Introduction

This design is a controller for an ultrasonic rangefinder. This design is based on the HC-SR04 – ultrasonic sensor module. Front/back photo is shown in Fig 1.

Fig 1. HC-SR04 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor module functions like sonar to determine distance to an object, as bats or dolphins do. It offers excellent non-contact range detection with high accuracy and stable readings. The distance of sensing is from 2cm to 400 cm (1 to 13ft.). Its operation is not affected by ambient light or optically non-reflective material, although acoustically absorbent materials like thick cloth can be more difficult to detect. The module contains both ultrasonic transmitter and receiver.
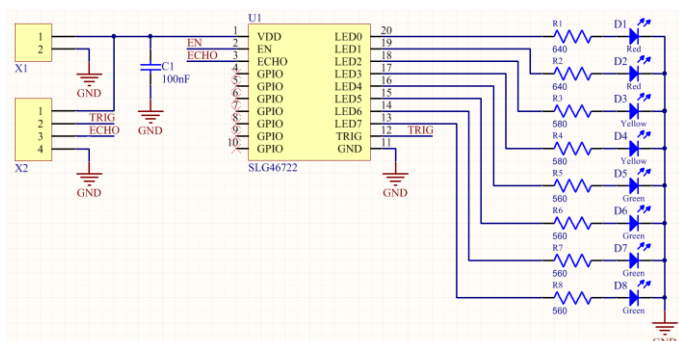
The application circuit is shown in Fig 2.

Fig 2. Ultrasonic Rangefinder typical application circuit

Ultrasonic Rangefinder circuit design

As shown in Fig 3. a controller/indicator for the HC-SR04 ultrasonic rangefinder module can be implemented using the following cell blocks: two 2-bit LUTs (LUT1 and LUT2), seven CNTs/DLYs (CNT0/DLY0, CNT1/DLY1, CNT2/DLY2, CNT3/DLY3, CNT4/DLY4, CNT5/DLY5 and CNT7/DLY7), Pipe Delay and four DFFs (DFF0, DFF1, DFF2 and DFF3).

Ultrasonic Rangefinder circuit analysis

When EN is HIGH the entire circuit becomes enabled. LED0 output is a status indicator: when LED0 is HIGH – circuit is operational, when LED0 is LOW – circuit stops its operation. When EN goes HIGH and stays HIGH longer than 60ms, TRIG output will generate a 10us HIGH pulse width continuing with a 60ms period. The combination of 2-bit LUT1, CNT0/DLY0 and CNT2/DLY2 forms this 10us generator with 60ms period. The 10us TRIG pulse is needed to start operation of the HC-SR04 which proceeds as follows: TRIG input of SR04 receives at least 10us HIGH pulse (5V), this will initiate an 8 cycle ultrasonic transmit burst at 40kHz frequency. The sensor receiver then waits for the reflected ultrasonic burst. When the sensor detects the ultrasonic burst from receiver, it will set the Echo pin high (5V) with a delay (width) which is proportional to the distance to object that reflected it. To obtain the distance, the width (Ton) of Echo pin is measured.

Time = Width of Echo pulse, in μs

- Distance in centimeters = Time / 58
- Distance in inches = Time / 148
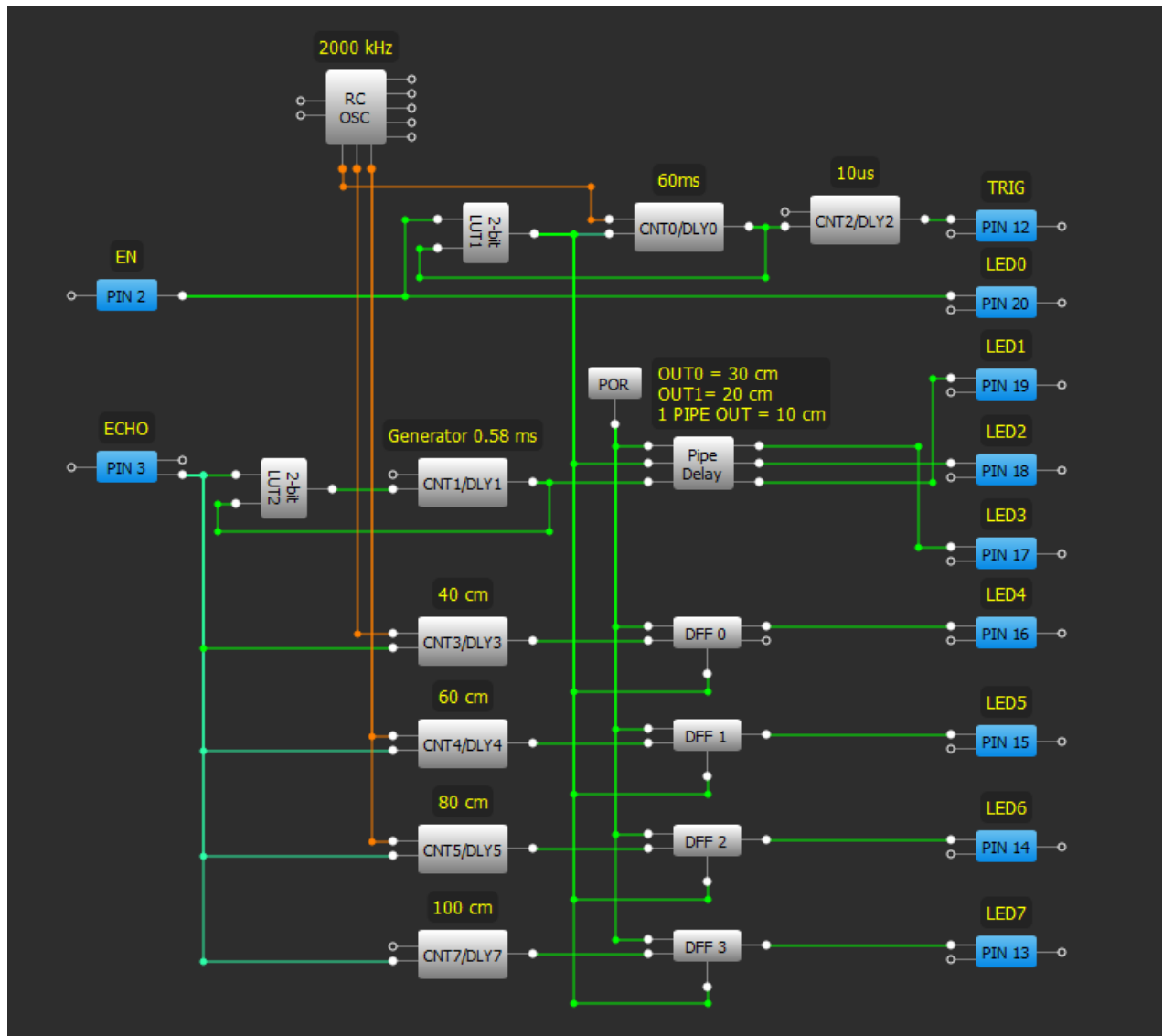- Or you can utilize the speed of sound, which is 340m/s.

Fig 3. Ultrasonic Rangefinder schematic

A combination of CNT/DLYs and DFFs performs the conversion of HC-SR04 ECHO pulse width to the number of LEDs indicating the distance. The GreenPAK converts the distance in steps of 10cm in the range of 10 to 30cm. The step size then becomes 20 cm in the range of 40 to 100cm. CNT1/DLY1 count settings makes a 580μs delay generator (10cm step distance equivalent). The combination of CLK and CNT setting allows for many other step and range settings available to the designer.

The DLY1 delay generator together with Pipe Delay can perform 3 conversions of ECHO (pulse width) into distance information for the 10, 20, 30cm range. CNTs/DLYs 3, 4, 5, 7 each form independent converters of ECHO (pulse width) 40 to 100 cm range by virtue of their CLK source and DLY count settings. The converters operate as follows: when input signal ECHO is HIGH for longer than the CNTs/DLYs configured delay, the outputs of CNTs/DLYs go HIGH and clocks the DFFs, then the corresponding LED outputs go HIGH.

The functionality waveforms that describe the device operation are shown in Fig 4 and 5.

Related Files

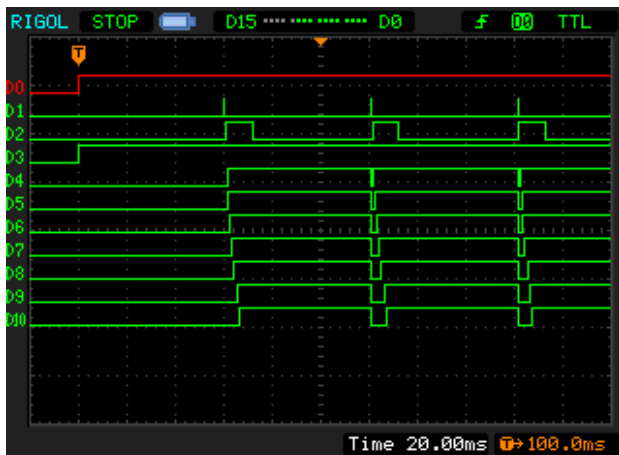Programming code for **GreenPAK Designer**.

Fig 4. Timing waveforms when the object distance is >100cm

D0 – PIN#2 (EN)

D1 – PIN#12 (TRIG)

D2 – PIN#3 (ECHO)

D3 – PIN#20 (LED0)

D4 – PIN#19 (LED1)

D5 – PIN#18 (LED2)

D6 – PIN#17 (LED3)

D7 – PIN#16 (LED4)

D8 – PIN#15 (LED5)

D9 – PIN#14 (LED6)

D10 – PIN#13 (LED7)

Fig 5. Timing waveforms when the object distance is =65cm

D0 – PIN#2 (EN)

D1 – PIN#12 (TRIG)

D2 – PIN#3 (ECHO)

D3 – PIN#20 (LED0)

D4 – PIN#19 (LED1)

D5 – PIN#18 (LED2)

D6 – PIN#17 (LED3)

D7 – PIN#16 (LED4)

D8 – PIN#15 (LED5)

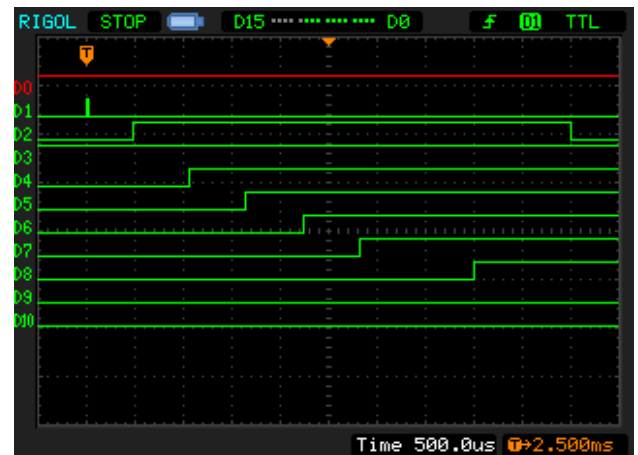D9 – PIN#14 (LED6)

D10 – PIN#13 (LED7)

Conclusion

An ultrasonic rangefinder can be easily implemented using a GreenPAK3 programmable mixed-signal ASICs. This design can be very useful in applications such as: automotive parking sensors, industrial distance approximation, robotics, etc. Using GreenPAK3 minimizes the use of external components, and its low power consumption provides power savings.

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