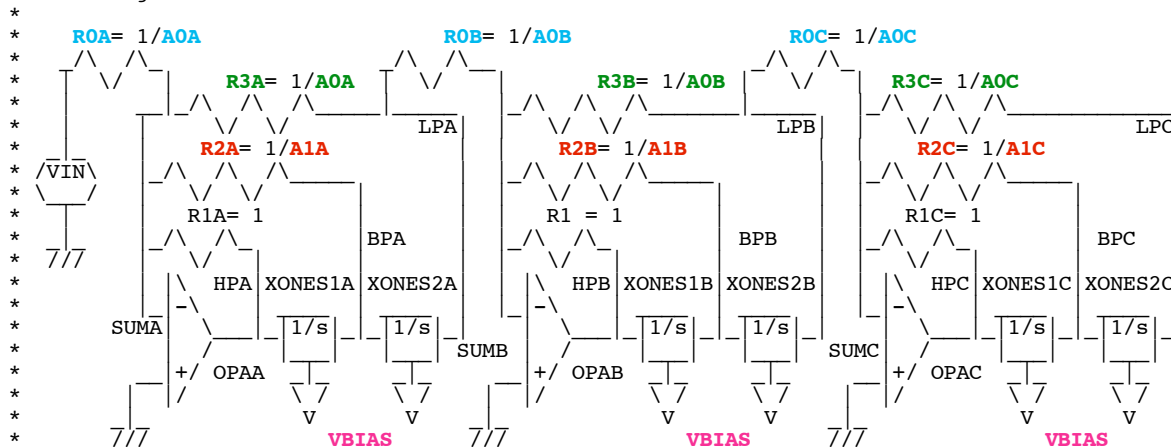


# Butterworth\_6P\_VCF

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## Butterworth terms

```

* (s^2 + 0.5176s + 1)(s^2 + 1.4142s + 1)(s^2 + 1.9319s + 1)
.OPTIONS GMIN=1e-18 METHOD=gear srcsteps = 1 gminsteps = 1
=====
V_IN VIN 0 PULSE( -.5 .5 1u 1u 1u 10m 20m ) AC = 1

```

<b>ROA</b>	VIN	SUMA	1	
R1A	SUMA	HPA	1	
<b>R2A</b>	SUMA	BPA	1.9319	
<b>R3A</b>	SUMA	LPA	1	
XOPA1A	SUMA	HPA	OPA	
XONES1A	HPA	BPA	<b>VBIAS</b>	ONE_S
XONES2A	BPA	LPA	<b>VBIAS</b>	ONE_S
<b>ROB</b>	LPA	SUMB	1	
R1B	SUMB	HPB	1	
<b>R2B</b>	SUMB	BPB	.707	
<b>R3B</b>	SUMB	LPB	1	
XOPA1B	SUMB	HPB	OPA	
XONES1B	HPB	BPB	<b>VBIAS</b>	ONE_S
XONES2B	BPB	LPB	<b>VBIAS</b>	ONE_S
<b>ROC</b>	LPB	SUMC	1	
R1C	SUMC	HPC	1	
<b>R2C</b>	SUMC	BPC	.5176	
<b>R3C</b>	SUMC	LPC	1	
XOPA1C	SUMC	HPC	OPA	
XONES1C	HPC	BPC	<b>VBIAS</b>	ONE_S
XONES2C	BPC	LPC	<b>VBIAS</b>	ONE_S

```

E_INVERT OUT0 0 LPC 0 -1
VBIAS VBIAS 0 DC 1

```

```

*#0 =====A Bessel is Best for Low Phase Distortion=====
.control
set pensize = 2
*#1 =====SET VCF VBIAS TO 1=====
set outfile0 = "Butterworth_6P_VCF_1.txt"
tran 1m 40m 0 10m
run
plot vin out0 title Vbias_1

let saveData = 1
if (saveData>0)
"VpwlA OUTA 0 PWL(" >$outfile0
let NoOfTime = length(time)
echo "Number of points is $&NoOfTime "
let n = 0
repeat $&NoOfTime
let timestep = time[n] - time[n-1]
let timme = time[n]
let vout = out0[n]
if (timestep > 1u)
"+ $&timme $&vout " >> $outfile0
let n = n+1
"+ )" >>$outfile0
ac dec 50 1 10000
run
plot db(out0) ylimit -20 0 title Vbias_1

```

```

*#2 =====SET_VCF_VBIAS_TO_100m=====
alter      vbias_dc = .1
set        outfile1 = "Butterworth_6P_VCF_100m.txt"
tran       1m      40m      0      10m
run
plot       vin out0 title Vbias_100m

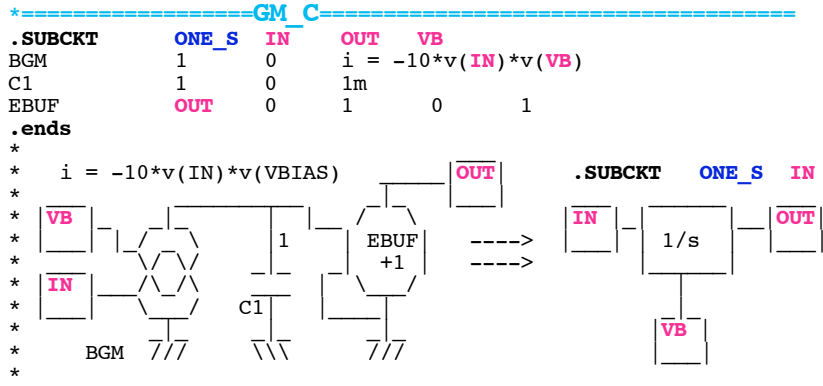
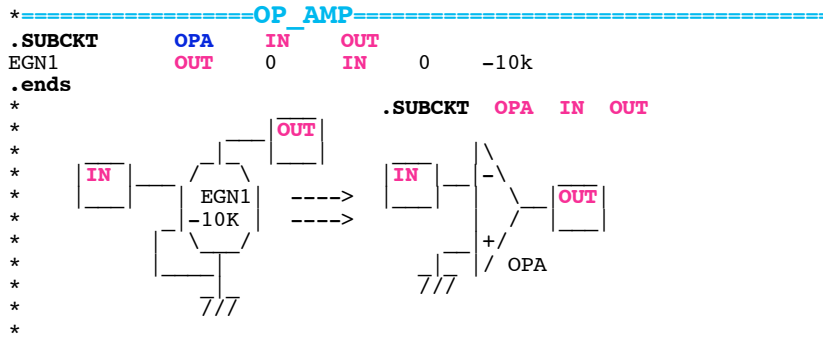
let        saveData = 1
if         (saveData>0)
echo      "VpwlB OUTB 0 PWL(" >$outfile1
let       NoOfTime = length(time)
echo      "Number of points is $&NoOfTime "
let       n = 1
repeat    $&NoOfTime
let       timestep = time[n] - time[n-1]
let       timme = time[n]
let       vout = out0[n]
if        (timestep > 1u)
echo      "+ $&timme $&vout " >> $outfile1
endif
let       n = n+1
end
echo      "+ )" >>$outfile1
endif
ac        dec 50 1 10000
run
plot      db(out0) ylimit -20 0 title Vbias_100m

*#3 =====SET_VCF_VBIAS_TO_30m=====
alter      vbias_dc = .03
set        outfile2 = "Butterworth_6P_VCF_30m.txt"
tran       1m      40m      0      10m
run
plot       vin out0 title Vbias_30m

let        saveData = 1
if         (saveData>0)
echo      "VpwlC OUTC 0 PWL(" >$outfile2
let       NoOfTime = length(time)
echo      "Number of points is $&NoOfTime "
let       n = 0
repeat    $&NoOfTime
let       timestep = time[n] - time[n-1]
let       timme = time[n]
let       vout = out0[n]
if        (timestep > 1u)
echo      "+ $&timme $&vout " >> $outfile2
endif
let       n = n+1
end
echo      "+ )" >>$outfile2
endif
ac        dec 50 1 10000
run
plot      db(out0) ylimit -20 0 title Vbias_30m

.endc

```



```

.end
=====END_OF_SPICE=====

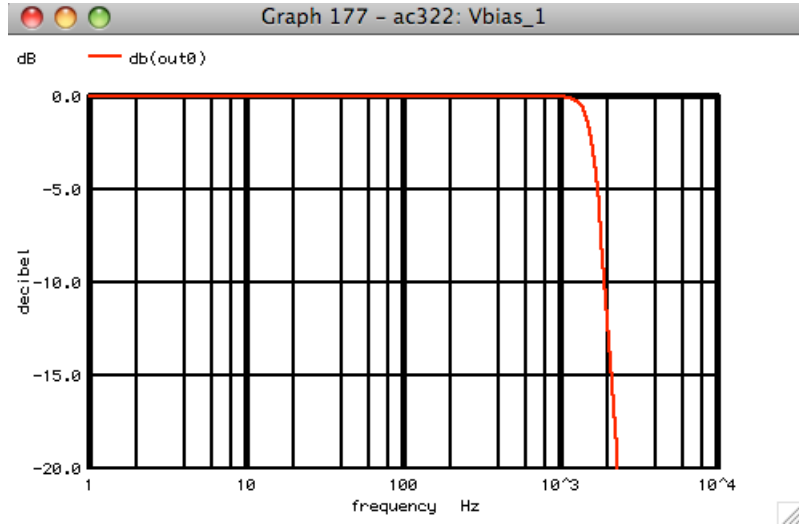
```

A Butterworth is designed for good pass band response as opposed to the Low Phase Distortion response of a Bessel

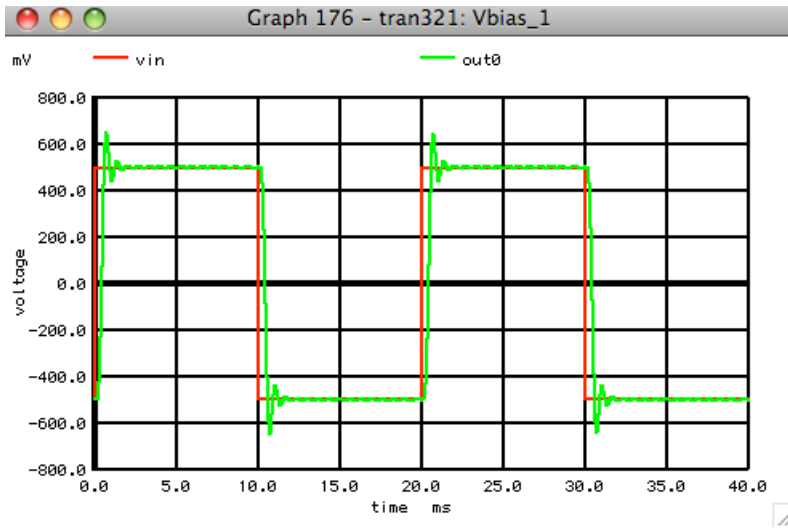
```

*#1 =====SET_VCF_VBIAS_TO_1=====
set outfile0 = "Bessel_6P_VCF_1.txt"
VBIAS VBIAS 0 DC 1

```



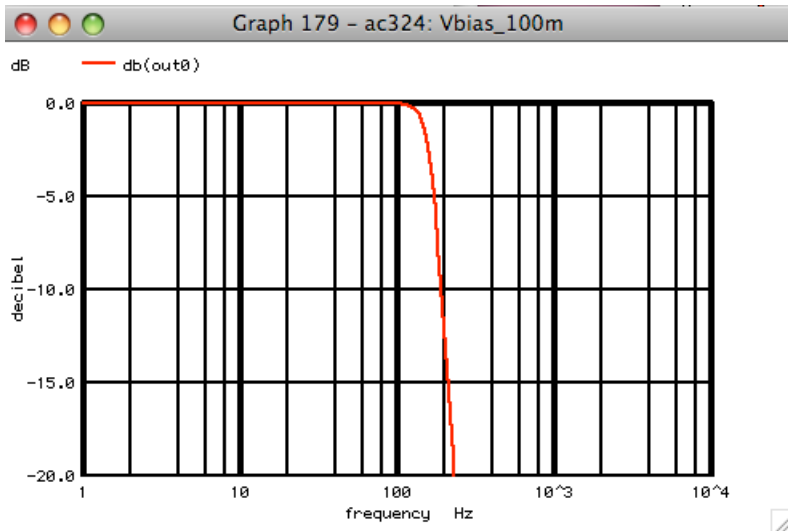
The fundamental is a square wave at 25Hz. With VBIAS set to 1V, the filter's bandwidth is a little above 1kHz. That means the 40th harmonic of the 25Hz is the 3dB point. Up to the 3dB point, there is very little attenuation of the harmonics.

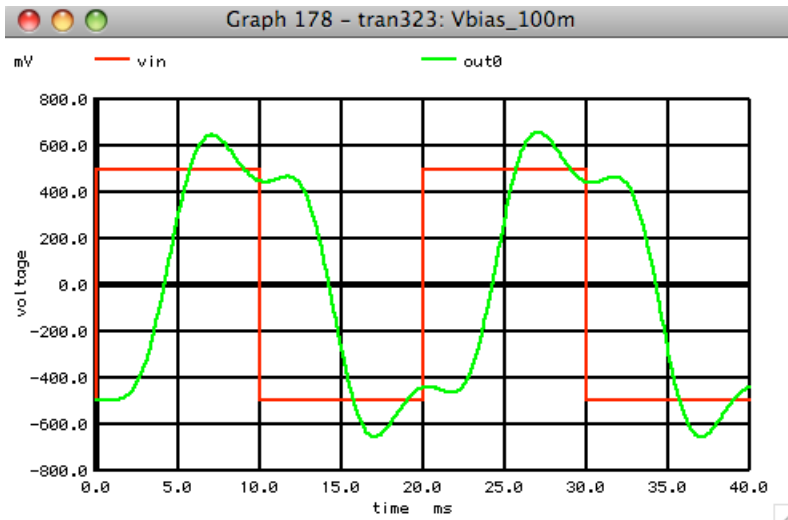


But the output waveform has picked up a definite ringing compared the same conditions as for a bessel response.

```
*#2 =====SET_VCF_VBIAS_TO_100m=====
alter      vbias dc = .1
set        outfile1 = "Bessel_6P_VCF_100m.txt"
```

When VBIAS is set now to 100m, the bandwidth of the 6pole filter is now ten times smaller.



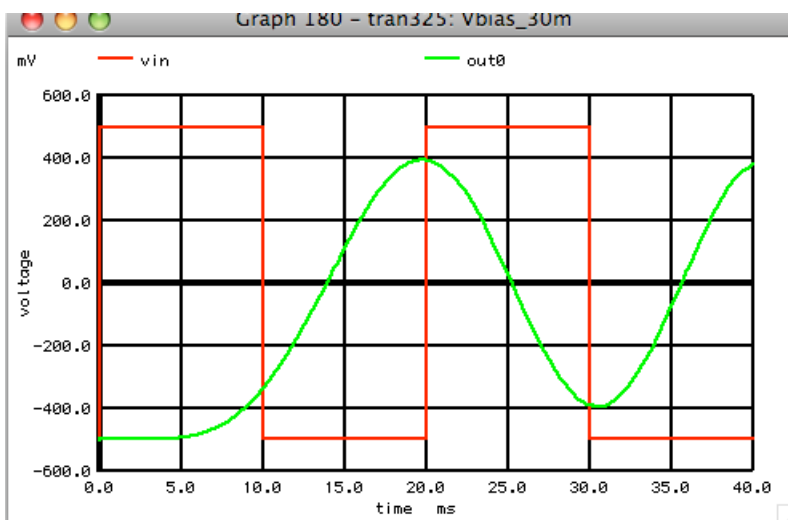
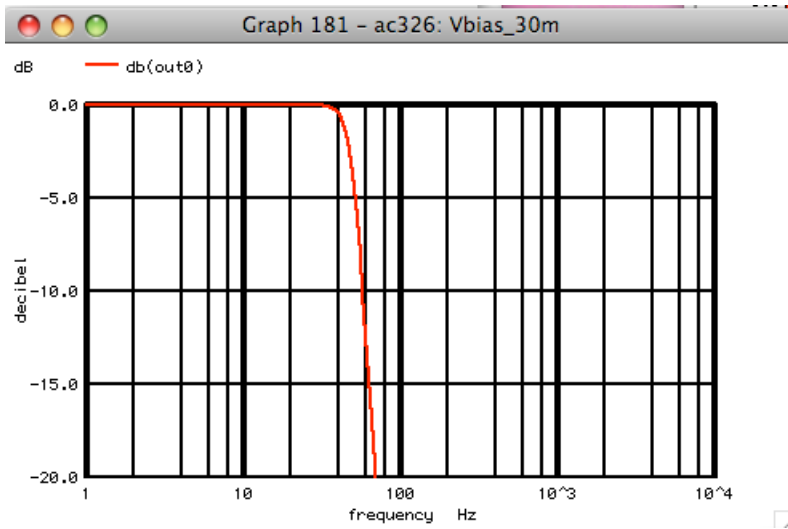


There is now about a 4 msec delay between the input and output waveforms. The 3dB point is now about at the 4th harmonic of 25Hz. The output waveform has developed a larger lower frequency ringing/

```

*#3 =====SET_VCF_VBIAS_TO_30m=====
alter      vbias dc = .03
set        outfile2 = "Bessel_6P_VCF_30m.txt"
Setting VBIAS down to 30m means all the
odd harmonics are now attenuated.

```



The input to output delay has now increased to about 14msec and the output waveform is now close to being a pure 25Hz sinewave.