Instituto Tecnológico de Costa Rica

Escuela de Ingeniería Electrónica

Filtros y perfilador

Procesamiento Digital de Señales

Integrantes:

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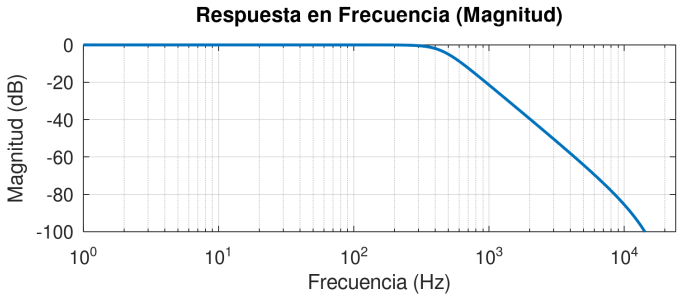
Profesor:

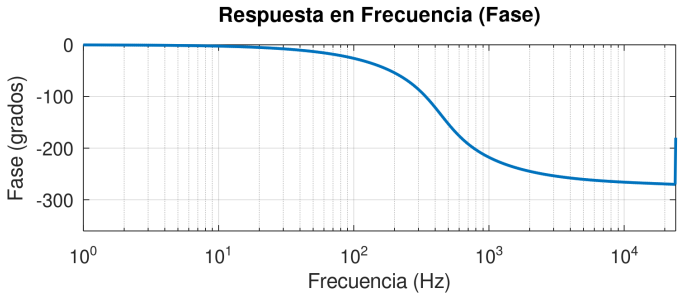
Dr.-Ing. Pablo Alvarado Moya

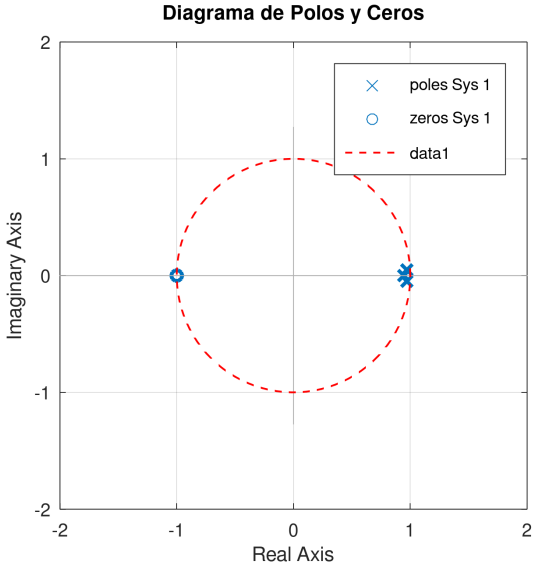
8 de octubre de 2024

Respuesta en frecuencia de los filtros

Butterworth LowPass







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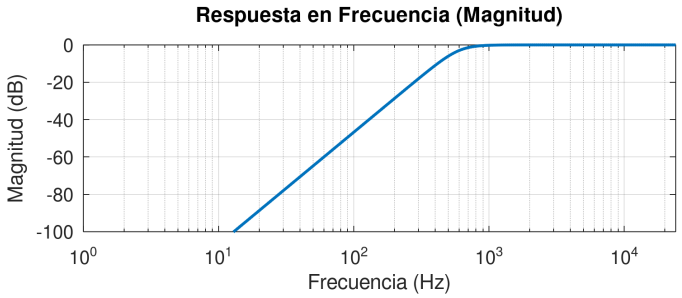
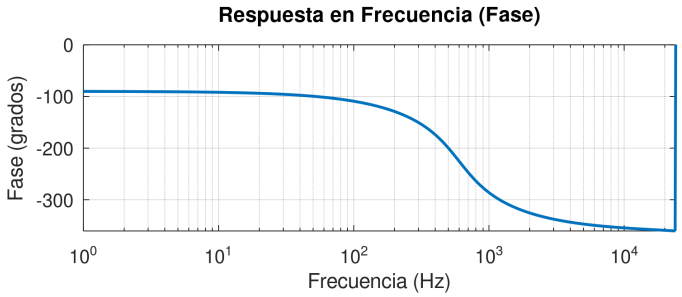
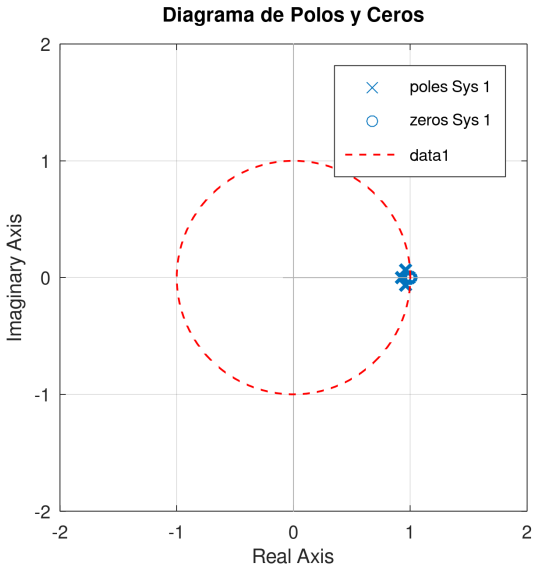
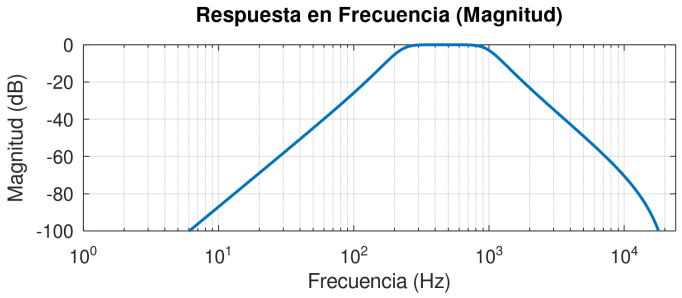
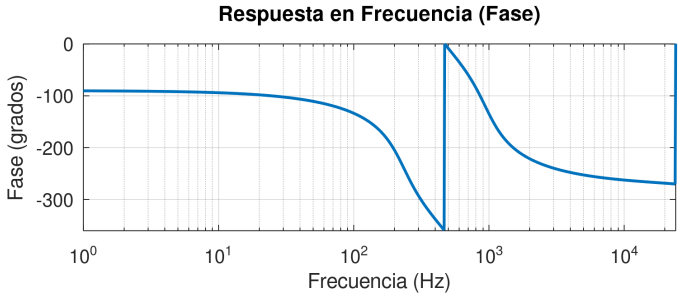


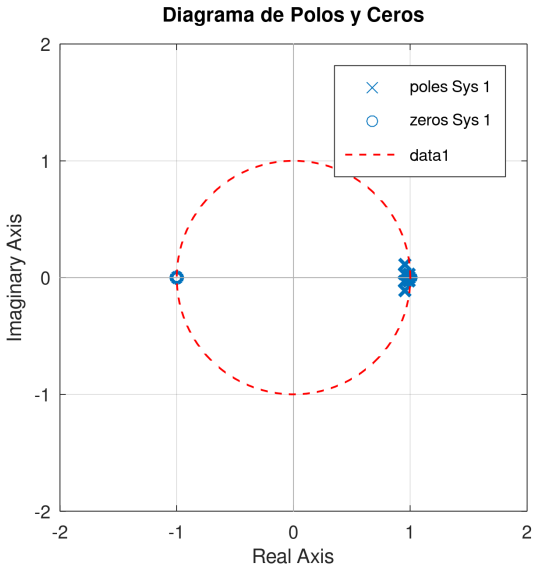




Butterworth BandPass







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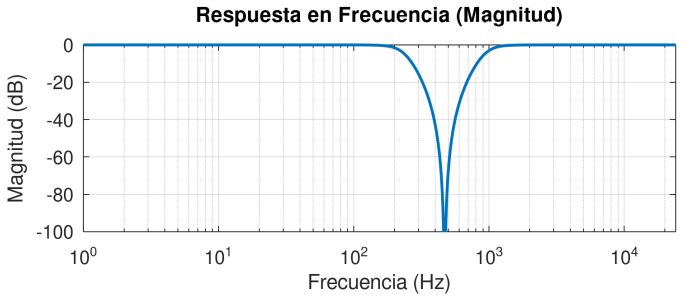
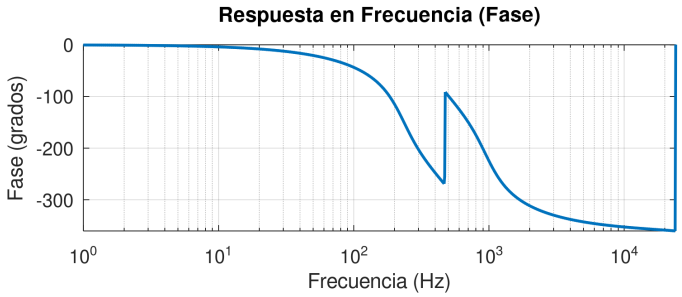
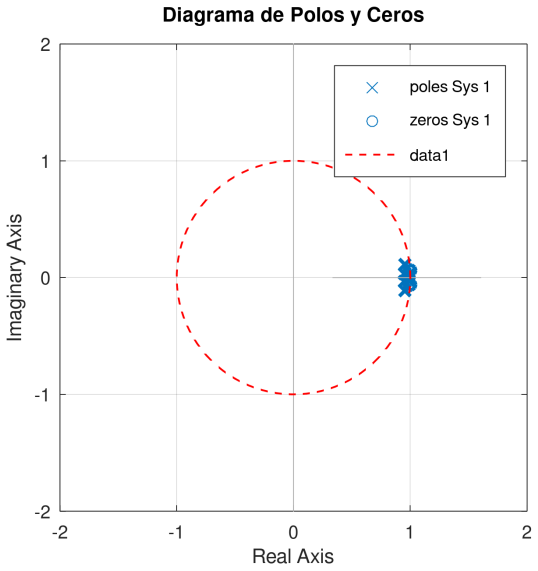
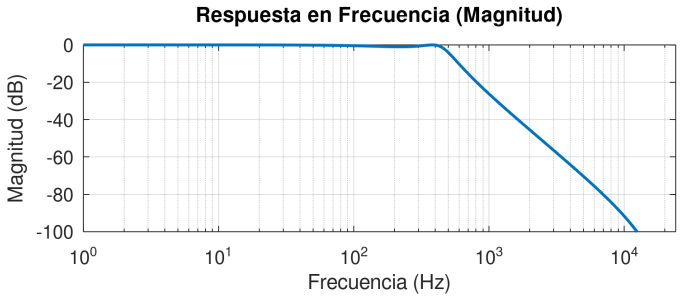
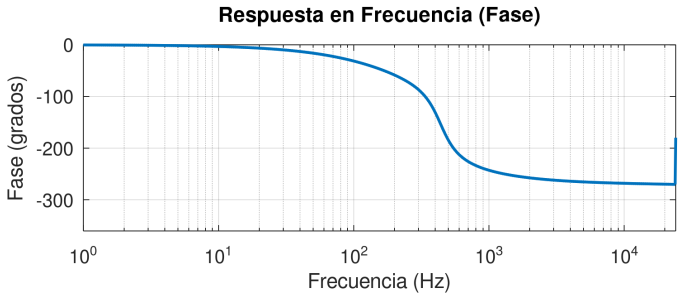


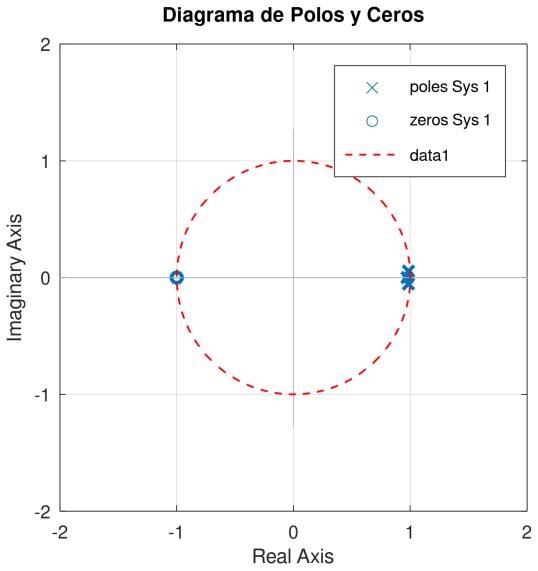




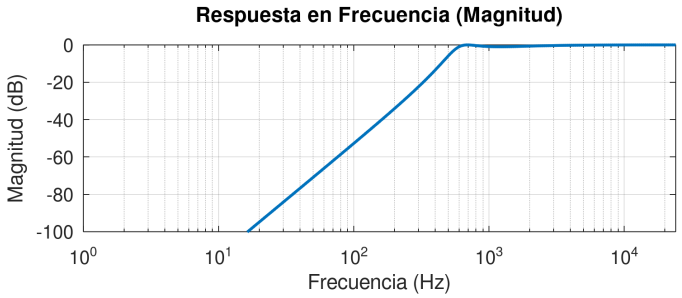
Chebyshev1 LowPass

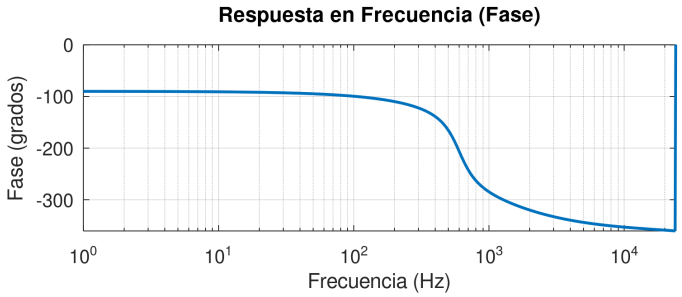


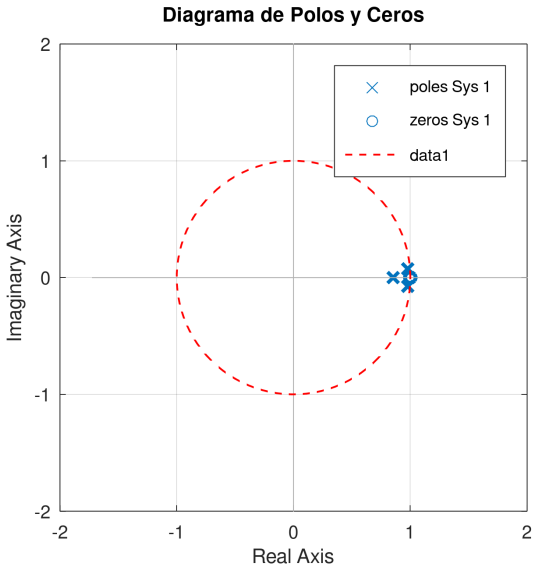




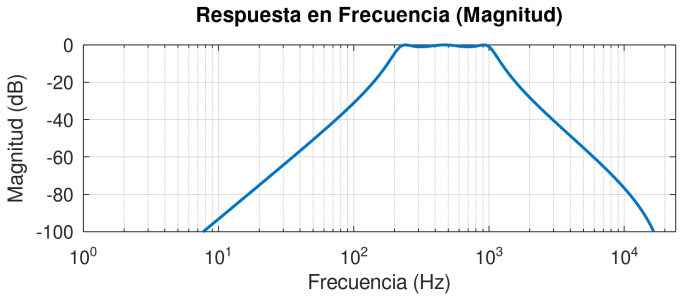
Chebyshev1 HighPass

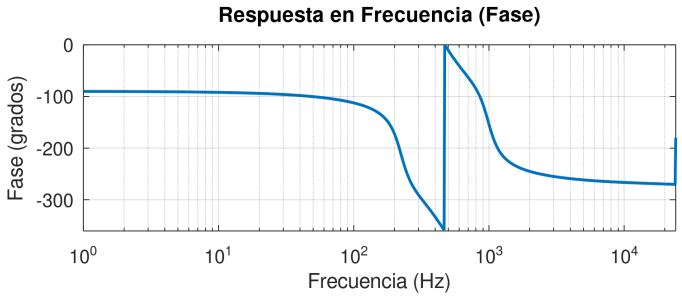


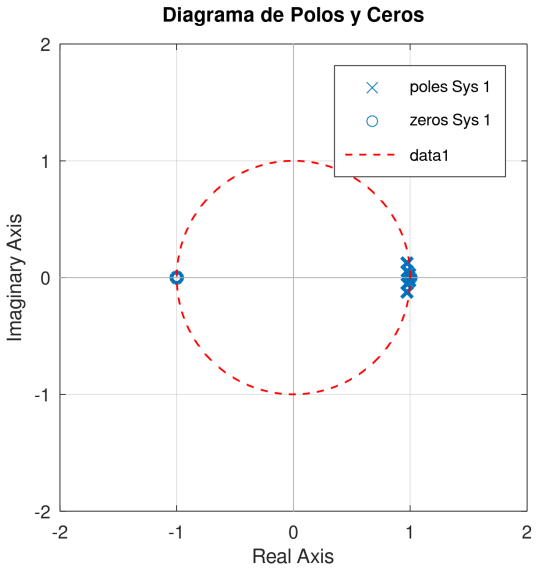




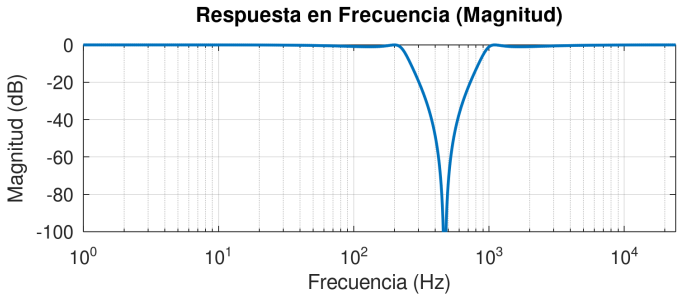
Chebyshev1 BandPass

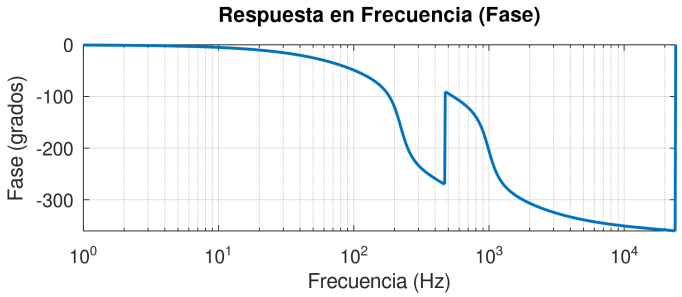


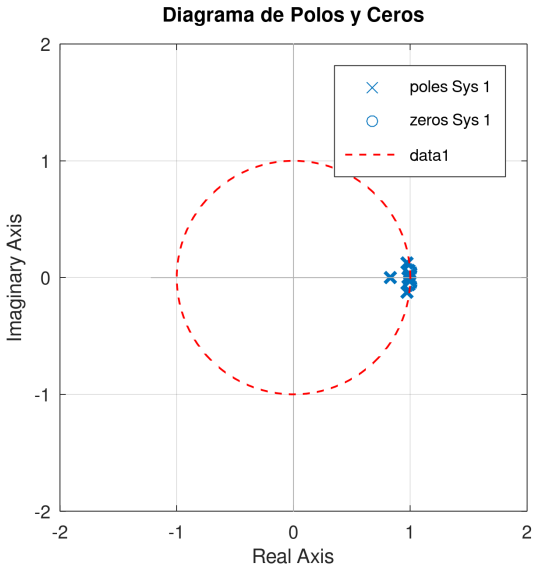




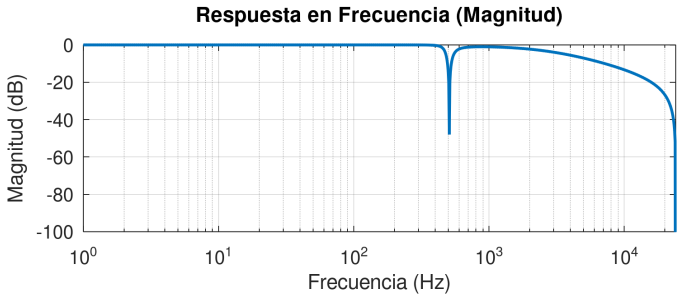
Chebyshev1 StopPass

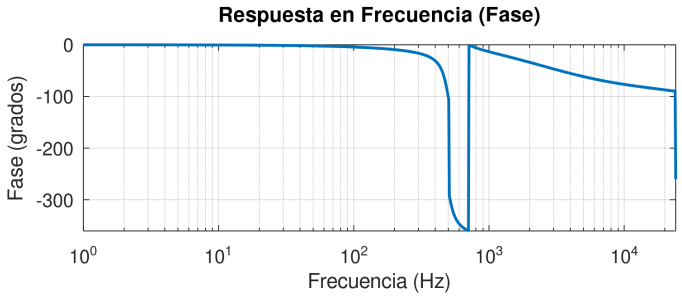


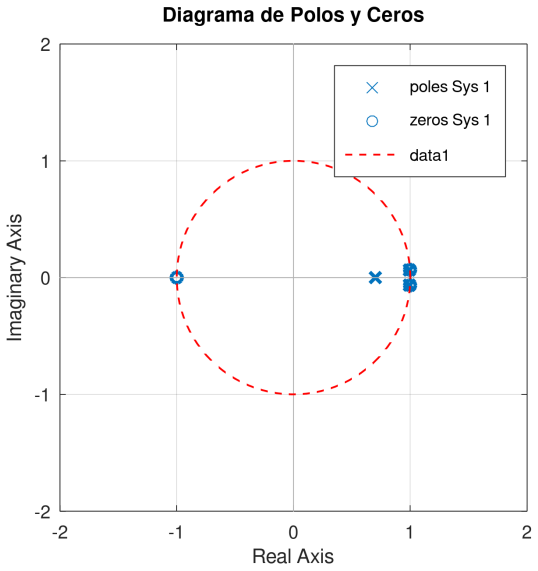




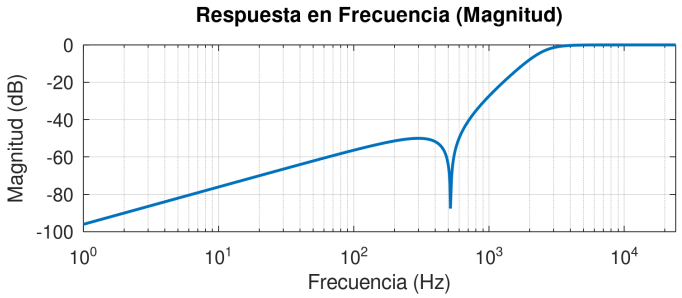
Chebyshev2 LowPass

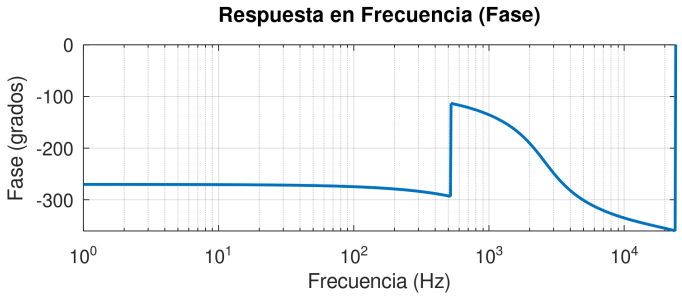


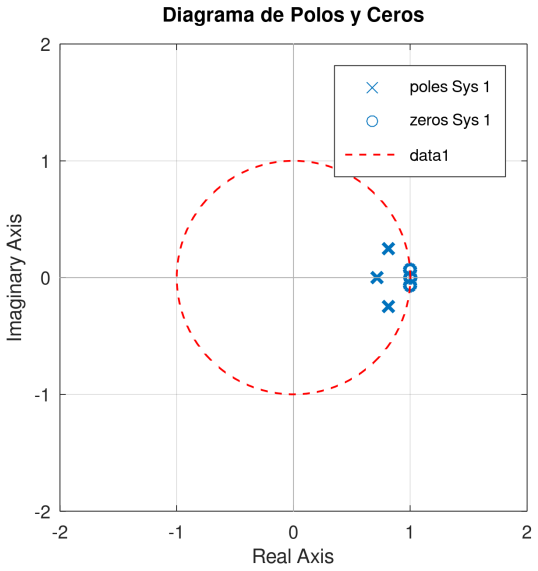




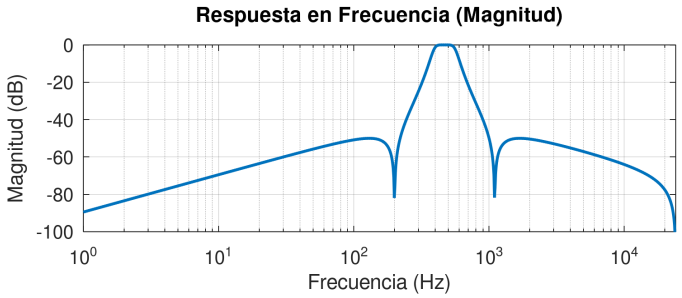
Chebyshev2 HighPass

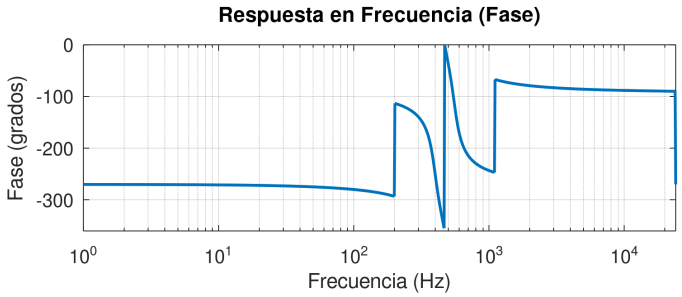


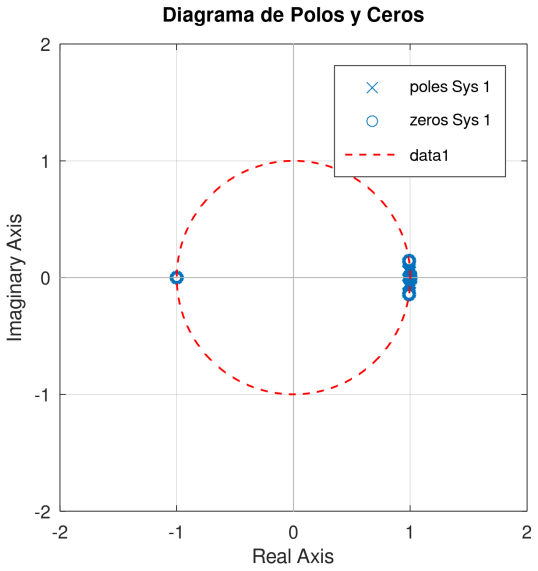




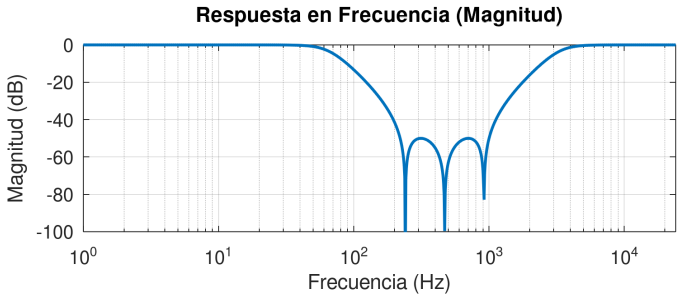
Chebyshev2 BandPass

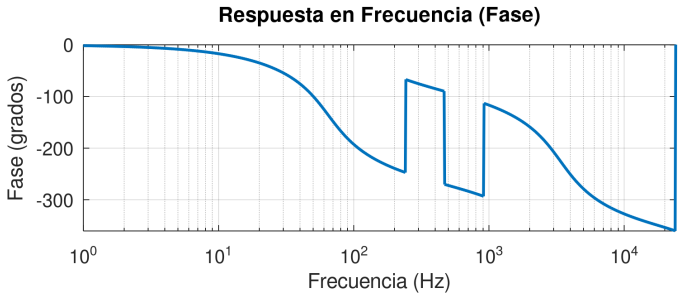


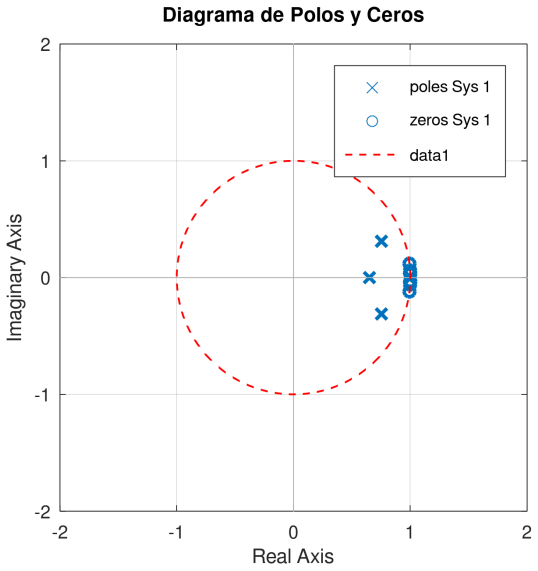




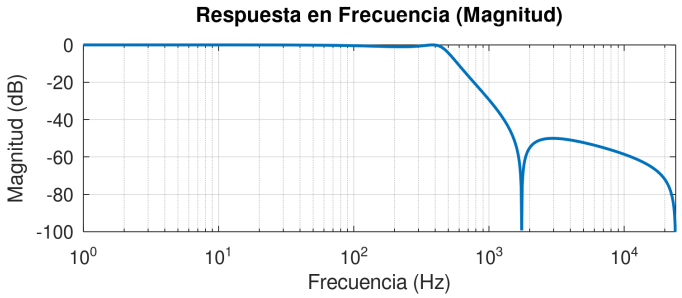
Chebyshev2 StopPass

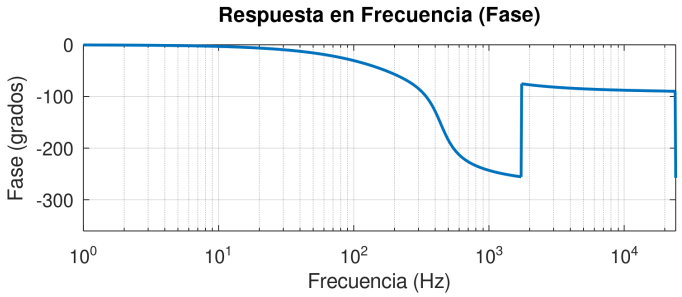


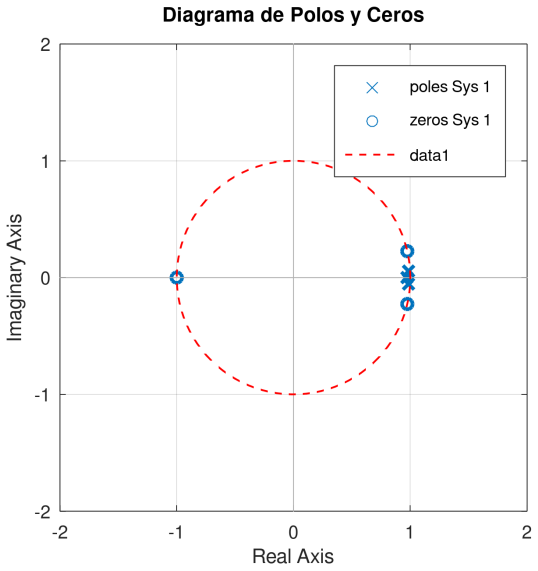




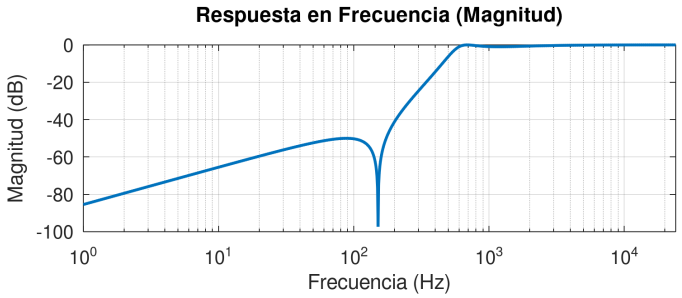
Elliptic LowPass

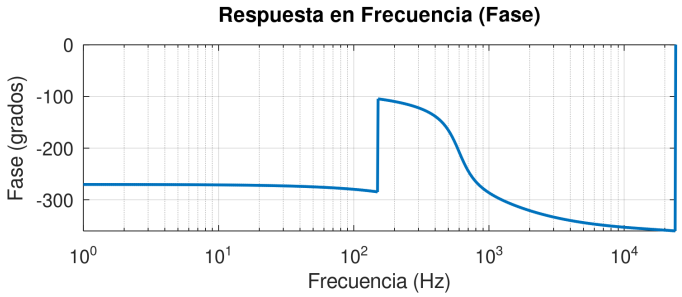


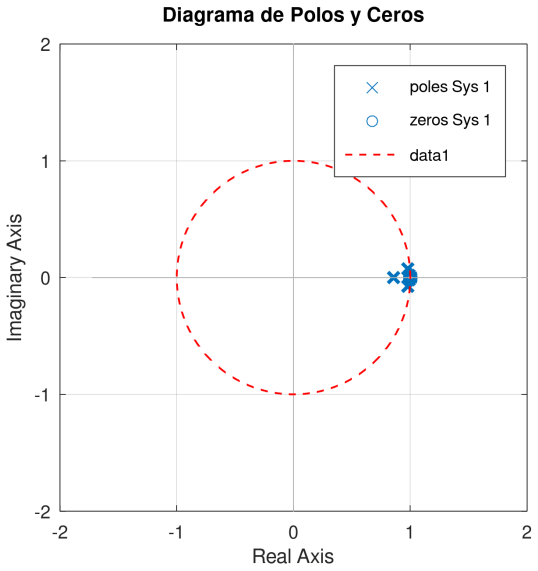




Elliptic HighPass







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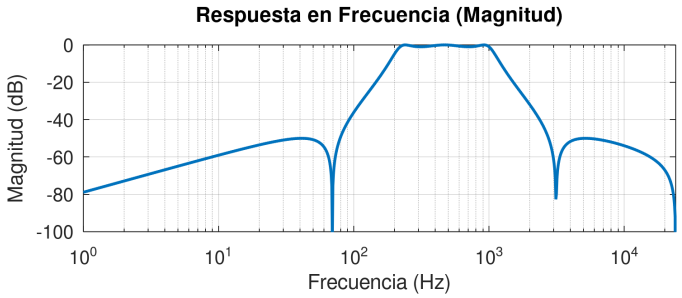
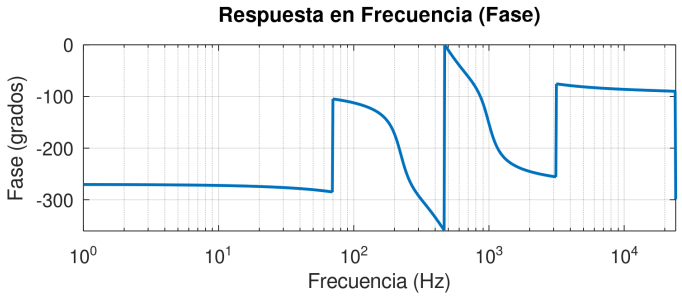
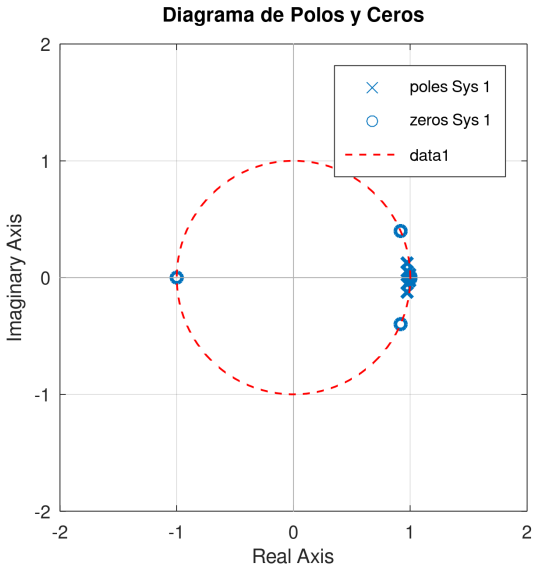
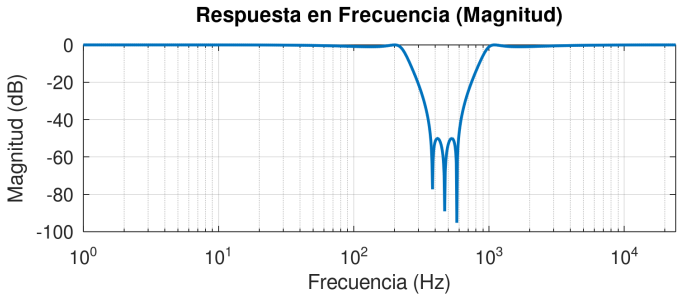
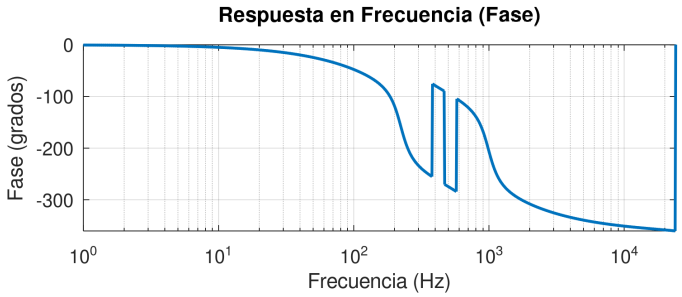


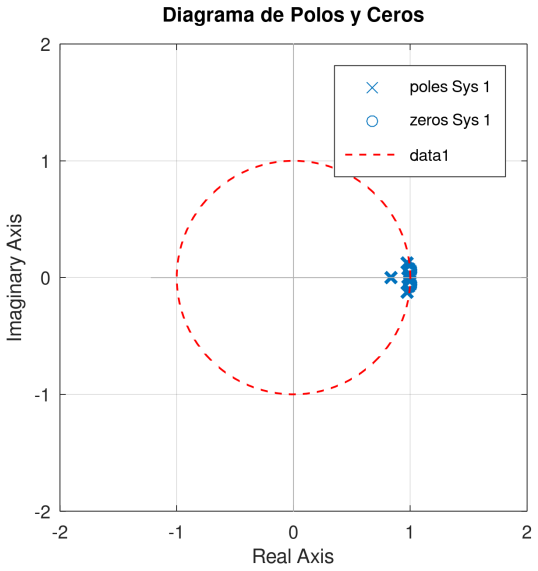




Elliptic StopPass



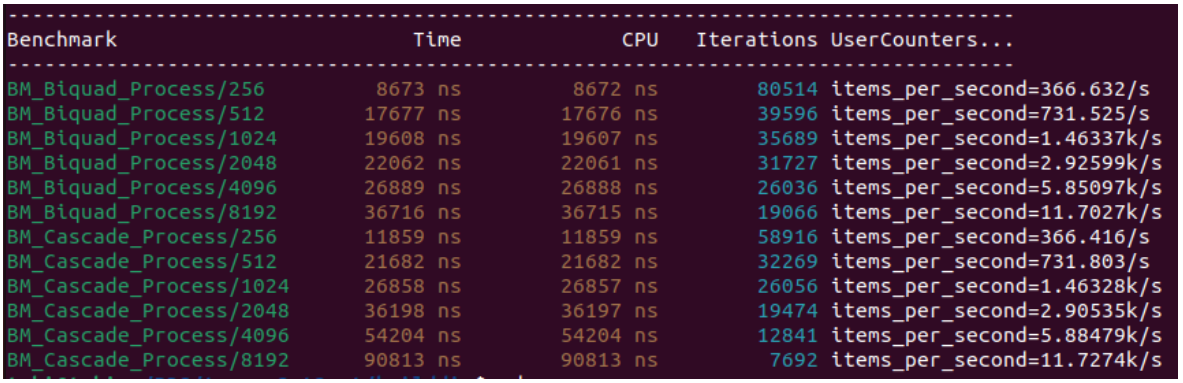




Perfilador

Es muy necesario antes de empezar la sección, identificar que el objetivo primordial es hacer lo más pequeño posible el tiempo de la cascada, ya que el biquad no refleja necesariamente en el process el uso de métodos con lógica avanzada dado que esto implicaría cambiar métodos internos que potencialmente cambiarían la lógica de biquad para algunas pruebas (la lógica vectorial no está integrada directamente con la continuidad de la lógica sin vectores).

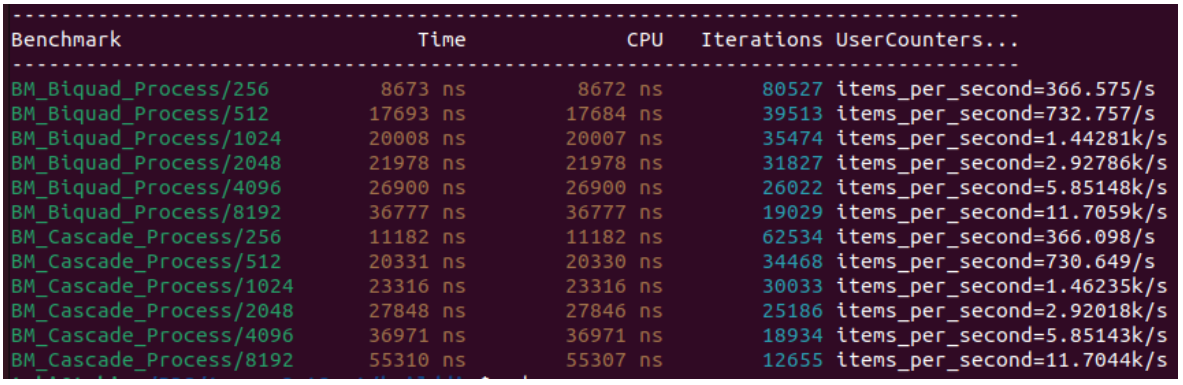
En la Figura 1 observamos como un método con la transpuesta, sin loop unrolling y recorriendo totalmente cada buffer de resultados parciales es la solución más lenta.



Benchmark	Time	CPU	Iterations	UserCounters...
BM_Biquad_Process/256	8673 ns	8672 ns	80514	items_per_second=366.632/s
BM_Biquad_Process/512	17677 ns	17676 ns	39596	items_per_second=731.525/s
BM_Biquad_Process/1024	19608 ns	19607 ns	35689	items_per_second=1.46337k/s
BM_Biquad_Process/2048	22062 ns	22061 ns	31727	items_per_second=2.92599k/s
BM_Biquad_Process/4096	26889 ns	26888 ns	26036	items_per_second=5.85097k/s
BM_Biquad_Process/8192	36716 ns	36715 ns	19066	items_per_second=11.7027k/s
BM_Cascade_Process/256	11859 ns	11859 ns	58916	items_per_second=366.416/s
BM_Cascade_Process/512	21682 ns	21682 ns	32269	items_per_second=731.803/s
BM_Cascade_Process/1024	26858 ns	26857 ns	26056	items_per_second=1.46328k/s
BM_Cascade_Process/2048	36198 ns	36197 ns	19474	items_per_second=2.90535k/s
BM_Cascade_Process/4096	54204 ns	54204 ns	12841	items_per_second=5.88479k/s
BM_Cascade_Process/8192	90813 ns	90813 ns	7692	items_per_second=11.7274k/s

Figura 1: Resultados perfilador 1

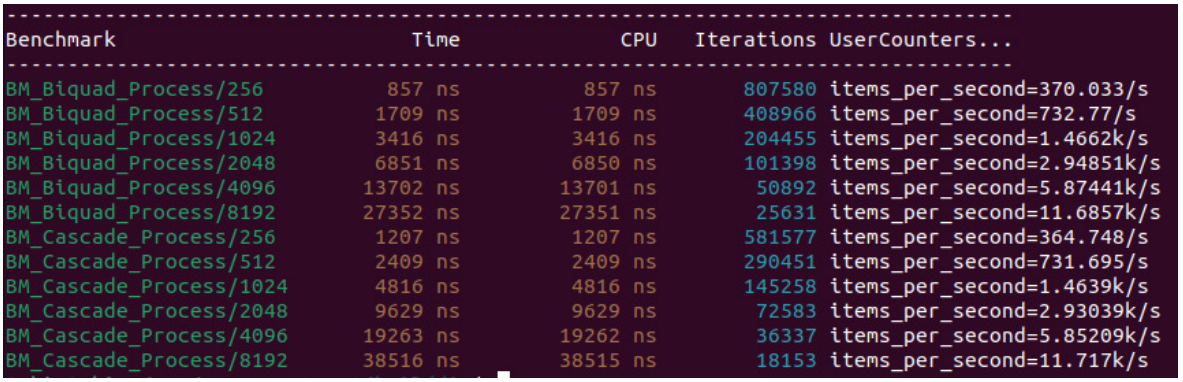
En la Figura 2, por su parte tenemos la transpuesta pero con una especie loop unrolling en la que se trabaja muestra por muestra, haciendo que los resultados parciales se reflejen directamente en el resultado final, disminuyendo el recorrido de los buffers a sola un ciclo para todas las muestras.



Benchmark	Time	CPU	Iterations	UserCounters...
BM_Biquad_Process/256	8673 ns	8672 ns	80527	items_per_second=366.575/s
BM_Biquad_Process/512	17693 ns	17684 ns	39513	items_per_second=732.757/s
BM_Biquad_Process/1024	20008 ns	20007 ns	35474	items_per_second=1.44281k/s
BM_Biquad_Process/2048	21978 ns	21978 ns	31827	items_per_second=2.92786k/s
BM_Biquad_Process/4096	26900 ns	26900 ns	26022	items_per_second=5.85148k/s
BM_Biquad_Process/8192	36777 ns	36777 ns	19029	items_per_second=11.7059k/s
BM_Cascade_Process/256	11182 ns	11182 ns	62534	items_per_second=366.098/s
BM_Cascade_Process/512	20331 ns	20330 ns	34468	items_per_second=730.649/s
BM_Cascade_Process/1024	23316 ns	23316 ns	30033	items_per_second=1.46235k/s
BM_Cascade_Process/2048	27848 ns	27846 ns	25186	items_per_second=2.92018k/s
BM_Cascade_Process/4096	36971 ns	36971 ns	18934	items_per_second=5.85143k/s
BM_Cascade_Process/8192	55310 ns	55307 ns	12655	items_per_second=11.7044k/s

Figura 2: Resultados perfilador 2

Por último, se realiza una optimización agresiva de la versión anterior, utilizando banderas del compilador para aprovechar la arquitectura y prefetch a L1 de los datos en un rango de 16 posiciones de float.



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-------------------------------------------------------------------------------
Benchmark                        Time             CPU   Iterations UserCounters...
-------------------------------------------------------------------------------
BM_Biquad_Process/256          857 ns          857 ns       807580 items_per_second=370.033/s
BM_Biquad_Process/512         1709 ns         1709 ns       408966 items_per_second=732.77/s
BM_Biquad_Process/1024        3416 ns         3416 ns       204455 items_per_second=1.4662k/s
BM_Biquad_Process/2048        6851 ns         6850 ns       101398 items_per_second=2.94851k/s
BM_Biquad_Process/4096       13702 ns        13701 ns        50892 items_per_second=5.87441k/s
BM_Biquad_Process/8192       27352 ns        27351 ns        25631 items_per_second=11.6857k/s
BM_Cascade_Process/256        1207 ns         1207 ns       581577 items_per_second=364.748/s
BM_Cascade_Process/512        2409 ns         2409 ns       290451 items_per_second=731.695/s
BM_Cascade_Process/1024       4816 ns         4816 ns       145258 items_per_second=1.4639k/s
BM_Cascade_Process/2048       9629 ns         9629 ns        72583 items_per_second=2.93039k/s
BM_Cascade_Process/4096      19263 ns        19262 ns        36337 items_per_second=5.85209k/s
BM_Cascade_Process/8192      38516 ns        38515 ns        18153 items_per_second=11.717k/s
```

Figura 3: Resultados perfilador 3