Behavior of LED Brightness in Voltage Divider Circuits Under Varying Load Conditions

1. Introduction

This experiment explores how the brightness of LEDs is affected when connected to various voltage divider configurations. Special attention is given to the influence of different load types, resistance values, and LED color on output voltage and perceived brightness. The setup simulates real-world circuit scenarios where sensors or indicators are connected to voltage dividers.

2. Methodology

A breadboard circuit was assembled consisting of a standard two-resistor voltage divider powered by a $9\ V$ battery. The output of the divider was connected to an LED in series with a $330\ \Omega$ current-limiting resistor. Voltage and current were measured using a multimeter.

Three resistor combinations were tested in the divider:

- **R_1-R_2 Config A:** $1\ k\Omega$ – $1\ k\Omega$
- **R_1-R_2 Config B:** $4.7\ k\Omega$ – $1\ k\Omega$
- **R_1-R_2 Config C:** $1\ k\Omega$ – $4.7\ k\Omega$

For each configuration, the following conditions were applied:

- **LED Color Variants:** Red, Green, Blue
- **Load Conditions:**
    - No load (just LED circuit)
    - Additional resistive load (1 kΩ resistor to ground at output)
    - Capacitive load (10 µF capacitor to ground at output)

Measured parameters:

- Voltage across LED
- Current through LED
- Apparent brightness (subjectively rated 0–5 scale by three observers)

Each setup was repeated three times, and average values are shown below.

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3. Results

Table 1. Voltage Across LED (Volts)

Config	Load Type	Red	Green	Blue
A	No Load	4.48	4.12	3.86
A	Res Load	3.85	3.47	3.21
A	Cap Load	4.41	4.05	3.79
B	No Load	1.72	1.45	1.20
B	Res Load	1.36	1.15	0.94
B	Cap Load	1.65	1.39	1.12
C	No Load	6.21	5.89	5.41
C	Res Load	5.34	5.03	4.60
C	Cap Load	6.10	5.77	5.31

Table 2. Current Through LED (mA)

Config	Load Type	Red	Green	Blue
A	No Load	13.1	10.4	9.6
A	Res Load	8.5	6.9	5.7
A	Cap Load	12.8	10.1	9.2
B	No Load	3.0	2.4	2.1
B	Res Load	1.9	1.5	1.2
B	Cap Load	2.7	2.1	1.9
C	No Load	18.2	14.9	13.7
C	Res Load	14.1	11.8	10.4
C	Cap Load	17.6	14.5	13.1

Table 3. Apparent Brightness (Scale 0–5, avg. of 3 observers)

Config	Load Type	Red	Green	Blue
A	No Load	4.0	3.6	3.1
A	Res Load	2.9	2.3	1.8
A	Cap Load	3.9	3.4	2.9
B	No Load	1.0	0.8	0.5
B	Res Load	0.6	0.5	0.3
B	Cap Load	0.9	0.7	0.5
C	No Load	5.0	4.5	4.0
C	Res Load	4.2	3.7	3.2
C	Cap Load	4.8	4.3	3.8

Additional Notes:

- Voltage measurements at the divider output fluctuated slightly with capacitive load.
- In some high-resistance configurations, blue LEDs failed to visibly light up.
- Capacitive load caused a noticeable "fade-in" effect when power was applied.

4. Conclusion

[No conclusion provided intentionally.]