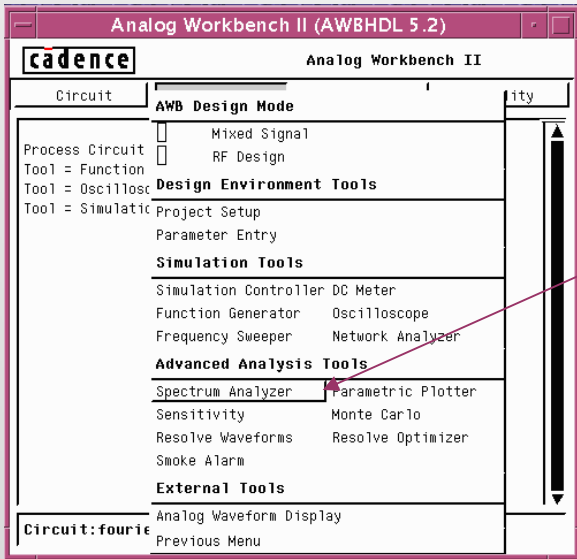


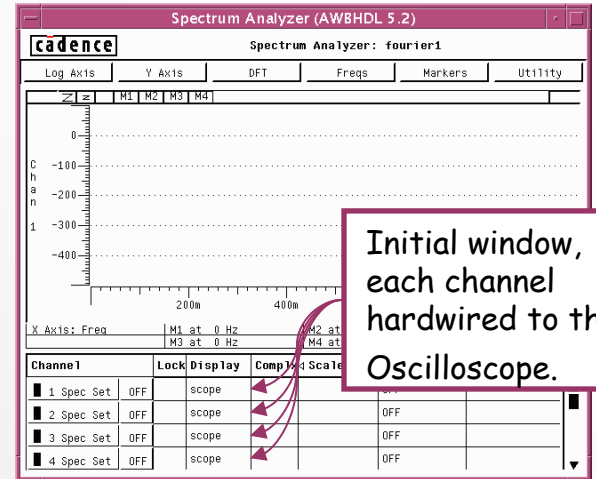
## AWB's Spectrum Analyzer and the Fourier Series waveform reconstruction...

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

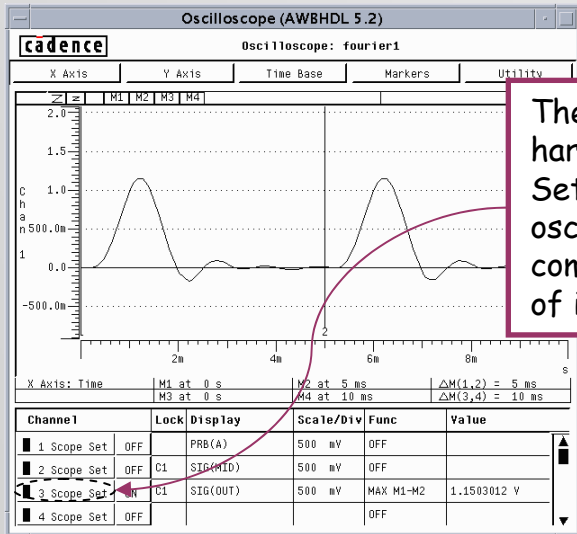
The basic idea of the Fourier series is that a periodic function with period  $\omega_0 = \frac{2\pi}{T_0}$  could be described by a weighted sum of cosine and sine functions.



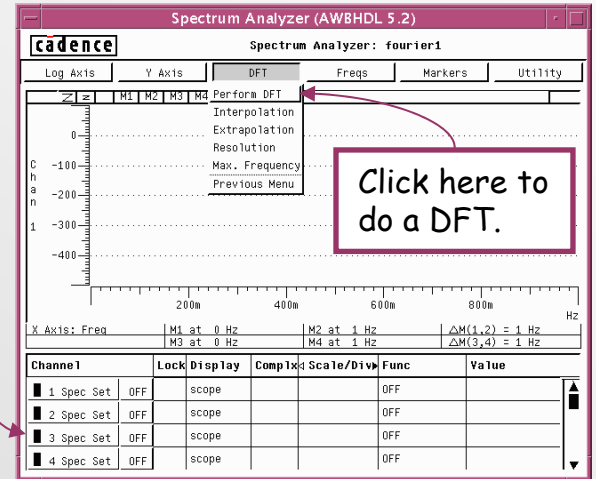
The Spectrum Analyzer is an advance analysis tool in AWB.



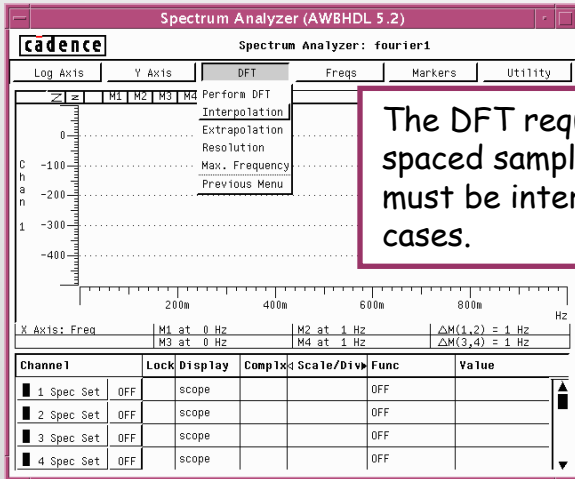
Initial window, each channel hardwired to the Oscilloscope.



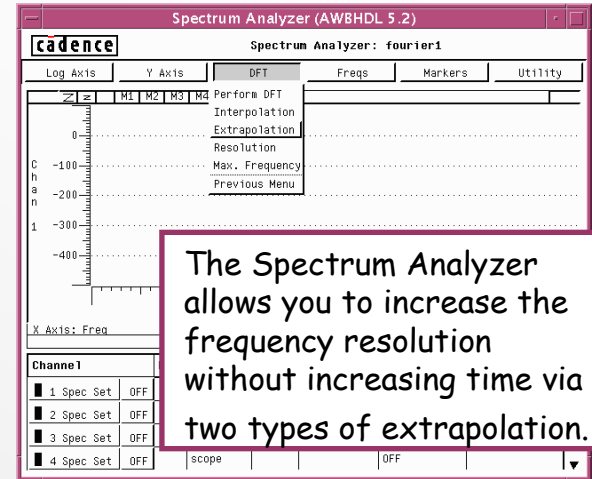
The Spectrum Analyzer is hardwired to the Oscilloscope. Set the markers in the oscilloscope to bound one complete cycle of the waveform of interest.



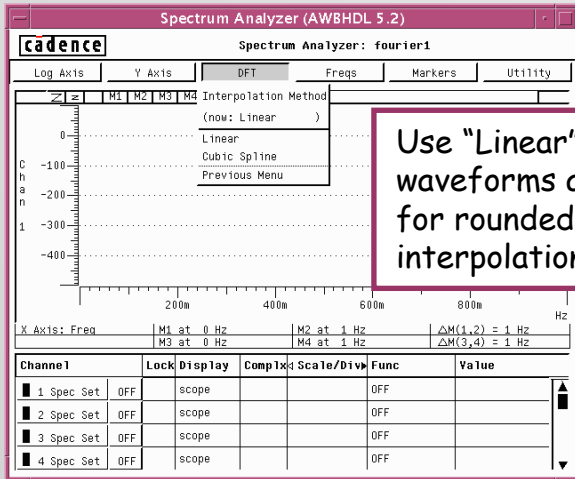
Click here to do a DFT.



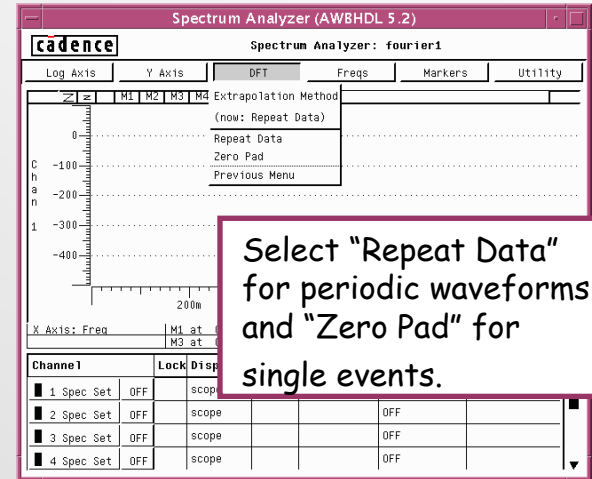
The DFT requires evenly spaced samples. Data points must be interpolated in some cases.



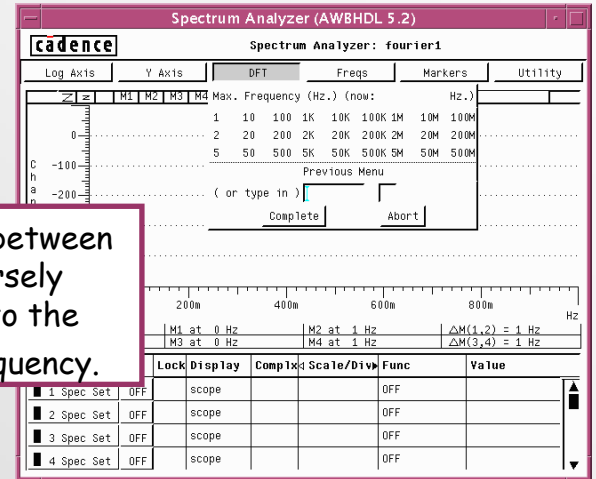
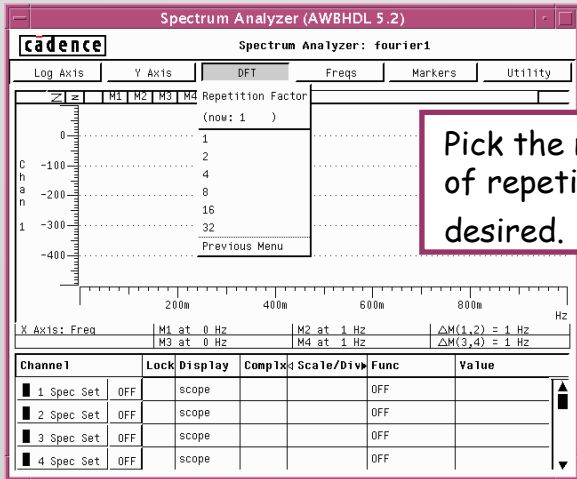
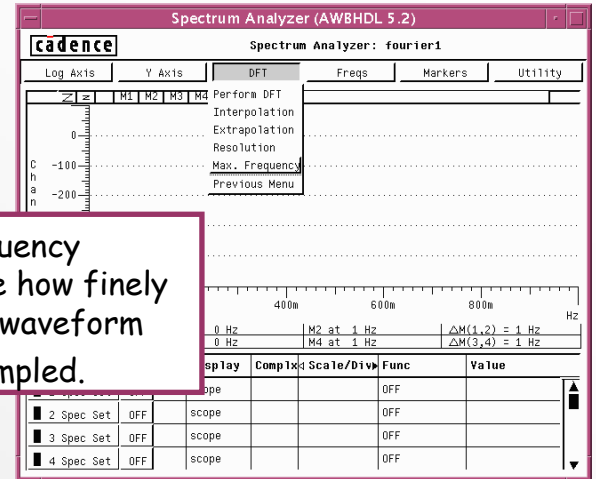
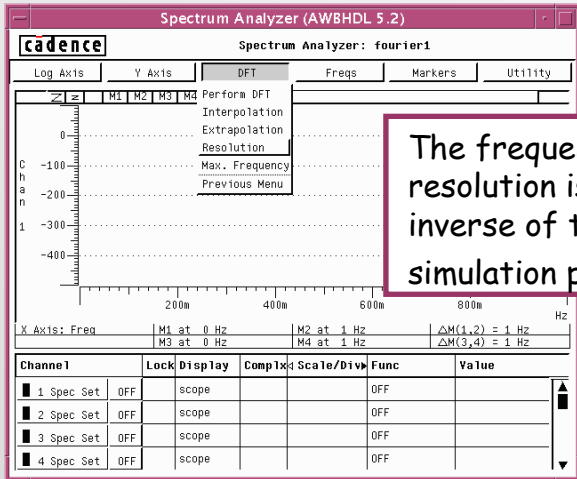
The Spectrum Analyzer allows you to increase the frequency resolution without increasing time via two types of extrapolation.

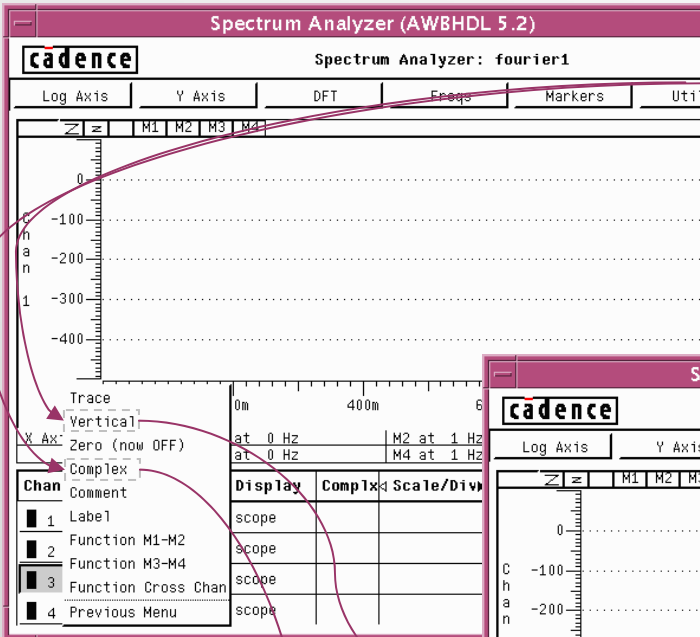


Use "Linear" for jagged waveforms and "Cubic Spline" for rounded waveforms for interpolation.



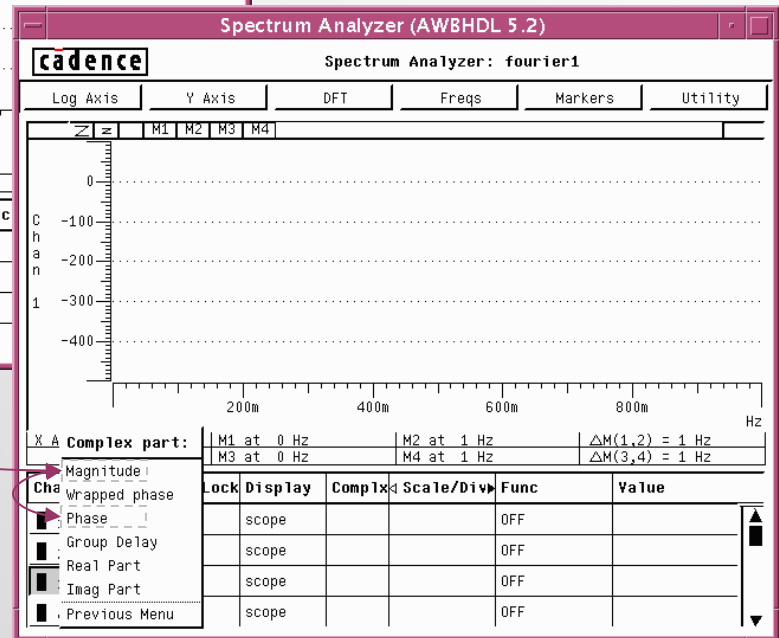
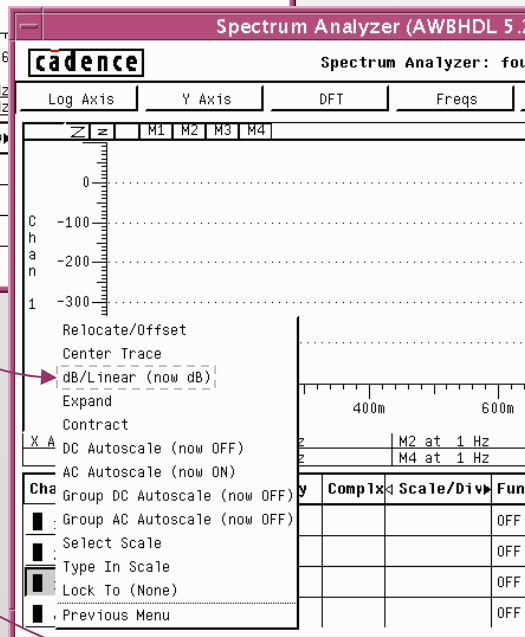
Select "Repeat Data" for periodic waveforms and "Zero Pad" for single events.





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 Window

Default Variables:

```

Tolerance: 0.1%
A: 1.0
B: 1.0
C: 1.0
D: 1.0
E: 1.0
F: 1.0
G: 1.0
H: 1.0
I: 1.0
J: 1.0
K: 1.0
L: 1.0
M: 1.0
N: 1.0
O: 1.0
P: 1.0
Q: 1.0
R: 1.0
S: 1.0
T: 1.0
U: 1.0
V: 1.0
W: 1.0
X: 1.0
Y: 1.0
Z: 1.0

```

**Function Generator (AWBHDL 5.2)**

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

Chan 1 Scale 500m V

Chan 2 Scale 200m

Chan 3 Scale 200m

Chan 4 Scale 200m

Complete Abort

**Oscilloscope (AWBHDL 5.2)**

cadence Oscilloscope: fourier1

X Axis: Time Y Axis: Voltage

Output waveform

Channel 1: PRB(A) 500 mV OFF

Channel 2: C1 SIG(MID) 500 mV OFF

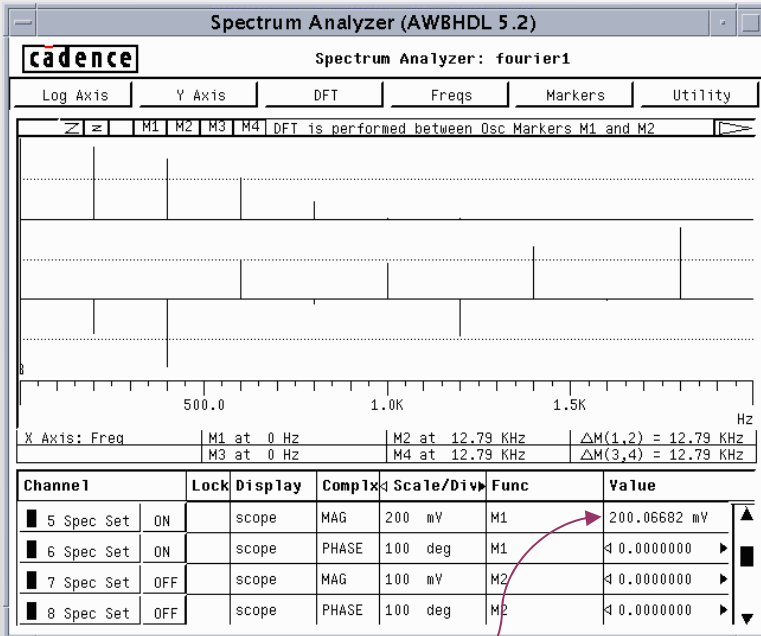
Channel 3: C1 SIG(OUT) 500 mV MAX M1-M2

Channel 4: OFF

Value: 1.1503012 V

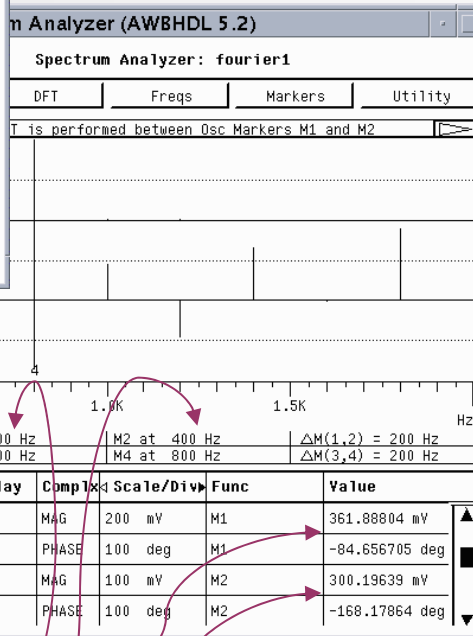
Consider this example on using the Spectrum Analyzer and reconstruction of the time domain waveform ...

Mode: ; Lib: worklib Grid: 0.05000 5 (296,291)



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

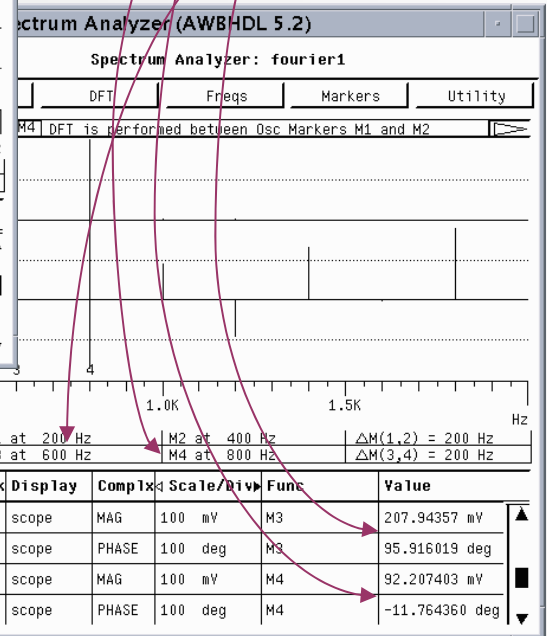


Magnitude and phase at 200Hz

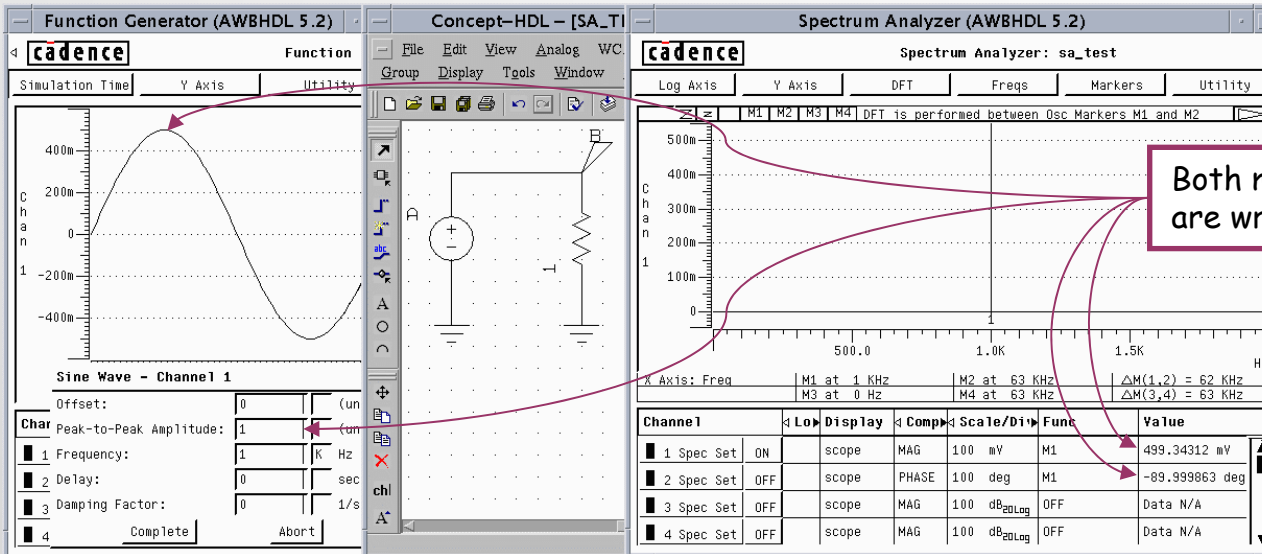
Magnitude and phase at 400Hz

Magnitude and phase at 800Hz

Magnitude and phase at 600Hz



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:

$$V = V_{off} + V_{amp} \sin(2\pi \cdot \text{freq} \cdot (\text{TIME} - t_d) + \text{phase}/360)$$

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 :

$$t_d = -\text{phase}/(360 \cdot \text{frequency})$$

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

Brian





DRAWING\_FOURIER3

LAST\_MODIFIED=Fri Mar 3 03:59:11 2002

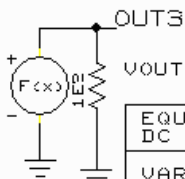
User Variables:

```

AMP0=200E-3      WAMP0=AMP0
AMP1=361.70FF-3  WAMP1=AMP1
AMP2=1000.00FF-3 WAMP2=AMP2
AMP3=1000.00FF-3 WAMP3=AMP3
AMP4=92.2E-3     WAMP4=AMP4

ANG1=-84.65      WANG1=(90+ANG1)*(PI/180) } SHIFT 90 DEGREES
ANG2=-163.18     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 } CONVERT TO RADS/SECOND
FREQ2=400        WRAD2=2*PI*FREQ2
FREQ3=600        WRAD3=2*PI*FREQ3
FREQ4=800        WRAD4=2*PI*FREQ4
    
```



$$V_{OUT} = \text{VAR} \langle \text{WAMP0} \rangle + \text{VAR} \langle \text{WAMP1} \rangle * \langle \text{SIN} \langle \text{VAR} \langle \text{WRAD1} \rangle * \text{TIME} + \text{VAR} \langle \text{WANG1} \rangle \rangle \rangle + \text{VAR} \langle \text{WAMP2} \rangle * \langle \text{SIN} \langle \text{VAR} \langle \text{WRAD2} \rangle * \text{TIME} + \text{VAR} \langle \text{WANG2} \rangle \rangle \rangle + \text{VAR} \langle \text{WAMP3} \rangle * \langle \text{SIN} \langle \text{VAR} \langle \text{WRAD3} \rangle * \text{TIME} + \text{VAR} \langle \text{WANG3} \rangle \rangle \rangle + \text{VAR} \langle \text{WAMP4} \rangle * \langle \text{SIN} \langle \text{VAR} \langle \text{WRAD4} \rangle * \text{TIME} + \text{VAR} \langle \text{WANG4} \rangle \rangle \rangle$$

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

```

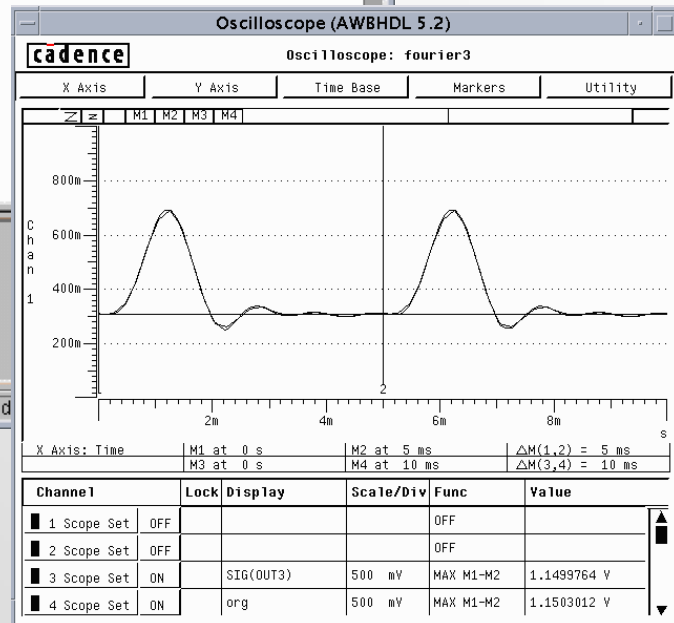
VAR<WAMP0>+VAR<WAMP1>*<SIN<VAR<WRAD1>*TIME+VAR<WANG1>>>+
VAR<WAMP2>*<SIN<VAR<WRAD2>*TIME+VAR<WANG2>>>+
VAR<WAMP3>*<SIN<VAR<WRAD3>*TIME+VAR<WANG3>>>+
VAR<WAMP4>*<SIN<VAR<WRAD4>*TIME+VAR<WANG4>>>
    
```

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

No HDL Direct errors found.

...HDL written  
zoom  
grid off

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



Concept-HDL - [FOURIER4.SCH.1.1 [in hierarchy]]

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

```

SUM
DC COMPONENT --- TOTAL
1ST HARMONIC --- DC
2ND HARMONIC --- 1ST
3RD HARMONIC --- 2ND
4TH HARMONIC --- 3RD
4YEAH

```

```

FREQ0=200\VARIABLE
FREQ1=400\VARIABLE
FREQ2=600\VARIABLE
FREQ3=800\VARIABLE

AMP0=200E-3\VARIABLE
AMP1=361.00E-3\VARIABLE
AMP2=3000.00E-3\VARIABLE
AMP3=207.00E-3\VARIABLE
AMP4=92.2E-3\VARIABLE

ANG1=-64.7\VARIABLE
ANG2=-166.2\VARIABLE
ANG3=95.9\VARIABLE
ANG4=-11.8\VARIABLE

```

DRAWING FOURIER4  
LAST\_MODIFIED=Fri Mar 8 13:32:12 2002

Concept HDL Direct: Created Netlist.  
No HDL Direct errors found.  
...HDL written  
grid off

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...

