconductors would be unclear, little materials used. The usefulness of semiconductors comes from the remarkable effects of placing p and n-type materials next to each other. These mappings are called Mon connections. The isolated pn compound makes a semiconductor diode. Other semiconductor components More complex mechanisms; bipolar npn transistors, for example, are made by clamping the p layer between two n layers, hence the name npn. Current through ideal ideal the compound is given by the diode equation. $'displaystyle I(V) I_-mathrm-sat'sat'bigg'exp'bigg fraceV'nkT'bigg)-1'bigg,$ (1), where $V$is a drop in voltage through the intersection, $Imathrm-sat'$ is constantly called current and depends on temperature, depending on temperature, Saturation on the specific geometry of the compound, as well as on the material of the compound, $e - 1.6 times10-19, mathrmC'$ - is the charge of the electron, $k - 1.38 times10-23, mathematicianJ/K'$ - Boltzmann's constant, and T - is the temperature in Kelvin. (A good approximation to memorization is that at room temperature, $kT-about 1/40, mathrm'eV$.) The constant cost of $n ranges from 1 to 2 depending on the specific diode, but is usually equal to 2 for discrete diodes. Notice from Eq. (1) that the diode's response is directional and very non-linear. When forward is biased, ($V $positive) huge currents can flow through the diode due to exponential dependence on $I $$V$. When the diode is reverse biased, ($V $negative), the current then approaches $-I_'mathrm'sat'$. So $I, it's usually very small (picoamps are not uncommon), very few current streams. Thus, the diode acts as a valve with one way; the current can only flow in one direction. Keep in mind that while Eq. (1) correctly describes the dependence of diode voltage, implicit temperature dependence in $Imathrm'sat'$ dominate over the apparent dependence in Eq. (1). For example, the current usually goes down rather than upwards, as the temperature decreases. When forward is biased, the positive end of the diode is called anode, and the negative end is called cathode. The terms anode and cathode date back to the days of vacuum tube diodes. The diode symbol appears on the right. The direction of the arrow indicates the direction of the current stream. On the diode itself, the cathode is usually marked with a painted stripe, as shown on the right. This group can be hard to see on some of our diodes. Light-emitting diodes (LED) are marked differently; The cathode is a shorter lead (but make sure the wires have not been trimmed), or, on some LEDs, lead adjacent to the apartment on a plastic case. after commons.wikimedia.org nonlinear Circuit Equilibrium Unlike purely linear circuits, chains containing non-linear elements, such as diodes, cannot be reduced to linear equation systems. Consequently, equilibrium tensions and tots in nonlineary circuits are much more difficult to determine. While these equilibrium quantities can be found with complex computer programs such as MultiSim, quick, approximate analysis methods are often useful, especially for simple schemes. Two quick methods will be used in this course: (I) Graphic Analysis and (II) Iterative Analysis (I) Graphic Analysis - Load Lines Consider a simple scheme on the right that contains a voltage source $V $0, a resistor R, and a generic non-linear component with impedance $Z (V)$ where V is a voltage throughout the component. No matter the non-linear component, voltage source and resistor set certain limits on possible equilibrium voltages and toses. For example, the current price I0 may not exceed $V 0/R$, a current that flows when the non-linear component of the $$Z is zero. In these conditions, the voltage of the V on the non-linear component is zero. In addition, the $$V can't exceed the voltage of the source $V $0, and this maximum voltage is only obtained when the $$Z voltage is endless and $I $0. Differences between zero and infinity produce intermediate current and voltage values. (We have suggested here that the non-linear device does not contain any internal power source, therefore, $ Possible values fall on the curve provided by the parametric equations $I-V_0/(R)$ and $V-ZV_0/(R)$, where V_0 the $Z Zvaries from zero to infinity. (2) This equation could be obtained directly from its endpoints, $I-V_0/R$$V $0 and $0 $I $V V_0 $. Line defined by Eq. (2) is called a load line because it is determined solely by the load (and the power source) and not by the non-linear component. The non-linear component submits to its own equation, or characteristic curve, $I q (V)$. In balance, both the load line and the characteristic curve must be satisfied at the same time. Consequently, equilibrium current and voltage for the chain are given by crossing the load line (Eq. (2)) and the characteristic equation $I q(V)$. For example, suppose that the nonlinear component is a diode ($I-matrmeha sat 4'times10'-10', 'mathrm'A'$), a movable battery of $1,'mathrm'k'Omega$1k battery resistor $2', mathrm'V'$, as shown below on the left. The load line and diode characteristic (Eq. 1) for this chain intersect, as shown below on the right, at equilibrium voltage $V'0.75', matrmema VS$ and current $I 1.25, matrmem.mA$. Fig. 1: Resistor Diode Equilibrium Fig. 2: Analysis of the load line Equilibrium voltage and current through the diode is sometimes referred to as the operating point of the chain. (II) The iterative analysis of Nelinea equilibrium can also be found iteratively: by guessing the initial solution, determining the consequences of guessing, and then iteratively refining guesswork. This method is best explained by example: the use of a diode chain in rice. 1, guess the current (say, $I'5, mathrmmA$) and then invert the diode characteristic $'displaystyle V(I) (nkT/e) I/I_'mathrm-sat)$, to find the voltage through the diode that would produce this current, $V'0.81706', 'math'V$.' Next, subtract this voltage from the battery voltage to determine the voltage through the resistor $V-0-V'18294, mathrmV'$, and divide into resistance $R $1.18294, matrm.mA$. Repeat and continue to iter until the numbers converge. The first five iterations are given in the table on The results converged in six decimal places. Iteration Resistance Tension (V) Initial guess 5.00000 0.81706 1.18294 1 1.18294 0.74499 1.25501 2 1.25501 0.74795 1.25205 3 1.25205 0.25205 0.74783 1.25217 4 1.25217 0.74783 1.25217 5 1.25217 0 .74783 1.25217 The obvious accuracy of the iterative method is deceptive because it relies on accurate knowledge of the $I 'mathrm'sat' and n. Don't worry; Answers with accuracy better than 10% rarely required in electronics. Be careful: iterative methods do not always converge. In fact, the described sequence works backwards (guess the diode voltage, calculate the current, find resistance to the drop in voltage, and subtract from the battery voltage to clarify the diode voltage to guess) do not converge. Try it for yourself! The study of the convergence of these methods is called the theory of the iterized map and, surprisingly, is the basis of the theory of chaos. Load line analysis and iterative analysis give the same values for equilibrium voltage and current. Note that the diode equation is Eq. (1) was used in both methods. With some loss of accuracy, you can use experimental data taken from the actual diode instead. The perturbation analysis that determines the chain's response to small changes in its parameters is just as important as determining its original equilibrium. The general theme of the system's response to small changes in parameters (outrage) is called perturbation analysis. In the Fig. 1 scheme, for example, perturbation analysis can be used to determine changes in diode voltage during small changes in the voltage source. I) Graphic analysis of perturbations By definition, the perturbation analysis takes into account only small changes in the parameters of the system. Therefore, it is convenient and acceptable for linearity around equilibrium conditions. Thus, the curved characteristic curve becomes a straight line. Using the diagram in rice. 1 as an example, consider a small battery voltage change of $10,000,delta V_0, mathrmV'$. This outrage shifts the load line upwards, as shown on the right, and the intersection will shift accordingly. Then you can read the graph from a new crossing point: a change in the diode voltage of $'Delta V'0'0088, matrmam.V.$ In this case, $Delta V$ is much less than the change in battery voltage $Delta V_0$. (For graphic clarity, the tilt of the linear diode characteristic has been reduced; otherwise the $'Delta V$ would be so small as to be unreadable.) Fig. 3: Perturbation Analysis (II) Small Signal Perturbation Analysis The aforementioned graphic procedure is completely equivalent to the following method: First, calculate a slight perturbation of the signal z non-linear diode at its operating point. A small pulse of the signal is a reciprocal tilt of the diode characteristic curve at the operating point. $z'dfrac's partial partial I'bigg's operating ;p oint'$. Then use the $$z in linear analysis of the diagram. Because The curve is not linear, z must be recalculated if the voltage through the diode changes (i.e. if the operating point changes). For more information, see Problem 3.1 - Forward and Reverse Diode Behavior get diode 1N4448. The 1N4448 label shows the type of diode. Tens of thousands of different types of diodes are available. Many types are made by several different manufacturers; each manufacturer certifies that their diode meets industry specifications. Parts with labels that start with 1N are always diodes, while parts that start with 2N are transistors, but not all diodes and transistors follow this naming convention. The specifications of diod 1N4448 are on the website of the Library of Physics. This lab also uses a different type of diode, the 1N5234B, which is very difficult to distinguish from 1N4448 visually. Make sure you don't mix the two types, and make sure you return the diode to the proper drawer. Use the Double Banana connector, BNC cable and minigrabbers to connect DMM to the diode. Set DMM in the diode scale. (On the portable Fluke DMM, it's a scale indicated by the yellow diode symbol; make sure you press the yellow shift button to switch between that scale and the continuity scale. With a double banana earth plug connected to COM (Fluke) or LO (Kitley) Banana entering the plug, the red lead minigrabber will be a positively biased reference to black lead; Thus, for diode conduction, red lead must be attached to the diode anode, and black lead must be attached to the cathode. On the diode itself, the cathode is marked with a black stripe; 1N4448 above, the strip is at the bottom. DMM diode settings are trying to impress at $1, mathrm-mA $ through the diode, while measuring the voltage throughout the diode. If the diode is forward biased, the voltage measurement will be a forward drop in the voltage of the diode at $1, matrmemamas. If it is reversed biased, the maximum output voltage of DMM (about $7, mathrmV'$ for Fluke, and $2.5, mathrmV'$ for Keatley) will not be enough to drive $1, matrma$, and meter will read the error code (OL for Fluke, and open to Keithley). Confirm that the diode holds a unidirectional, measuring the drop in voltage forward when the diode is biased, and the error code when the diode is reversed biased. You have to get ahead of the voltage drop by an order of $0.6, mathrmV'$. Problem 3.2 - Reliance on temperature voltage reduction forward receives from laboratory staff diode, installed on a plastic stick 1N4448. Repeat measuring the voltage fall forward with DMM. Does this diode have exactly the same voltage drop forward as the diode that you used in Part 3.1? tensions forward between diode types and even between diodes of the same type. Squeeze the diode between your fingers. The voltage should fall forward as the diode heats up to the temperature of the finger. What is the new value? For more dramatic results, dip the diode into liquid nitrogen, which can be obtained from the laboratory staff. What is the drop in tension ahead now? Diodes are often used as temperature sensors, measuring this voltage drop forward. Warning: Since diodes of the same type can have significantly different characteristics, use the same diode for all experiments in this lab. If you need to use the diode the other day, mark it with a piece of tape with your name and leave it in the cubbies store at the back of the lab. Problem 3.3 - Offset Adder Functionality I am now exploring the behavior of the Offset Adder circuit included in the board box at your lab station. An image of the offset adder and a brief description of its functionality can be found in the Lab 1 guide immediately after problem 1.1.3. Temporarily ignore the BNC Nest entrance. Measure the output voltage (from the BNC output connector) when the Offset Adjust handle is rotated. See how the voltage can range from about $-9 to $9,' and 'mathrm'V'$. Try downloading the output with several different resistor values. By constructing the V-I curve, prove that the circuit is a relatively rigid (low yield impedance) voltage source as long as the output current is stored below about 24 mA. Problem 3.4 - DMM's diode resistance measurements are a useful coarse indicator of diode performance and are often used to determine whether the diode has burned out. However, DMM measurements are single current measurements and do not determine the full relationship between voltage forward diodes and forward current. This ratio, $I (V)$, is called diode characteristic curve, and is very useful for understanding how diodes work in a chain The easiest way to get this curve is to measure the current through the diode, while driving a diode with a variable source of voltage and measuring voltage through the diode. To measure the diode characteristic curve, build the diagram shown on the right. Use a stick mounted diode that you used in exercise 3.2 for these measurements. Vary the tension throughout the diode with a shifted adder. Recording both current and voltage $V $5 in about five points. Focus on the voltage near the voltage in front of the back you found earlier and make sure you stay below the current limit that you found in exercise 3.3. The section of the resulting characteristic curve on linear and log linear paper. Note that you have to measure the voltage directly through the diode, at the point marked $V $. If you measure the voltage on the shifted adder on the other side of the current counter, you will also measure a small but not necessarily insignificant all over the current counter. Getting enough points to be thoroughly thoroughly diode is tiring. In addition, the slow pace at which data can be collected manually causes the diode to heat up significantly at high point currents, disrupting the measurement. Curve Tracer is a tool that automatically and relatively quickly measures characteristic curves. The quick information about the curve tracer can be found here: A guide to the curve of the tracing. Problem 3.5 - The diode characteristic curve is measured with the Tracer curve Use the Tracer curve to find your diodes characteristic curve. Export Curve Tracer data to the file and plot the dots on the graph. Save this data for future use. Add points from problem 3.4 to your story. Use the curve Tracer Data Analysis feature to get $I 1N4448 diode 1N4448, $e installed on a plastic stick 1N4448, for 3.2. Assuming the diode is at room temperature, calculate the n. Repeat the measurement, this time with a diode immersed in liquid nitrogen at $T 77, mathematics. Impose cold diode data on the room temperature diode data graph. Repeat the Data Analysis feature and calculate the cold n. Problem 3.6 - Diode Reverse Current Build scheme on the right. Measure the reverse diode current at about $-12,'mathrm-V'$. The current is too small to measure directly, so use the Keithley 2110 DMM to measure voltage through the resistor, and the Om's law to draw a conclusion about the current. Remember that Keatley has an input of $10, a matrix of M'Omega$; You will have to consider this intransigence to correctly calculate the reverse diode current. Compare your response to the $-I_ you found in the 3.5 problem. The imperfections of the connection in real diodes often result in the reverse biased current more than the $-I_-mathrm-sat'$ however, Eq. (1), with the ideal value of the $I 'mathrm'sat'$, is still valid in the forward area. Problem 3.7 - The diode equilibrium, using the same diode as before, to build a diagram shown on the right. $V by turning on offset adjust on Offset Adder. What is the current $$I and voltage $V 'out' for $V'in' 0.5, 0.7,1,2,4,$ and $8, mathv'$? Replace the $10 resistor, 'mathrm'k'Omega$ resistor with a $1', 'mathrm'k'Omega$. Again, measure the current and output voltage for multiple input voltages. Using the diode graph obtained in problem 3.5, perform a graphic analysis of the load line for each of the resistors. Do the equilibrium points predicted by the load line analysis agree with your data? Problem 3.8 - Offset Adder Functionality II Connect signal generator to offset Adder input. Now the output of adder Offset will be the amount of signal connected to the Offset Adder input and the internal offset installed by the Offset Adjust handle. Explore offset Adder's output on the area, and play with different biases and inputs until you understand offset Adder. Problem 3.9 - Small Signal Build the diagram on the right. Adjust the Signal Generator and Offset Adder to produce $0.1', mathrm'Vpp$sine wave ride at $0.4, q0.6,$ and $0.8', mathrm V'$ DC offset. Save trace images for $V and $V for each offset voltage. In addition, write down the amplitude of the AC component $V out $ for each offset voltage; you'll use these values later. Since diodes carry current only in one direction, they can be used to correct AC signals; fix the tools to convert the AC signal into dc. Consequently, diodes are sometimes referred to as straighteners, especially when used in this application. There are several electronic circuits like light dimmers and some electric motor controllers that run away from ac in. Most non-battery electronics, however, require that the air conditioning outlet be converted to dc. Problem 3.10 - Half wave Fix Build a semi-wave straightener chain on the right. Use a signal generator to generate $5,'mathrm-Vpp'$, $60,' and 'mathrm'Hz'$ sine wave. Show the output of the signal generator on channel 1 of the area, and the voltage through the resistor on Channel 2. This last strain is the exit of the chain. Save the images of the tracks and explain all the features of the voltage. The fix, as envisaged by the previous scheme, is only the first step in converting AC power into DC power. Gross disturbances in the signal produced by the above chain should be smoothed, as a rule, by the high-capacity filter capacitor. Because of the technological limitations, the ceramic capacitors that you have used so far do not have a high enough capacity to use in this application. Therefore, the exercises below use electrolytic capacitors. Unlike ceramic capacitors, electrolytic capacitors are polarized. One lead polarized capacitor should have negative potential compared to the other. Negative lead is usually marked with a strip containing stylized marks minus or zeros, and sometimes with an arrow. In addition, xed capacitors are sometimes marked by weakening and plus signs on positive lead. On the right are three styles of electrolytic capacitors. Radial Capacitor Negative Lead on Top Axial Capacitor I Negative Lead in The Right Axial Capacitor II Positive Lead Left What Happens If You Reverse Capacitor Displacement? They can explode... Watch the video on the right. Even if the capacitor does not explode, it will be damaged if it is ever reversed biased: its capacity will go down, and its resistance to leakage (resistance through the capacitor, which is infinite in the ideal capacitor, and almost so in the ceramic capacitor) will decrease. In general, electrolytic capacitors will not work as well as Capacitors. Always use a ceramic capacitor if it is available in the required size. Electrolytic capacitors (and a slightly more efficient type of capacitor called a tantalum capacitor) should only be used for applications such as fix filtering. Hotfix. Use one for a normal high or low pass filter, and never use them in circuits in which they can ever be reverse biased. Problem 3.11 - Filtered Half Wave Fix Add $10, mu-mathematician f capacitor to your chain. (If you are using an electrolytic capacitor, make sure you obey the polarity markings on the body's capacitor.) Save images of output wave shapes. Notice the amplitude of ripples. How it changes when you: a) Double the frequency of input; b) Double the filter capacitor C; c) Double the resistor load $R-L$? (See analytical question 3.15) Problem 3.12 - LED light-emitting diodes (LID) are diodes made from the semiconductor materials of Gallium Arsenide (GAA), not silicon. GaAs connections have a very useful property that they emit light when forward biased. Build a diagram on the right using a red LED for the diode. The LED should not glow. Measure the voltage through the resistor to demonstrate that the current is not flowing. Now change the polarity of the food; The LED must now light. Measure the voltage drop through the resistor and LED. and calculate the current trhough LED. Replace resistors priced at $300, $3k,$,Omega$, 30k$-Omega$, and 300k$-Omega$ resistors for $100-Omega$ How does the brightness of the LED change? How does the drop in forward tension change? How much current does it take to light an LED? Problem 3.13 - LED characteristic curves Compare the characteristic curves of red, green and blue LEDs. What fundamental constant partly explains your observations? Problem 3.14 - The zener diodes chain often require DC voltage less than the voltage of the power chain. This voltage can be obtained with voltage dividers, but the dividers are not rigid and therefore their output voltage will decrease when loaded. In addition, the voltage of the divider will follow any fluctuations in the power voltage. Better circuits use a device called the diode zener. Diodes are diodes specially optimized for reverse destruction. Use the curve Tracer to get the characteristic curve of the diode 1N5234B 1N5234B $6.2, matemarma.V.$ zener diode. (Make sure you switch from the Diode Tracer window to the window of the zener Diode Tracer.) By using the diode zener at the bottom of the leg, you can make the voltage of a divide-like circuit whose ouput voltage is quite tight, i.e. independent (to the point) of the load, and largely regardless of the input voltage. The resistor, R, should be used in the upper leg. Design and build a scheme with zener, which will reduce the voltage from 12V to 6.2V. The current $R U.S. dollars should be limited to about $15. Hint: Given the characteristic curve of zener, should zener be forward or back biased? What is the smallest load resistor $R'mathrm'L'$, placed in parallel with the diode, which will not significantly reduce the voltage of the chain exit? The $R is not a load resistor. Don't Try Small Values for R' Problem 3.15 - Frequency Doubling Many Many devices (including diodes) demonstrate a very useful phenomenon of doubling the frequency: when the signal amplitude is sufficiently high, they double the signal frequency. Doubling the frequency, for example, is used to produce short-wave coherent light. Few lasers are mad in blue or short wavelengths. Powerful red lasers, however, are easy to build. The way out of such red lasers can be applied to the frequency of doubling the crystal, and the blue light will come out. This blue light can be applied to another crystal, giving ultraviolet light. Although the process is a loss-making process, doubling the frequency is the most effective way to create intense, short-wave laser pulses. We are studying the doubling of the frequency in the spice diode chain. You'll run MultiSim and download desktop-Mulitisim-Lab 3'BiasDiod. In this chain, the C1 capacitor is used to block the DC signal component through the diode. Measure the chain's output through R2, load. VAC sets the amplitude of the AC signal by controlling the diode, while VDC (1V) sets the DC displacement. Both VAC and VDC can be changed by clicking on the numerical value to the right of them. Set the VAC to 0.00001. Here the non-linear effects are insignificant. Start MultiSim and look at the result by leaking out the AC analysis (→ analysis → transitional analysis). The graphics program will pop up with an input display (at amplitude 0.00001V) and a smaller output signal. Because both wave shapes look like ideal sinus waves, it is difficult to determine the purity of the waves directly from these areas. The best way to determine their spectral content is to find their Fourier View. Use → analyses→ the Fourier Display analysis will vary into the graphics of the introduction and output of the harmonic content. Both waves are almost pure sinus waves (note the log vertical scale).) There will be several high-order harmonics, but their amplitude will be many orders of magnitude lower. Now go back to the diagram and adjust the VAC to 1V. Repeat the simulation and pay attention to the gross distortion of the output wave. Look at the FFT display: there will now be a whole series of slowly decreasing higher harmonics. The first few harmonics will not be that much lower in the amplitude. Play with VAC. What input signal with the lowest amplitude is needed for a significant doubling of the frequency? (No hard threshold.) Are harmonicas ever stronger than fundamental? Why do you think the frequency is doubling? The rest of the problem can be done away from the lab. Problem 3.16 - Ripple Straightener Find (approximate) expression for (peak-peak) amplitude in straightener built in 3.11 as input voltage and frequency function, load resistor, and filter capacitor. Does your model agree with your observations? Problem 3.17 - Small signal analysis I find the operating point for the chain at 3.9 for all three shifted voltages. Then do a graphic analysis for three offsets to predict the AC current component Use a diode characteristic curve obtained at 3.5. Problem 3.18 - Small Signal Analysis II Now repeat 3.17 using a small signal impulse perturbation method: calculate the small diode impedance signal at each operating point; then use this movement in a linear analysis of voltage separations. Show how a large impedance signal will give the voltage divider a way out much more than the actual answer. Please complete the student evaluation report for the lab