Author: Oleg Gorodechny
Date: December 2, 2014

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.

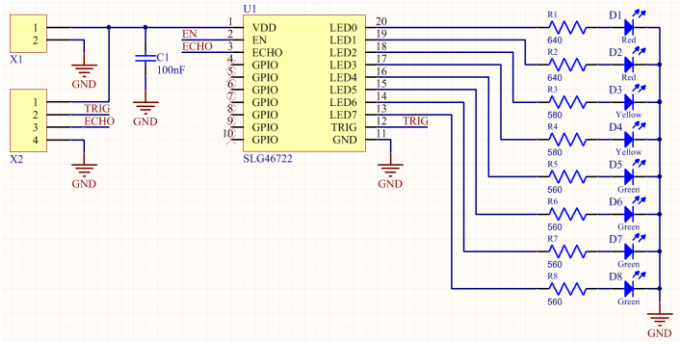

Fig 2. Ultrasonic Rangefinder typical application circuit

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.

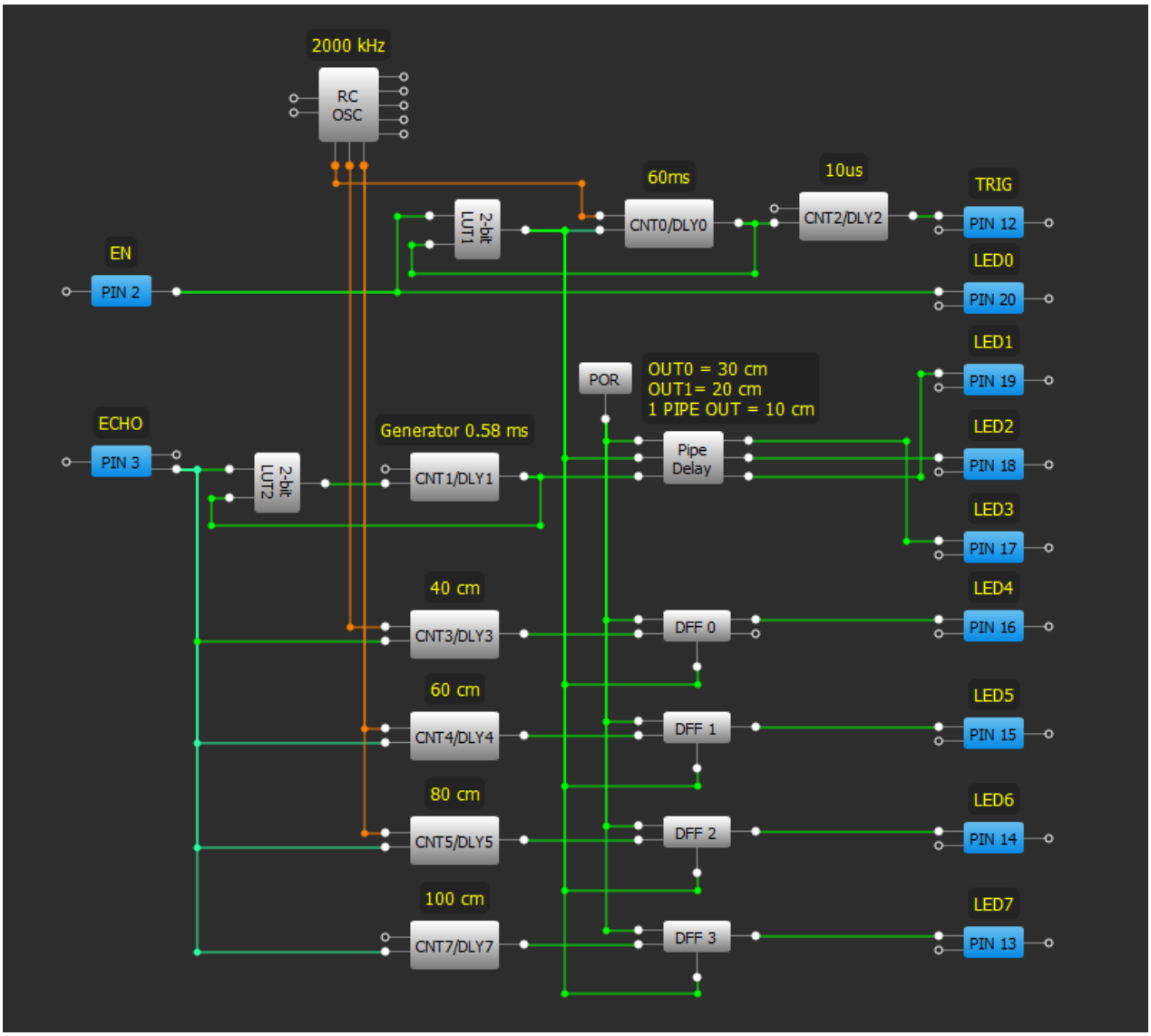

Fig 3. Ultrasonic Rangefinder schematic

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.

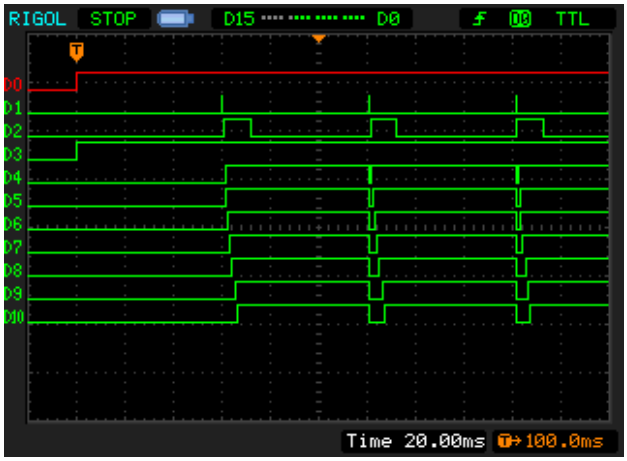

Fig 4. Timing waveforms when the object distance is >100cm

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)

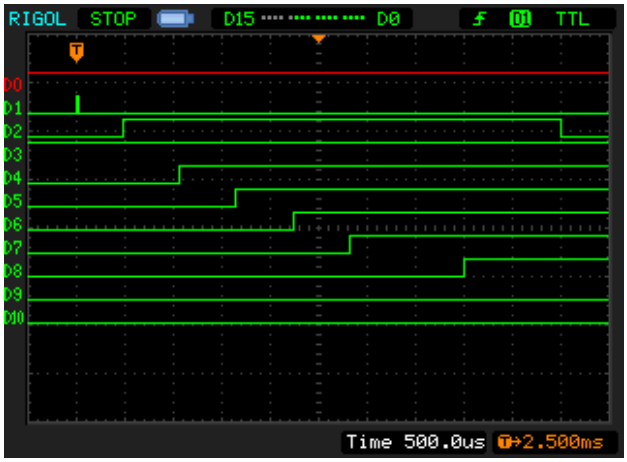

Fig 5. Timing waveforms when the object distance is =65cm

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)

Related Files

Programming code for **GreenPAK Designer**.

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.

IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD-PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers who are designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only to develop an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third-party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising from your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Disclaimer Rev.1.01 Jan 2024)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit www.renesas.com/contact-us/.

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.