

AN-1199 GreenPAK™ RPS Counter

This GreenPAK RPS (revolutions per second) counter is designed to count revolutions of rotating objects with blades such as fidget spinner, drone propeller, fan etc. It is able to count up to 199 RPS, which is 11940 RPM (revolutions per minute). Basically, it is a frequency counter ([described here](#)) modified to meet the requirements:

- Contactless sensor to avoid contact with rotating parts.
- Frequency divider, since the sensor “sees” every blade, the output pulses must be divided by the number of blades.
- Start button, after pressing the button, the device will start counting for one second and then display the counted value for one more second or until the next pressing.
- Low power 7-segment LCD. In order to reduce power consumption, the LED display was replaced with the LCD.

The current consumption (I_{cc}) of the device is determined by two phases:

- Counting phase. I_{cc} depends on IR sensor emitter and is set to 20 mA. However, I_{cc} can be reduced by increasing resistance of R1 (see Figure 1), but this will also reduce sensor sensitivity. Counting phase lasts for 1 second after power on or after pressing button “Start”.
- Displaying phase. I_{cc} depends on GreenPAK’s internal blocks and 7-segment LCD, and is about 70 μ A. Displaying phase starts right after counting and lasts until power is off or button “Start” is pressed again.

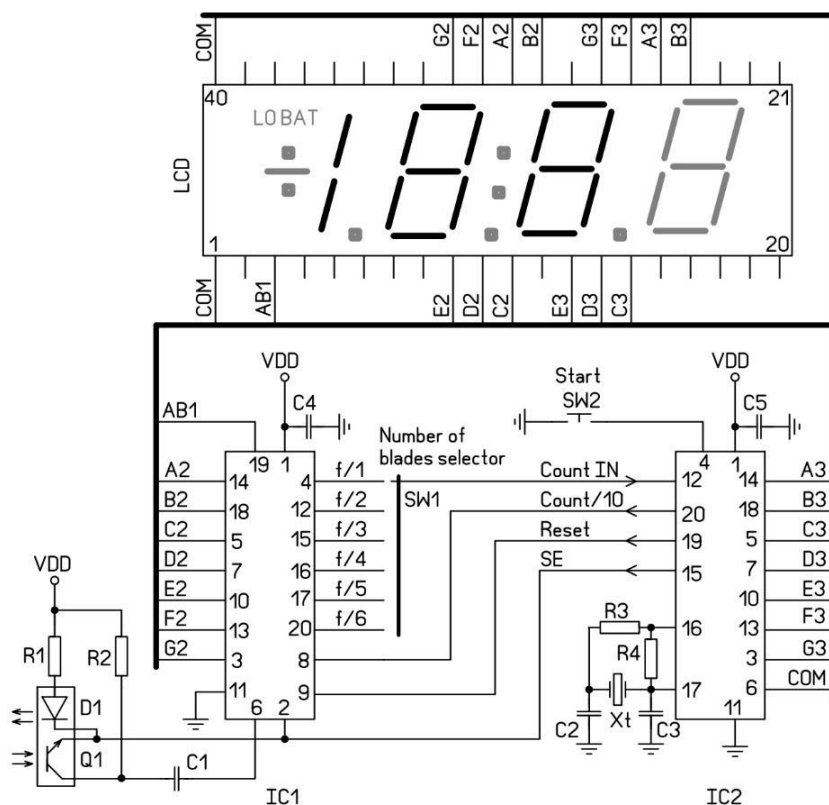


Figure 1. GreenPAK RPS Counter Schematic Diagram

Figure 2 shows the block diagram of the device. It consists of:

- Reflective sensor which includes an infrared emitter and phototransistor. It converts reflections from the blades' infrared light into electrical pulses.
- ACMP (analog comparator) detects pulses higher than 500 mV.
- Frequency divider is used to divide input pulses by the number of the blades (set manually from 1 to 6).
- Two binary counters along with two 7-segment decoders count and convert divided pulses and display the result on the 7-segment LCD.
- Crystal oscillator together with the frequency divider form a 0.5 Hz reference clock. It is also used to power down the IR sensor and ACMP after counting is done.
- Osc 0. An internal 25 kHz oscillator divided by 16 (~1.5 kHz) provides the AC current to drive the 7-segment LCD. It is powered down while counting.

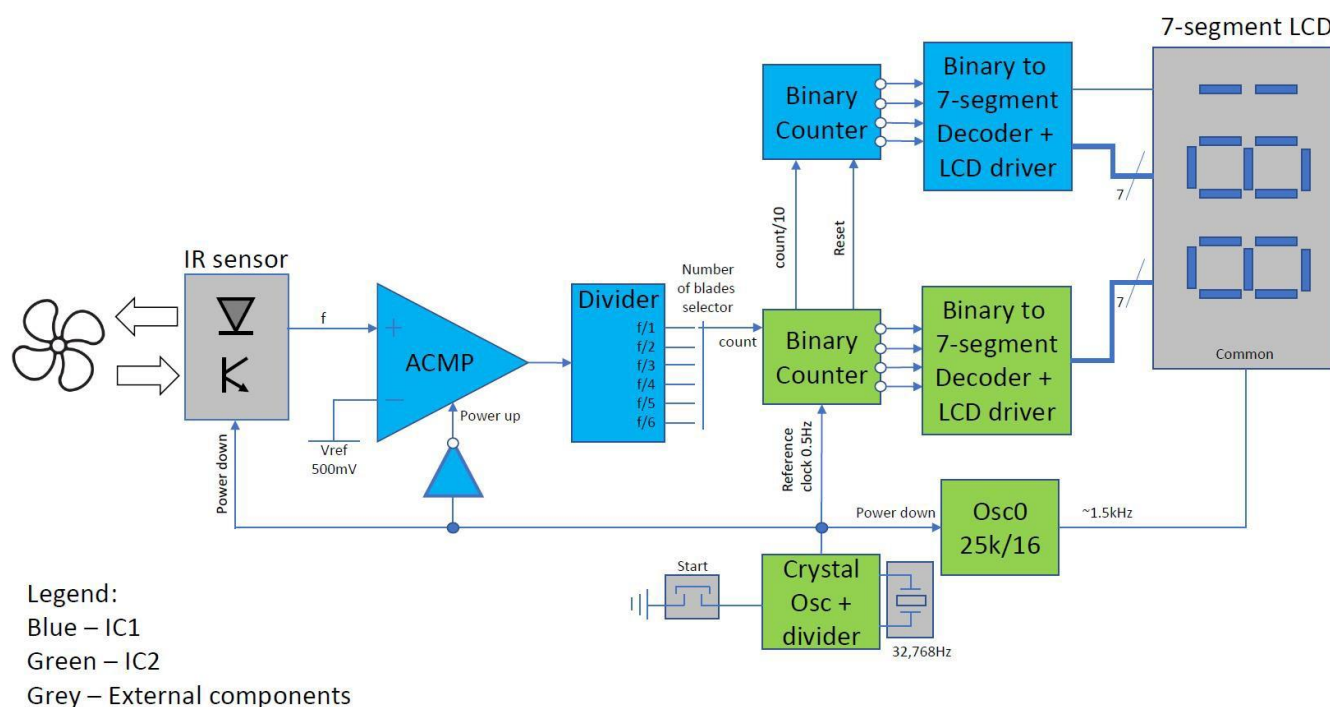


Figure 2. GreenPAK RPS Counter Block Diagram

To build the RPS counter, two GreenPAK ICs are needed. The SLG46533 was chosen because of the great variety of internal blocks. For full schematic diagram and BOM refer to Figure 1 and Table 1 respectively.

#	Symbol	Value (Type)	Quantity
1	IC1, IC2	SLG46533V	2
2	LCD	VI302-DPRC	1
3	D1, Q1	TCRT5000L	1
4	R1	160 Ohm (±5%, 0.1W)	1
5	R2	100 kOhm (±5%, 0.1W)	1
6	R3	20 kOhm (±5%, 0.1W)	1
7	R4	20 MOhm (±5%, 0.1W)	1
8	C1, C4, C5	100 nF (10V, ±10%, X7R)	3
9	C2	330 pF (50V, ±10%, X7R)	1
10	C3	10 pF (50 V, ±10%, C0G/NP0)	1
11	Xt	32,768 Hz (R26-32.768- 12.5)	1
12	SW1	CK1035 (Rotary Switch, 6 Position)	1
13	SW2	PTS645SL50-2 LFS (12V, 50mA, 130gf)	1

Table 1. BOM

For project screenshots refer to Figures 3 and 4.

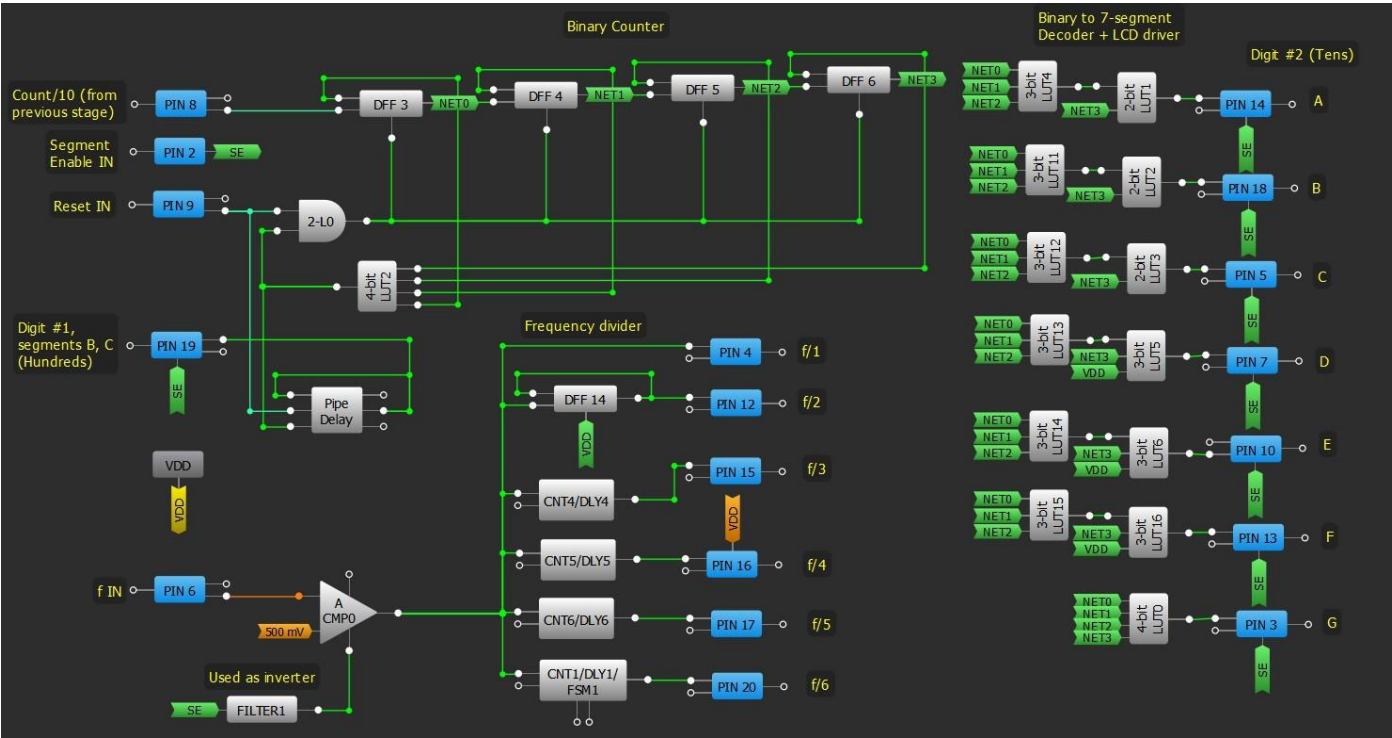


Figure 3. GreenPAK Designer Project, IC1

Properties	PINs 2, 8, 9	PINs 3, 5, 7, 10, 13, 14, 18, 19	PIN 6	PINs 4, 12, 15, 16, 17, 20
I/O selection	Digital input	Digital input/output	Analog input/output	Digital Output
Input mode	Digital in without Schmitt trigger	Digital in without Schmitt trigger	Analog input/output	None
Output mode	None	1x open drain NMOS	Analog input/output	1x push pull
Resistor	Floating	Floating	Floating	Floating
Resistor value	Floating	Floating	Floating	Floating

Table 2. IC1 Pin Settings

IN3	IN2	IN1	IN0	2-bit LUT0 OUT	2-bit LUT1 OUT	2-bit LUT2 OUT	2-bit LUT3 OUT	3-bit LUT4 OUT	3-bit LUT11 OUT	3-bit LUT12 OUT	3-bit LUT13 OUT	3-bit LUT14 OUT	3-bit LUT15 OUT	3-bit LUT16 OUT	3-bit LUT5 OUT	3-bit LUT6 OUT	4-bit LUT0 OUT	4-bit LUT2 OUT
0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	1	1	1
0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1
0	0	1	0	0	0	0	0	1	0	1	1	0	1	1	1	1	1	1
0	0	1	1	1	0	0	0	0	1	1	0	0	0	1	1	1	0	1
0	1	0	0	-	-	-	-	1	0	1	1	1	1	0	1	0	1	1
0	1	0	1	-	-	-	-	1	1	0	1	1	0	0	0	0	0	0
0	1	1	0	-	-	-	-	0	1	1	0	0	1	0	0	0	0	1
0	1	1	1	-	-	-	-	1	1	1	1	1	1	0	0	0	1	1
1	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
1	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1
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1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1

Table 3. IC1 LUT Settings

Properties	DFF3	DFFs 4, 5, 6, 14
Type	DFF/LATCH	DFF/LATCH
Mode	DFF	DFF
2 consecutive DFFs for ASM	Disable	-
nSET/nRESET option	nRESET	nRESET
Initial polarity	Low	Low
Q output polarity	Inverted	Inverted

Table 4. IC1 DFF Settings

Properties	CNT4/DLY4	CNT5/DLY5	CNT6/DLY6	CNT1/DLY1/FSM1
Type	CNT/DLY	CNT/DLY	CNT/DLY	CNT/DLY
Mode	Counter	Counter	Counter	Counter/FSM
Counter data	2	3	4	5
Edge select	Falling	Falling	Falling	Falling
Output polarity	Inverted (nOUT)	Inverted (nOUT)	Inverted (nOUT)	Inverted (nOUT)
Q mode	None	None	None	Reset
Stop and restart	None	None	None	Disable
Clock	Ext. Clk. (From matrix)	Ext. Clk. (From matrix)	Ext. Clk. (From matrix)	Ext. Clk. (From matrix)

Table 5. IC1 CNT/DLY Settings

Properties	ACMP0
100uA pullup on input	None
Hysteresis	50 mV
Low bandwidth	Disable
IN+ gain	Disable
Connections	
IN+ source	PIN 6 (IO4)
IN- source	500 mV

Table 6. IC1 ACMP0 Settings

Properties	FILTER1/EDGE DET1
Type	FILTER
Output polarity	Inverted

Table 7. IC1 FILTER1 Settings

Properties	3-bit LUT10/Pipe Delay
Type	Pipe Delay
OUT0 PD num	1
OUT1 PD num	1
OUT1 output polarity	Inverted (nOUT)

Table 8. IC1 Pipe Delay Settings

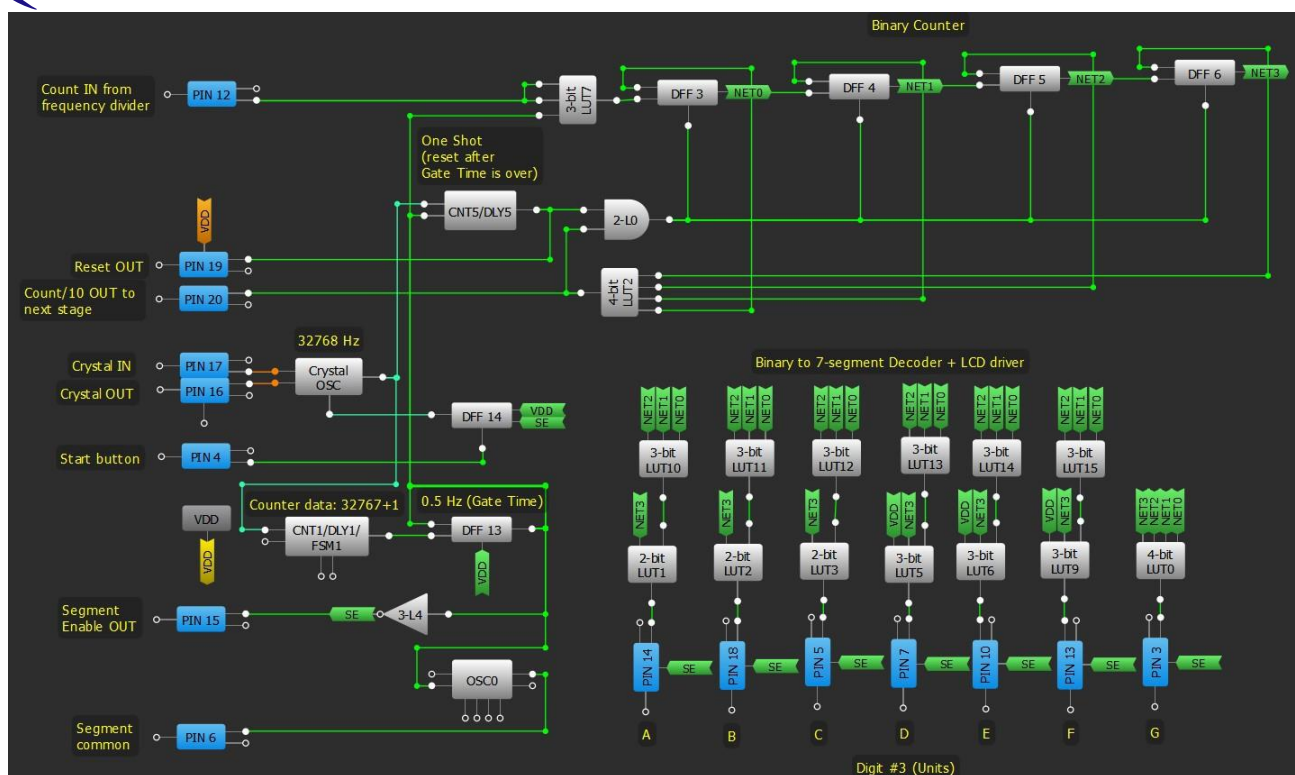


Figure 4. GreenPAK Designer Project, IC2

Properties	PINs 12	PINs 4	PINs 3, 5, 7, 10, 13, 14, 18	PINs 6, 15, 19, 20
I/O selection	Digital input	Digital input	Digital input/output	Digital Output
Input mode	Digital in without Schmitt trigger	Digital in with Schmitt trigger	Digital in without Schmitt trigger	None
Output mode	None	None	1x open drain NMOS	1x push pull
Resistor	Floating	Pull UP	Floating	Floating
Resistor value	Floating	10K	Floating	Floating
Note: PINs 16 and 17 will be set automatically after Crystal OSC enabled.				

Table 9. IC2 Pin Settings

IN3	IN2	IN1	IN0	2-bit LUT0 OUT	2-bit LUT1 OUT	2-bit LUT2 OUT	2-bit LUT3 OUT	3-bit LUT4 OUT	3-bit LUT11 OUT	3-bit LUT12 OUT	3-bit LUT13 OUT	3-bit LUT14 OUT	3-bit LUT15 OUT	3-bit LUT5 OUT	3-bit LUT6 OUT	3-bit LUT7 OUT	3-bit LUT9 OUT	3-bit LUT10 OUT	4-bit LUT0 OUT	4-bit LUT2 OUT
0	0	0	0	0	0	1	1	Inverter	1	1	0	0	0	1	1	0	0	1	1	1
0	0	0	1	0	1	1	1		1	1	1	0	0	0	1	1	0	1	1	1
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1	1	1	1	-	-	-	-		-	-	-	-	-	-	-	-	-	-	0	1
1	1	1	1	-	-	-	-		-	-	-	-	-	-	-	-	-	-	1	1

Table 10. IC2 LUT Settings

Properties	DFF3	DFFs 4, 5, 6, 13, 14
Type	DFF/LATCH	DFF/LATCH
Mode	DFF	DFF
2 consecutive DFFs for ASM	Disable	-
nSET/nRESET option	nRESET	nRESET
Initial polarity	Low	Low
Q output polarity	Inverted	Inverted

Table 11. IC2 DFF Settings

Properties	CNT5/DLY5	CNT1/DLY1/FSM1
Type	CNT/DLY	CNT/DLY
Mode	One Shot	Counter/FSM
Counter data	1	32767
Edge select	Rising	Rising
Output polarity	Inverted (nOUT)	Non-inverted (OUT)
Q mode	None	Reset
Stop and restart	None	Disable
Clock	Ext. Clk. (From matrix)	Ext. Clk. (From matrix)

Table 12. IC2 CNT/DLY Settings

Properties	Crystal OSC
Enable crystal oscillator	Enable
Power down enable	PD for crystal OSC

Table 13. IC2 Crystal OSC Settings

Properties	OSC0
Control pin mode	Power down
OSC power mode	Force Power On
Clock selector	OSC
EXT CLK Pin selector	PIN 20 (IO17)
Fast start-up	Disable
RC OSC Frequency	25 kHz
'CLK' predivider by	8
'OUT0' second divider by	2
'OUT1' second divider by	1

Table 14. IC2 OSC0 Settings

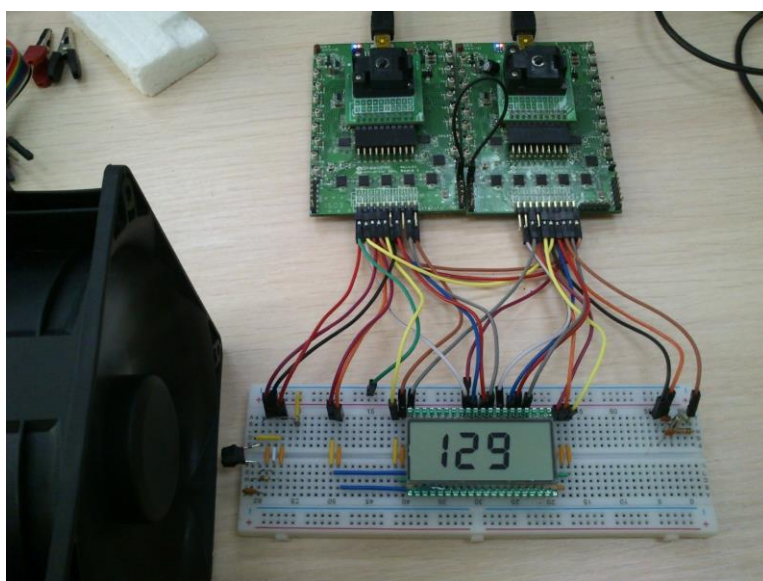


Figure 5. GreenPAK RPS Counter Prototype

Conclusion

The GreenPAK RPS Counter is designed to count revolutions of moderately slow objects. However, adding another GreenPAK IC will allow increasing the counting limit to 1999 RPS (119940 RPM). This design is easy to scale and can be used as a reference for many similar applications.

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