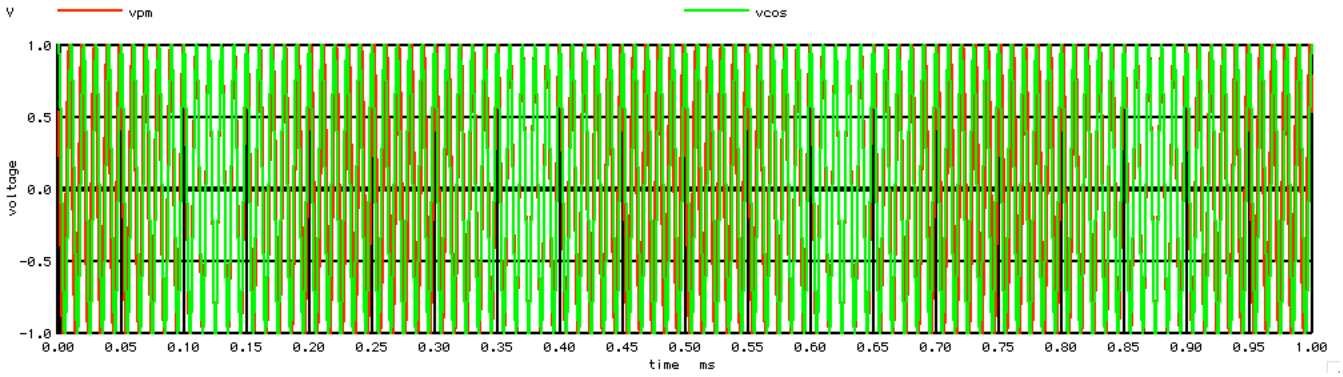
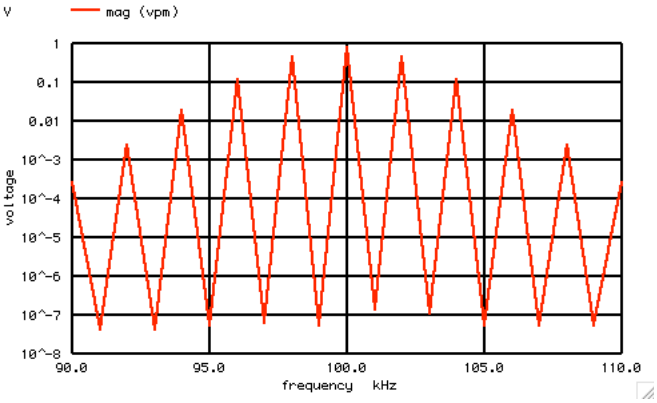
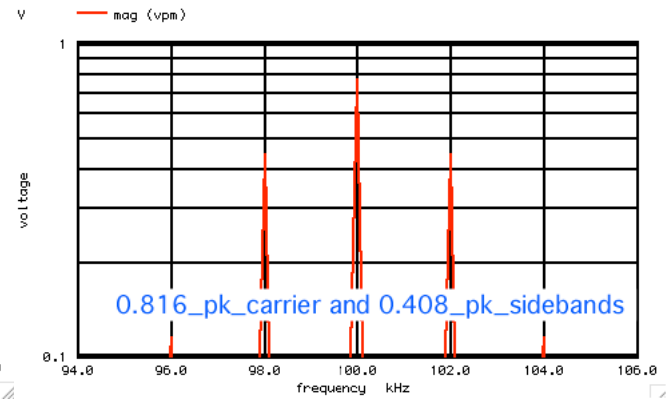
```
=====================SIMPLE_PM_WAVEFORM_GENERATION=====================================
1)   1V_pk_True_PM is nonlinear              = constant 1V_pk signal
2)   1V_pk_100%_AM for this FFT              = 1_pk_carrier and 0.5_pk_sidebands
3)   1V_pk_1_radian_PM                       = 0.816_pk_carrier and 0.408_pk_sidebands
4)   1V_pk_0.1_radian_PM                     = 1_pk_carrier and 0.05_pk_sidebands
5)   FFT_resolution_Hz                       = 1/total_time_sec
6)   Nyqust_Hz                              = 0.5/Sample_time_sec
7)   Num_Bins for FFT                        = Nyqust_Hz/FFT_resolution_Hz
```



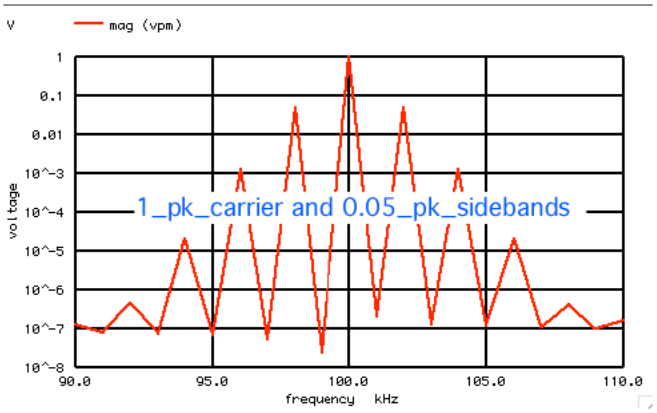
1) A true PM signal does not change the magnitude of a carrier.
   Therefore a +/- one radian signal will produce a nonlinear spectrum.
2) A +/- one radian PM spectrum tries to resemble a 100% AM spectrum with a 1_pk_carrier
   and two 0.5_pk_sidebands.
3) The PM nonlinearity produces instead a 0.816_pk_carrier and 0.408_pk_sidebands.






```
=====================Find_Ave_RmsCOS=====================================
RMS_level_Expect       .707   RMS_level_Cos  0.707494
=====================Find_Ave_RmsPM======================================
RMS_level_Expect       .707   RMS_level_RM   0.706941
=====================FFT_and_Plot_PM=====================================
FFT_BandWidth_Hz=      500000
FFT_resolution_Hz=     1000
Fundamental+sideband   0.765163 + 0.44003 + 0.440031
Total_RMS              0.986269
=====================FFT_and_Plot_Vcos===================================
FFT_BandWidth_Hz=      500000
FFT_resolution_Hz=     1000
Fundamental+sideband   0.999954 + 1.47099E-07 + 3.50213E-08
Total_RMS              0.999954
```

4) For ten time smaller modulation, both a 10%_AM and a 10%_radian_PM produce a 1_pk_carrier
   and two 0.05_pk_sidebands.




```
======================Find_Ave_RmsCOS=====================================
RMS_level_Expect        .707    RMS_level_Cos   0.707494
======================Find_Ave_RmsPM======================================
RMS_level_Expect        .707    RMS_level_RM   0.707486
======================FFT_and_Plot_PM=====================================
FFT_BandWidth_Hz=       500000
FFT_resolution_Hz=      1000
Fundamental+sideband    0.997456 + 0.0499352 + 0.0499354
Total_RMS               0.999953
======================FFT_and_Plot_Vcos===================================
FFT_BandWidth_Hz=       500000
FFT_resolution_Hz=      1000
Fundamental+sideband    0.999954 + 1.59501E-07 + 3.57084E-08
Total_RMS               0.999954
```

5) One needs for instance 1 whole second to measure a signal to a 1Hz resolution.
6) At least two samples are needed to detect the presents of an AC signal.
7) FFT translate samples over time to bins of frequency. The bin's width is the FFT_resolution_Hz and the Maximum frequency is Nyqust_Hz

====================MacSpiceCode==

SIMPLE_PM_WAVEFORM_GENERATION

```
*=========Create_Signal==================
VTime      VTime  0       DC      0     PWL(     0       0     1       1)
Vfreq1     Vfreq1 0       DC      2
BMOD       VMOD   0       V       = cos(6.2831853*2000*V(VTime))
BPM        VPM    0       V       = 1*cos(6.2831853*100k*V(VTime)+1*V(VMOD))
BCOS       VCOS   0       V       = 1*cos(6.2831853*100k*V(VTime))
```

```
.control
*TRAN              TSTEP  TSTOP  TSTART TMAX    ?UIC?
tran               .1u    1m     0       .1u
set                pensize = 2
plot               vpm    vcos
echo               "======================Find_Ave_RmsCOS====================================="
let averVal =      mean(vcos)
let noisAC =       vcos - averVal
let RmsVal =       sqrt(mean(noisAC* noisAC))
echo               "RMS_level_Expect        .707    RMS_level_Cos   $&RmsVal   "
unlet averVal
unlet RmsVal
echo               "======================Find_Ave_RmsPM======================================"
let averVal =      mean(VPM)
let noisAC =       VPM - averVal
let RmsVal =       sqrt(mean(noisAC* noisAC))
echo               "RMS_level_Expect        .707    RMS_level_RM   $&RmsVal   "
unlet averVal
unlet RmsVal
echo               "======================FFT_and_Plot_PM====================================="
linearize
let                FFT_BandWidth_Hz =      500k
let                FFT_resolution_Hz =     1k
echo               "FFT_BandWidth_Hz=      $&FFT_BandWidth_Hz"
echo               "FFT_resolution_Hz=     $&FFT_resolution_Hz"
set                specwindow=   "rectangular"
spec               $&FFT_resolution_Hz  $&FFT_BandWidth_Hz   $&FFT_resolution_Hz     v(vpm)
plot               mag (vpm) ylog xlimit 90k 110k
plot               mag (vpm) ylog xlimit 95k 105k ylimit .1 1
let fund =         mag(vpm[99])
let upsb =         mag(vpm[101])
let lpsb =         mag(vpm[97])
echo               "Fundamental+sideband   $&fund + $&upsb + $&lpsb "
let totalrms =     sqrt( fund*fund +upsb*upsb+ lpsb*lpsb)
echo               "Total_RMS      $&totalrms "
echo               "======================FFT_and_Plot_Vcos==================================="
destroy
let                FFT_BandWidth_Hz =      500k
let                FFT_resolution_Hz =     1k
echo               "FFT_BandWidth_Hz=      $&FFT_BandWidth_Hz"
echo               "FFT_resolution_Hz=     $&FFT_resolution_Hz"
set                specwindow=   "rectangular"
spec               $&FFT_resolution_Hz  $&FFT_BandWidth_Hz   $&FFT_resolution_Hz     v(vcos)
plot               mag (vcos) ylog xlimit 90k 110k
plot               mag (vcos) ylog xlimit 95k 105k ylimit .1 1
let fund =         mag(vcos[99])
let upsb =         mag(vcos[101])
```

```
let lpsb =       mag(vcos[97])
echo             "Fundamental+sideband   $&fund + $&upsb + $&lpsb "
let totalrms =   sqrt( fund*fund +upsb*upsb+ lpsb*lpsb)
echo             "Total_RMS      $&totalrms "

.endc
.end
```

4.4.11_12.03PM

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