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Fundamental optical logic gates

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A circuit of optical AND, OR, NOT, NAND and NOR gates has been proposed using photoresistors and light emitting diodes. These gates are intrinsically safe and have numerous potential applications in the field of instrumentation and other fibre optic systems. A future scope of these circuits has also been described.

During the last few years, frequent attempts [1] – [4] have been made towards the study of fundamental optical logic gates. This is because of their practical applications in the field of fibre optic and other instrumentation systems. This has become possible due to availability of various binary, ternary and multiternary optoelectronic materials having the properties of optical bistability. Recently, the authors [5] have developed AND, OR, NOT, NAND and NOR gates using SCR, LDR and LED. In this paper, we extend the development of these gates using photoresistors and light emitting diodes. Silicon control rectifier (SCR) is not used in the present circuit. These gates may not be very fast but they are intrinsically safe and can be used for the monitoring of data in any hazardous environment, such as an underground coal mine, petroleum industry, chemical and fertilizer industry.

The logic 1 and 0 is represented by the hight state when light is on and by the low state when light is off, respectively. Figure 1 shows the circuit diagram of an optical AND gate with two inputs having optical power P_{11} and P_{12}. The

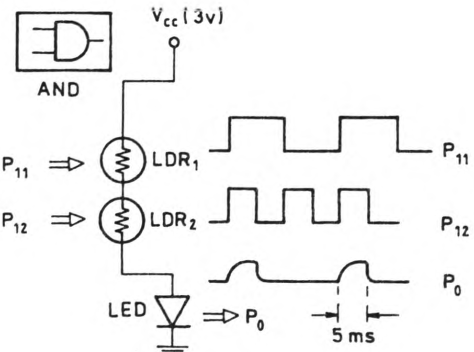

Fig. 1. Optical AND gate

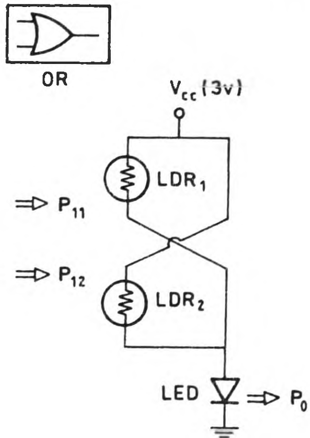

Fig. 2. Optical OR gate

photoresistors LDR_1, LDR_2 are connected in series with LED and power supply V_{cc}. The output of AND gate is at high state only when both the optical inputs P_{11} and P_{12} are at high state, so that the condition $P_0 = P_{11} \times P_{12}$ is satisfied, otherwise it will remain at low state and LED will not glow. The response of two optical pulse waves P_{11}, P_{12} and its output P_0 are also shown in Fig. 1.

The function of OR gate has been realised in Figure 2. The output power P_0 is at high state only when any one of the inputs P_{11} or P_{12} is at high state, *i.e.*, $P_0 = P_{11} + P_{12}$.

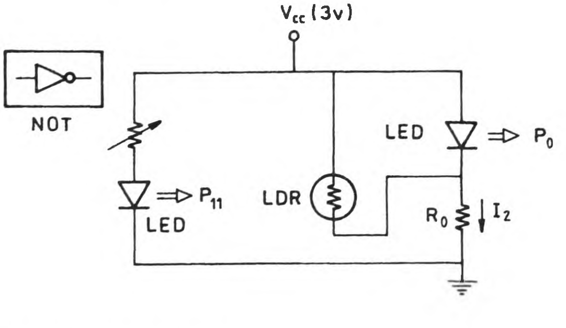

Fig. 3. Optical NOT gate

The condition of NOT gate has been realised in Figure 3, where the output is low for high input and vice-versa, *i.e.*, $P_0 = \overline{P_{11}}$.

The optical NAND and NOR gates are illustrated in Figures 4 and 5, which satisfy the conditions $P_0 = \overline{P_{11} \times P_{12}}$ and $P_0 = \overline{P_{11} + P_{12}}$, respectively.

The operating voltage of these gates is 3.0 V and maximum current drawn is about 20 mA and hence the maximum power dissipation is 0.6 Watt, which is well in the intrinsically safe region. This power dissipation is much lower than that of the specified limit in the different standards of intrinsic safety chart for highly fam-

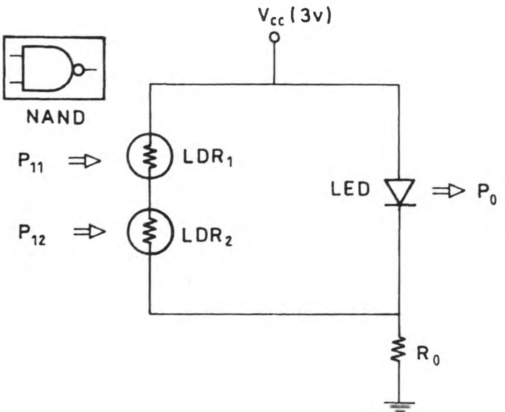

Fig. 4. Optical NAND gate

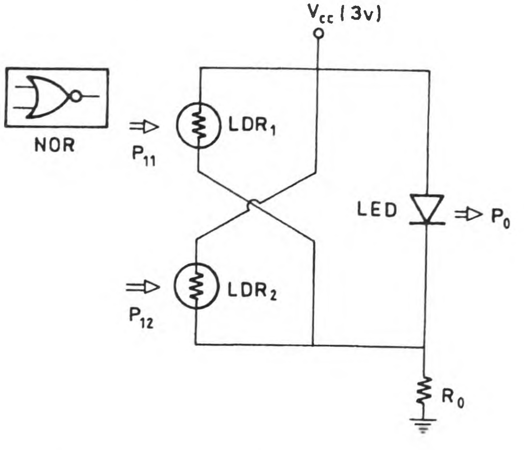

Fig. 5. Optical NOR gate

mable gases. Due to low power consumption, these elements may be used in the safety device equipment and control, such as the fibre optic instrumentation systems, the monitoring system [6] of CH_4 and CO in an underground coal mine, ethylene and acetylene monitoring system in the petrochemical industry, monitoring of different hydrocarbons and other gases like NO_x, SO_2 and CS_2 in chemical, pharmaceutical, cosmetic and fertilizer industries.

The source used in the present circuit, *i.e.*, V_{cc} may be replaced by photovoltaic cell and more reliable all-optical logic gates may be designed to switch on and switch off the different monitoring systems when the prescribed danger limit is exceeded. Further, with the help of these gates all-optical flip-flops [2], [7], decoders, encoders, multivibrators, *etc.*, can also be designed.

The circuit of these gates is relatively simpler than our earlier circuit [5] and cost competitive, too. It may be used in safety devices in which the speed is not so important as the fact that they are kept in corrosive, explosive and hazardous environment for continuous monitoring. Hence, an intrinsically safe system may be designed using these gates.

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