

# Application Note

## Analog Clock Motor Driver

### AN-CM-241

#### **Abstract**

*This application note describes how to implement all the active electronic functions needed in an analog clock, including motor driver and crystal oscillator using a GreenPAK IC. This application note comes complete with design files which can be found in the References section.*

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## Analog Clock Motor Driver

### 1 Terms and Definitions

CMIC	Configurable mixed-signal circuit
IC	Integrated circuit

### 2 References

For related documents and software, please visit:

[GreenPAK™ Programmable Mixed-Signal Products | Renesas](#)

Download our free [GreenPAK Designer](#) software [1] to open the .gp files [2] and view the proposed circuit design. Use the [GreenPAK development tools](#) [3] to freeze the design into your own customized IC in a matter of minutes. Renesas Electronics provides a complete library of application notes [4] featuring design examples as well as explanations of features and blocks within the IC.

- [1] [GreenPAK Designer Software](#), Software Download and User Guide, Renesas Electronics
- [2] [AN-CM-241 Analog Clock Motor Driver.gp](#), [GreenPAK Design File](#), Renesas Electronics
- [3] [GreenPAK Development Tools](#), [GreenPAK Development Tools Webpage](#), Renesas Electronics
- [4] [GreenPAK Application Notes](#), [GreenPAK Application Notes Webpage](#), Renesas Electronics
- [5] Lavet-type stepping motor, En.wikipedia.org, (2018)

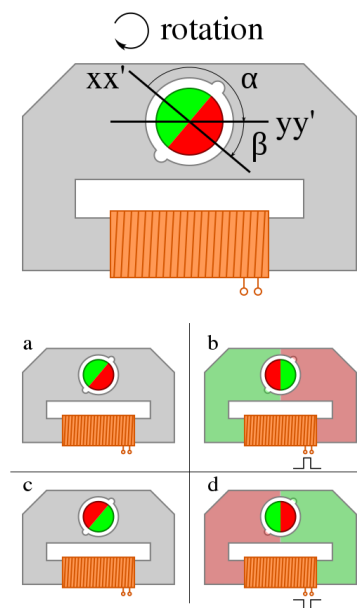
### 3 Introduction

Even in a digital world, classic analog clocks have a timeless style that is here to stay. We can use a dual-rail **GreenPAK™** CMIC to implement all the active electronic functions needed in an analog clock, including motor driver and crystal oscillator. **GreenPAKs** are low-cost, tiny devices that fit right in with smart watches. As an easy-to-build demonstration, I obtained a cheap wall clock, removed the existing board, and replaced all the active electronics with one **GreenPAK** device.

### 4 Background: Lavet Type Stepper Motors

A typical analog clock uses a Lavet type stepper motor to turn the pinion gear of the clock mechanism. It is a single-phase motor that consists of a flat stator (stationary part of the motor) with an inductive coil wrapped around an arm. Between the arms of the stator lies the rotor (moving part of the motor) which consists of a circular permanent magnet with a pinion gear attached to the top of it. The pinion gear coupled with other gears move the clock hands.

The motor works by alternating the polarity of current in the stator coil with a pause between the polarity changes. During current pulses, the induced magnetism pulls the motor to align the poles of the rotor and stator. While the current is off, the motor is pulled to one of two other positions by reluctant force. These reluctance rest positions are engineered by the design of non-uniformities (notches) in the metal motor housing so that the motor rotates in one direction (see [Figure 1](#)).



**Figure 1: Lavet Type Stepper Motor Rotation Pattern (En.wikipedia.org, 2018)**

### 5 Motor Driver

The attached design uses a SLG46121V to produce the required current waveforms through the stator coil. Separate 2x push-pull outputs on the IC (labeled  $M_1$  and  $M_2$ ) connect to each end of the coil, and drive the alternating pulses. It is necessary to use push-pull outputs for this device to operate correctly.

The waveform consists of a 10 ms pulse each second, alternating between  $M_1$  and  $M_2$  with each pulse. The pulses are created with just a few blocks driven from a simple 32.768 kHz crystal oscillator circuit. The OSC block conveniently has built-in dividers to help divide down the 32.768 kHz clock. CNT1 outputs a clock pulse every second. This pulse triggers a 10 ms one-shot circuit. Two LUTs (labeled 1 and 2) demultiplex the 10 ms pulse to the output pins. Pulses are passed to  $M_1$  when DFF5 output is high,  $M_2$  when low.

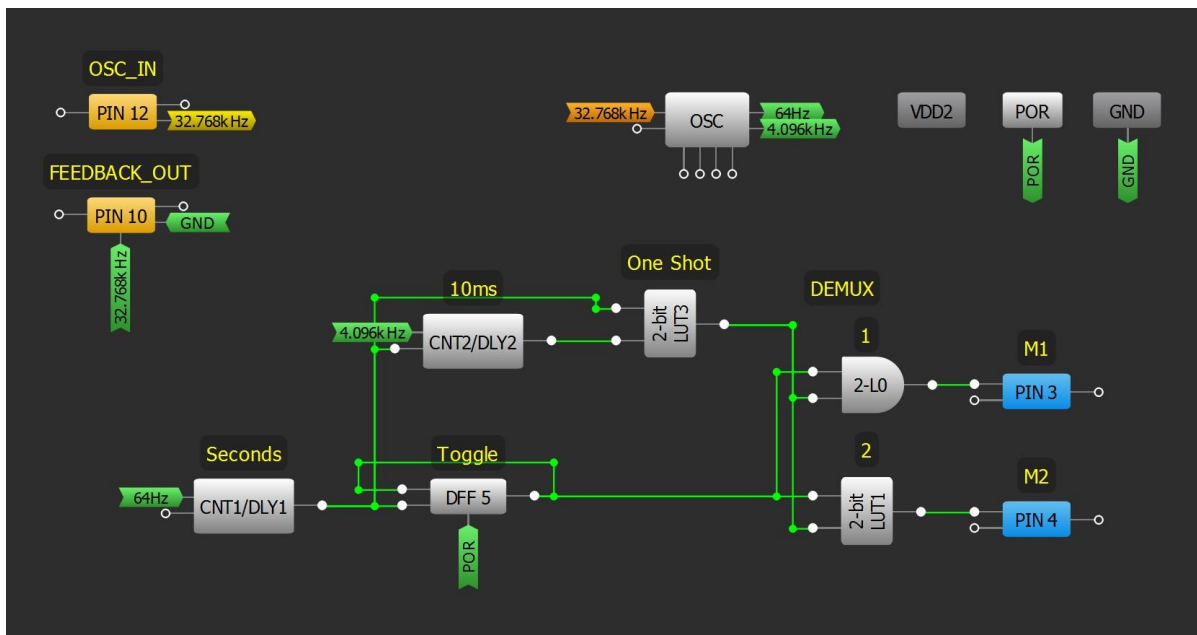


Figure 2: Circuit Diagram of Internal Connections

## 6 Crystal Oscillator

The 32.768 kHz crystal oscillator uses just two pin blocks on the chip. PIN12 (OSC\_IN) is set as a low-voltage digital input (LVDI), which has relatively low switching current. The signal from PIN12 feeds into the OE of PIN10 (FEEDBACK\_OUT). PIN10 is configured as a 3-state output with input wired to ground, making it act like an open drain NMOS output. This signal path naturally inverts, so no other block is needed. Externally, the PIN 10 output is pulled up to VDD2 (PIN11) by a 1M $\Omega$  resistor (R4). Both PIN10 and PIN12 are powered by the VDD2 rail, which in-turn is current limited 1 M $\Omega$  resistor to VDD. R1 is a feedback resistor to bias the inverting circuit, and R2 limits output drive. Adding the crystal and capacitors completes the Pierce oscillator circuit as shown in Figure 3.

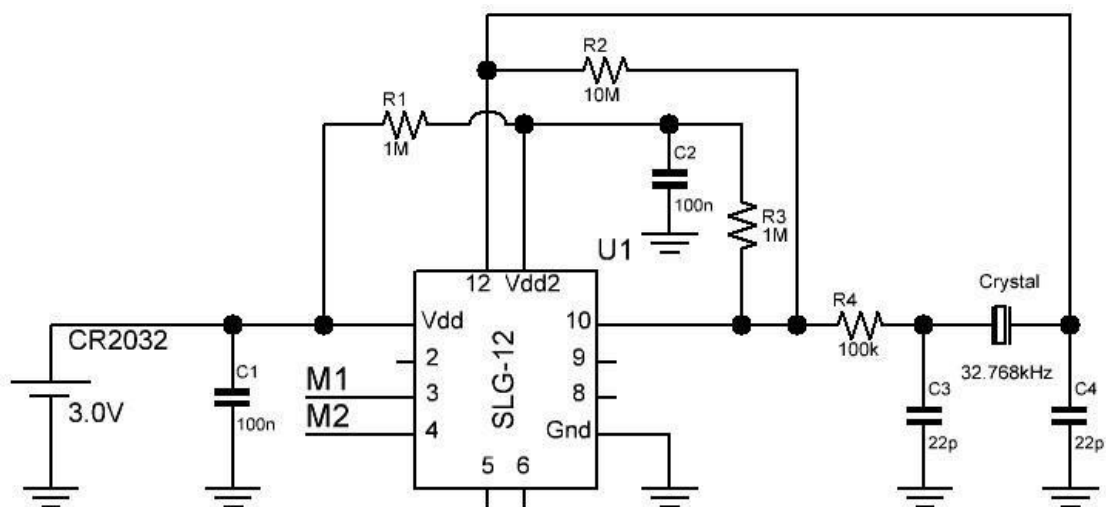


Figure 3: Circuit Diagram of External Connections

### 7 Results

VDD was powered by a CR2032 lithium coin battery which typically provides 3.0 V (3.3 V when fresh). The output waveform consists of alternating 10 ms pulses as shown below in [Figure 4](#). Averaged over a minute, the measured current draw was roughly 97 uA including the motor drive. Without the motor, the current draw was 2.25 uA.

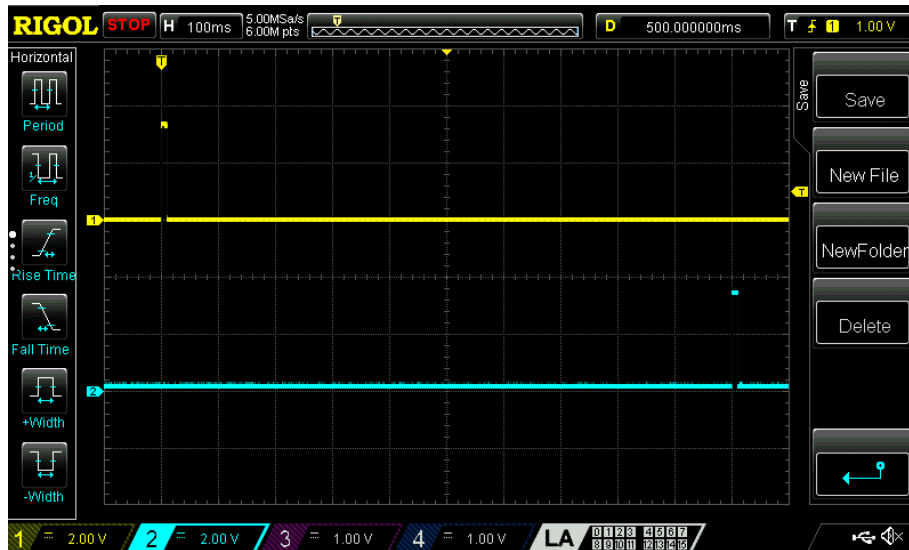


Figure 4: Motor Driver Output Waveform, 10 ms on, 990 ms off

### 8 Conclusion

This application note provides a GreenPAK demonstration of a complete solution for driving an analog clock stepper motor and can be the basis for other more specialized solutions. This solution only uses a portion of the GreenPAK resources, which leaves the IC open to additional functions left only to your imagination

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