APPLICATION OF OPTICAL LOGIC GATES

Avireni Srinivasulu, L.Parthasarathy and Alemayehu G/Egziabher
Faculty of Electrical Engineering
Defence University Engineering College

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 $R_{11} = R_{21} = R_{31}$, $R_{12} = R_{22} = R_{32}$, $R_{13} = R_{23} = R_{33}$, and $R_{14} = R_{24} = R_{34}$. 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, $OP_o = \overline{OP_i}$.

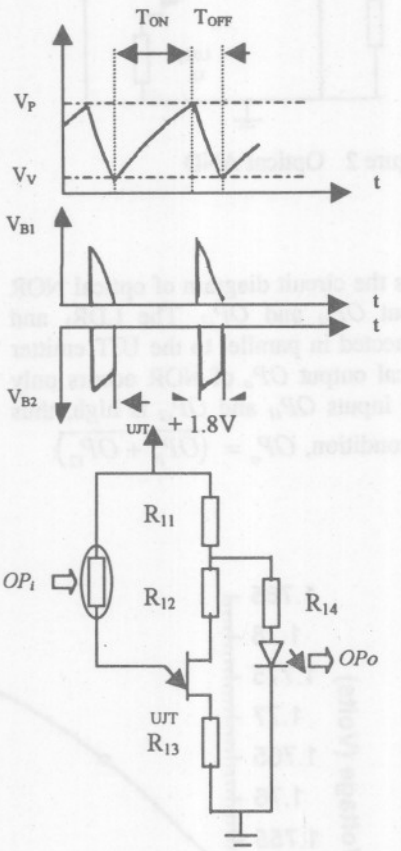

Figure 1 Optical NOT

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, $OP_o = (OP_{i1} * OP_{i2})$.

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

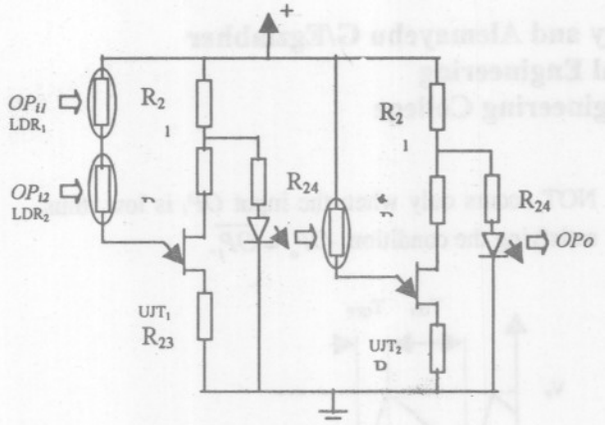

Figure 2 Optical AND

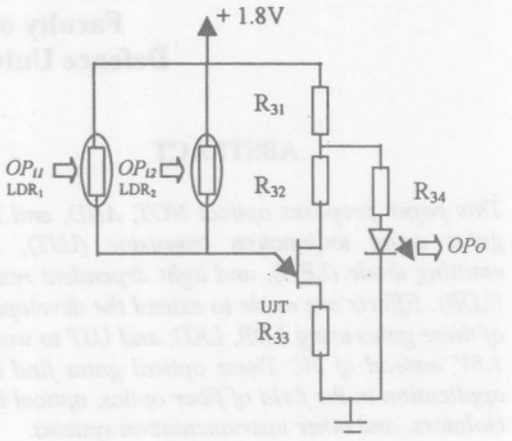

Figure 3 Optical NOR

Optical NOR

Figure 3 shows the circuit diagram of optical NOR with light input OP_{i1} and OP_{i2}. The LDR_1 and LDR_2 are connected in parallel to the UJT emitter terminal. Optical output OP_o of NOR occurs only when both the inputs OP_{i1} and OP_{i2} is high, thus satisfying the condition, $OP_o = \overline{(OP_{i1} + OP_{i2})}$.

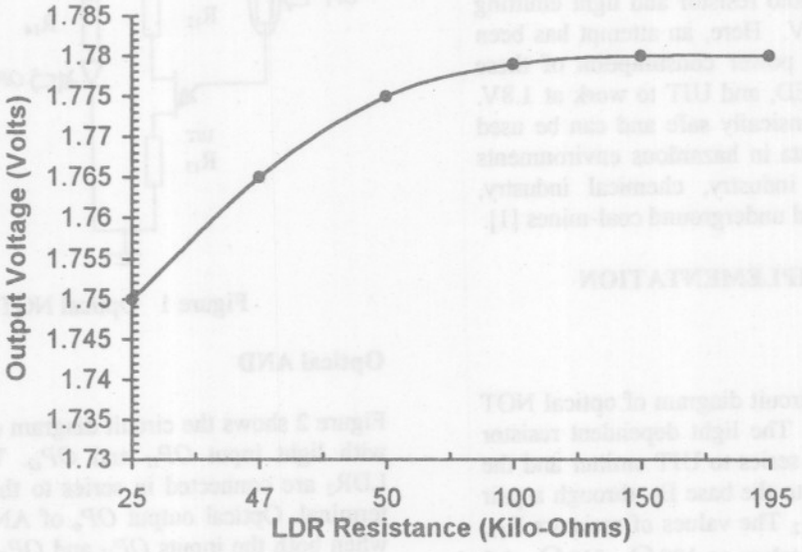

Figure 4. Output Voltage Vs LDR Resistance.

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 CH_4 and CO_2 in underground coalmine, ethylene and acetylene monitoring system in petrochemical industry, monitoring of different hydrocarbons and gases like NO_x, SO_2, and 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.

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