

Introduction

The DS1086 is a welcomed addition to the EconOscillator™ family. While it is similar to the DS1085, the DS1086 is capable of generating frequencies from 260kHz to 133MHz with a spread-spectrum output. A spread-spectrum system clock/oscillator is important when EMI is a concern of the end application. In addition to the spread-spectrum output, the DS1086 gives the designer the ability to easily change the frequency of the oscillator in-circuit, on-the-fly using the 2-wire interface.

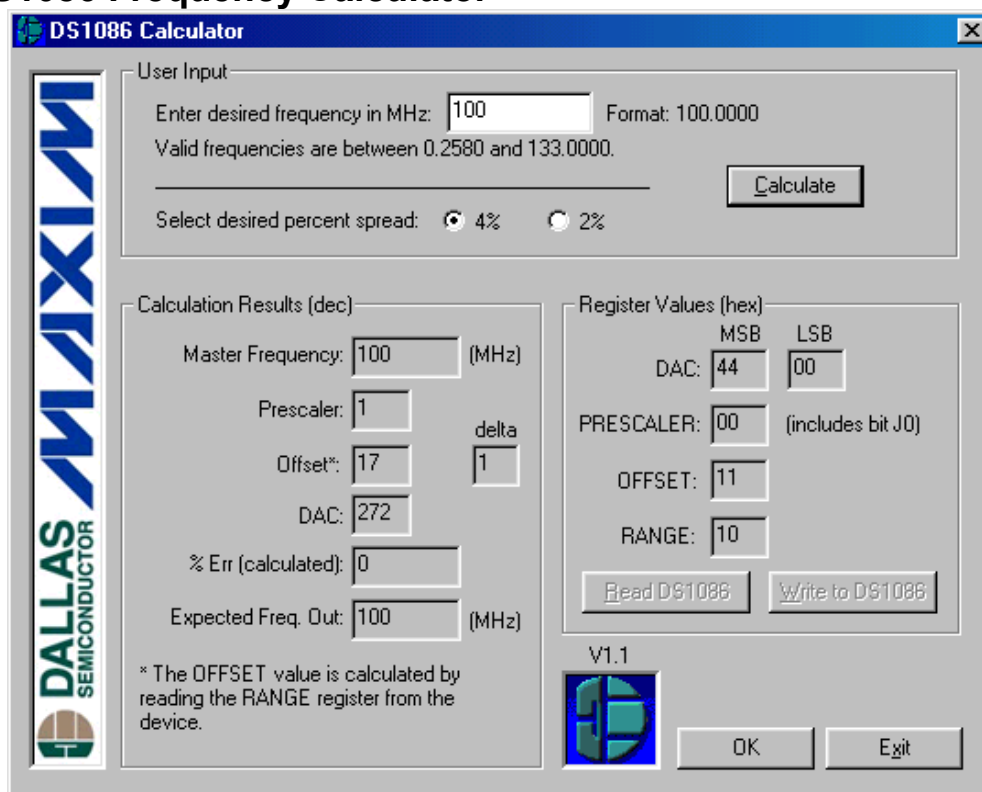
The purpose of this application note is to introduce the *DS1086 frequency calculator*, which is available for download, and to show an algorithmic approach to calculating the values needed to program into the DS1086 to generate a specified frequency.

This application note assumes that the reader is already familiar with the DS1086 data sheet.

The Calculator

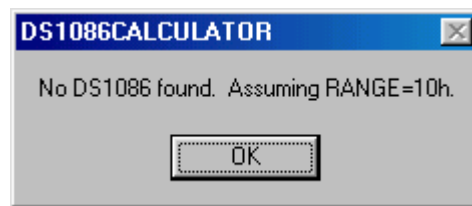
The DS1086 frequency calculator is a Windows 95/98/NT application available for download at [ftp://ftp.dalsemi.com/pub/silicon_timed/DS1086Calculator.exe](http://ftp.dalsemi.com/pub/silicon_timed/DS1086Calculator.exe). It can be used standalone to calculate the values to program into the DS1086 registers, or in conjunction with a DS1086 EV Kit (available in the future).

Figure 1. DS1086 Frequency Calculator



Once the calculator's executable file is downloaded and executed, the dialog shown in Figure 1 will appear. To use the calculator, simply enter a desired frequency between .258 and 133 (in MHz) in the edit box and select the desired percent spread (2% or 4%). Then click on Calculate (or Alt + C). The software will first check to see if an EV Kit is connected to the PC's serial port. If so, the RANGE register is read from the DS1086 and used in the calculation. Otherwise, a dialog box similar to Figure 2 will appear stating that 10 hex (16 decimal) will be used in the calculation in place of an actual RANGE value. Clicking on OK will remove the dialog and show the results of the calculation. The values on the left side of the calculator, in the *Calculation Results* section, show results of the intermediate calculations (in decimal) and are defined below. These are then used to generate the hex register values shown on the right side of the calculator in the *Register Value* section. These are the values that need to be programmed into the DS1086 device registers to set the desired frequency assuming that RANGE was read from an actual device. If an EV Kit is connected, the Read and Write buttons will be enabled and can be used to program the DS1086 to the frequency you just calculated.

Figure 2. DS1086 RANGE Message



Master Frequency

This is what the internal master oscillator needs to be trimmed to in order to generate the desired output frequency. Valid frequencies are between 66Mhz and 133Mhz in 10kHz step increments. The output frequency is determined by this *Master Frequency* divided by the *Prescaler*.

Prescaler

The *Master Frequency* is divided by the *Prescaler*. Valid *Prescaler* values are 2^x , where x can be 0 to 8. Thus, the *Prescaler* divides the *Master Frequency* by 1, 2, 4, 8, 16, 32, 64, 128, or 256.

Offset

This value selects the range of frequencies (refer to Table 2 in the data sheet) used to generate the *Master Frequency*. When used in conjunction with *DAC*, a specific frequency within the range is selected. This value is meaningless if RANGE is not known. See *delta* below.

delta (the difference between Offset and RANGE)

This is the delta of *Offset* from the factory programmed RANGE value (refer to Table 2 in the data sheet). For example, a delta of +2 selects the frequency range of 102.4 to 112.63MHz. The relationship between *Offset* and *delta* can be better described as follows: $Offset = \text{factory programmed value of RANGE} + delta$.

DAC

Once a range of frequencies is chosen, *DAC* is used to select a particular frequency within that range. The value of *DAC* is multiplied by 10kHz (0.01MHz) and then added to the minimum frequency of the selected range. For example, suppose the range of 92.16 to 102.39MHz has been selected (refer to Table 2 in the data sheet). If *DAC* were say, 500 (dec), the *Master Frequency* would then be $92.16 + 500(0.01) = 97.16\text{MHz}$.

% Err (calculated)

This value is the percent error between the desired frequency, which the user inputs, and the *Expected Freq Out* (see below). This error is the theoretical quantizing error created by the 10kHz step size.

Expected Freq Out

This is the frequency you would expect to measure at the output. However, it is purely the calculated expectation. Refer to the DS1086 data sheet for the specified frequency tolerance, as well as tempco and voltco performance.

Percent Spread

The 4% and 2% radio buttons are used to select the desired percent spread. The selection is written into the J0 bit (b4) of the PRESCALER register. For this selection to have any effect on the frequency output, the DS1086 SPRD pin must be tied to V_{CC} . Otherwise, if no spread (dither) is desired, the SPRD pin should be tied to GND. Refer to the data sheet for more information.

Algorithm

The DS1086 data sheet does a great job of showing how to calculate register values by hand. However, it fails to discuss how such calculations and decision making could be implemented in software or firmware. When the register values are given, calculating the frequency is straightforward. However, when the frequency is given, calculating the register values is much more complicated. Furthermore, the process of calculating the register values either by hand or by soft/firmware is further complicated by its dependency on the factory programmed RANGE register value. The flowchart included in Appendix A shows an example algorithm of how to programmatically solve for the DS1086 register values when given a desired frequency. Comments accompany the flowchart and provide a step-by-step narrative. While the flowchart provides a solid foundation, there may be improvements you might wish to implement depending on your applications requirements. One such improvement would be to continue searching for all possible solutions to generate the desired frequency and then choosing the solution with the smallest calculated error.

Conclusion

The DS1086, with its spread-spectrum output, is a welcomed addition to the EconOscillator family. Its features complement those of its siblings. Due to the overwhelming interest in the DS1086, a frequency calculator has been created to make it easier incorporating the DS1086 into your application. Likewise, to simplify the challenge of working backwards and calculating the register values from a given frequency, a flowchart has been provided for those applications where the frequency needs to be calculated programmatically.

Download DS1086 calculator from: ftp://ftp.dalsemi.com/pub/silicon_timed/DS1086Calculator.exe.

Maxim Integrated Products / Dallas Semiconductor Contact Information

Dallas Semiconductor
4401 S. Beltwood Parkway
Dallas, TX 75244
Tel: 972-371-4448

Maxim Integrated Products, Inc
120 San Gabriel Drive
Sunnyvale, CA 94086
Tel: 408-737-7600

Product Literature / Samples Requests:
(800) 998-8800

Sales and Customer Service:
(408) 737-7600

World Wide Website:
www.maxim-ic.com

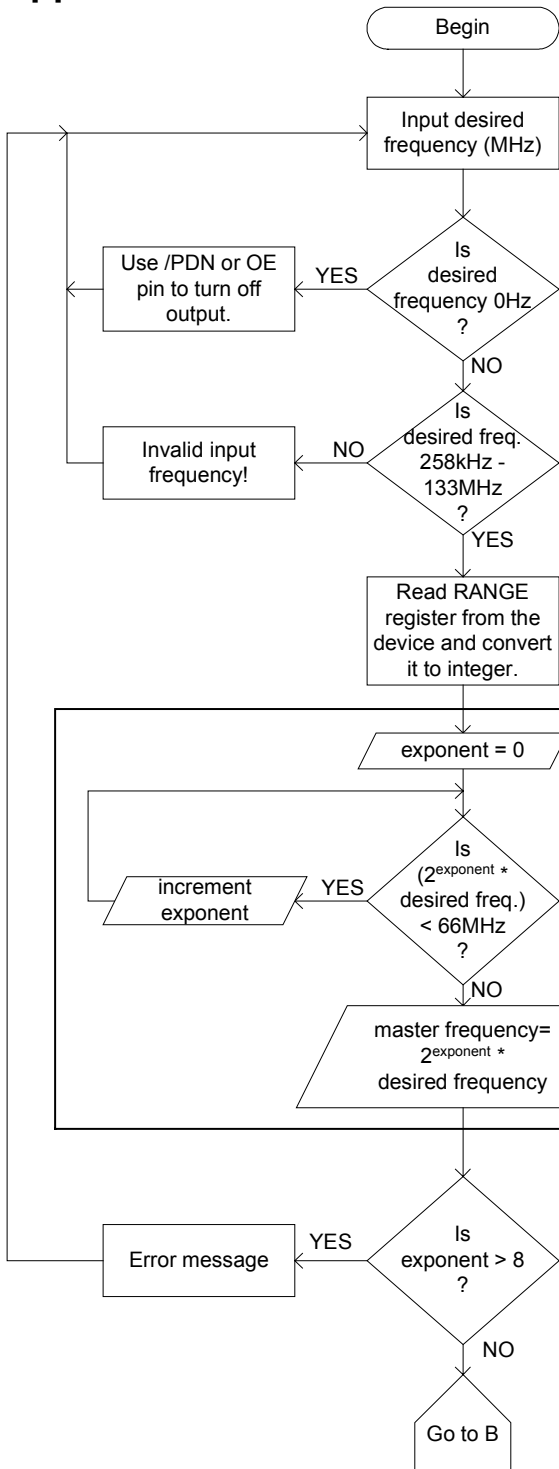
Product Information:
<http://www.maxim-ic.com/MaximProducts/products.htm>

Ordering Information:
<http://www.maxim-ic.com/BuyMaxim/Sales.htm>

FTP Site:
<ftp://ftp.dalsemi.com>

Tech Support:
MixedSignal.Apps@dalsemi.com

Appendix A



Input desired frequency

Can be input real-time or as an input parameter. Floating point numbers are valid, such as *float* or *double*.

Validate frequency

The DS1086 can generate master oscillator frequencies of 66MHz-133MHz. The prescaler then divides by 1-256 to generate lower frequencies.

Read default offset in RANGE register

The *read-only* RANGE register is unique to each device and is programmed into each DS1086 during production testing. It is a back-up copy of the OFFSET register factory default value.

Calculate needed master frequency and prescaler

This algorithm favors lower master frequencies (and hence lower current) over a higher prescaler (and hence an smaller effective step size). An algorithm that does just the opposite (favors a smaller step size over current) can be substituted.

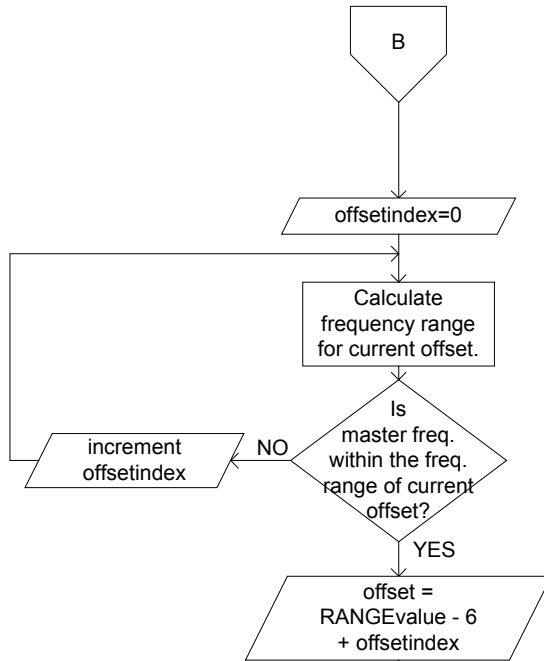
The exponent (and hence prescaler) is incremented until a master frequency over 66MHz is found. A nice improvement would be to find all or several solutions (and choose solution with smallest error).

$$\text{master frequency} = \text{prescaler} * \text{desired frequency}$$

where prescaler is 2^x (valid values of x are 0 to 8). The value of x is what is programmed into the PRESCALER register.

2^8 is the largest valid prescaler value.

This check is not necessary since the desired frequency has already been validated. However, it is included here to emphasize that 8 is the max even though it uses 4 bits in the PRESCALER register.



Calculate Offset

Example: 61.44 - 71.67MHz for OS-6 range. Refer to the "Offset Settings" table in the datasheet.

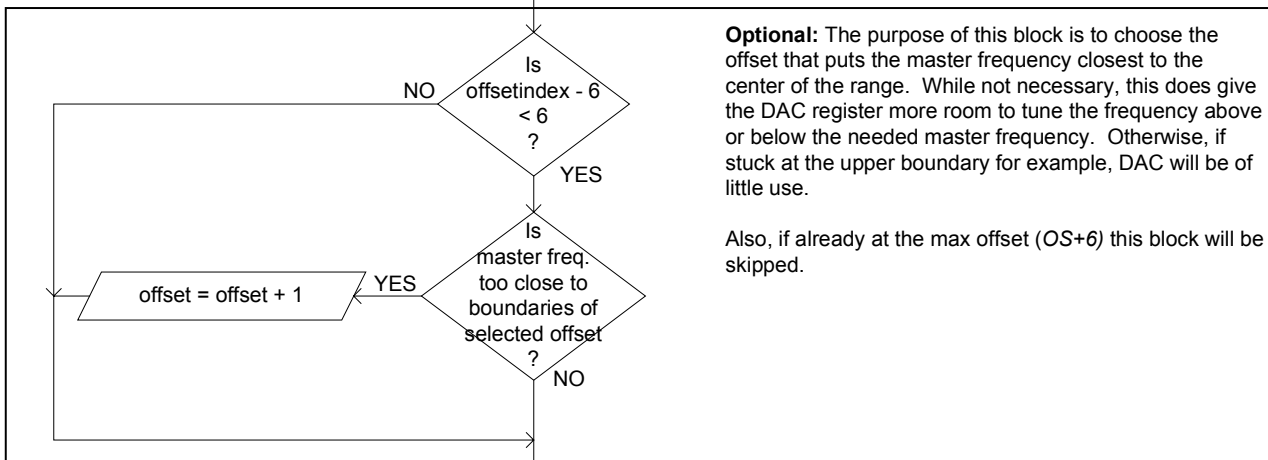
*Min frequency of smallest offset = 61.44MHz (from table)
Delta frequency per offset = 5.12MHz*

*Min freq of current offset = 61.44 + (offsetindex * 5.12)
Max freq of current offset = 61.44 +(offsetindex * 5.12)+(1023*0.01 step)*

$offset = RANGEvalue - 6 + offsetindex$

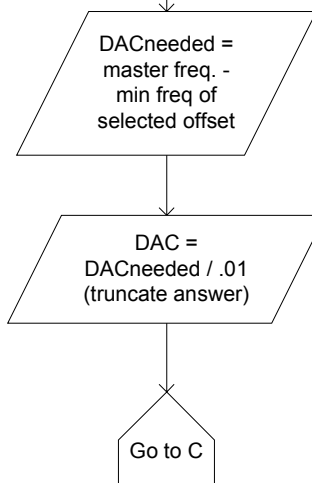
-6 corresponds to 61.44MHz frequency range.

RANGEvalue is the value read from the RANGE register (with 3 MSBits masked).



Optional: The purpose of this block is to choose the offset that puts the master frequency closest to the center of the range. While not necessary, this does give the DAC register more room to tune the frequency above or below the needed master frequency. Otherwise, if stuck at the upper boundary for example, DAC will be of little use.

Also, if already at the max offset (OS+6) this block will be skipped.



Calculate DAC

$DACneeded = master\ freq. - min\ freq\ of\ selected\ offset$

$DAC = DACneeded / .01$

0.01 is the master oscillator step size.

Format device registers

The DS1086 has the following registers that need to be programmed: PRESCALER (1 byte), DAC (2 bytes), and OFFSET (1 byte). The ADDR word does not affect the frequency. Likewise, the RANGE register is *read-only*.

Exponent, offset, and DAC have already been calculated, but now they need to be placed (shifted) into the correct bit locations of their corresponding registers PRESCALER, OFFSET, and DAC, respectively.

