Music Synthesizer
SLG47011

This application note describes how to create a Music Synthesizer using AnalogPAK SLG47011. The design provides the sequential playback of several simple monophonic melodies.

The application note comes complete with design files which can be found in the Reference section.

Contents

1. Terms and Definitions

DFF	D Flip-Flop
LUT	Look-up Table
MF	Multi-Function
OSC	Oscillator

2. References

For related documents and software, please visit: AnalogPAK™ | Renesas

Download our free Go Configure Software Hub [1] to open the design file [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. Find out more in a complete library of application notes [4] featuring design examples as well as explanations of features and blocks within the GreenPAK IC.

[1] Go Configure Software Hub, Software Download and User Guide, Renesas Electronics

[2] AN-CM-372 Music Synthesizer.aap, AnalogPAK Design File, Renesas Electronics

[3] GreenPAK Development Tools, GreenPAK Development Tools, Renesas Electronics

[4] GreenPAK Application Notes, GreenPAK Application Notes, Renesas Electronics

[5] SLG47011 Datasheet, Renesas Electronics

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3. Introduction

The music synthesizer is a simple square wave variable frequency generator, which reproduces variable frequency output according to the programmed pattern in a memory table. The design provides the sequential playback of several simple monophonic melodies (10 in this design). The app note explains how to convert the .mid file into the required .txt format for filling the Memory Table and how to work with the Memory Control Counter to control the Memory Table. Also, it explains how to configure the PAK to reproduce the desired frequencies with the desired rhythm to create a melody.

4. Operating Principle and AnalogPAK Design

The AnalogPAK Design is shown in Figure 1.

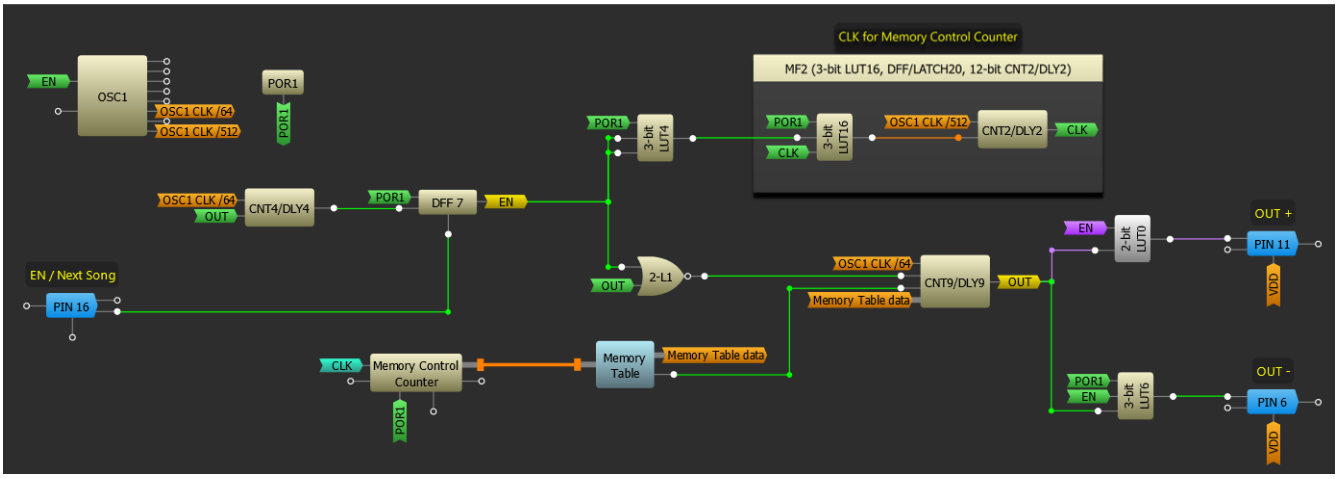

Figure 1. Music Synthesizer AnalogPAK Design

The PIN 16 is an Enable (EN / Next Song) signal that turns ON the music synthesizer. As soon as the signal EN goes HIGH, the clock for the Memory Control Counter starts (MF2). Changing the counter data of the CNT2/DLY2 results in clock frequency. Depending on this frequency, the design has the ability to reproduce the necessary amount of notes per second. In other words, it is possible to change the rhythm of the melody (note duration).

Then the Data Out signal of the Memory Control Counter goes to the Address Bus input of the Memory Table. Memory Table is a storage of 4096 12-bit words (Figure 2).

The Memory Control Counter is configured for one range with counter overflow. Ten melodies are stored in the memory table. Melodies are separated by a word whose value is 1. Melodies in this design occupy only 588 words. Thus, about 70 melodies of the same length can be stored in the memory table.

Data from the Memory Table is sent to a 12-bit CNT9/DLY9 Dynamic Counter as counter data. The CNT9/DLY9 is configured as Delay. The Load input of a Dynamic Counter is sent from the Memory Table Data ready.

Multifunction Dynamic Counter divides OSC1 CLK/512 frequency with a counter value that comes from a memory table with its "rhythm" frequency.

Output frequency (note pitch) will change on the output corresponding to the division coefficients that are programmed into a memory table with a "rhythm" frequency.

Output from a CNT9/DLY9 is a sequence of note frequencies (counter data from Memory Table). Each note has a duration corresponding to the rhythm frequency. This square wave output signal is sent via 2-bit LUT0 to PIN 11 (OUT+) and inverted (3-bit LUT6) to PIN6 (OUT-) and a piezo speaker, which reproduces a tone.

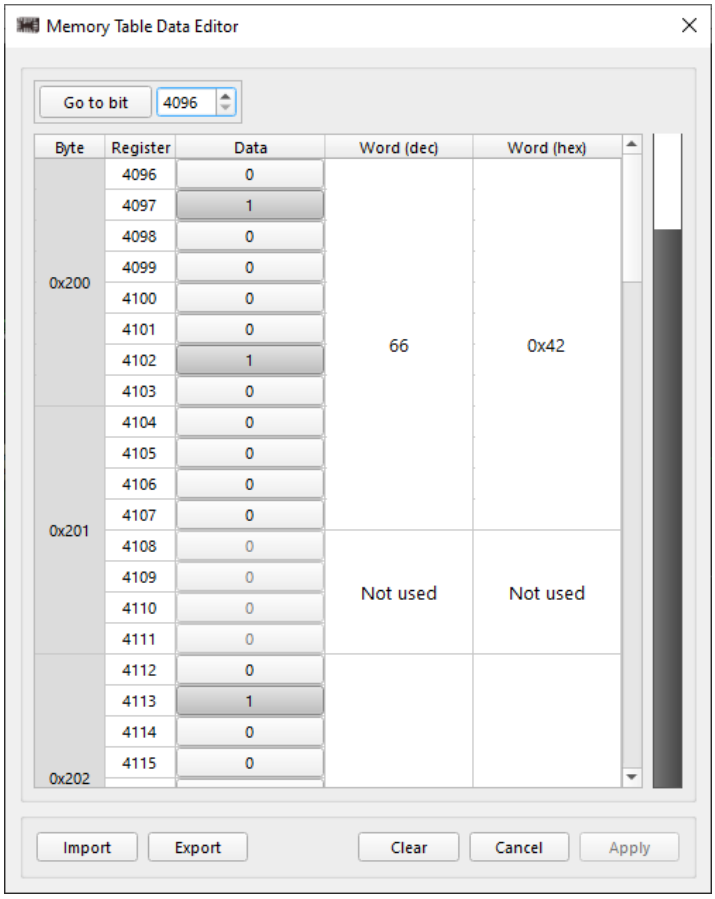

Figure 2. Memory Table Data Editor

Melodies separator, the word “1” is a 52 kHz signal (length of the pulse 9.6 us), which is detected by CNT4/DLY4. CNT4/DLY4 is configured as Frequency Detect. Its output goes HIGH if the time between the rising and falling edges is less than the set time (12.8 us), which is equivalent to the length of the pulse. The output goes LOW if after the last rising/falling edge and specified time the second edge has not come. When the “1” is detected, CNT4/DLY4 output goes HIGH and clocks the DFF7. If the DFF7 output is HIGH the system is powered down (3-bit LUT4 and 2-bit LUT1).

When you press the button on PIN16, the HIGH signal nRESET’s the DFF7 and the next melody starts playing.

After 10 melodies, overflow occurs and everything starts again with the first melody.

5. Converter .mid to .txt

The Memory Table can be filled with a .txt file. Figure 3 shows the converter window for .mid files. You need to select files and click on File Convert. The result will be the Counter Data Value for CNT2/DLY2, the Upper limit (table size) for the Memory Control Counter, and the .txt file with words’ values. At the end of each melody, the converter automatically adds the word “1” – melodies separator.

Note that melodies in .mid format must be monophonic.

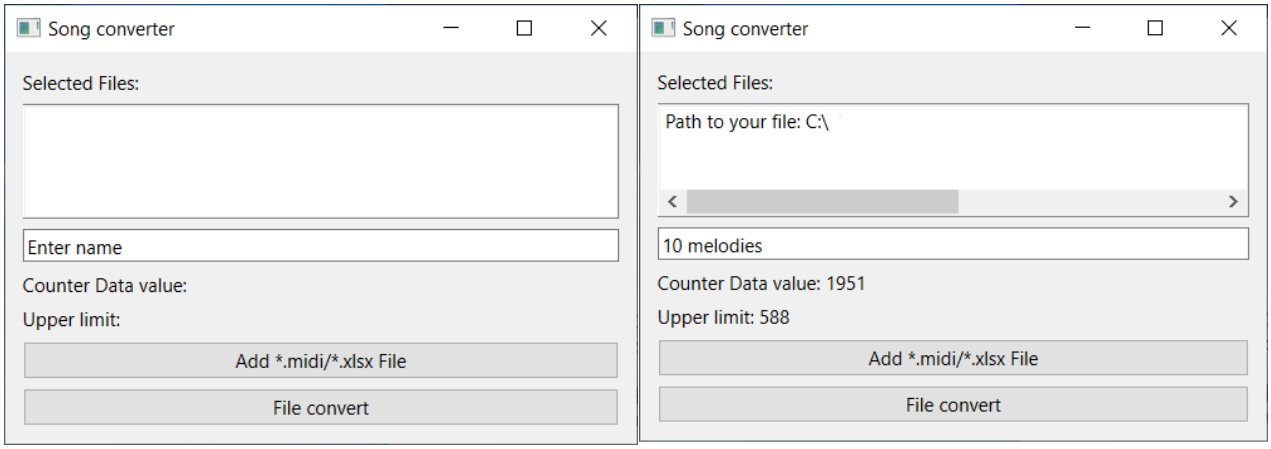

Figure 3. Song Converter

The Counter Data Value for CNT2/DLY2 is calculated with formula:

$$CNT\ Data = \frac{min\ note\ length}{2} \cdot \text{OSC CLK} - 2$$

Min note length is the duration of the shortest note in the melody. Determining the duration of this note allows to determine the rhythm frequency. This note will be represented with one word in Table Memory. And longer notes will have a duration of (2n x min) note length (Table 1).

Table 1. Note Length

Note Duration	Symbol	Beat
Whole Note	𝅝	4
Half Note	𝅗𝅥	2
Quarter Note	♩	1
Eighth Note	♪	1/2
Sixteenth Note	𝅘𝅥𝅯	1/4

6. Design Testing

OSC CLK – 39.0625 kHz

Note frequency:

$$f = \frac{OSC\ CLK}{2 \cdot (CNT\ Data + 2)}$$

CNT Data	1	2	3	4	5	6	7	8	9	10
Expected frequency, kHz	6.51	4.88	3.91	3.26	2.79	2.44	2.17	1.95	1.78	1.63
Obtained frequency, kHz	6.49	4.90	3.91	3.25	2.78	2.45	2.17	1.95	1.77	1.62

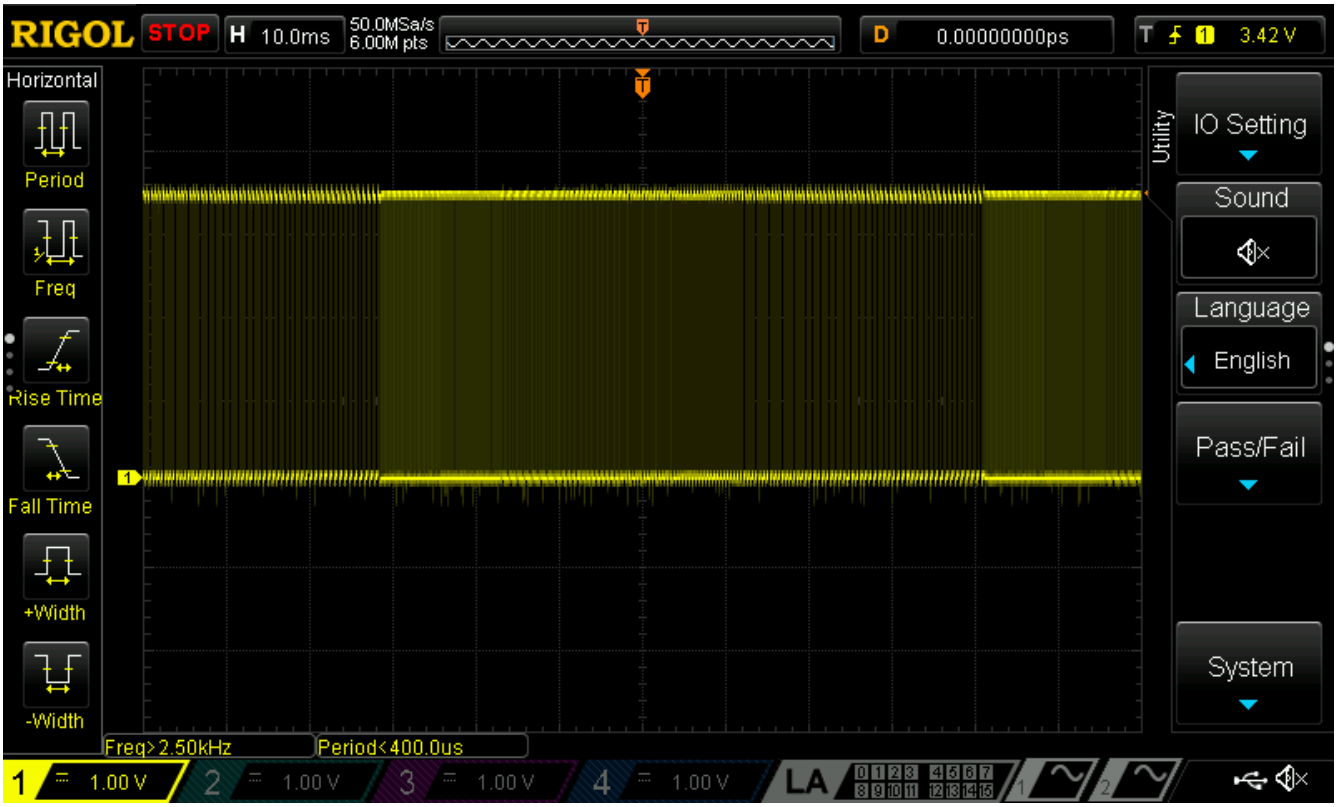

Figure 4. Sequences of notes, CNT DATA = 1 to 10

7. Conclusion

This application note describes how to configure the AnalogPAK SLG47011 to create a Music Synthesizer that is capable of sequential playing several simple monophonic melodies.

The AnalogPAK's internal resources, including the Memory Table, Memory Control Counter, oscillators, logic, and GPIOs are easy to configure to implement the desired functionality for this design.

8. Revision History

Revision	Date	Description
1.00	Sep 23, 2024	Initial release.

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