APPLICATION OF OPTICAL LOGIC GATES

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ABSTRACT

This paper proposes optical NOT, AND, and NOR gates using unijunction transistor (UJT), light emitting diode (LED), and light dependent resistor (LDR). Efforts are made to extend the development of these gates using LDR, LED, and UJT to work at 1.8V instead of 3V. These optical gates find their application in the field of fiber optics, optical logic isolators, and other instrumentation systems.

INTRODUCTION

During the last few years [2-5] attempts have been made towards study and development of fundamental optical gates. Recently, great interest has been shown in developing various optical systems [1] that provide bi-stability, because of their practical application in the field of fiber optics, optical logic isolators, and other instrumentation system. The most recent development [6] is OR, AND, NOT, NAND, and NOR gates using photo resistor and light emitting diode working at 3V. Here, an attempt has been made to reduce the power consumption of these gates using LDR, LED, and UJT to work at 1.8V. These gates are intrinsically safe and can be used for monitoring of data in hazardous environments such as petroleum industry, chemical industry, fertilizer industry, and underground coal-mines [1].

GATES IMPLEMENTATION

Optical NOT

Figure 1 shows the circuit diagram of optical NOT with light input $OP_i$. The light dependent resistor LDR is connected in series to UJT emitter and the power supply $+1.8V$ to the base $B_2$ through a pair of resistances $R_{11}$, $R_{12}$. The values of resistors $R_{11}$, $R_{12}$, $R_{13}$, and $R_{14}$ are taken as $100\Omega$, $510\Omega$, $4.6$ k$\Omega$, and $10\Omega$ respectively and $R_{11} = R_{31} = R_{31}$, $R_{12} = R_{22} = R_{32}$, $R_{13} = R_{33}$, and $R_{14} = R_{34} = R_{34}$. Logic 1 and Logic 0 are represented by LED on and LED off respectively. Optical output $OP_o$ of

NOT occurs only when the input $OP_i$ is low, thus satisfying the condition, $OP_o = \overline{OP_i}$.

Optical AND

Figure 2 shows the circuit diagram of optical AND with light input $OP_{i1}$ and $OP_{i2}$. The LDR$_1$ and LDR$_2$ are connected in series to the UJT$_1$ emitter terminal. Optical output $OP_o$ of AND occurs only when both the inputs $OP_{i1}$ and $OP_{i2}$ are high, thus satisfying the condition, $OP_o = (OP_{i1} \cdot OP_{i2})$.

Without any additional components, the same Fig.2 optical AND can be modified as optical NAND gate.

Optical NOR

Figure 3 shows the circuit diagram of optical NOR with light input $O_{P1}$ and $O_{P2}$. The LDR$_1$ and LDR$_2$ are connected in parallel to the UJT emitter terminal. Optical output $O_{P0}$ of NOR occurs only when both the inputs $O_{P1}$ and $O_{P2}$ is high, thus satisfying the condition, $O_{P0} = (O_{P1} + O_{P2})$.

The realization of the designed logic gates were realized successfully using UJT type No 2N2646. All the LDRs are similar types and have resistance 10 kΩ when the light from the LED falls on it and has dark resistance 150 MΩ. The power dissipation of Figs. 1 & 3 is approximately 1mW and Fig. 2, is approximately 2mW, which is well below intrinsic safe region of highly flammable
gases. The variation of the output voltage \( (OP_o) \) Vs LDR resistance is plotted in Fig. 4.

These circuits though not fast, but find useful in hazardous environment, where speed is not important. Some of the applications are monitoring system \([7]\) of \( \text{CH}_4 \) and \( \text{CO}_2 \) in underground coalmine, ethylene and acetylene monitoring system in petrochemical industry, monitoring of different hydrocarbons and gases like \( \text{NO}_x, \text{SO}_2, \) and \( \text{CS}_2 \) in chemical, pharmaceutical, cosmetic, and fertilizer industry \([1],[2]\).

**CONCLUSIONS**

Optical NOT, AND, and NOR were realized successfully using LDR, LED, and UJT working at 1.8V. Fiber optic systems and other areas mentioned above can employ these optical gates for their intrinsic safety, because of low power dissipation. As these gates are operated at 1.8V and the total power dissipation is 1 mW to 2 mW, which can’t create any electrical spark thus it has intrinsic safety characteristics. Other logic gates, multivibrators, multiplexers, and demultiplexers can be established similarly.

**REFERENCES**


