Introduction

This GreenPAK3 programmable mixed-signal ASIC device is configured for an infrared proximity sensor. The design approach relies on relative changes of an objects' IR reflected brightness as the distance varies. With the IR illumination source facing out from the detector area, the farther away an object, the less light is reflected by it. The GreenPAK3 steps through 7 increasing levels of IR illumination intensity, while the detector sensitivity remains fixed at a baseline level. As the illumination increases, the IR detector will provide a logic true output at its threshold setting, and the intensity step ups will halt. The resulting proximity is indicated linearly by a column of seven LED's. At a distance exceeding the limits of the sensitivity of the detector, all seven LED's are ON. As the distance to the object decreases, the number of LED's that are ON also decreases. So with a known object, this design is also useful for simple distance/ranging.

This design is constructed in 2 main parts: receiver module and LED driver/scale.

The receiver module consists of an IR LED emitter and integral IR detector with built-in amplifier-comparator having 36 kHz bandpass filter. The light emitted from the IR LED is modulated at the same frequency, so the system is protected from interference from other IR sources. Conceivable interference sources may include remote controls for TV's or similar equipment. If desired, the TSOP31236 can be substituted by alternate receiver modules having 36kHz modulation – commonly used in remote controls. This design requires some initial tuning to determine the best value of resistor R2 by making test measurements of the distance to the object. This resistance value depends on the brightness of the particular IR LED, photo detector sensitivity, and desired distance range. Fig 1. and Fig 2. show two options for implementation of this design. Fig 1. provides a linear measurement of distance, but requires more external components and resources from the GreenPAK3. Fig 2. loses some linearity of distance measurement but uses fewer external components and resources from the GreenPAK3.

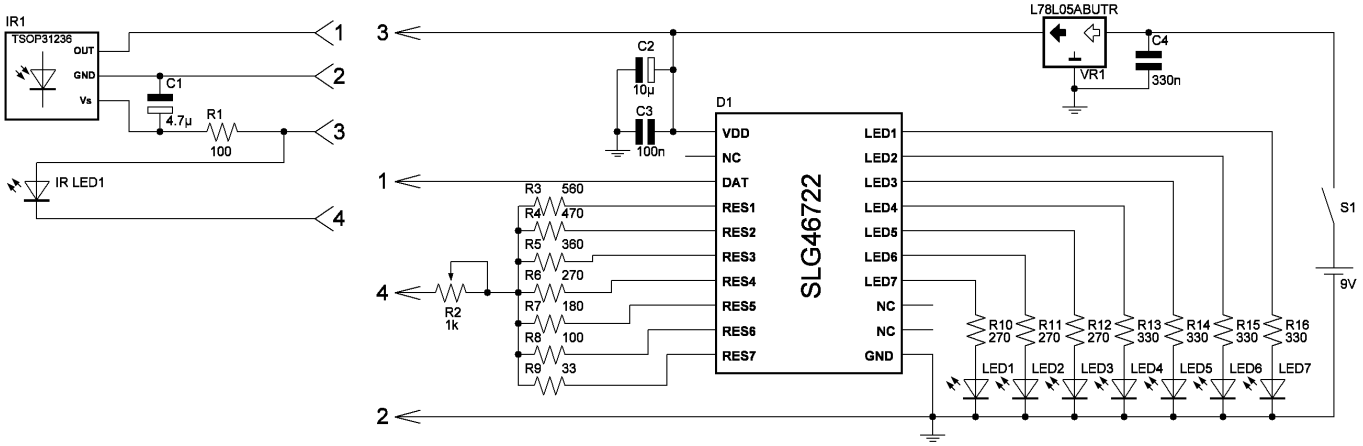

Fig 1. Infrared proximity sensor, linear implementation

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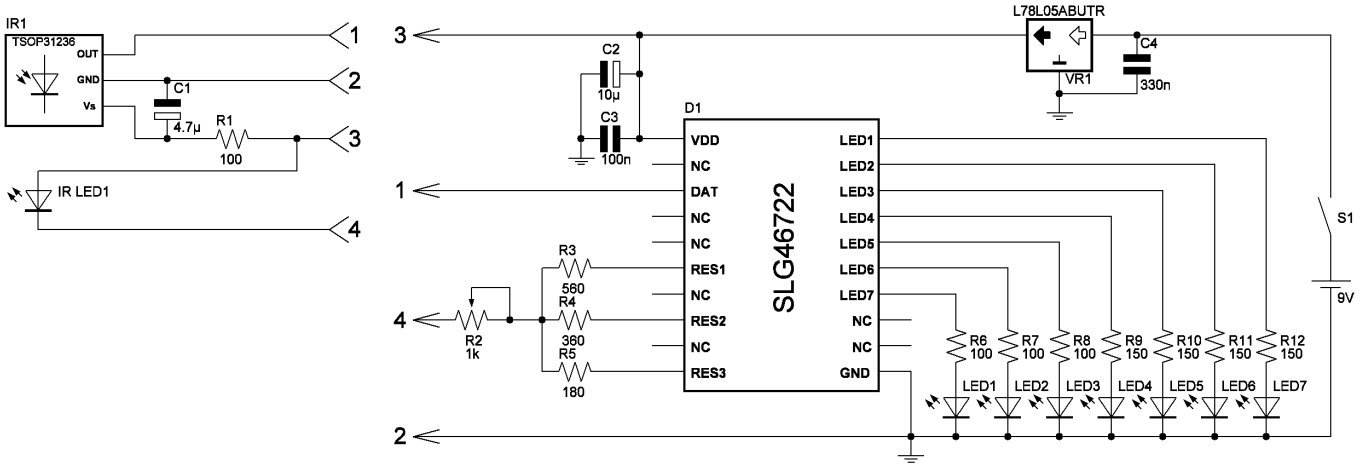

Fig 2. Infrared proximity sensor, pseudo-linear implementation

Infrared Proximity Sensor Circuit Design

As can be seen in Fig 3. and Fig 4. schematics, the linear implementation uses five DFFs, Pipe Delay, seven 3-bit LUTs, two 2-bit LUTs, two CNT/DLYs, RC OSC, seventeen PINs. The pseudo-linear implementation uses four DFFs, seven 3-bit LUTs, five 2-bit LUTs, two CNT/DLYs, RC OSC, thirteen PINs. Both versions use timing generators that are implemented with CNT/DLYs and 2-bit LUTs. The first generator is implemented using CNT0/DLY0 and 2-bit LUT1 with approximately 600Hz output frequency. The second generator is implemented using CNT1/DLY1 and 2-bit LUT2 its output frequency is 72 kHz but then divided by DFF5 to 36 kHz with 50% duty cycle. Using DFFs and Pipe Delay (linear implementation) a shift register is implemented. Shift register cells are connected to output LUTs, 3-bit LUT0 - LUT6 (linear implementation) and 3-bit LUT0 - LUT6, 2-bit LUT3 - LUT5 (pseudo-linear implementation).

Infrared Proximity Sensor Circuit Analysis

In both implementations, when DAT (PIN3) is HIGH, all indicator LEDs will sequentially turn on, while the equivalent current limiting resistance for IR LED decreases(increasing IR LED intensity). The output intensity control is stepped through its levels by R2-R9 for linear implementation, R2-R5 for non-linear implementation. When DAT (PIN3) is LOW, all indicator LEDs turn off, while the equivalent current limiting resistance for IR LED output increases (decreasing IR LED intensity to minimum). In order to modulate the IR LED at 36kHz, the second generator is used. The IR LED stepping through its' brightness levels is controlled by the shift register. Each clock input from the first generator will thereby increment, and illuminate another display LED. This continues until DAT falls LOW which resets the shift register/indicator LED's. DAT will then go high again after the photo detector response time, and the cycle repeats from the beginning. The functionality waveforms for both implementations can be seen on Figs 5, 6, 7 and 8.

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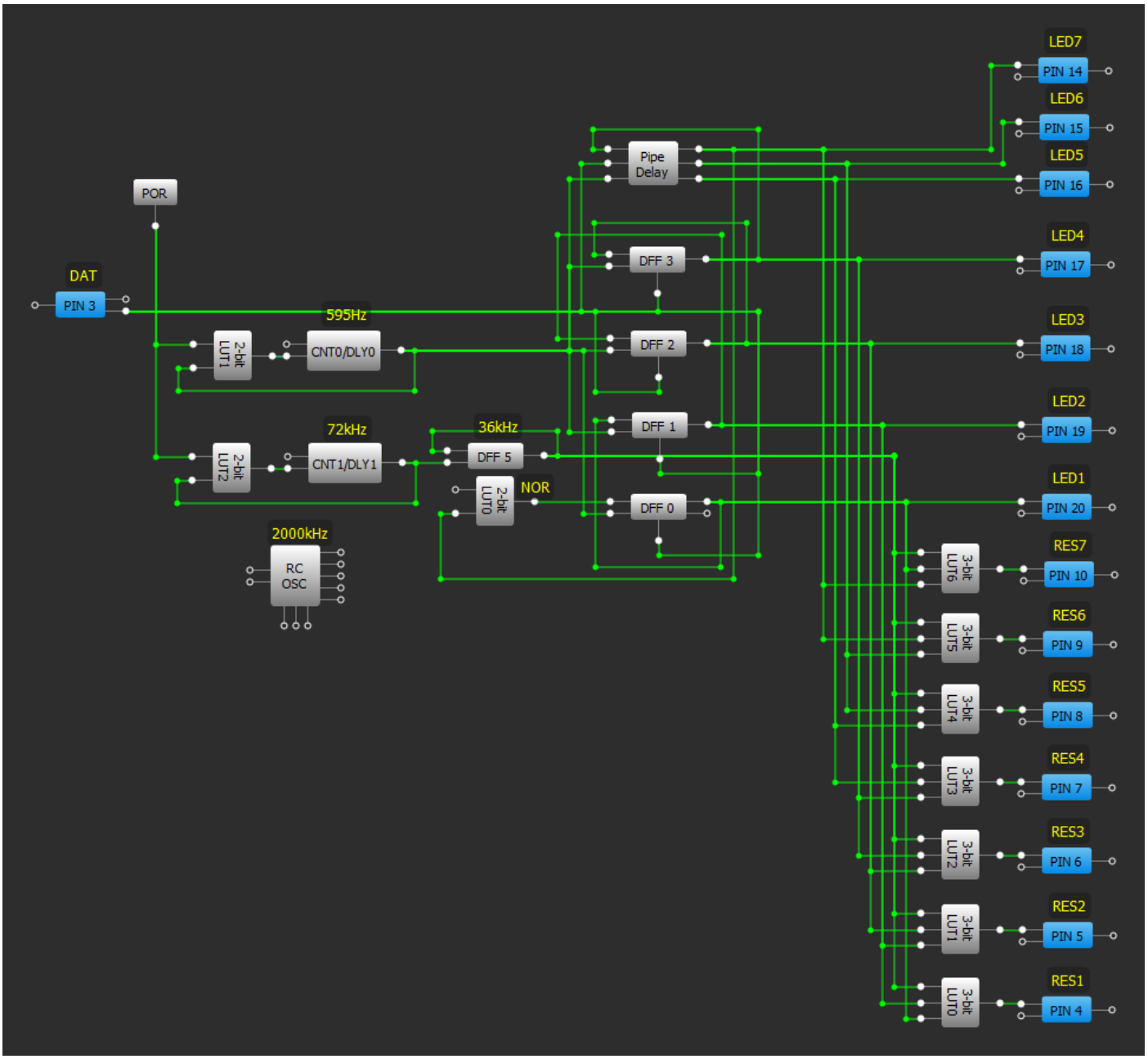

Fig 3. Infrared Proximity Sensor (linear implementation) schematic

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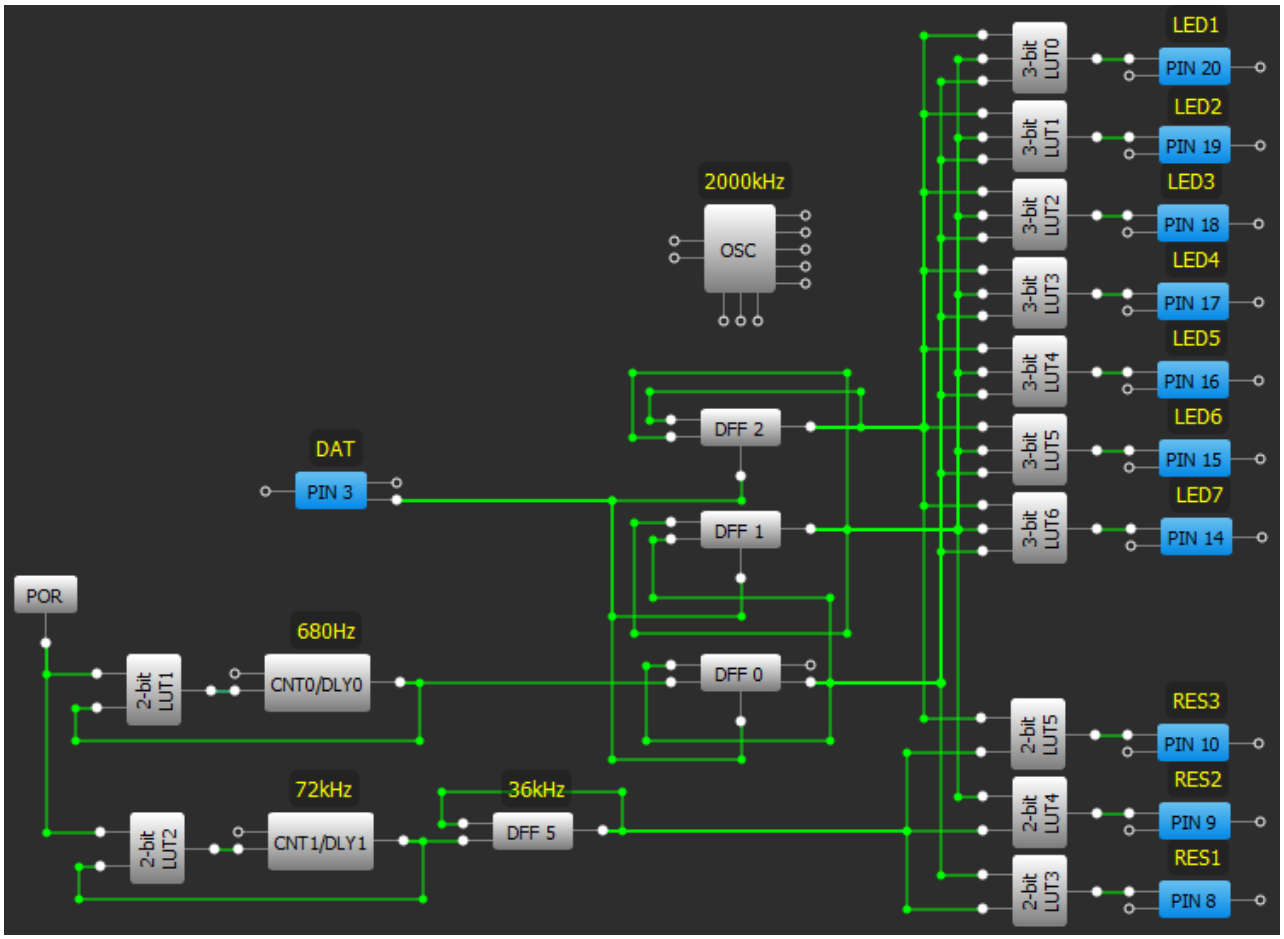

Fig 4. Infrared Proximity Sensor (pseudo-linear implementation) schematic

D0 (bottom line) – PIN3 (DAT)
D1 (2nd line) – PIN4 (RES1) with external 5kΩ pull up resistor
D2 (3rd line) – PIN5 (RES2) with external 5kΩ pull up resistor
D3 (4th line) – PIN6 (RES3) with external 5kΩ pull up resistor
D4 (5th line) – PIN7 (RES4) with external 5kΩ pull up resistor
D5 (6th line) – PIN8 (RES5) with external 5kΩ pull up resistor
D6 (7th line) – PIN9 (RES6) with external 5kΩ pull up resistor
D7 (8nd line) – PIN10 (RES7) with external 5kΩ pull up resistor
D8 (9rd line) – PIN20 (LED1)
D9 (10th line) – PIN19 (LED2)
D10 (11th line) – PIN18 (LED3)
D11 (12th line) – PIN17 (LED4)
D12 (13th line) – PIN16 (LED5)
D13 (14th line) – PIN15 (LED6)
D14 (top line) – PIN14 (LED7)

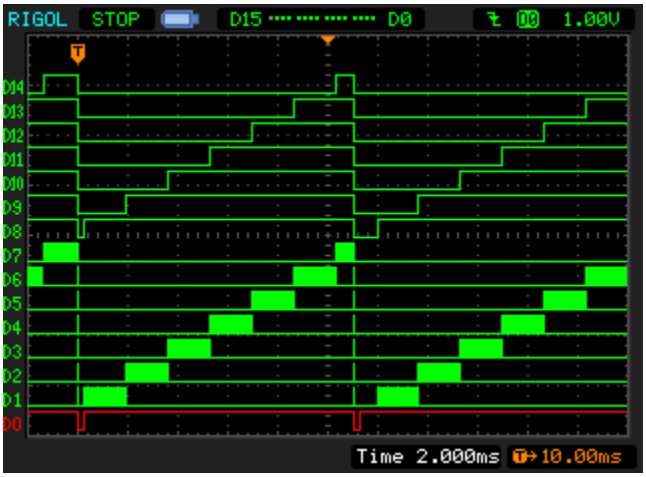

Fig 5. Infrared Proximity Sensor (linear implementation) functionality waveform. Sensor is far from the object.

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D0 (bottom line) – PIN3 (DAT)
D1 (2nd line) – PIN4 (RES1) with external 5kΩ pull up resistor
D2 (3rd line) – PIN5 (RES2) with external 5kΩ pull up resistor
D3 (4th line) – PIN6 (RES3) with external 5kΩ pull up resistor
D4 (5th line) – PIN7 (RES4) with external 5kΩ pull up resistor
D5 (6th line) – PIN8 (RES5) with external 5kΩ pull up resistor
D6 (7th line) – PIN9 (RES6) with external 5kΩ pull up resistor
D7 (8nd line) – PIN10 (RES7) with external 5kΩ pull up resistor
D8 (9rd line) – PIN20 (LED1)
D9 (10th line) – PIN19 (LED2)
D10 (11th line) – PIN18 (LED3)
D11 (12th line) – PIN17 (LED4)
D12 (13th line) – PIN16 (LED5)
D13 (14th line) – PIN15 (LED6)
D14 (top line) – PIN14 (LED7)

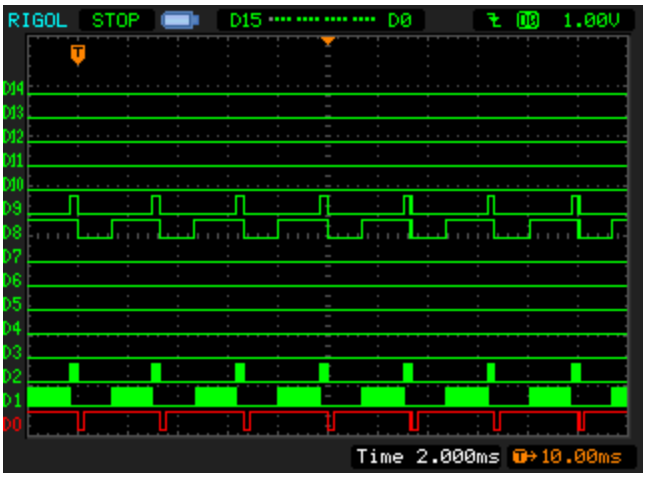

Fig 6. Infrared Proximity Sensor (linear implementation) functionality waveform. Sensor is close to the object.

D0 (bottom line) – PIN3 (DAT)
D1 (2nd line) – PIN6 (RES1) with external 5kΩ pull up resistor
D2 (3rd line) – PIN8 (RES2) with external 5kΩ pull up resistor
D3 (4th line) – PIN10 (RES3) with external 5kΩ pull up resistor
D4 (5th line) – PIN20 (LED1)
D5 (6th line) – PIN19 (LED2)
D6 (7th line) – PIN18 (LED3)
D7 (8nd line) – PIN17 (LED4)
D8 (9rd line) – PIN16 (LED5)
D9 (10th line) – PIN15 (LED6)
D10 (top line) – PIN14 (LED7)

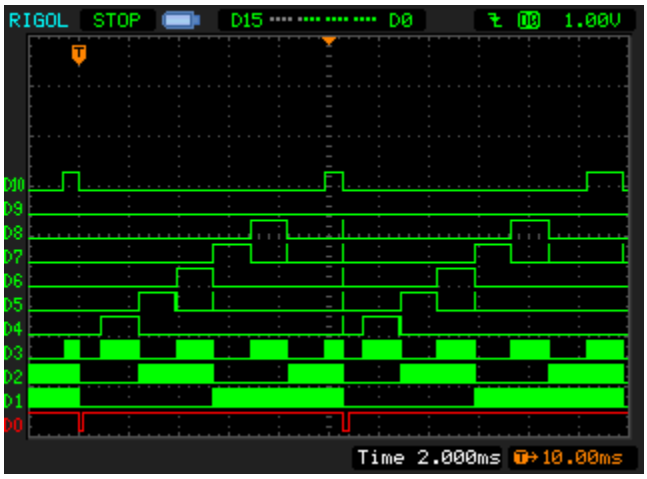

Fig 7. Infrared Proximity Sensor (pseudo-linear implementation) functionality waveform. Sensor is far from the object.

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D0 (bottom line) – PIN3 (DAT)
D1 (2nd line) – PIN6 (RES1) with external 5kΩ pull up resistor
D2 (3rd line) – PIN8 (RES2) with external 5kΩ pull up resistor
D3 (4th line) – PIN10 (RES3) with external 5kΩ pull up resistor
D4 (5th line) – PIN20 (LED1)
D5 (6th line) – PIN19 (LED2)
D6 (7th line) – PIN18 (LED3)
D7 (8nd line) – PIN17 (LED4)
D8 (9rd line) – PIN16 (LED5)
D9 (10th line) – PIN15 (LED6)
D10 (top line) – PIN14 (LED7)

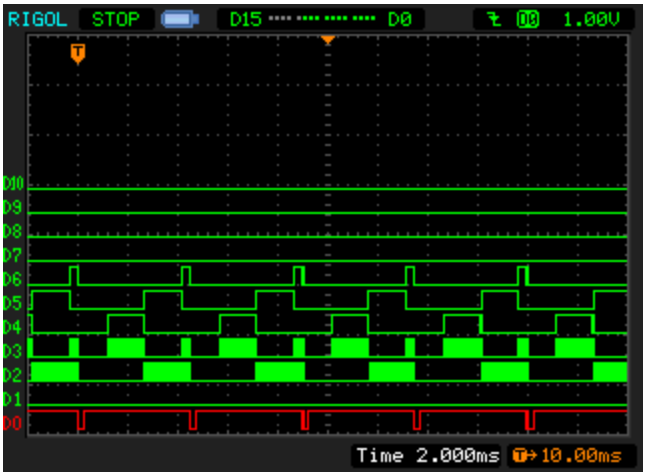

Fig 8. Infrared Proximity Sensor (pseudo-linear implementation) functionality waveform. Sensor is close to the object.

Conclusion

It is possible to implement an infrared proximity sensor using GreenPAK3. This design can be very useful in applications such as: automotive parking sensors, home security motion sensors, distance approximation for industrial or robotics, etc. Using GreenPAK3 minimizes the use of external components and its low power consumption provides power savings.

Related Files

Programming code for **GreenPAK Designer**.

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