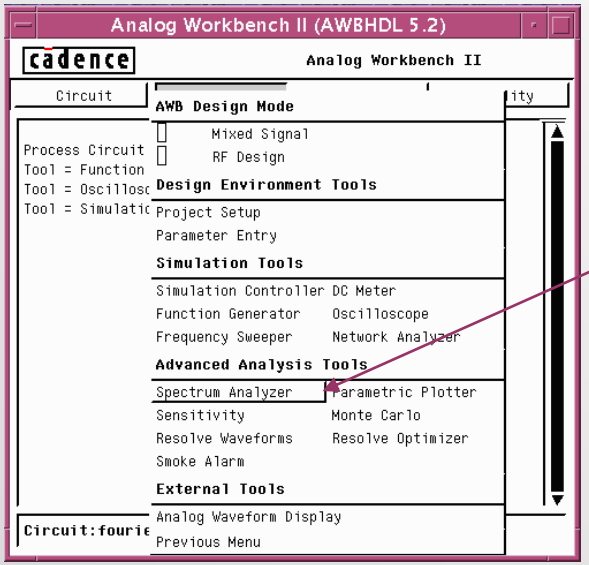
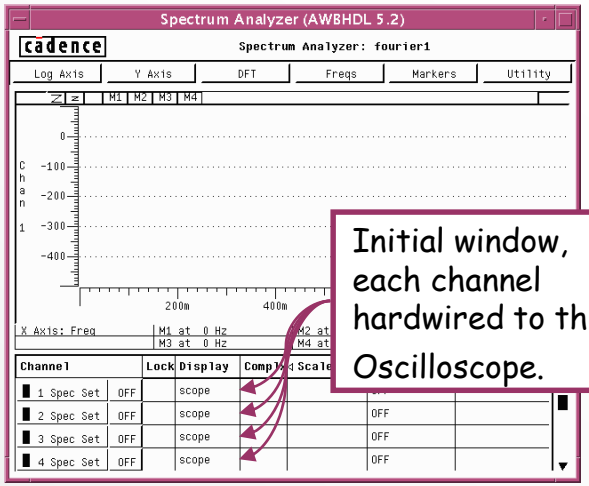
AWB's Spectrum Analyzer and the Fourier Series waveform reconstruction...

$$f(t) = a_0 + \sum_{n=1}^{\infty} C_n \cos(n\omega_0 t + \theta_n)$$

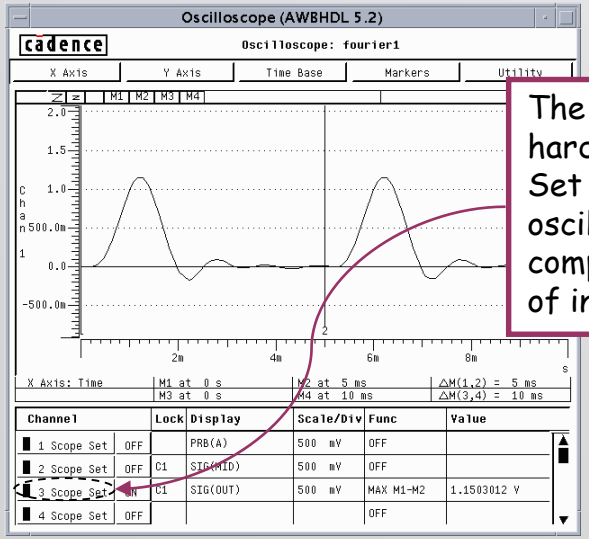
The basic idea of the Fourier series is that a periodic function with period $\omega_0 = \frac{2\pi}{T_0}$ could be described by a weighted sum of cosine and sine functions.



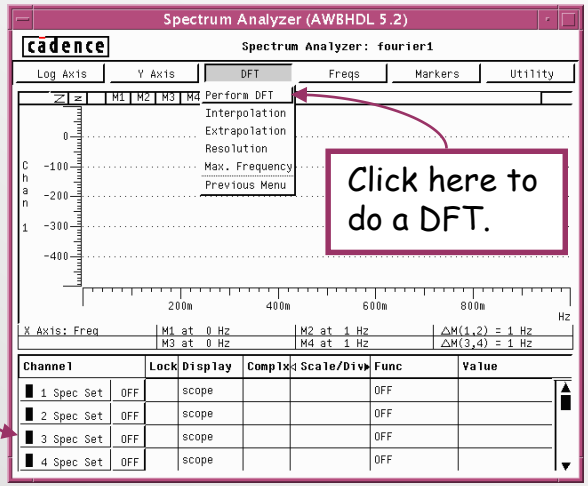

The Spectrum Analyzer is an advance analysis tool in AWB.



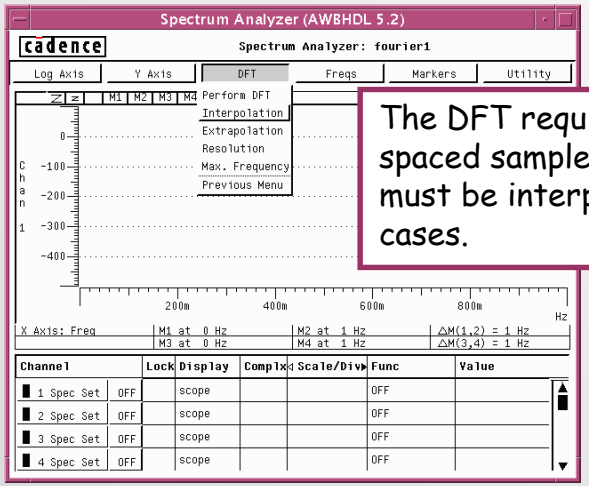

Initial window, each channel hardwired to the Oscilloscope.



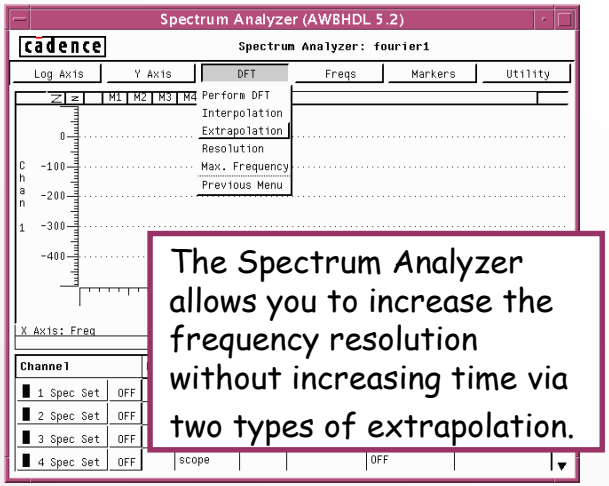

The Spectrum Analyzer is hardwired to the Oscilloscope. Set the markers in the oscilloscope to bound one complete cycle of the waveform of interest.



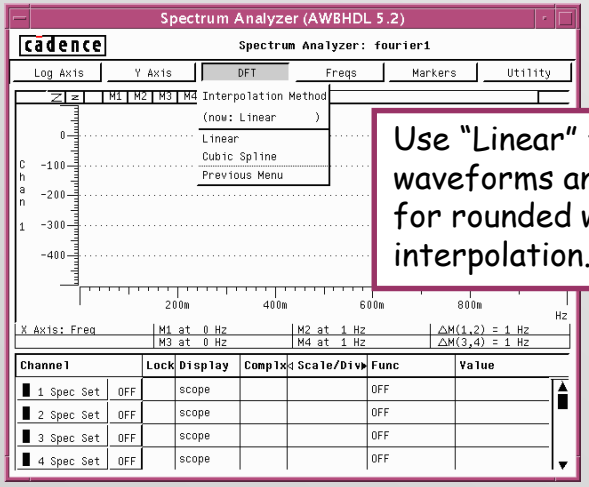

Click here to do a DFT.



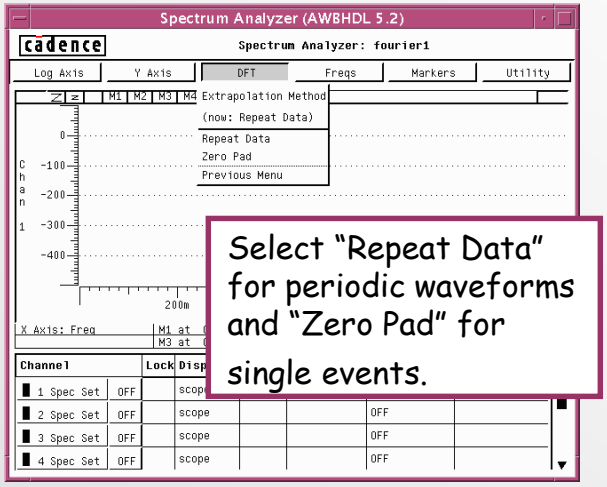

The DFT requires evenly spaced samples. Data points must be interpolated in some cases.



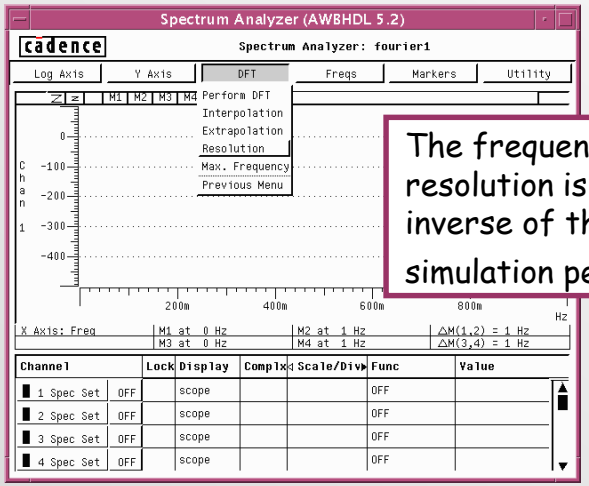

The Spectrum Analyzer allows you to increase the frequency resolution without increasing time via two types of extrapolation.



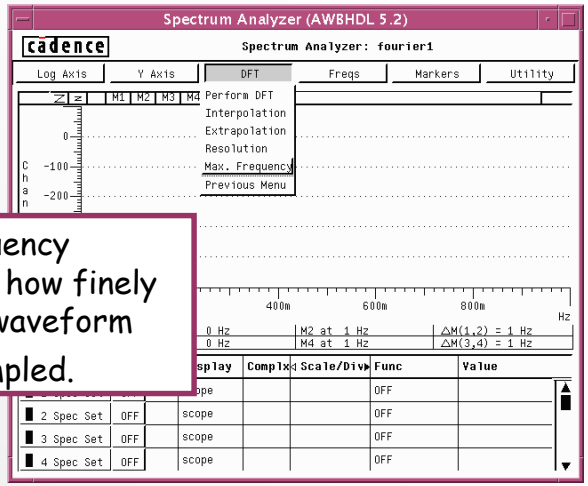

Use "Linear" for jagged waveforms and "Cubic Spline" for rounded waveforms for interpolation.



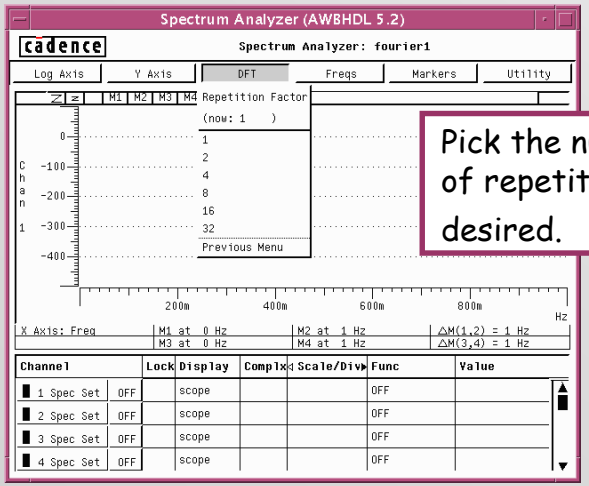

Select "Repeat Data" for periodic waveforms and "Zero Pad" for single events.



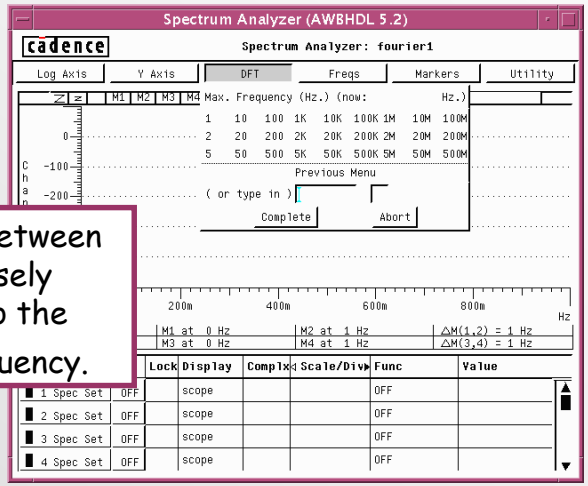

The frequency resolution is the inverse of the simulation period.



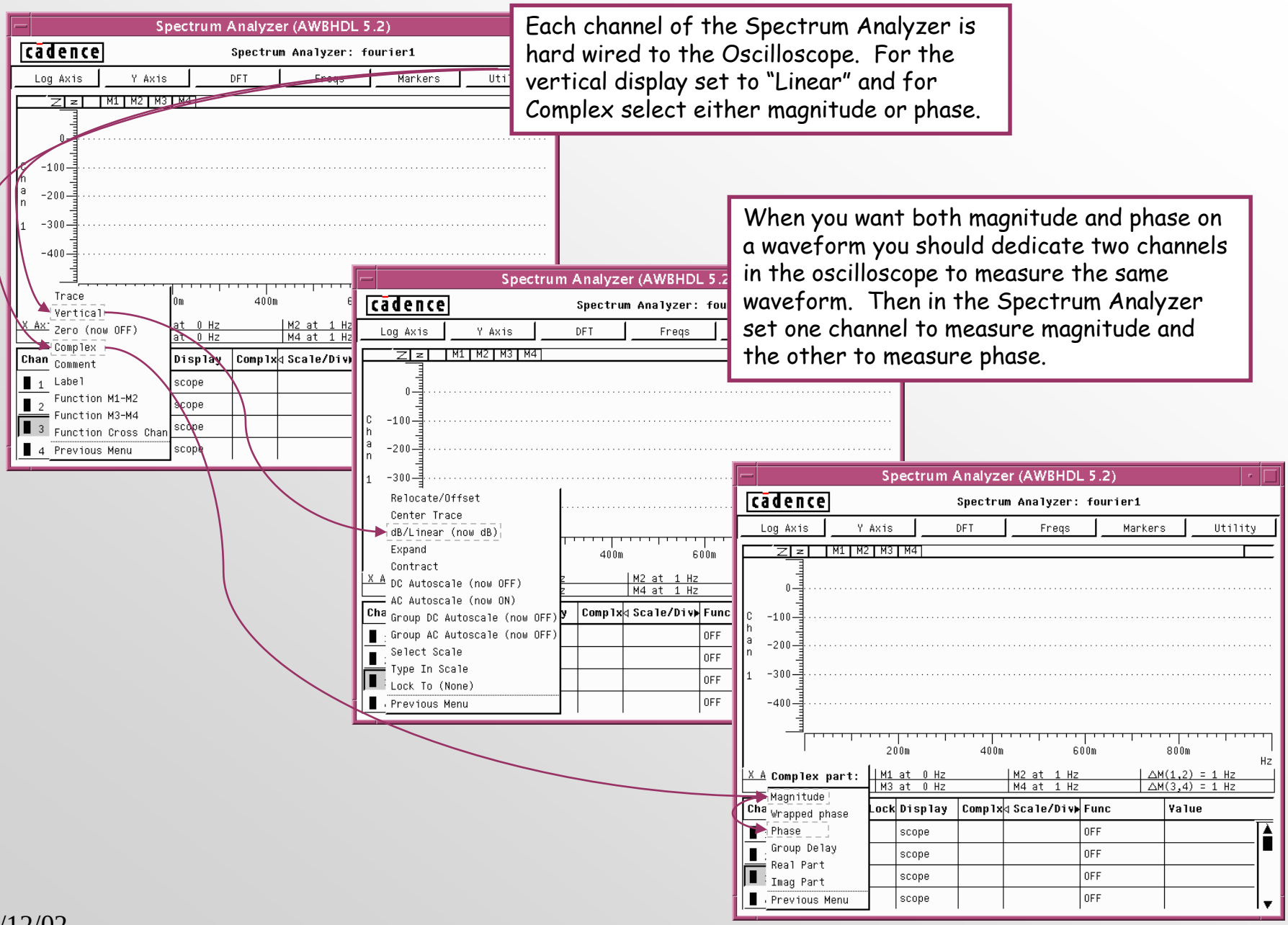

Max Frequency determine how finely the input waveform will be sampled.




Pick the number of repetitions desired.

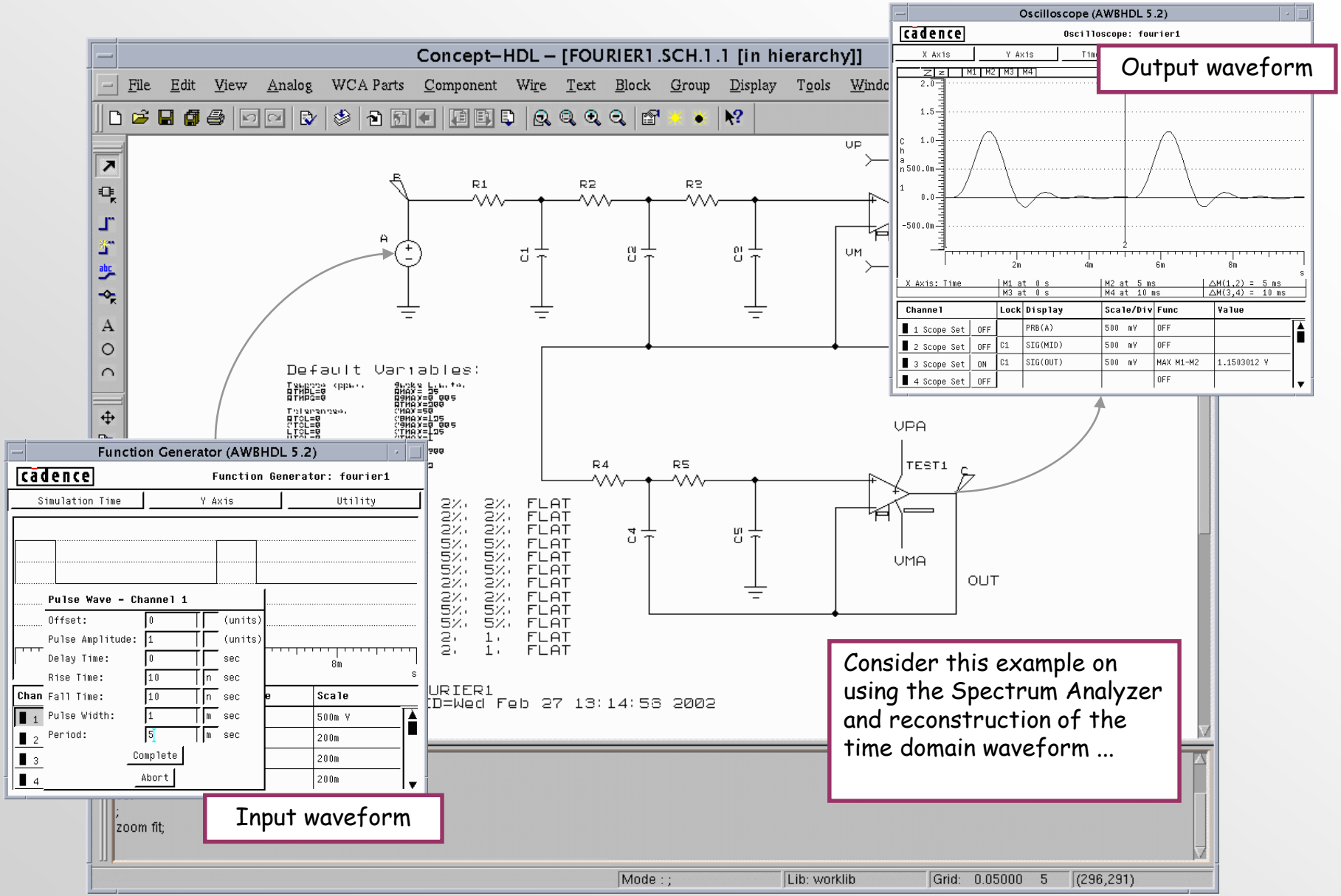


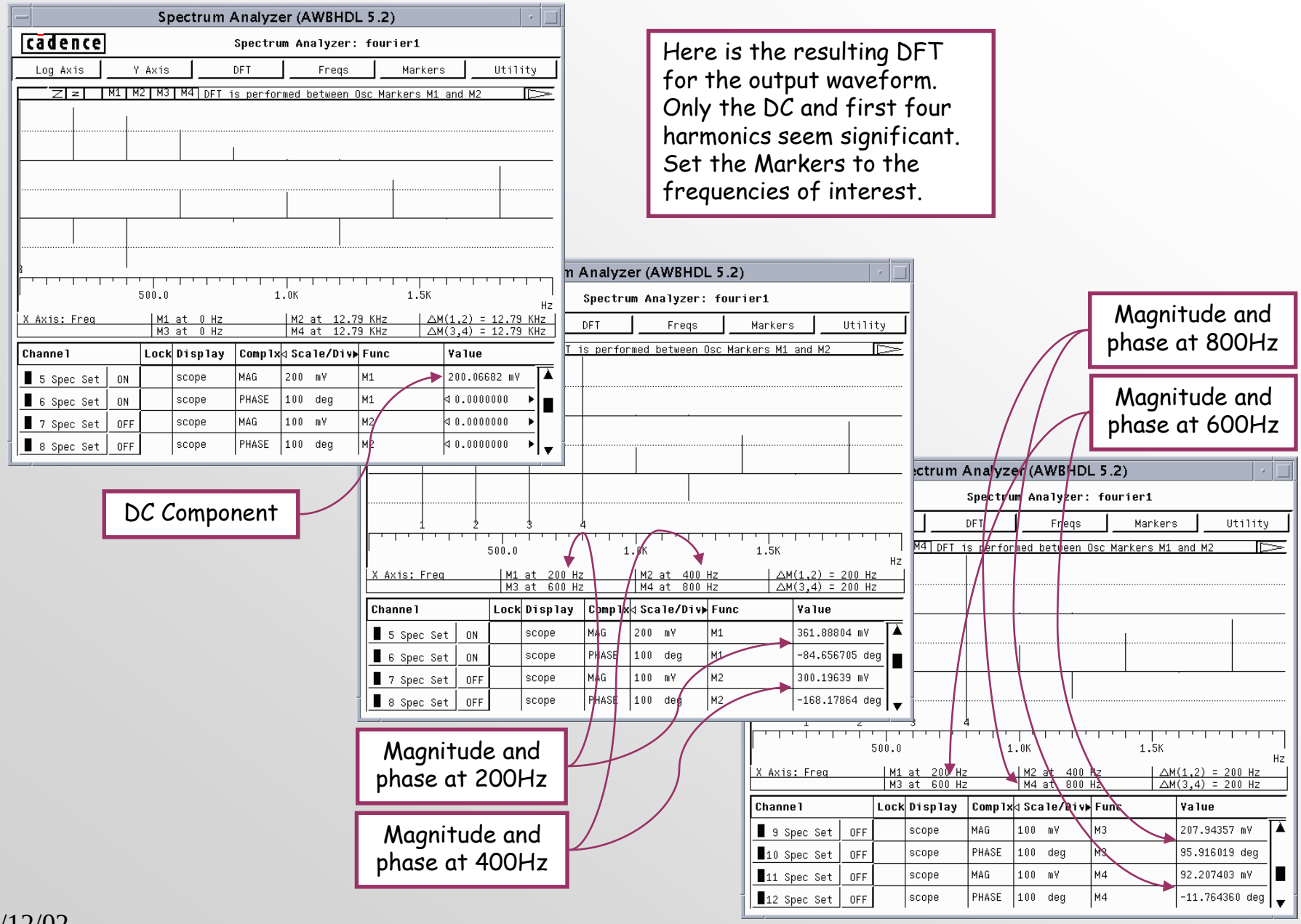

The interval between points is inversely proportional to the maximum frequency.



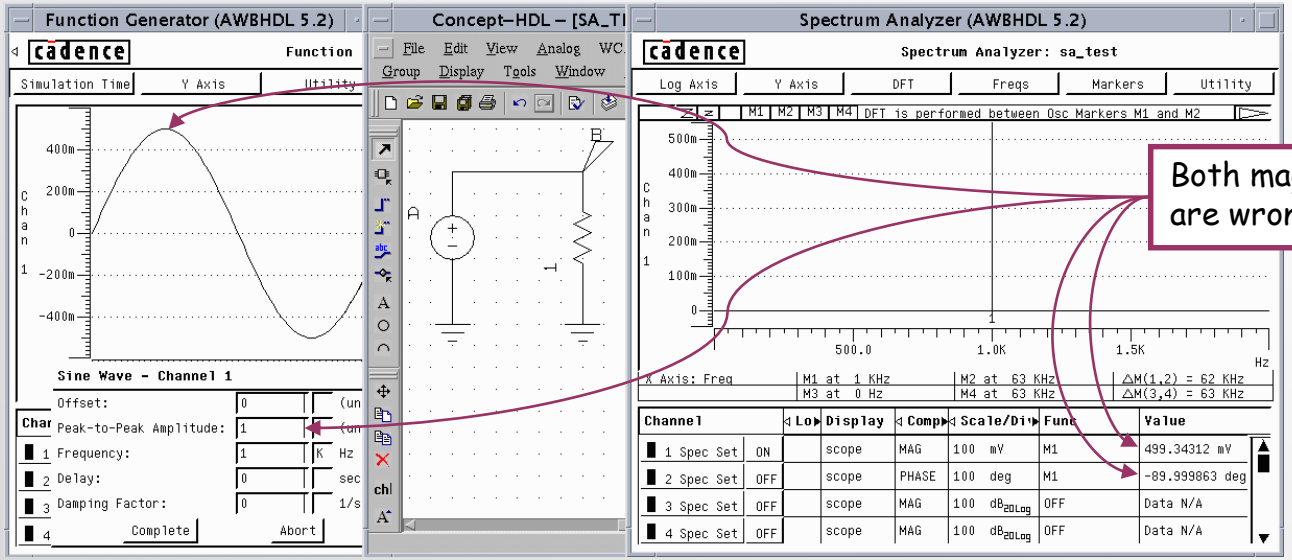

Each channel of the Spectrum Analyzer is hard wired to the Oscilloscope. For the vertical display set to "Linear" and for Complex select either magnitude or phase.

When you want both magnitude and phase on a waveform you should dedicate two channels in the oscilloscope to measure the same waveform. Then in the Spectrum Analyzer set one channel to measure magnitude and the other to measure phase.


Concept–HDL – [FOURIER1.SCH.1.1 [in hierarchy]]
File Edit View Analog WCA Parts Component Wire Text Block Group Display Tools
Default Variables:
R1
R2
R2
C1
C2
C2
UP
UM
R4
R5
C4
C5
UPA
TEST1
UMA
OUT
zoom fit;
Mode : ;
Lib: worklib
Grid: 0.05000 5
(296,291)
Oscilloscope (AWBHDL 5.2)
cadence
Oscilloscope: fourier1
X Axis
Y Axis
X Axis: Time
M1 at 0 s
M2 at 5 ms
M3 at 0 s
M4 at 10 ms
ΔM(1,2) = 5 ms
ΔM(3,4) = 10 ms
Channel
Lock
Display
Scale/Div
Func
Value
1 Scope Set OFF
PRB(A) 500 mV OFF
2 Scope Set OFF C1 SIG(MID) 500 mV OFF
3 Scope Set ON C1 SIG(OUT) 500 mV MAX M1-M2 1.1503012 V
4 Scope Set OFF OFF
Function Generator (AWBHDL 5.2)
cadence
Function Generator: fourier1
Simulation Time
Y Axis
Utility
Pulse Wave - Channel 1
Offset: 0 (units)
Pulse Amplitude: 1 (units)
Delay Time: 0 sec
Rise Time: 10 n sec
Fall Time: 10 n sec
Pulse Width: 1 m sec
Period: 5 m sec
Complete
Abort
Output waveform
Input waveform
Consider this example on using the Spectrum Analyzer and reconstruction of the time domain waveform …


Spectrum Analyzer (AWBHDL 5.2)
cadence
Spectrum Analyzer: fourier1
Log Axis
Y Axis
DFT
Freqs
Markers
Utility
M1
M2
M3
M4
DFT is performed between Osc Markers M1 and M2
500.0
1.0K
1.5K
Hz
X Axis: Freq
M1 at 0 Hz
M3 at 0 Hz
M2 at 12.79 KHz
M4 at 12.79 KHz
ΔM(1,2) = 12.79 KHz
ΔM(3,4) = 12.79 KHz
Channel
Lock
Display
Complx
Scale/Div
Func
Value
5 Spec Set ON scope MAG 200 mV M1 200.06682 mV
6 Spec Set ON scope PHASE 100 deg M1 0.0000000
7 Spec Set OFF scope MAG 100 mV M2 0.0000000
8 Spec Set OFF scope PHASE 100 deg M2 0.0000000
Here is the resulting DFT for the output waveform. Only the DC and first four harmonics seem significant. Set the Markers to the frequencies of interest.
DC Component
Spectrum Analyzer: fourier1
X Axis: Freq
M1 at 200 Hz
M3 at 600 Hz
M2 at 400 Hz
M4 at 800 Hz
ΔM(1,2) = 200 Hz
ΔM(3,4) = 200 Hz
5 Spec Set ON scope MAG 200 mV M1 361.88804 mV
6 Spec Set ON scope PHASE 100 deg M1 -84.656705 deg
7 Spec Set OFF scope MAG 100 mV M2 300.19639 mV
8 Spec Set OFF scope PHASE 100 deg M2 -168.17864 deg
Magnitude and phase at 200Hz
Magnitude and phase at 400Hz
Magnitude and phase at 800Hz
Magnitude and phase at 600Hz
9 Spec Set OFF scope MAG 100 mV M3 207.94357 mV
10 Spec Set OFF scope PHASE 100 deg M3 95.916019 deg
11 Spec Set OFF scope MAG 100 mV M4 92.207403 mV
12 Spec Set OFF scope PHASE 100 deg M4 -11.764360 deg

However, a problem exists in the DFT results ...




Both magnitude and phase are wrong...

Hi Andy,

Derek assigned SR 31903762 to me. This one discusses the DFT in relation to the time delay on the V_SINUSOIDAL parts. First, your conclusion is correct that the phase is -ve of what you expect. In fact, the transient waveform for the impulse generator is "flipped". The reason for this lies in the equation that Spice Plus (and also PSpice) uses for the SIN independent source:

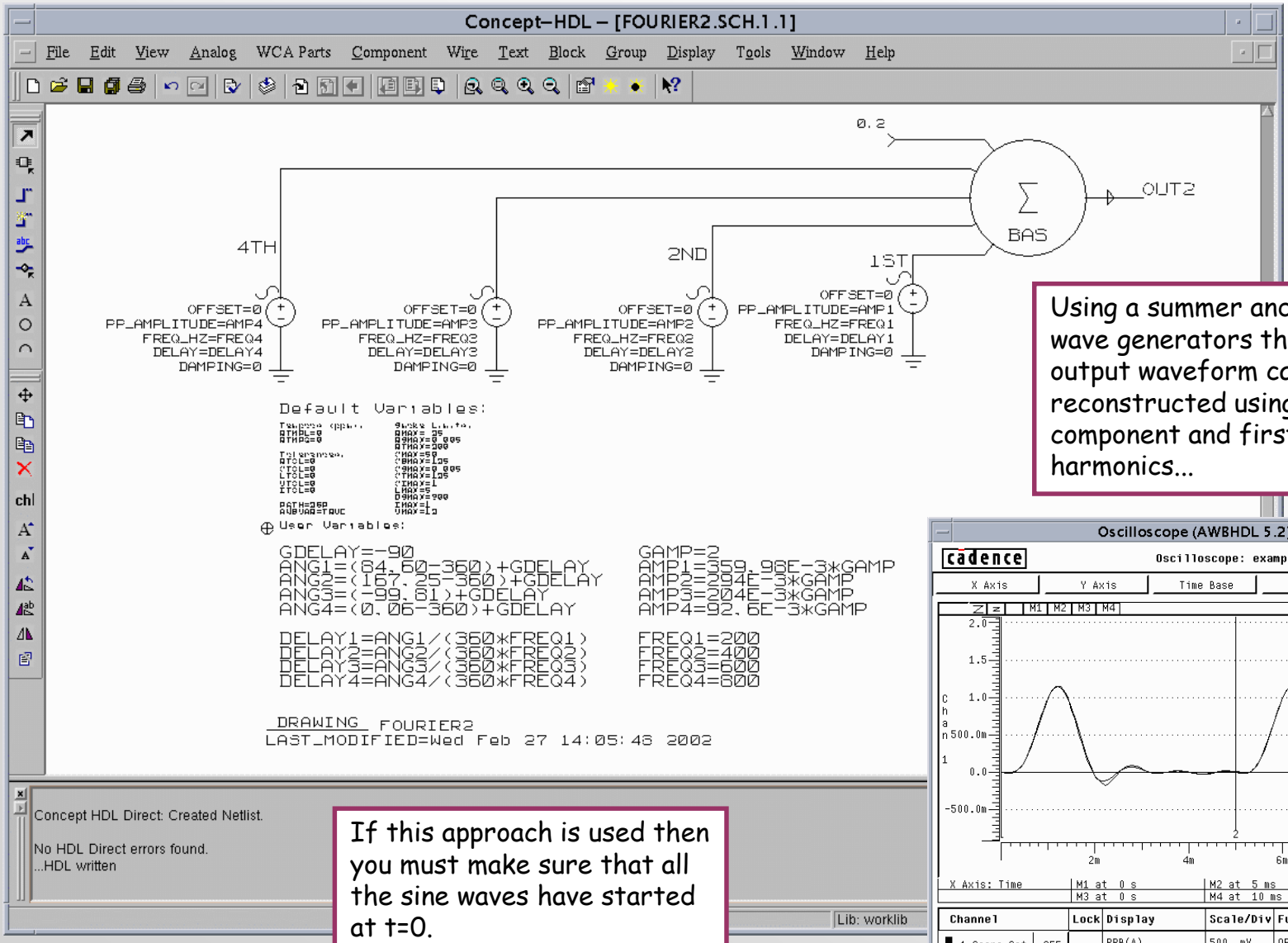
V = Voff + Vamp*sin(2*PI*(freq*(TIME-td)+phase/360))

This equation has both a "phase" and a "td" (time-delay) input. The V_SINUSOIDAL part in AWB, however, only includes a time delay parameter ("td"). When using "td", it is necessary to define it in terms of phase as :

td = -phase/(360*frequency)

This is the -ve of the definition that I found in the testcase that was sent.

Brian




Using a summer and sine wave generators the filtered output waveform can be reconstructed using the DC component and first four harmonics...




If this approach is used then you must make sure that all the sine waves have started at t=0.

Concept–HDL – [FOURIER3.SCH.1.1 [in hierarchy]]

File Edit View Analog WCA Parts Component Wire Text Block Group Display Tools Window Help

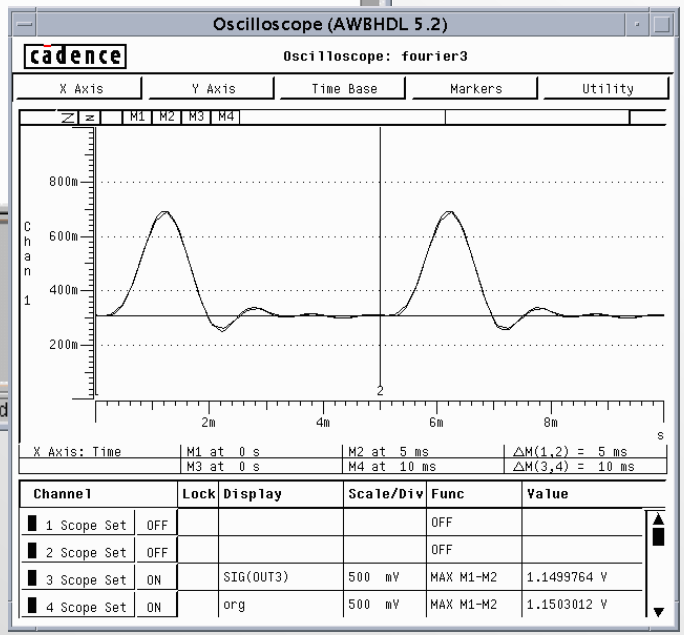
```
DRAWING FOURIER3
LAST_MODIFIED=Fri Mar  3 03:59:11 2002

User Variables:

AMP0=200E-3      WAMP0=AMP0
AMP1=361.9E-3    WAMP1=AMP1
AMP2=300.2E-3    WAMP2=AMP2
AMP3=207.9E-3    WAMP3=AMP3
AMP4=92.2E-3     WAMP4=AMP4

ANG1=-84.65      WANG1=(90+ANG1)*(PI/180)  SHIFT 90 DEGREES
ANG2=-168.18     WANG2=(90+ANG2)*(PI/180)  CONVERT TO RADIANS
ANG3=95.92       WANG3=(90+ANG3)*(PI/180)
ANG4=-11.76      WANG4=(90+ANG4)*(PI/180)

FREQ1=200        WRAD1=2*PI*FREQ1
FREQ2=400        WRAD2=2*PI*FREQ2  CONVERT TO RADS/SECOND
FREQ3=600        WRAD3=2*PI*FREQ3
FREQ4=800        WRAD4=2*PI*FREQ4

OUT3
F(x)  1E3

VOUT=VAR(WAMP0)+VAR(WAMP1)*(SIN(VAR(WRAD1)*TIME+VAR(WANG1)))+VAR(WAMP2)*(SIN(VAR(WR

EQUATION TO SUM THE FIRST FOUR HARMONICS AND THE
DC COMPONENT OF A FOURIER SERIES

VAR(WAMP0)+VAR(WAMP1)*(SIN(VAR(WRAD1)*TIME+VAR(WANG1)))+
            VAR(WAMP2)*(SIN(VAR(WRAD2)*TIME+VAR(WANG2)))+
            VAR(WAMP3)*(SIN(VAR(WRAD3)*TIME+VAR(WANG3)))+
            VAR(WAMP4)*(SIN(VAR(WRAD4)*TIME+VAR(WANG4)))
```

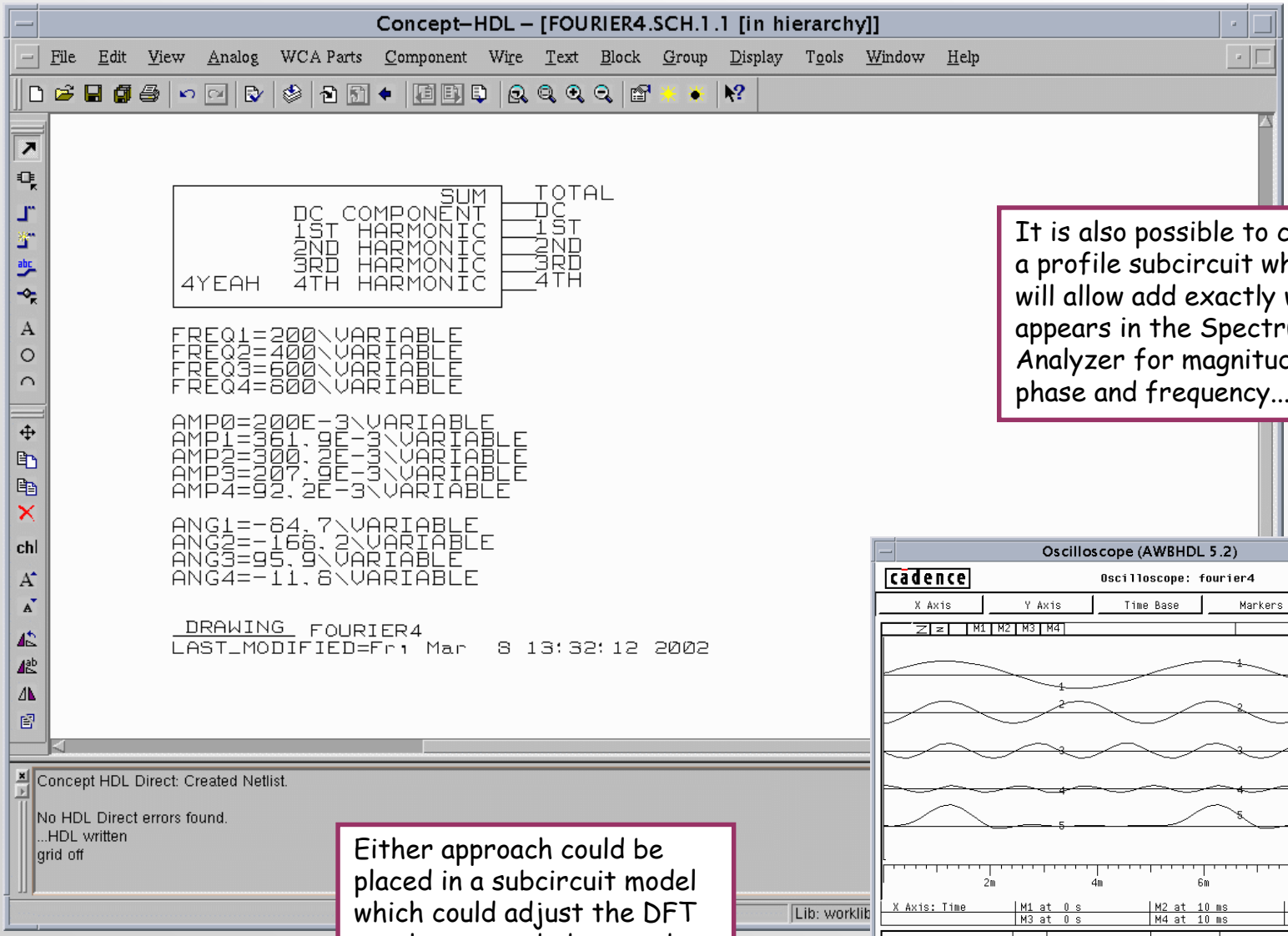
No HDL Direct errors found.
...HDL written
zoom
;
grid off

For Help, press F1 klib Grid

Or using a profile model the filtered output waveform can be reconstructed using the DC component and first four harmonics…

This approach only requires a conversions to be made to radians and radians/second.






It is also possible to create a profile subcircuit which will allow add exactly what appears in the Spectrum Analyzer for magnitude, phase and frequency…




Either approach could be placed in a subcircuit model which could adjust the DFT results as needed to produce the corrected reconstructed waveform…