

**Application Note AN3101-08: Two-Phase Quadrature Oscillator**  
**by Shultz Wang**

**Introduction**

This application note presents an algorithm for a simple sine wave generator. The generated sine waves may be outputted as pure test signals, used as inputs for other calculations, or used to control other functions.

**Algorithm**

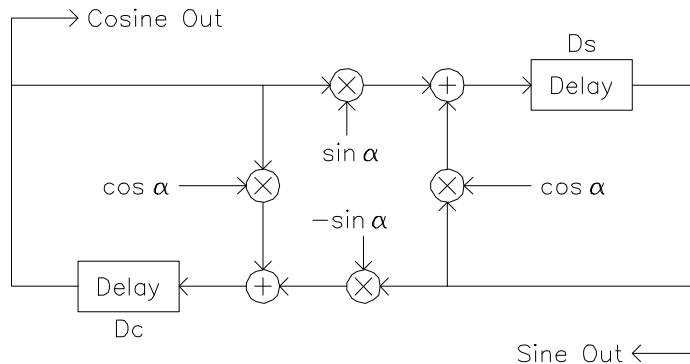
Start off with the basic sum of angles formulae for sine and cosine.

$$\begin{aligned}\sin(A+\alpha) &= \sin(A)\cos\alpha + \cos(A)\sin\alpha, \\ \cos(A+\alpha) &= \cos(A)\cos\alpha - \sin(A)\sin\alpha.\end{aligned}$$

The equations may be used as a predictor for the next point if the current point is known, by letting A be the current angle, and  $\alpha$  be the step size.

$$\begin{aligned}\sin[n+1] &= \sin[n]\cos\alpha + \cos[n]\sin\alpha, \\ \cos[n+1] &= \cos[n]\cos\alpha - \sin[n]\sin\alpha.\end{aligned}$$

This is sufficient information to generate a block diagram.



The incremental angle  $\alpha$  is determined by the desired output frequency and is described by the following formula:

$$\alpha = 2\pi f/fs \text{ (f = selected frequency, fs = sampling frequency).}$$

The oscillators need to be started by placing correct values of  $\sin[n]$  and  $\cos[n]$  in the registers. This is most easily done at one of the multiples of  $\pi/2$  points. For convenience the point  $\sin[n]=0$ ,  $\cos[n]=1$  will be chosen.

## Source Code

First calculate or select the following for each oscillator.

$\sin\alpha$   
 $\cos\alpha$   
 Ds (sine delay) Address (non-rotating)  
 Dc (cosine delay) Address (non-rotating)  
 Max (Maximum amplitude)

; Version 1: Explicit sine/cosine

```

CM    $(sinα)    $DcA ; Dc*sinα
LCMA  $(cosα)    $DsA ; Ds*cosα+Dc*sinα, store Ds in B
SCB   $(-sinα)   $DsA ; Save new Ds, -Ds(sinα)
CMA   $(cosα)    $DcA ; Dc*cosα-Ds*sinα
SCA   $040000    $DcA ; Save new Dc
  
```

For low frequencies,  $\cos\alpha$  is approximately 1, and  $\sin\alpha$  is approximately  $\alpha$ .

; Version 2: Approximate sine/cosine

; New Ds = Ds+Dc\* $\alpha$

; New Dc = Dc-Ds\* $\alpha$

```

CM    $(α)    $DcA ; Dc*α
LCMA  $040000  $DsA ; Ds+Dc*α, store Ds in B
SCB   $(-α)   $DsA ; Save new Ds, -Ds*α
CMA   $040000  $DcA ; Dc-Ds*α
SCA   $040000  $DcA ; Save new Dc
  
```

Using the approximation introduces larger errors and increases THD. With  $\sin\alpha=\$002000$ ,  $\cos\alpha=\$03ff7f$ , THD=0.0116%. With the approximation,  $\alpha=\$002000$ , THD=1.3%.

; Version 3: Approximate sine/cosine, one constant from memory

```

CM    $040000    $DcA ; Dc
AMC   $0          $αA ; Dc*α
LCMA  $040000    $DsA ; Ds+Dc*α, store Ds in B
SCA   $040000    $DsA ; Save new Ds
BMC   $0          $αA ; Ds*α
CAM   $3c0000    $DcA ; Dc-Ds*α
SCA   $040000    $DcA ; Save new Dc
  
```

; Version 4: Two constants from memory

```

CM    $3c0000    $DsA ; -Ds
AMC   $0          $sαA ; -Ds*sinα
XCM   $040000    $cαA ; cosα, store -Ds*sinα in B
AMB                   $DcA ; Dc*cosα-Ds*sinα
LCA   $040000    $DcA ; Store Dc in B
SCA   $040000    $DcA ; Save new Dc
BMC   $0          $sαA ; Dc*sinα
XCM   $040000    $cαA ; cosα, store Dc*sinα in B
AMB                   $DsA ; Ds*cosα+Dc*sinα
SCA   $040000    $DsA ; Save new Ds
  
```

If there will be no microprocessor starting up the oscillators, there will need to be a startup routine placed right after the oscillator. Due to the resetting of the cosine, there may be a discontinuity in the generated cosine wave, therefore the sine wave should be preferentially used.

```

; Self reset for drift removal, auto startup; For versions 1, 2, 3
CM    $040000    $DsA ; Load new Ds
SKIP  N          $4   ; Skip reset if new Ds < 0
CB    $040000    ; B->A
SKIP  Z          $1   ; Skip non-negative check if old Ds = 0,
                    ; remove if auto startup not needed
SKIP  !N         $2   ; Skip reset if old Ds >= 0
DAC   $0         $(Max) ; Load max amplitude
SCA   $0         $DcA ; Dc=Max

```

; Version 4 self reset code addition; Place before oscillator

```

CM    $040000    $DsA ; Read last Ds
SCA   $0         $TmA ; Save last Ds

```

; Self reset for drift removal, auto startup; For version 4

```

SKIP  N          $5   ; Skip reset if new Ds < 0
CM    $040000    $TmA ; Read old Ds
SKIP  Z          $1   ; Skip non-negative check if old Ds = 0, auto startup
SKIP  !N         $2   ; Skip reset if old Ds >= 0
DAC   $0         $(Max); Load max amplitude of output waveform
SCA   $0         $DcA ; Dc=max

```

Sample oscillator:

; f=238.7Hz, Max=-12dB

```

CM    $002000    $400 ; Dc*α
LCMA  $03ff7f    $401 ; Ds+Dc*α, store Ds in B
SCB   $3fe000    $401 ; Save new Ds, -Ds*α
CMA   $03ff7f    $400 ; Dc-Ds*α
SCA   $040000    $400 ; Save new Dc

```

; Self reset for drift removal, auto startup

```

CM    $040000    $401 ; Load new Ds
SKIP  N          $5   ; Skip reset if new Ds < 0
CB    $040000    ; B->A
SKIP  Z          $1   ; Skip non-negative check if old Ds = 0, auto startup
SKIP  !N         $2   ; Skip reset if old Ds >= 0
DAC   $0         $010000 ; Load max amplitude
SCA   $0         $400 ; Dc=1

```

; Output sine wave

```

CM    $040000    $401 ; Read sine
SCA   $0         $410 ; Write sine to channel 0

```

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### **Contact Information:**

Wavefront Semiconductor  
200 Scenic View Drive  
Cumberland, RI 02864 U.S.A.  
Tel: +1 401 658-3670  
Fax: +1 401 658-3680  
On the web at [www.wavefrontsemi.com](http://www.wavefrontsemi.com)  
Email: [info@wavefrontsemi.com](mailto:info@wavefrontsemi.com)

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