Description

The RT5602A transversal filter family includes six standard filter responses. Each design is a monolithic 64-tap delay line with the finite impulse response or weighting defined by the relative sizes of split electrodes in the device. Custom filter designs are possible with a single mask change.

Sample rates from 1 kHz to 1 MHz allow a wide range over which the user may "tune" the filter response by simply changing the external trigger frequency. The transversal filter is unique in that filter cutoff rates exceed 150 dB/octave while preserving linear phase response in the passband. This is important in reduction of pulse distortion for telemetry signals, and a minimization of overshoot in the step response. The pinout configuration is shown in Figure 1, a block diagram is shown in Figure 4, and package dimensions are shown in Figure 14.

Typical Applications

- Telemetry and modems with PSK, QPSK, FM & FSK Formats
- Antialias filter for data acquisition systems
- Tracking/Programmable filter
- Matched filter/fixed correlator
- Real-time 64-point discrete Fourier transforms via the Chirp-Z Transform
- Pulse compression

Device Operation

The sample rate is one-fourth the clock trigger frequency ($f_S = f_C/4$). At the negative transitions of ø1 (see Figure 5), new samples of the input waveform are entered (clocked) into the device and are clocked along the internal bucket-brigade delay line (BBD).

For test purposes, the unfiltered-but-buffered output of the delay line is accessible at BBD Out, delayed from the input by 65 sample periods.

The spectral characteristic depends on the sample frequency; thus, the frequency characteristic may be shifted merely by shifting the sample frequency. At the extremes, the sample frequency is limited as shown in Figure 2. At the low end, the filter performance degrades due to leakage; it degrades at the high end due to limitations of the on-chip timing circuitry.

The maximum usable input signal is limited by the tolerable harmonic distortion. Linearity, in general, increases as signal amplitudes are reduced. Thus, an improved harmonic-distortion ratio may be obtained by reducing signal amplitude, but at the expense of reduced dynamic range.

Cascade or Parallel Operation

To cascade two or more transversal filters requires a parallel connection of the clock input pins (pin 15). For synchronized

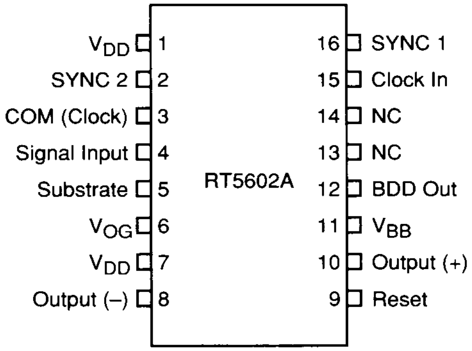
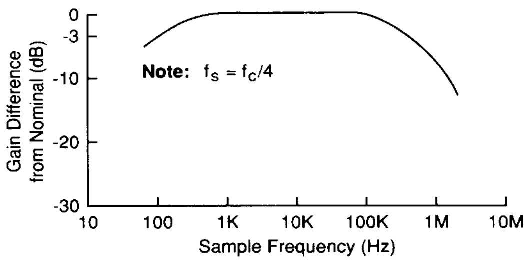


Figure 1. Pinout Configuration



Note: Input signal frequency adjusted to be within passband

Figure 2. Insertion Loss vs Sample Rate

parallel clocking, Sync 1, Sync 2, and the trigger line (pin 16) must be clocked with the waveforms shown in Figure 5. The sync waveforms can be derived from the trigger clock with a flip flop and level shifted to the specified value.

Standard Filters

The pre-programmed types are:

RT5602AAP-011 Narrow Lowpass
RT5602ACP-011 Narrow Bandpass
RT5602AEP-020 Sine Chirp
RT5602AFP-020 Cosine Chirp
RT5602AGP-011 Sine Chirp, Hanning Windowed
RT5602AHP-011 Cosine Chirp, Hanning Windowed

Special Function Devices

The AEP and AFP versions of the RT5602A filter family have impulse responses corresponding to a sine chirp and cosine

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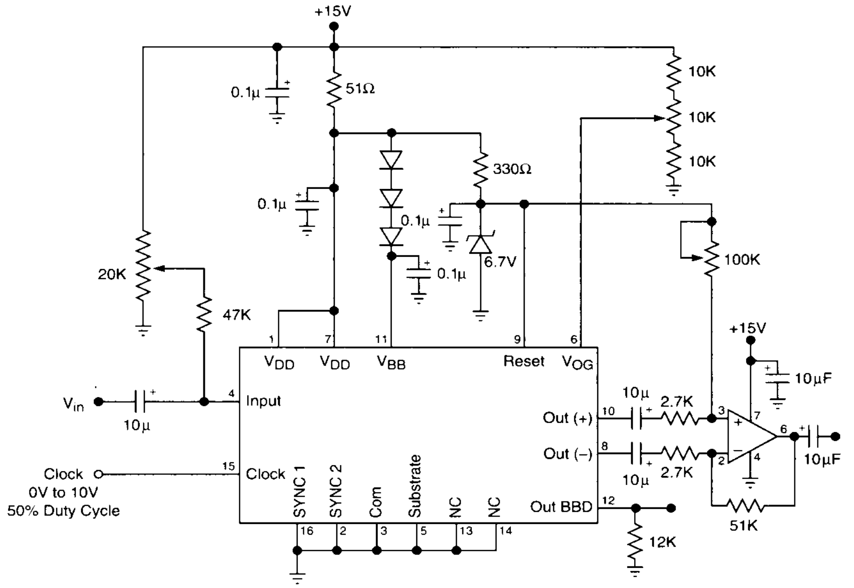


Figure 3. Suggested Drive Circuit

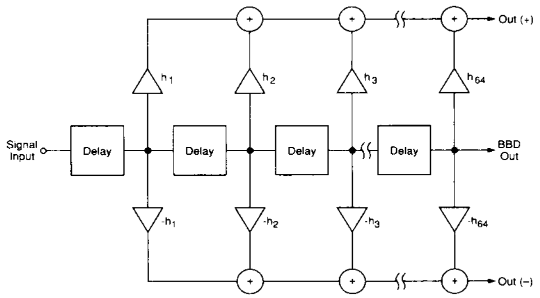
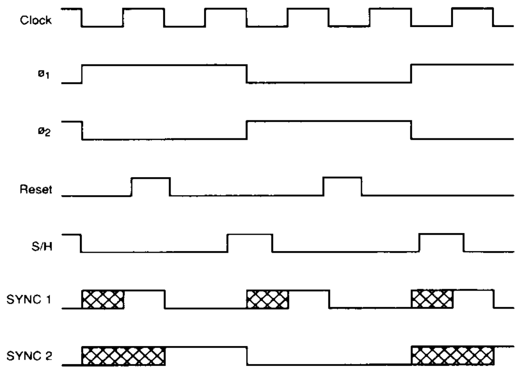


Figure 4. Transversal Filter Functional Block Diagram

chirp, respectively. The AGP and AHP versions are sine and cosine chirps with Hanning windows. These devices can be used to implement a 64-point chirp-z transform, or they can perform pulse compression of chirp waveforms such as those used in sonar and radar. For a particular application, Reticon can provide applications assistance.

Custom Filters

Low cost customized filter responses are made possible by modification of the mask(s) used in device fabrication. Requests for custom responses can be submitted as either a desired frequency response or a desired impulse response.



Reset waveform = ϕ_1 waveform.

SYNC 1 and SYNC 2:

= "don't care". Trailing edges must not extend into next clock period more than ~ 20nsec.

Figure 5. Device Timing

Filter Impulse Response

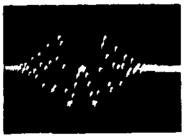


Figure 6. RT5602AGP Windowed Sine Chirp Impulse Response

Figure 7. RT5602AHP Windowed Cosine Chirp Impulse Response

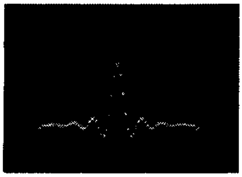


Figure 8. RT5602AAP Narrow Low-pass Filter

Figure 9. RT5602ACP Narrow Bandpass Filter

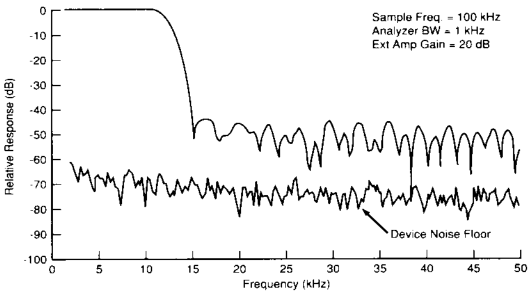


Figure 10. RT5602AAP Narrow Low-pass Filter Spectral Response Including 20 dB of Gain from External Amp

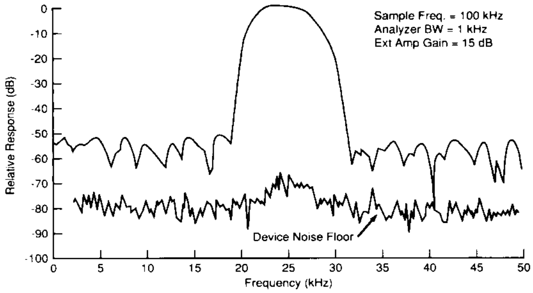


Figure 11. RT5602ACP Narrow Bandpass Filter Spectral Response Including 15 dB of Gain from External Amp

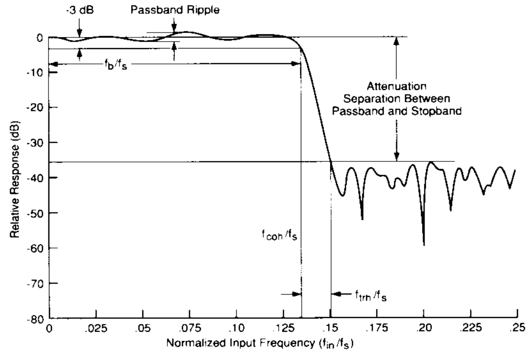


Figure 12. Illustration of Frequency Characteristic Definitions, Low-pass Filter

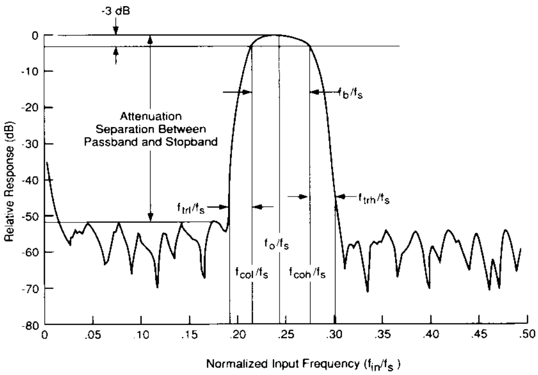


Figure 13. Illustration of Frequency Characteristic Definitions, Bandpass Filter

Table 1. Absolute Minimum/Maximum Ratings

	Min	Max	Units
Input voltage-any terminal with respect to common	–0.4	+20	V
Output short-circuit duration-any terminal	Indefinite		
Operating temperature	0	70	°C
Storage temperature	–55	+125	°C
Lead temperature (soldering, 10 sec.)		300	°C

CAUTION: Observe MOS Handling and Operating Procedures

Note: This table shows stress ratings *exclusively*: functional operation of this product under any conditions beyond those listed under standard operating conditions is not suggested by the table. Permanent damage may result if the device is subject to stresses beyond those absolute min/max values. Moreover, reliability may be diminished if the device is run for protracted periods at absolute maximum values.

Although devices are internally gate-protected to minimize the possibility of static damage, the MOS handling precautions should be observed. Do not apply instantaneous supply voltages to the device or insert or remove device from socket while under power. Use decoupling networks to suppress power supply turn-off/on switching transients and ripple. Applying AC signals or clock to device with power off may exceed negative limit.

Table 2. Device Characteristics and Operation Range [2, 3]

Parameter	Sym	Min	Typ	Max	Units
Supply voltages	V_{DD}	14	15	16	V
	V_{BB}		V_{DD}-2		V
V_{reset}		5	6	8	V
Clock frequency (trigger)	f_c	.004		4	MHz
RT5602AAP corner frequency [1]			$f_c/32$ ($f_s/8$)		Hz
RT5602ACP center frequency [1]			$f_c/16$ ($f_s/4$)		Hz
Clock amplitude		4.6	10	V_{DD}	V
Sync amplitude		10		V_{DD}	V
Clock input capacitance			10		pF
DC power dissipation			180		mW
Input signal amplitude			1	3	V_{p-p}
Input DC bias			6		V
Input impedance (@ f_s = 100 kHz)			30		KΩ
Input capacitance (@ 5V)			7		pF
Output impedance			1.2		KΩ
Bandwidth [4]					
RT5602AAP	f_b/f_s		0.12		
RT5602ACP	f_b/f_s		0.055		
Low cutoff frequency [4]					
RT5602ACP	f_{col}/f_s		0.222		
High cutoff frequency [4]					
RT5602AAP	f_{coh}/f_s		0.125		
RT5602ACP	f_{coh}/f_s		0.275		
Low transition width [4]					
RT5602ACP	f_{trl}/f_s		.03		
High transition width [4]					
RT5602AAP	f_{trh}/f_s		0.025		
RT5602ACP	f_{trh}/f_s		0.035		

Notes:

1 fs is the internal sample frequency = $f_c/4$ (where f_c = clock frequency)
2 fc = 1 MHz for impulse response; f_c = 400 kHz otherwise; T_A = 25°C
3 Tested using the circuit in Figure 3
4 Normalized to a sample frequency (f_s) of 1 Hz. To denormalize, multiply the given parameter by the applied f_s.

Table 3. Performance Standards

Parameter (at 25°C)	Sym	Typ	Units
Dynamic range for $3V_{p-p}$ input signal			
RT5602AAP	DR	63	dB
RT5602ACP	DR	65	dB
Dynamic range for $1V_{p-p}$ input signal			
RT5602AAP	DR	53	dB
RT5602ACP	DR	55	dB
Harmonic distortion for $1V_{p-p}$ input signal [1]			
RT5602AAP	THD	-55	dB
RT5602ACP	THD	-55	dB
Harmonic distortion for $3V_{p-p}$ input signal			
RT5602AAP	THD	-40	dB
RT5602ACP	THD	-40	dB
Insertion loss			
RT5602AAP		20	dB
RT5602ACP		15	dB
Pass band ripple			
RT5602AAP		.2	dB
RT5602ACP		.2	dB
Shape factor			
RT5602AAP		1.2	
RT5602ACP		2.2	
Rollup rate			
RT5602ACP		271	dB/octave
Rolloff rate			
RT5602AAP		185	dB/octave
RT5602ACP		291	dB/octave
Separation between pass band and stop-band			
RT5602AAP		42	dB
RT5602ACP		50.9	dB

Note:
[1] 0 dB = $1V_{p-p}$

Dynamic range is defined as:

$$\text{Dynamic range} = 20 \log \frac{V_{out\,(max)}\,(V_{rms})}{V_{noise}\,(V_{rms})}$$

Insertion loss is defined as:

$$\text{Insertion loss} = -20 \log \frac{V_{out}\,(V_{p-p})}{V_{in}(V_{p-p})}$$

The Shape factor is defined as:

For the low-pass filter,

$$\text{Shape factor} = \frac{\text{Attenuation bandwidth at -40 dB}}{\text{3 dB bandwidth}} = \frac{1 + f_{trh}}{1 + f_{coh}}$$

For the bandpass filter,

$$\text{Shape factor} = \frac{\text{Attenuation bandwidth at -40 dB}}{\text{3 dB bandwidth}} = 1 + \frac{f_{trl} + f_{trh}}{\Delta f}$$

Table 4. Pin Connections [1]

Pin	Function	Suggested Voltage Signal Connection
1	V_{DD}	See Figure 3
2	Sync 2	Common
3	Clock Common	Common
4	Signal In	AC-coupled on 6V DC bias
5	Substrate	Common
6	V_{OG}	5-10V
7	V_{DD} (Supply)	See Figure 3
8	V_{out} (-) [1]	-Input of differential amplifier
9	V_{reset}	+5V to + 8V
10	V_{out} (+) [1]	+Input of differential amplifier
11	V_{BB}	See Figure 3
12	BBD Out [2]	100KΩ to common
13	N/C	Common
14	N/C	Common
15	Trigger In	Clock at 4 times sample frequency; amplitude 10V
16	Sync 1	Common

Note:
1 Based on Figure 3
2 10KΩ if used and "high speed"; 100KΩ if not used or "low speed"

16-Pin Plastic

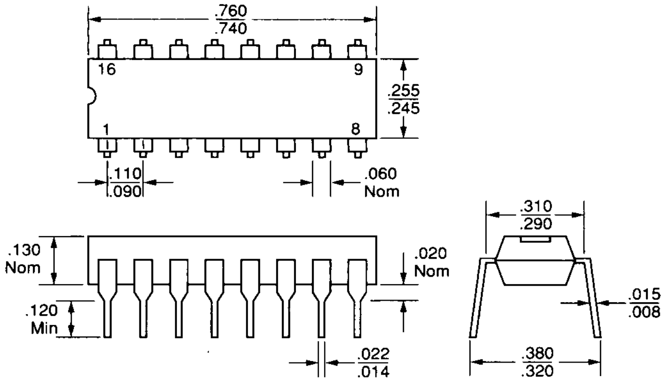


Figure 14. Package Dimensions

Ordering Information

Part Number	Description
RT5602AAP-011	64-stage low-pass transversal filter, 16-pin plastic package
RT5602ACP-011	64-stage bandpass transversal filter, 16-pin plastic package
RT5602AEP-020	64-stage sine chirp transversal filter, 16-pin plastic package
RT5602AFP-020	64-stage cosine chirp transversal filter, 16-pin plastic package
RT5602AGP-011	64-stage sine chirp transversal filter with Hanning window, 16-pin plastic package
RT5602AHP-011	64-stage cosine chirp transversal filter with Hanning window, 16-pin plastic package

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