Author: Bilal Ahmed
Date: January 27, 2017

Introduction

This tachometer can be used to measure the RPM (revolutions per minute) of a rotating object. In this application note, GreenPAK SLG46533V and GreenPAK SLG46140V are used to design an optical contactless tachometer with the use of an infrared sensor. The measurement range of this tachometer is 1 - 9999 rpm, with an accuracy of 0.01% (using a sample clock of 2MHz for measuring a maximum of 9999), this would give an accuracy of less than 1 rpm at all readings. This design can be modified to suit other requirements such as, changing the sensor sensitivity, changing the distance of measurement from the rotating object, etc.

Transistors Q1, Q2 toggle control between the first two 7 segment displays and Q3, Q4 between last two 7 segment displays on each half cycle of the internally generated clock in the GreenPAK.

Infrared Sensor

The IR sensor consists of an infrared transmitter LED and infrared receiver LED. The two are shielded from each other as shown in the figure 2.

Good sensor design ensures predictable and reliable operation. Here are some important notes:

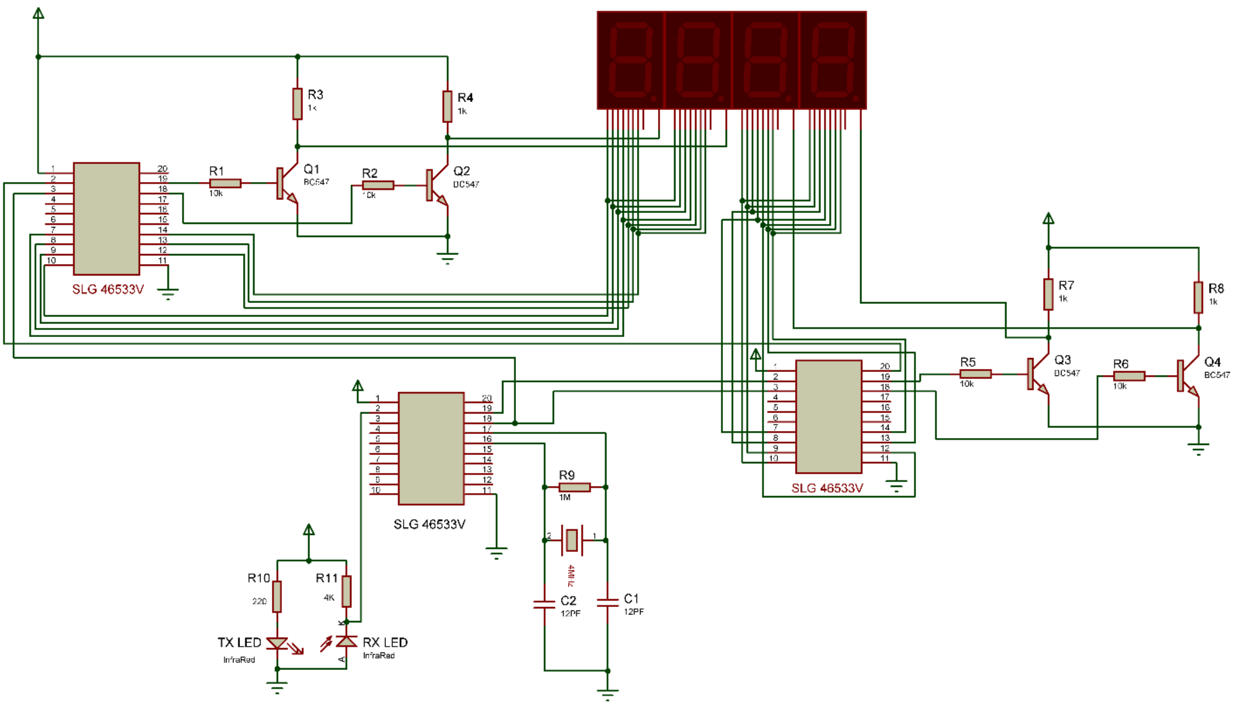

Figure 1. Top Level Schematic

(i) Ensure there are no infrared light leaks between the two LED's. The receiver should receive only the light reflected from the rotating object where it is aimed.

(ii) The 220-ohm resistor on the infrared transmitter LED must be properly rated (2W or more). It can generate considerable heat that must be dissipated for safety.

(iii)The most important part is to set the infrared receiver LED sensitivity. This can be adjusted by varying the resistor of the infrared receiver LED. For this case it was between 2-4K ohm and it works pretty well at a distance of 5-7 cm from the Fan. Here high resistance means high sensitivity.

For infrared receiver to receive the light, a reflecting tape is attached on the Fan. When fan made one revolution the light is reflected from the tape and is received by the receiver LED. The number of times it is received in half minute will be equivalent to the RPM of fan (since both rising and falling edges triggers the counters). In order to speed up the process, 8 pieces of tape may be attached on fan. This helps calculate the RPM with 8x faster timing (i.e. 3.75 sec). The piece of tape must be attached so that the light is properly reflected during each revolution of the fan.

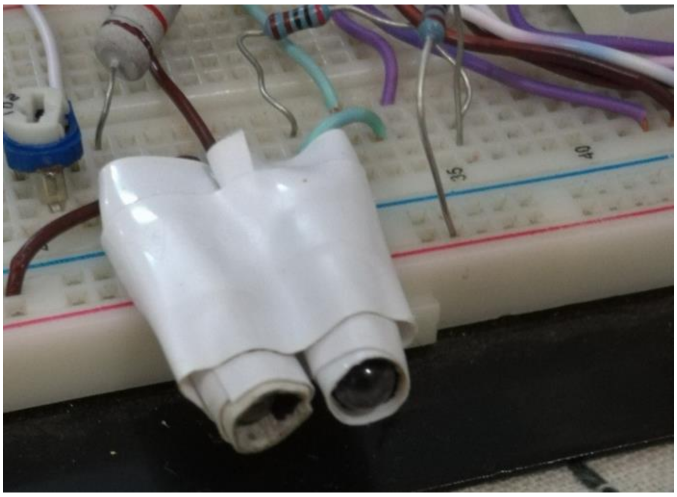

Figure 2 Infrared sensor

This means the sensor counters remain enabled for 3.75sec, and for 0.5sec the 7 segment display remain frozen at the final output.

When an internal oscillator is used, the connections of pin 16 and pin 17 in schematic are not required. However, for better accuracy over varying ambient temperatures, the crystal oscillator option should be used.

The design can be configured for counting revolutions during a particular time, but the revolution number cannot exceed beyond 9999.

GreenPAK Design Code

The GreenPAK design code is done in three GreenPAK chips.

GreenPAK SLG46533V Sensor Code

There are two circuits that can be used for the clock: internal oscillator, or crystal oscillator (both files are attached and either can be used). Each circuit consists of a 4.25 sec timer. It generates a 3.75sec "high" time, and a 0.5sec "low" time for the "Enable sensor input for counters" signal.

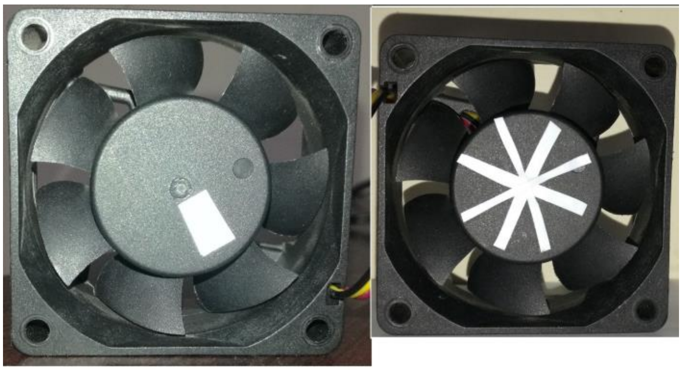

Figure 3. Reflecting tape for infrared beam interruption

Normally a high is present at Pin 2, and whenever the infrared is reflected back from the tape (8 times every cycle), a momentarily low is observed. The rising and falling edges are both detected and if the 3.75 sec timer is enabled, it is passed on to the first counter block.

Tradeoff between sample time and accuracy

In order to tradeoff between sample time and accuracy we can vary the measurement interval of the tachometer (from 3.75 sec). It is due to the fact that some application requires higher accuracy like industrial motors whose rpm needs to be maintained at fix speed, based on the present speed inputs.

For these type of applications a more accurate reading is required which can be obtained by increasing the sample time.

However, some applications are OK with less accuracy but a faster update rate is better, like measuring rpm of car engine.

This can be done by varying the time interval of the reading from 3.75 sec time to some higher/lower value. This can be achieved by changing the counter CNT0 and CNT1 values. The display time can be varied by changing the CNT5 and CNT6 values. It must be noted that CNT5 and CNT6 must have the same values.

Two BCD Counters in SLG46533V

There are two BCD counters implemented in each of the other two GreenPAK SLG46533V, each of them is a countdown counter. The incoming clock signal is from the sensor data (passed during the 3.75 sec time). The counter decrements during every sensor interrupt received. The 2nd counter starts the third counter in the other chip.

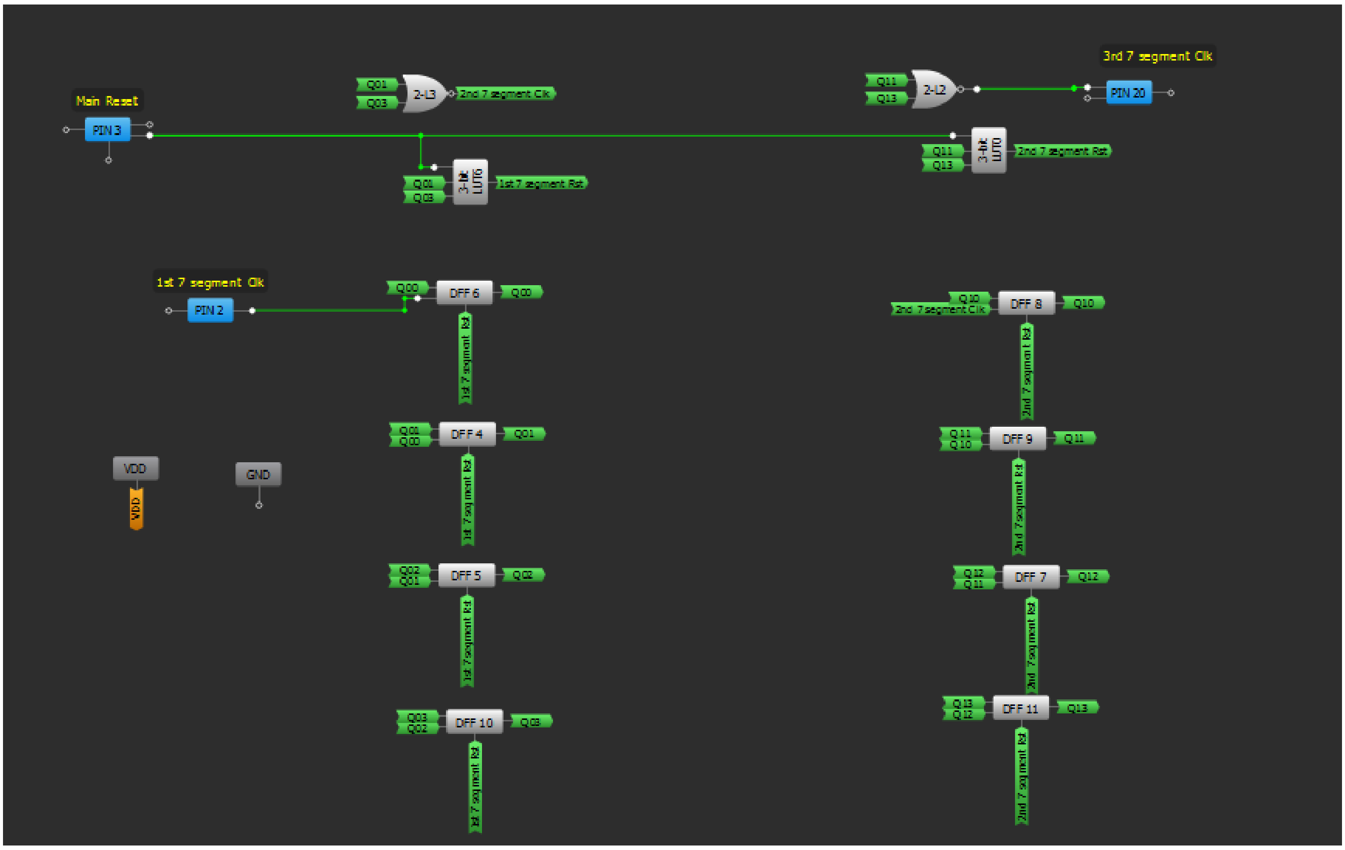

Figure 4. BCD counters in SLG46533V

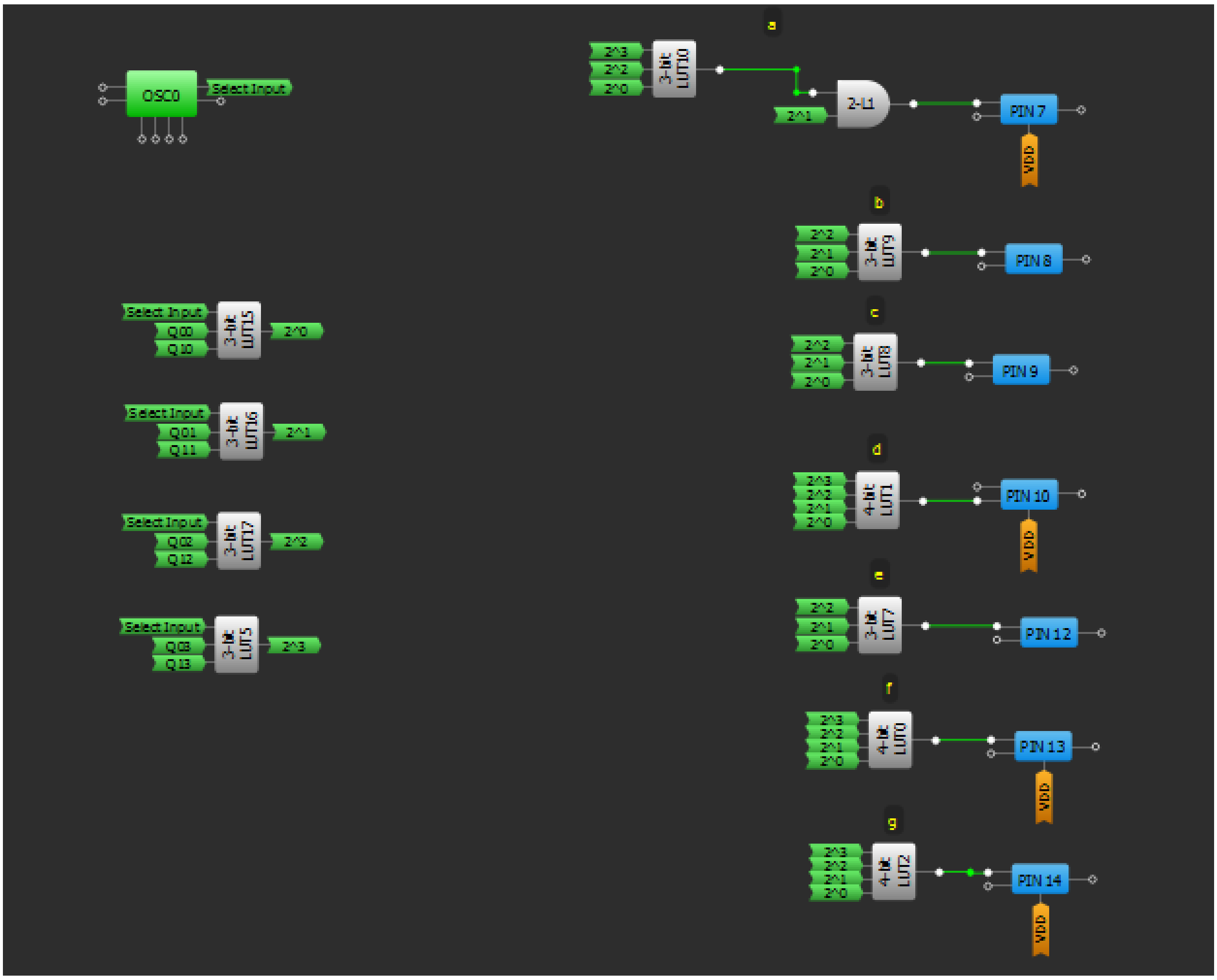

Figure 5. BCD to seven segment converter

This part of the code converts the four bit BCD code to seven segment display. The selection between two 7 segment displays is also made during each cycle of the clock.

All the counters reset at 0101 (equivalent to decimal 10 using negative logic). All the counters also reset when 3.75sec has elapsed. Counter 1 represents least significant digit and counter 4 represents most significant digit.

The relation between the first three counters is tabulated below. The first two of them is implemented in one chip and the third one is implemented in other chip.

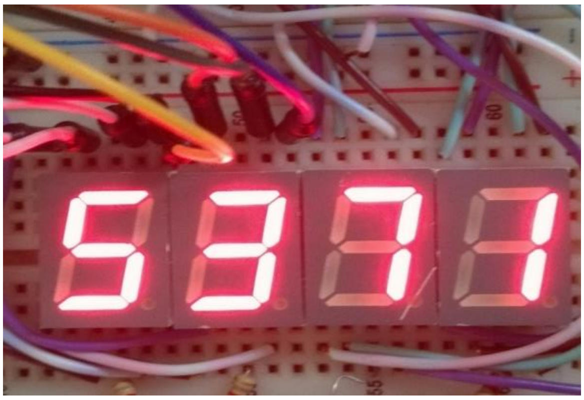

Figure 6. Display of Optical Tachometer

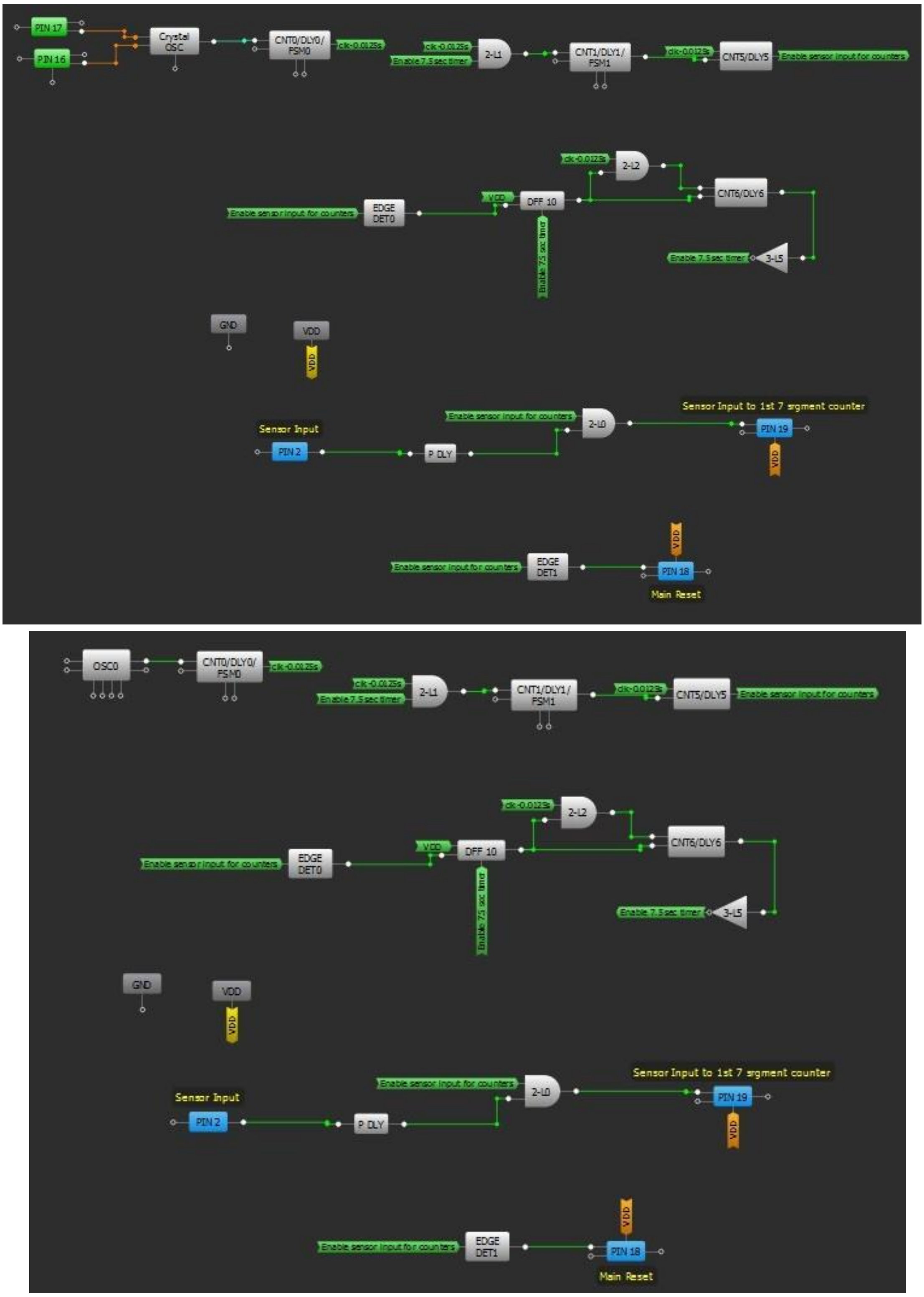

Figure 7. BCD to seven segment converter

Counter 3	Counter 4
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1110
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1101
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1100
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1011
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1010
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1001
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1000
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	0111
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	0110

Table 1. Relation between counter 3 and counter 4

Table 1 shows how first two counters starts counter 3. The counter 4 increments whenever counter 3 reaches its limit as tabulated below.

<table>
<tr><th>Counter 1</th><th>Counter 2</th><th>Counter 3</th></tr>
<tr><td rowspan="10">1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -></td><td>1111</td><td rowspan="10">1111</td></tr>
<tr><td>1110</td></tr>
<tr><td>1101</td></tr>
<tr><td>1100</td></tr>
<tr><td>1011</td></tr>
<tr><td>1010</td></tr>
<tr><td>1001</td></tr>
<tr><td>1000</td></tr>
<tr><td>0111</td></tr>
<tr><td>0110</td></tr>
<tr><td rowspan="4">1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -></td><td>1111</td><td rowspan="4">1110</td></tr>
<tr><td>1110</td></tr>
<tr><td>1101</td></tr>
<tr><td>1100</td></tr>
</table>

1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1011 1010 1001 1000 0111 0110	
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011 1010 1001 1000 0111 0110	1101
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011 1010 1001 1000 0111 0110	1100
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011	1011

1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1010 1001 1000 0111 0110	
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011 1010 1001 1000 0111 0110	1010
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011 1010 1001 1000 0111 0110	1001
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011 1010	1000

1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1001 1000 0111 0110	
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011 1010 1001 1000 0111 0110	0111
1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 -> 1111 -> 1110 -> 1101 -> 1100 -> 1011-> 1010 -> 1001 -> 1000 -> 0111 -> 0110 ->	1111 1110 1101 1100 1011 1010 1001 1000 0111 0110	0110

Table 2. First relation three BCD Counters

Conclusion

This tachometer was tuned by first matching its RPM against a Hall Effect based tachometer, and the results are well matched up to the tenth digit.

Because the Hall Effect based tachometer gave false readings at slow fan speeds, this is where this GreenPAK design is superior. The design can also be used to build an RPM measuring instrument based on a rotary encoder.

IMPORTANT NOTICE AND DISCLAIMER

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/.