

# EE230: Lab-4

## Simple Application Circuits

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## **1 Overview of the experiment**

### **1.1 Aim of the experiment**

The aim of the experiment is to understand and simulate a photo diode using an Op-Amp and a 3 Op-Amp based instrumentation amplifier.

### **1.2 Methods**

We start by analysing the circuits and then simulating in ngspice to check against theoretical expectations.

## 2 Design

### Photo Diode

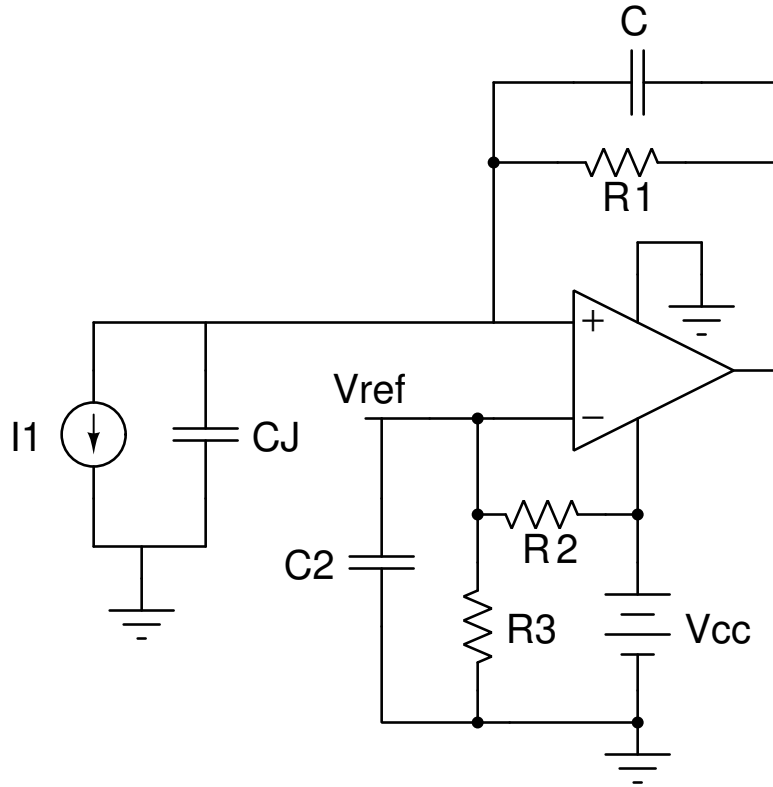


Figure 1: Photodiode

The circuit diagram of a Photo Diode is shown above. It uses a current source and a capacitor to simulate a Photodiode model and then uses its outputs as inputs to the Op-Amp.

The  $V_{cc}$  of the Op-Amp is grounded and the  $V_{ee}$  is equal to 5V.

## Instrumentation Amplifier

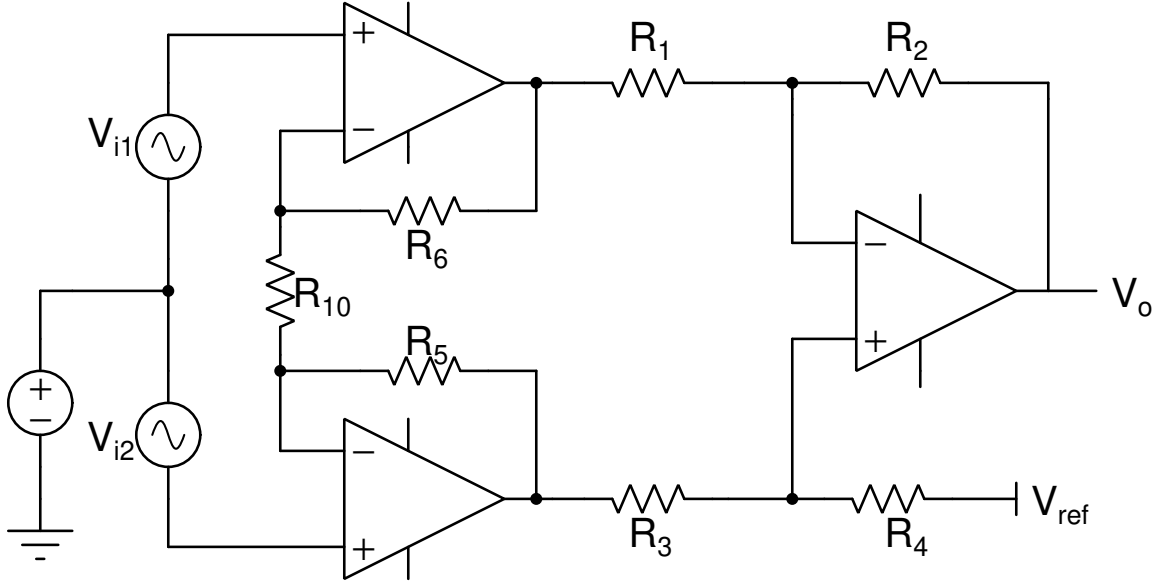


Figure 2: Instrumentation Amplifier

The circuit diagram of instrumentation amplifier is shown above.

An instrumentation amplifier is a type of differential amplifier that has been outfitted with input buffer amplifiers, which eliminate the need for input impedance matching and thus make the amplifier particularly suitable for use in measurement and test equipment.

Additional characteristics include very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedance. Instrumentation amplifiers are used where great accuracy and stability of the circuit both short- and long-term are required.

The gain of the amplifier is given:

$$A_v = \left(1 + \frac{2R_6}{R_{10}}\right) \frac{R_3}{R_2} \quad (1)$$

## 3 Simulation results

### 3.1 Photo Diode

#### 3.1.1 Code snippet

```
1 Photodiode application circuit using op-amp LM324
2
3 .include lm324.txt
4 *describe circuit
5 * <element-name> <nodes> <value/nodel>
6 x1 1 2 3 4 5 LM324
7 R1 2 5 1.4Meg
8 C1 2 5 3.3p
9 R2 1 3 13.7K
10 R3 1 0 280
11 C2 1 0 1u
12 CJ 2 0 11p
13 vp 3 0 5v
14 vn 4 0 0v
15 vref 1 0 0.1v
16 I1 2 0 0
17 *analysis command
18 .dc I1 0 2.4u 0.1u
19
20 .control
21 run
22
23 *display cmd
24 plot v(5)
25 *end control mode
26 .endc
27
28 *end netlist
29 .end
```

```
1 Photodiode application circuit using op-amp LM324
2
3 .include lm324.txt
4 *describe circuit
5 * <element-name> <nodes> <value/nodel>
6 x1 1 2 3 4 5 LM324
7 R1 2 5 1.4Meg
8 C1 2 5 3.3p
9 R2 1 3 13.7K
```

```

10 R3 1 0 280
11 C2 1 0 1u
12 CJ 2 0 11p
13 vp 3 0 5v
14 vn 4 0 0v
15 vref 1 0 0.1v
16 I1 2 0 dc 1.5u ac 1
17 *analysis command
18 .ac dec 10 10 100Meg
19
20 .control
21 run
22
23 *display cmd
24 plot vdb(5)
25 *end control mode
26 .endc
27
28 *end netlist
29 .end

```

## 3.2 Instrumentation Amplifier

### 3.2.1 Code snippet

```

1 Opamp based Instrumentation amplifier
2
3 .include ua741.txt
4 *describe circuit
5 * <element-name> <nodes> <value/nodel>
6 x1 1 2 3 4 5 ua741
7 x2 21 22 23 24 25 ua741
8 x3 31 32 33 34 35 ua741
9
10 R1 2 35 10K
11 R2 2 5 10K
12 R3 1 25 10K
13 R4 1 6 10K
14 R5 25 22 10K
15 R6 35 32 10K
16 R10 32 22 2.2K
17
18 vp1 3 0 15v
19 vn1 4 0 -15v
20 vp2 23 0 15v
21 vn2 24 0 -15v

```

```

22 vp3 33 0 15v
23 vn3 34 0 -15v
24
25 vcm 7 0 DC 0
26 vi1 21 7 dc 0
27 vi2 31 7 dc 0
28 vref 6 0 0
29 *analysis command
30 .DC vcm -2 2 0.01
31
32 .control
33 run
34
35 *display cmd
36 plot v(5) v(7)
37 *end control mode
38 .endc
39
40 *end netlist
41 .end

```

```

1 Opamp based Instrumentation amplifier
2
3 .include ua741.txt
4 *describe circuit
5 * <element-name> <nodes> <value/nodel>
6 x1 1 2 3 4 5 ua741
7 x2 21 22 23 24 25 ua741
8 x3 31 32 33 34 35 ua741
9
10 R1 2 35 10K
11 R2 2 5 10K
12 R3 1 25 10K
13 R4 1 6 10K
14 R5 25 22 10K
15 R6 35 32 10K
16 R10 32 22 2.2K
17
18 vp1 3 0 15v
19 vn1 4 0 -15v
20 vp2 23 0 15v
21 vn2 24 0 -15v
22 vp3 33 0 15v
23 vn3 34 0 -15v
24
25 vcm 7 0 DC 0

```

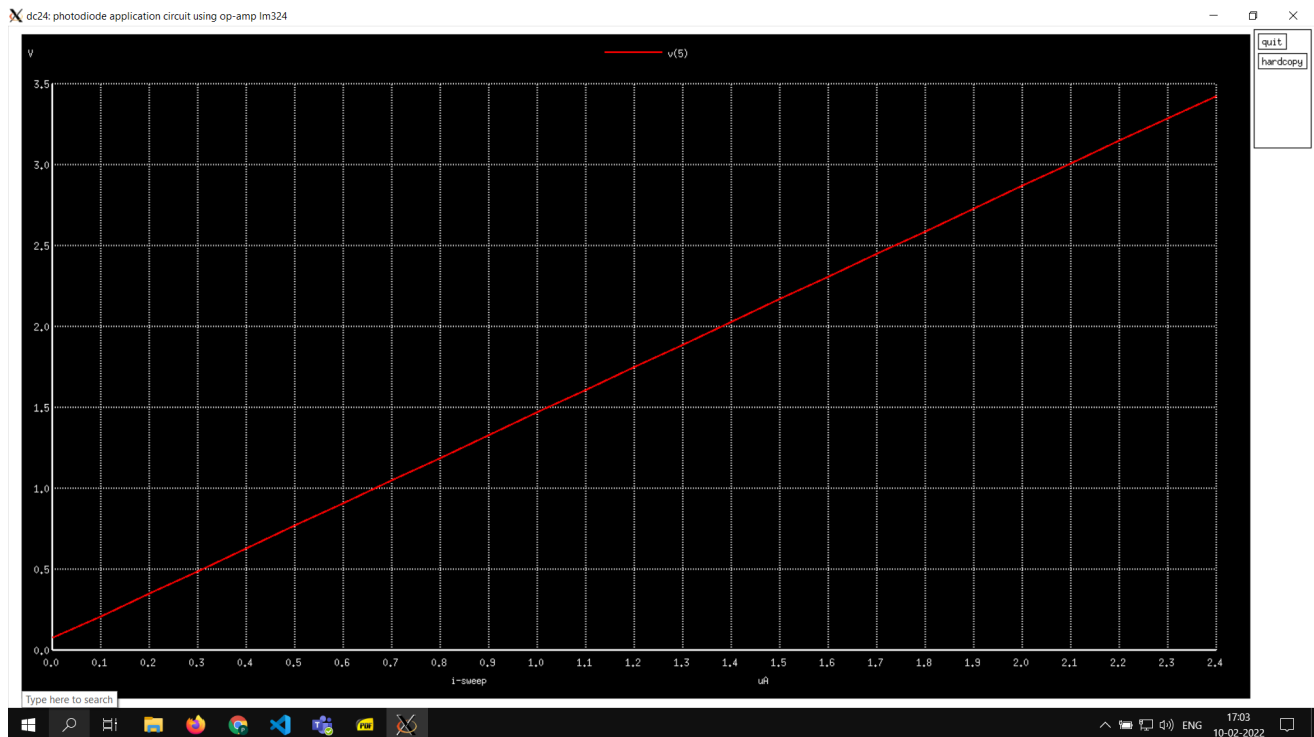
```

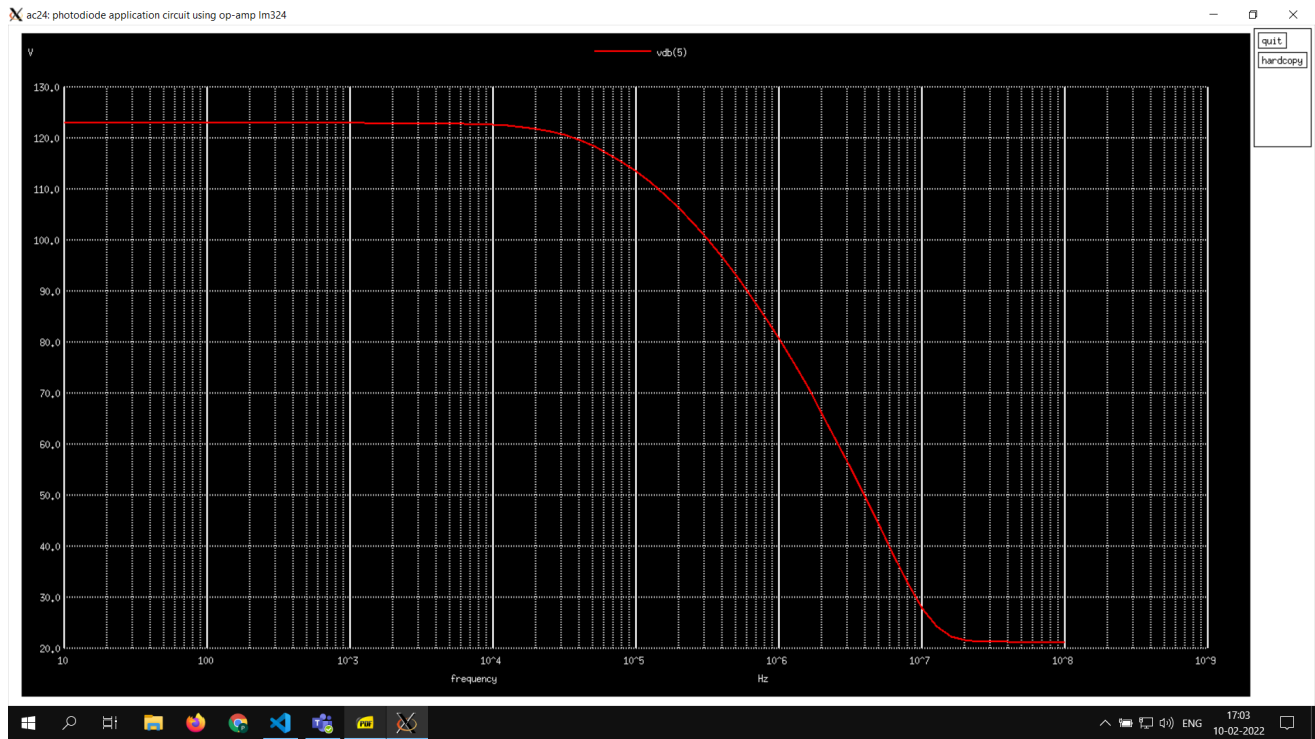
26 vi1 21 7 sin(0 250m 1k 0 0)
27 vi2 31 7 sin(0 -250m 1k 0 0)
28 vref 6 0 0
29 *analysis command
30 .tran 0.01ms 10ms
31
32 .control
33 run
34
35 *display cmd
36 plot v(5) v(21,31)
37 *end control mode
38 .endc
39
40 *end netlist
41 .end

```

### 3.2.2 Simulation results

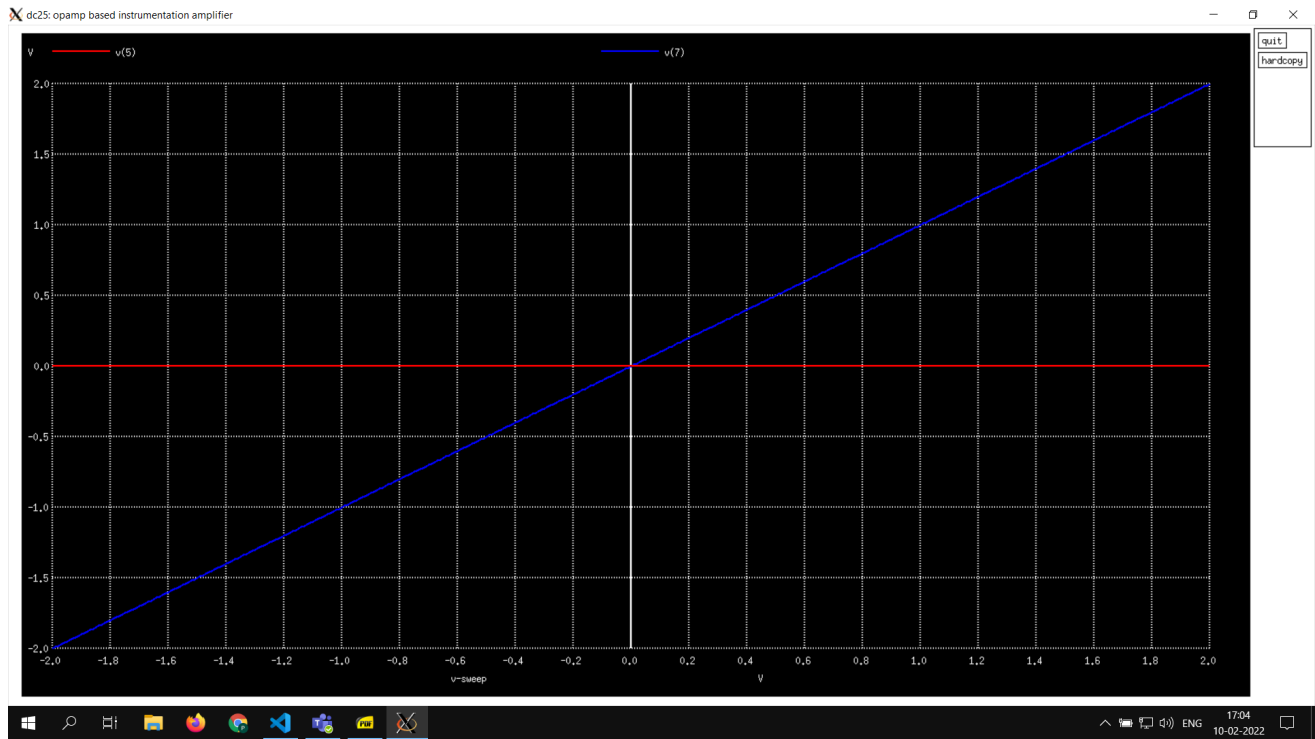
## Photo Diode

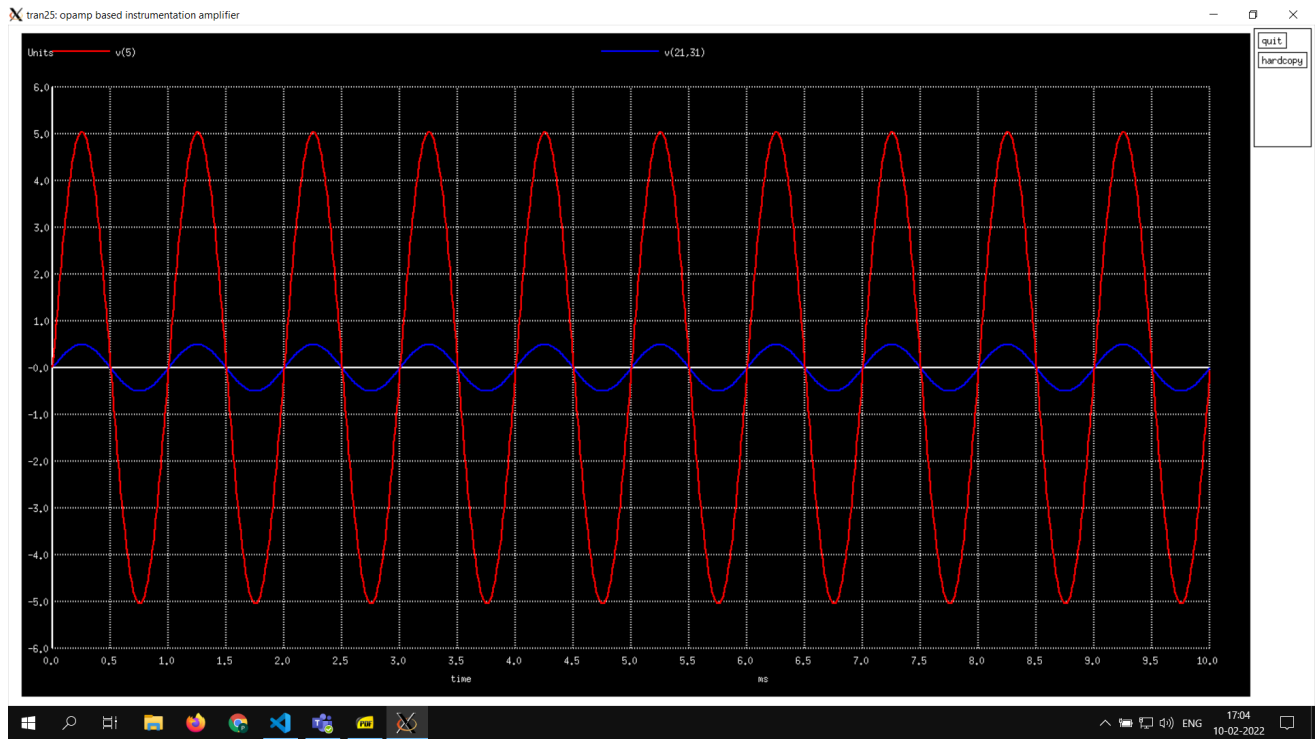




## Instrumentation Amplifier







## 4 Experiment completion status

All the sections were completed