*=========FFT_LEAKAGE================

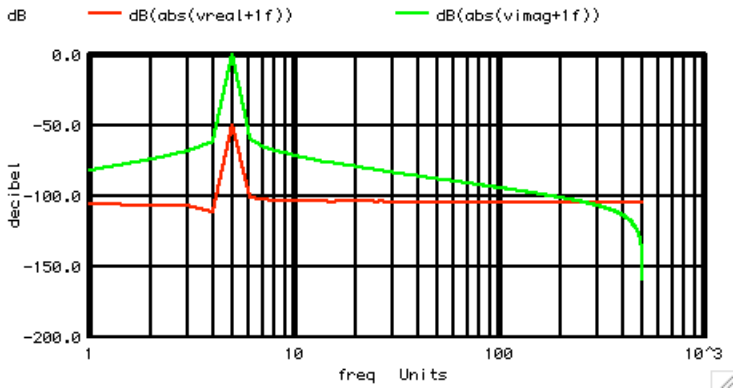
Does spectrum leakage always look like AM and PM of the fundamental? Frequency is now begin defined with a DC voltage source.

```
FFT_Leakage_tests
*=========Create_Signal=================
VTime      VTime  0      DC     0      PWL(   0      0    1      1)
Vfreq      Vfreq  0      DC     5.001k
BVAC       IN     0      V  =   sin( 6.283185307179586*V(Vfreq)*V(VTime))
.control
*TRAN      TSTEP  TSTOP  TSTART TMAX   ?UIC?
tran       1u     .999m  0       1u
set        pensize = 2
linearize
let        numb2 = length(in)
print      numb2
```

*=========FFT_and_Translate_into_dB_freq====================

This example uses only 1000 points.

```
let        ac       = in +j(0)
let        ac_fft   = fft(ac)
let        numb_f2  = (numb2)/2 -1
compose    freq     start = 1 stop = $&numb_f2  step =1
compose    vreal    start = 1 stop = $&numb_f2  step =1
compose    vimag    start = 1 stop = $&numb_f2  step =1
let        i        = 0
repeat     $&numb_f2
let        freq[i]  = freq[i]
let        vreal[i] = 2*real(ac_fft[i+1])
let        vimag[i] = 2*imag(ac_fft[i+1])
let        i        = i +1
end
plot       dB(abs(vreal+1f)) dB(abs(vimag+1f)) vs freq xlog
```

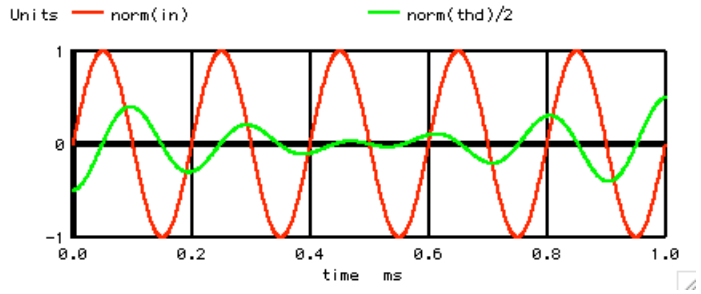


*=========View_The_THD====================

Now subtract a constant 5KHz term to view the distortion using the norm function.

```
let        funBin                 = 5k/1000
let        unvect                 = unitvec($&numb2)
let        fundspec               = unvect*0 +j(0)
let        fundspec[funBin]       = real(ac_fft[funBin])        +j(imag(ac_fft[funBin] ))
let        fundspec[numb2-funBin] = real(ac_fft[numb2-funBin])  +j(imag(ac_fft[numb2-funBin] ))
let        fund                   = ifft(fundspec)
let        dc_ofset               = real(ac_fft[0])
let        thdspec                = ac_fft
let        thdspec[0]             = 0        +j(0)
let        thdspec[funBin]        = 0        +j(0)
let        thdspec[numb2-funBin]  = 0        +j(0)
let        thd                    = ifft(thdspec)
```

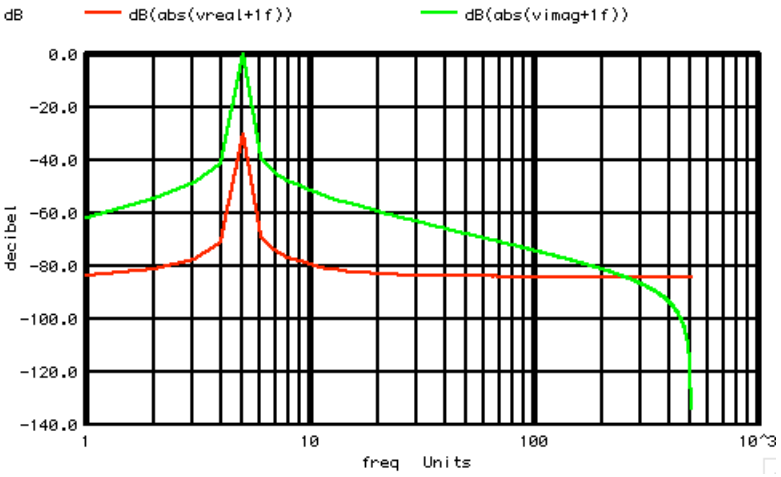
```
plot      norm(in) norm(thd)/2
```

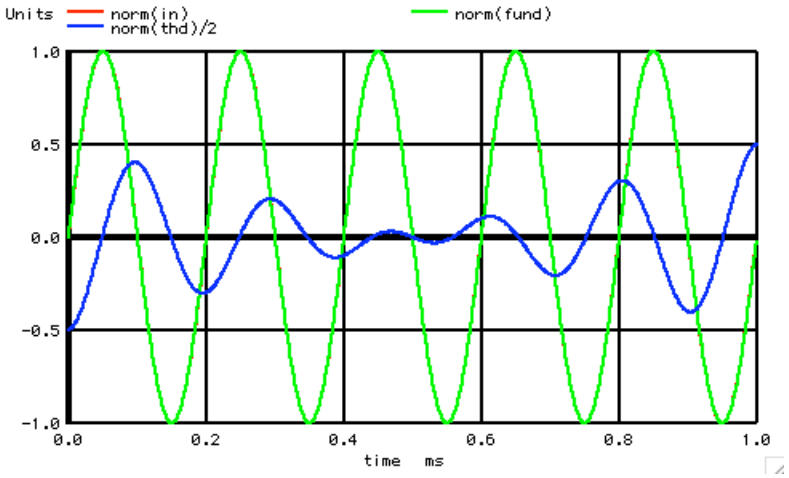



```
*=========And_the_values_can_be_calculated.====================
```

The resulting table shows the frequency as well as THD.

```
=================================================================
let       rms_Fund                = sqrt(mean(fund*fund))
let       rms_THD                 = sqrt(mean(thd*thd))
let       THD_percent             = 100*rms_THD/rms_Fund
let       FREQ_Hz                 = VFreq[0]
echo      "Freq_Hz=$&FREQ_Hz THD_percent=$&THD_percent Fund_rms=$&rms_Fund THD_rms=$&rms_THD"
=================================================================

Freq_Hz=5001 THD_percent=0.18168 Fund_rms=0.7073 THD_rms=0.00128

*=========Add_another_Order_of_Magnitude====================

Vfreq     Vfreq  0      DC     5.01k

=================================================================
```





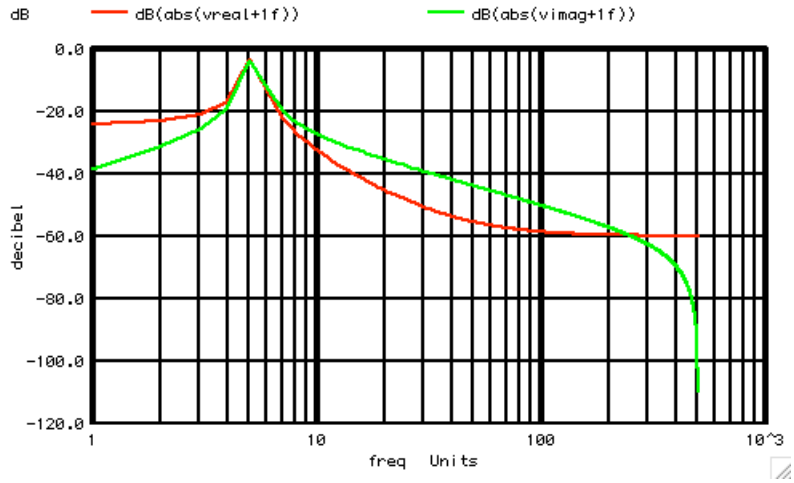
Freq_Hz=5010 THD_percent=1.82034 Fund_rms=0.706626 THD_rms=0.012863

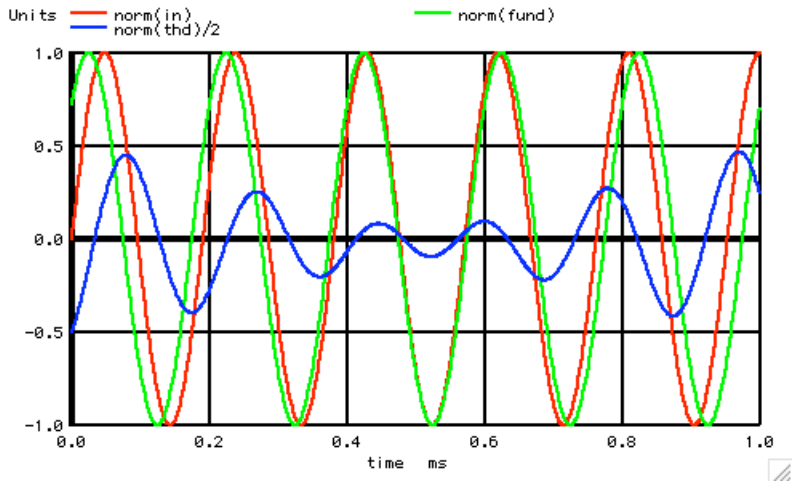
The THD still looks like it is being amplitude and phase modulated in the same way. Only the magnitude appears to be increasing.

***=========Now_Go_to_5.25KHz====================**

Vfreq Vfreq 0 DC 5.25k

==========





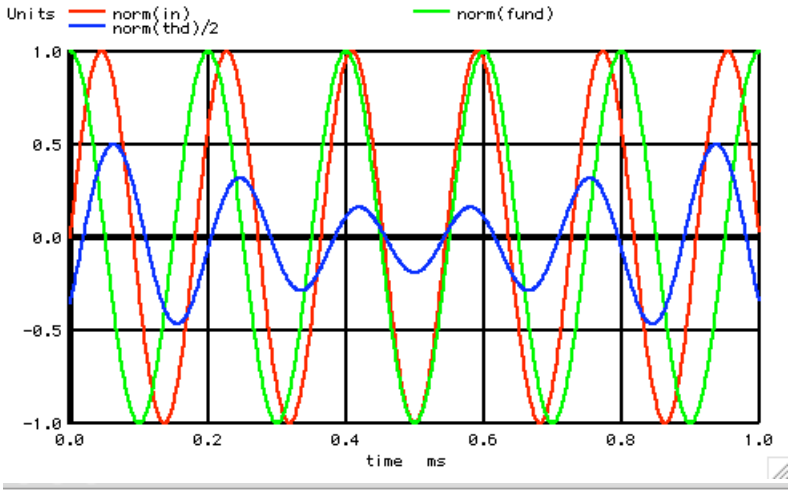
Freq_Hz=5250 THD_percent=48.1168 Fund_rms=0.636635 THD_rms=0.306328

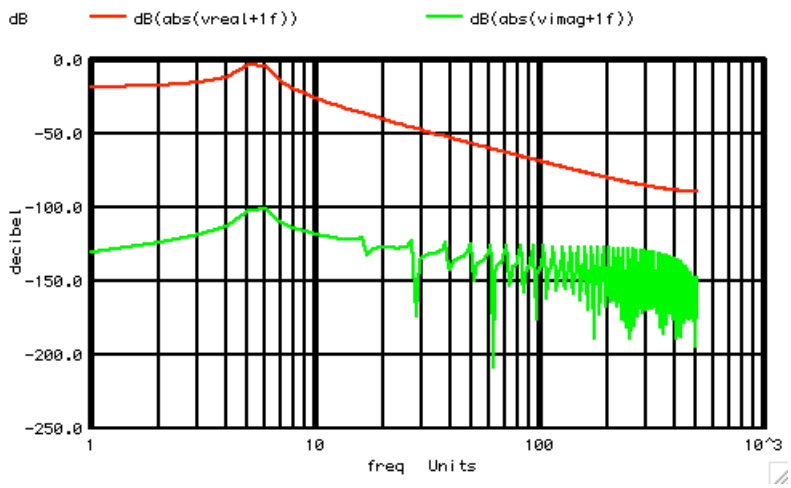
The start and stop phase of the THD appears to be moving slightly at this level of frequency offset.

*=========Now_Go_to_5.5KHz====================

Vfreq Vfreq 0 DC 5.25k

==========





Freq_Hz=5500 THD_percent=111.05 Fund_rms=0.471861 THD_rms=0.524001

There is discontinuity in the start and stop phase of the THD signal. One would expect that to be the thing creating the spread out of the spectrum. The windowing functions all attenuate these endpoints where the discontinuities are taking place.

==========Full_Netlist_For_Copy_Paste==========

```
FFT_Leakage_tests
*=========Create_Signal==================
VTime     VTime  0      DC     0      PWL(   0      0    1      1)
Vfreq     Vfreq  0      DC     5.05k
BVAC      IN     0      V  =   sin( 6.283185307179586*V(VFreq)*V(VTime))
.control
*TRAN     TSTEP  TSTOP  TSTART TMAX   ?UIC?
tran      1u     .999m  0       1u
set       pensize = 2
linearize
```

```
let       numb2 = length(in)
print     numb2

*=========Do_FFT_and_Plot_As_dB_Freq==================
let       ac = in +j(0)
let       ac_fft=fft(ac)
let       numb_f2 =  (numb2)/2 -1
compose   freq   start = 1 stop = $&numb_f2  step =1
compose   vreal  start = 1 stop = $&numb_f2  step =1
compose   vimag  start = 1 stop = $&numb_f2  step =1
let       i = 0
repeat    $&numb_f2
let       freq[i] =  freq[i]
let       vreal[i] = 2*real(ac_fft[i+1])
let       vimag[i] = 2*imag(ac_fft[i+1])
let       i = i +1
end
plot      dB(abs(vreal+1f)) dB(abs(vimag+1f)) vs freq xlog

*=========Extract_Error_Signal=========================
let       funBin                 = 5k/1000
let       unvect                 = unitvec($&numb2)
let       fundspec               = unvect*0 +j(0)
let       fundspec[funBin]       = real(ac_fft[funBin])        +j(imag(ac_fft[funBin] ))
let       fundspec[numb2-funBin] = real(ac_fft[numb2-funBin])  +j(imag(ac_fft[numb2-funBin] ))
let       fund                   = ifft(fundspec)
let       dc_ofset               = real(ac_fft[0])
let       thdspec                = ac_fft
let       thdspec[0]             = 0        +j(0)
let       thdspec[funBin]        = 0        +j(0)
let       thdspec[numb2-funBin]  = 0        +j(0)
let       thd                    = ifft(thdspec)
plot      norm(in) norm(thd)/2

*=========Calc_Values=========================
let       rms_Fund               = sqrt(mean(fund*fund))
let       rms_THD                = sqrt(mean(thd*thd))
let       THD_percent            = 100*rms_THD/rms_Fund
let       FREQ_Hz                = VFreq[0]
echo      "Freq_Hz=$&FREQ_Hz THD_percent=$&THD_percent Fund_rms=$&rms_Fund THD_rms=$&rms_THD "

.endc
.end
```