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Laboratory 2 – Active electronic elements

Introduction:

Review of Lab 1: Recall that in Lab 1, we looked at the difference between voltage and current sources.

1. We used passive elements – two resistors in series that act as a voltage divider to test the characteristics of the source.
2. The key conclusions of the assignment were
   a) It is fairly easy to make a nearly ideal voltage source (fixed *V* for any value of *I* drawn by load) – a battery is a common example.
   b) It is hard to make a good current source (fixed *I* for any value of *V* or load resistance *R*). A voltage source with a very large *R* in series with it, *sort of* acts like a non-ideal current source.

Today: In Lab 2, we will introduce the simplest *active* electronic element – a diode. The electronic symbol for a diode is:

Anode Cathode the physical device looks like:

Think of a diode as a one-way conductor, it only conducts current in one direction from its anode to its cathode once the potential at the anode is ~ 0.7 V above the cathode. The exact value of this potential varies slightly depending on the types of diodes.

When a diode is conducting, it is said to be 'ON', when it is not conducting, it is said to be 'OFF'

In all the following exercises, please take careful note of the polarity of the diodes (+and - terminals) when connecting them in your circuits.

Ex 1	Ex 2	Ex 3.A	Ex 3.B	Ex 3.C	Ex 4.A	Ex 4.B
/1+1+1	/2	/1	/1	/1	/3	/4

Total
/15

Exercise 1: Diode clamp

Connect up the circuit shown in Fig 1. Use the function generator to supply V_{in}.
Vary the amplitude of the input voltage in the range ~ 0 to 2 volts.
Observe V_{in} and V_{out} on the DSO.
Draw the observed V_{in} and V_{out} voltage waveforms as a function of time.

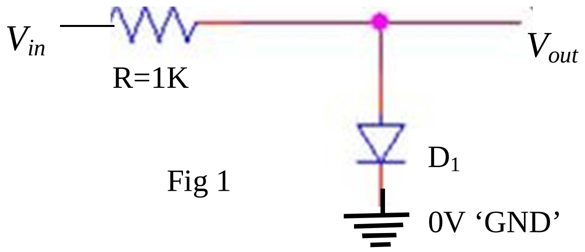

Fig 1

Q.A) What happens to diode D_1 conduction for $V_{in} > \sim 0.7V$? ___*D_1 forward biased conducts*

Q. B) What is *path* of I_{in} for $V_{in} > 0.7V$? ____________*through D_1 to ground*

Q. C) D_1 has a limit of ~ 10 mA on the current which it can safely pass when forward biased. What happens if I_{in} exceeds that value?
If $I_{in} > 10ma$, D_1 fails and becomes open ckt. $V_{out} \sim V_{in}$ is not protected any more (except for small voltage division through R). So this is a voltage protection device – for current protection use Zener diode.

Discussion Such diode "clamps" are used for voltage protection of inputs on most electronic equipment. In particular, a diode clamp can protect the input of a device from electrostatic potential discharge – friction & dry weather produces electrostatic potential on your fingers which is positive

Exercise 2: Diode Limiter

Connect up the circuit shown in Fig 2
Measure and draw the input and output voltage waveforms V_{in} ,V_{out} as a function of time.
Vary the amplitude of the input signal in a small range from 0 to 2V.

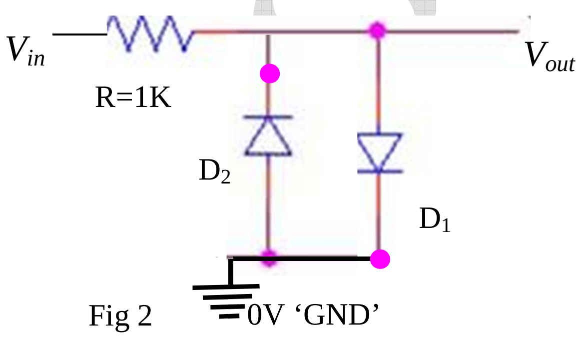

Fig 2

Q) What happens to D_1 and D_2 conduction state when V_{in} exceeds ~ 0.7 V in either positive or negative sign?
A)__$V_{in} > +0.7V$: ______ *D_1 forward biased conducts*
B)__ $V_{in} < -0.7V$: ______ *D_2 forward biased conducts , So V_{in} limited between +0.7V and -0.7V*

Discussion: Why are diode limiters useful? *When amplifying small signals with a large gain (something we will look at in the later labs), it is necessary to ensure that the input signal remains within limits at both signs – in electronic terms to limit the 'swing' of the signal. For example if an amplifier operates from +/- 100V power supplies, it can produce a maximum output voltage of +/-100V. If it has a gain of 200, the input signal must stay within a range of +/- 0.5V in order for the output not to saturate.*

Exercise 3:

Connect up the circuit shown in Fig 3 and observe the input signal (from the function generator, sine wave ~ 50 Hz, 5V amplitude) and output signal on two channels of your DSO.

Q.A) Draw a measured the input & output voltages as a function of time. Points 1-0 are measured on channel 1 of the DSO, points 2-0 are measured on channel 2

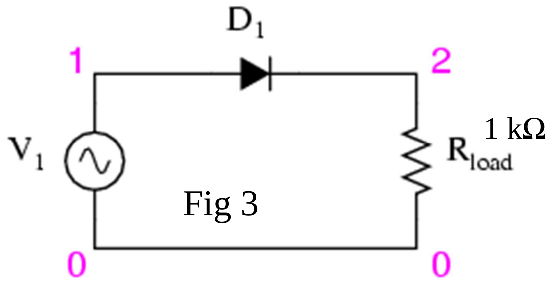

Fig 3

Solution: This is a half wave rectifier: Diode conducts in the positive half-cycle of input waveform

Q.B) How do your observations change if the input signal amplitude V_1 is less than ~ 0.7V?
No conduction in D_1 at all – V_{20} is zero
Q.C) Indicate on your waveform diagram when D_1 is conducting, and when it is not.
D_1 conducts in the positive half cycle of V_1 when V_1 > 0.7V

Exercise 4:

Extend your circuit earlier so that it now has four diodes as shown in Fig 4. As before, use the function generator to provide the input sine waveform. The circuit in Fig 4 should look familiar from previous studies. V_{in} is provided across points labeled 1 & 2, V_{out} is measured across 3 & 4
Q.A) Observe the waveforms under the following conditions carefully, and draw your measurements below:

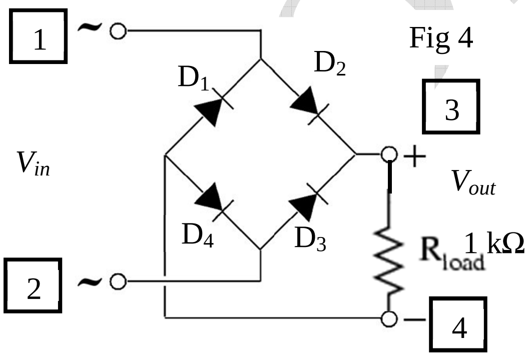

Fig 4

Q.A$_1$) Only V_{in} is measured across 1 & 2

Sine wave as produced by FG

Q.A$_2$) Only V_{out} is measured across 3 & 4

Full wave rectified output – both half cycles of sine are made positive.

Q.A$_3$) V_{in} and V_{out} are measured at the same time on two channels of the DSO

Points 2 and 4 are grounded. So D_4 not relevant in the circuit

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Q.B) Explain the circuit behavior you observe by ticking the appropriate options and concluding:

Positive half cycle of V_{in} : D_1 = ON/OFF D_2 = ON/OFF D_3 = ON/OFF D_4 = ON/OFF

Negative half cycle of V_{in} : D_1 = ON/OFF D_2 = ON/OFF D_3 = ON/OFF D_4 = ON/OFF

In positive half cycle, circuit behaves as a:_*Seen from V_{out} (3-4) circuit behaves as half-wave rectifier through D_1*

In negative half cycle, circuit behaves as a:_*Seen from V_{in}(1-2) circuit behaves as a negative clamp (like Exercise 1, with the opposite sign)*

$Hint_1$: Recall your work in Exercise 1

$Hint_2$: One end of the DSO probe is internally grounded – i.e. fixed to earth reference 0V.

$Hint_2$: what happens to D_4 if points 2 and 4 are at ground voltage?