GreenPAK Macro Circuit Design: Voltage Controlled Oscillator with External RC Circuit

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Introduction

The GreenPAK2 chip has an internal RC Oscillator (RC OSC), with a set of configurable frequencies in the range of 29.11 kHz – 8.43 MHz. But in very special cases the user might have a need for the clocking source that has a different frequency from those available on the RC OSC.. For this purpose, the user can create an RC based oscillator using external resistance and capacitance together with GreenPAK internal circuits.

Oscillator Circuit Design

The main idea of such oscillator is to charge capacitance to some voltage level through the resistance and then instantly discharging of the capacitance to 0V level, thus setting the oscillation period. Of course, there are many other ways to create the RC oscillator, but this case is the most predictable and flexible.

The well-known equation

$$V_C(t) = V\left(1 - e^{-\frac{t}{RC}}\right)$$

taking that V_C is a voltage on the capacitor that should not exceed some reference voltage V_{REF} , V is a voltage of the source that charges the capacitor, t is time, R is a resistor value and C is capacitor value, can be transformed to the following

$$t(V) = RCln\left(1 + \frac{V_{REF}}{V}\right) \text{ or } f(V) = \frac{1}{RCln\left(1+\frac{V_{REF}}{V}\right)}$$

where *f(V)* is a function of output frequency depending on the voltage of the source that charges the capacitor. Thus, the process should be like it is shown in Figure 1.

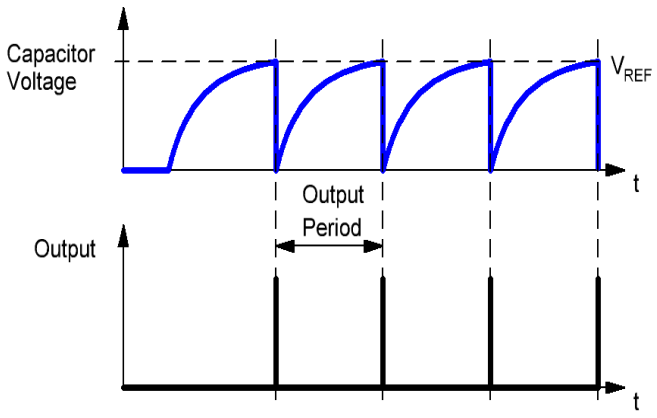


Figure 1. Oscillator Timing Diagrams

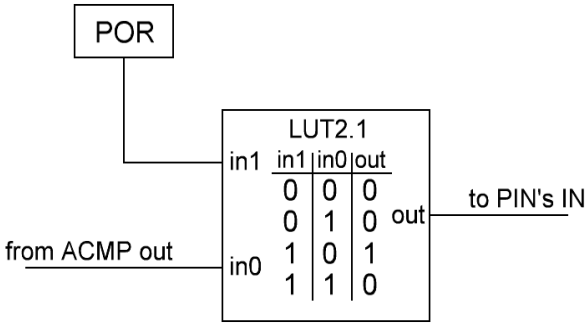
So, if the charging source voltage, reference voltage, R and C values are fixed the output frequency is fixed too. But the last formula shows that the output frequency can depend on the charging voltage source. Such devices that have a variable output frequency depending on input voltage are called Voltage Controlled Oscillators (VCO).

Designing such device using GreenPAK2 chip will require the use of ACMP, because this is a block that has different sets of reference voltages that can be easily changed if needed. The ACMP will monitor the voltage on capacitor and set the command to discharge it. Fortunately the same PIN that is used for sensing can be used for discharging. This PIN should be configured as “Analog Input and Open Drain Output”. So if IN of such PIN is HIGH it operates as analog input, if IN is LOW the PIN turns into open drain output with 0V level on it that can be used to discharge the capacitor. In this design the discharge should happen when the voltage on capacitor reaches the ACMP reference value (ACMP output is HIGH). So the Inverter should be placed between ACMP output and PIN’s IN. Inverter unit can be realized using 2-bit LUT with a proper truth table configured.

As the open drain output still has some resistance it will take some time to discharge the capacitor to 0V level. To make sure that the discharge process is completed the falling edge delay cell should be placed between the ACMP output and inverter.

The time needed for GreenPAK2 chip to turn on should be considered as well. For correct initialization POR output can be used to source second input of 2-bit LUT that is used as inverter.

For example, the ACMP0 configured to have 400mV reference is used. DLY0 is configured to be a falling edge delay for approximately 0.13us time. As inverter the 2-bit LUT1 is used. Its truth table is shown in Figure 2.



in1	in0	out
0	0	0
0	1	0
1	0	1
1	1	0

Figure 2. Inverter LUT Truth Table

The output can be sourced from ACMP0 and configured as push pull.

General application schematic is shown in Figure 3

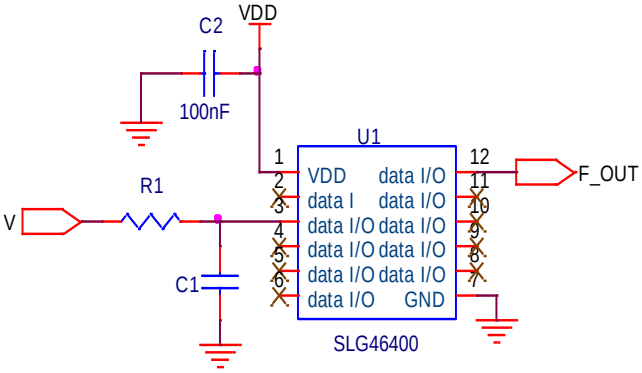


Figure 3. VCO Application Circuit

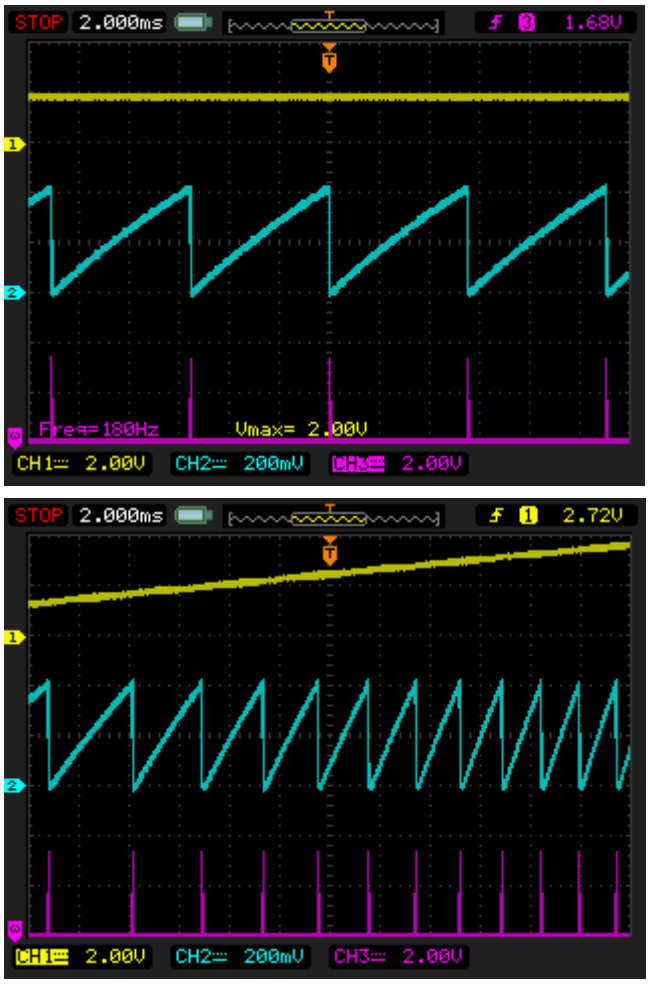


Figure 4. VCO Functionality Waveforms

Functionality waveform of real VCO circuit created in GreenPAK2 Designer with external R=1035kOhm and C=29.7nF is shown in Figure 4 where Channel1 (yellow/top line) – V (charging source voltage), Channel2 (light blue/bottom line) – PIN3 (SENSE&DISCHARGE), Channel3 (magenta/bottom line) – PIN3 (SENSE&DISCHARGE). As can be seen from Figure 4 the real waveform coincides with the theoretical shown in Figure 1.

Conclusion

Using the GreenPAK2 chips to create a RC based generator or voltage controlled oscillator is very simple. The design itself is straightforward and flexible, that allows creating oscillators with user specific values of output frequency.

Note: for proper output PIN operation its OE node should be connected to HIGH signal source, for example to VDD, if it is configured as push pull

Related Files

Programming code for **GreenPAK Designer.**

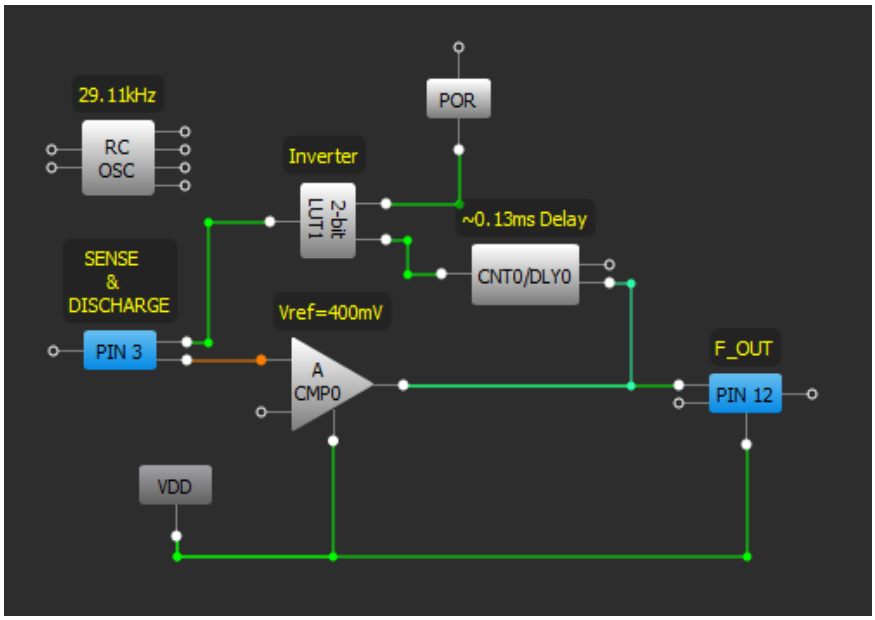


Figure 5. Voltage Controlled Oscillator Circuit in GreenPAK2 Designer.

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1	Roman Yankevych	8/19/2013	New application note

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