DESCRIPTION

The Reticon R5609, R5613, R5611, and R5612 are monolithic switched-capacitor low-pass, high-pass, and notch filters.

- The R5609 is a seven-pole, six-zero elliptic low-pass filter with over 75 dB out-of-band rejection and less than 0.2 dB of passband ripple.
- The Reticon R5613 is a linear-phase low-pass filter with over 60 dB out-of-band rejection. It has an elliptic stop band response for faster rolloff.
- The R5611 is a five-pole Chebyshev high-pass filter with 30 dB per octave rolloff and less than 0.6 dB of passband ripple.
- The R5612 is a four-pole notch filter with over 50 dB of rejection at the notch frequency.

The corner/center frequencies of these switched capacitor filters is tunable by the input trigger frequency over a wide frequency range from 1.0 Hz up to 25 KHz. The dynamic range is better than 75 dB. Signal handling capability is over 12 volts, peak-to-peak, and typical insertion loss is 0 dB. The device to device gain and phase tracking, over temperatuare range is typically better than 0.5%.

TYPICAL APPLICATIONS

- Antialias Filters
- Reconstruction Filters
- 60 and 120 Hz Interference Rejection
- Tracking Filters
- Audio Analysis
- Telecommunications
- Portable Instrumentation
- Biomedical/Geophysical Instrumentation
- Speech Processing

R5609/R5613 LOW-PASS, R5611 HIGH-PASS AND R5612 NOTCH FILTERS

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DEVICE OPERATION

The R5609, R5611, and R5612 are self-contained and require only an external clock trigger and plus and minus power supplies. The device characteristic and operating parameters were obtained using the test configuration shown in Figure 2.

The R5612 requires an input trigger of 55.93 KHz to produce a notch at 60 Hz. This may be provided by dividing a simple 3.58 MHz chroma crystal oscillator by 64.

The R5613 has a clock to cutoff frequency ratio of 128, which is useful for digital applications.

In applications where dc information must be passed through the filter, the output offset may be nulled out by varying the reference voltage, which will change the input trigger level and may require adjustment of clock voltage values. The reference input requires less than 100 μA of current and must always be well-filtered. A circuit that may be used to adjust out the output offset is shown in Figure 3.

A divide-by-two output is also available. This output contains a square wave at the sample rate and may be used for triggering, driving additional filters, etc. For example, the divide-by-two output from the notch filter may be used to drive additional notch filters to form a harmonic comb filter.

PRE/POST FILTERING CONSIDERATIONS

The sampling rates on the R5609, R5611, and R5612 vary from 50 times the corner frequency on the R5609 to 465 times the center frequency on the R5612. (Note: Sampling rate = ½ input clock trigger rate.) Because these sample rates will be far from the frequencies of interest in most cases, antialiasing filtering will usually not be required. However, as with all sampling systems, frequencies above half the sample rate will be aliased and may appear in the band of interest. If this is the case, an external antialiasing filter will be required on the input. A one or two pole Butterworth low-pass filter will usually suffice. In applications where clock residue may affect system performance, a single pole RC filter may be added to the output. Typical clock residue is 25 mV p-p for the R5611 and R5612. For the R5609 and R5613 the residue is 100 mV p-p.

CUSTOM DEVICES

Low cost customized filter responses are available by modification of a single mask layer used in device fabrication. For example, the R5609, 7 pole elliptic lowpass can be modified to become a 7 pole Butterworth, Chebyshev, or an elliptic with a new response.

The R5611 may be modified to a Butterworth or different Chebyshev response, while the Q on the R5612 notch filter may be changed. The trigger input to corner frequency ratio may be changed on all devices.

Fully customized devices are also available. Most classical polynomial and ladder filter designs can be duplicated within the following constraints:

PARAMETER	**Limit**
Maximum Output Voltage	12 volts p-p
Maximum Filter center frequency	50 kHz
Maximum Sample Rate	3 MHz
Input Impedance	$\geq$ 100 kΩ
Output Impedance	$\leq$ 1kΩ
Number of Poles	Up to 100 per chip
Q	$\leq$ 100

Switched-capacitor filters have several design advantages over conventional techniques. The most obvious is the ability to integrate several filters of one or more types into a single IC. Most filters can also be built to tolerances on the order of 1% or better.

Since multiple filters can usually be designed on a single chip, a savings in circuit board real estate, manufacturing insertion costs, testing costs, and inventory costs will be realized.

The stability of the switched-capacitor filters eliminates alignment problems thus eliminating the need for tight tolerance components and trimpots.

R5609, R5613, R5611, and R5612 DEVICE CHARACTERISTICS AND OPERATING PARAMETERS

PARAMETER	SYMBOL	MIN	TYPICAL	MAX	UNITS
Positive Supply	V_{DD}	4		11	Volts
Negative Supply	V_{SS}	-4		-11	Volts
Supply Current	I_D	6	9	11	ma
Voltage to any pin[1] with respect to V_{SS}		-0.5		22	Volts
Clock Trigger[1] Voltage Swing	V_C	VRef to VRef +3	CMOS/ TTL	V_{SS} to V_{DD}	Volts
Trigger Pulse Width tc = clock period	T_{cp}	100	tc/2	t_c-100	nS
Trigger Input Capacitance	c_c			10	pF
Corner/Center Frequency	f_0				
Low-pass		1.0[4]		25000	Hz
High-pass		1.0		8000	Hz
Notch		1.0		5000	Hz
Clock to Corner Frequency Ratio	$fc/_{fo}$				
- (R5613)		124	128	132	
Low-pass - (R5609)		97	100	103	
High-pass - (R5611)		485	500	515	
Notch - (R5612)		900	930	960	
Passband Ripple					
- (R5613)			Not Applicable		
Low-pass - (R5609)				0.2	dB
High-pass - (R5611)				0.6	dB
Notch - (R5612)				0.2	dB
Notch Q		2.9	3.0	3.1	
Notch Rejection		50	55		dB
Insertion Loss		-0.4	0	+0.4	dB
Input Impedance	R_i	1			Megohm
Input Capacitance	C_i			15	pF

PARAMETER	SYMBOL	MIN	TYPICAL	MAX	UNITS
Output Voltage Swing	V_O	12			Volts p-p
Maximum Output Current	I_O	4			mA
Dynamic Output Impedance				250	Ohms
Output Noise[2] Low-pass High-pass Notch				 2.5 1.0 1.5	 mV mV mV
Dynamic Range[3] Low-pass High-pass Notch			 75 80 80		 dB dB dB
Total Harmonic Distortion[3] *R5611, *R5612 (See Fig. 8 for R5609, R5613)				*0.3%	

1. Applying AC signals or input trigger to chip with power off may exceed negative limit.

2. Broadband to ½ the sample rate.

3. 12 volts p-p in, ± 10 volt supplies.

4. For improved low frequency operation it may be necessary to put ≈ 10µF capacitor in the clock line and ≈ 100µF capacitor in the signal input line.

WARNING: Observe MOS Handling and Operating Procedures. Maximum rated supply voltages must not be exceeded. Use decoupling networks to suppress power supply turn on/off transients, ripple and switching transients. Do not apply independently powered or AC coupled signals or clocks to the chip with power off as this will forward bias the substrate. Damage may result if external protection precautions are not taken.

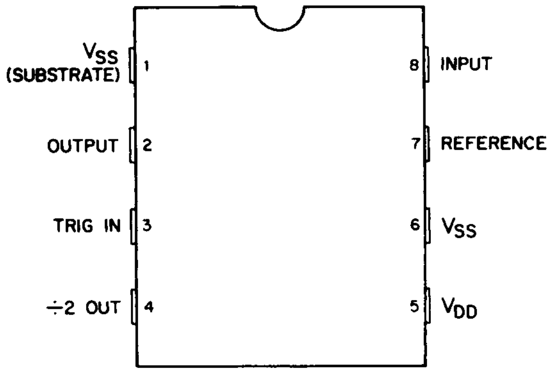

Figure 1. PINOUT.

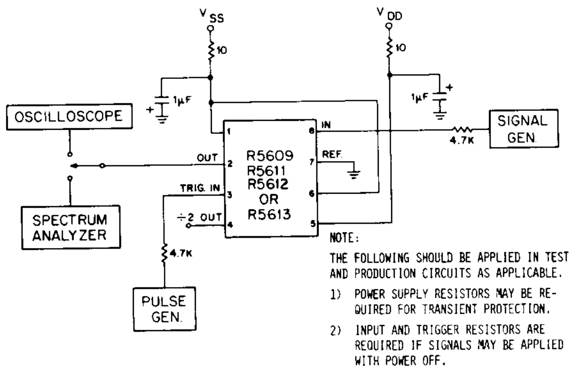

Figure 2. Test circuit for switched-capacitor filters.

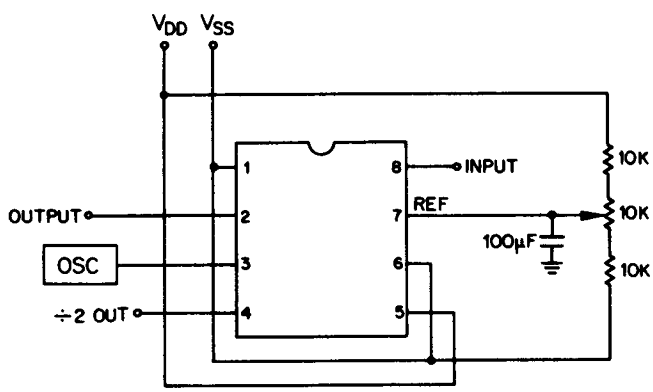

Figure 3. Circuit for nulling out the output DC offset.

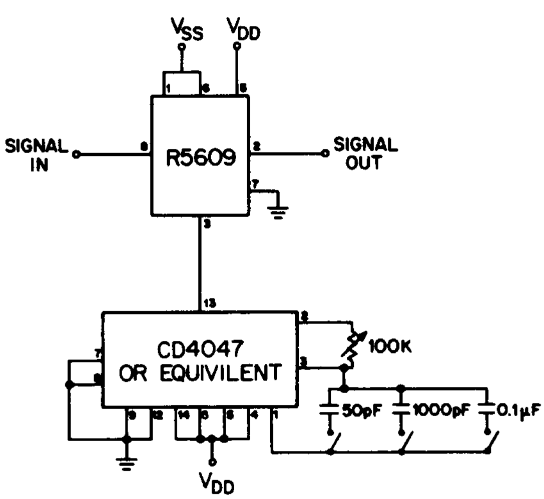

Figure 4. 100 dB/octave variable frequency low-pass filter.

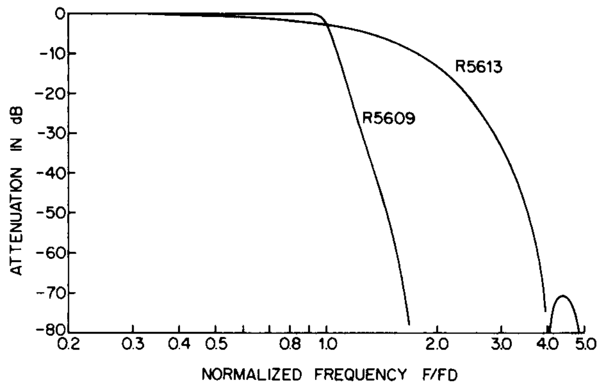

Figure 5. Magnitude response of R5609 and R5613 switched-capacitor filter.

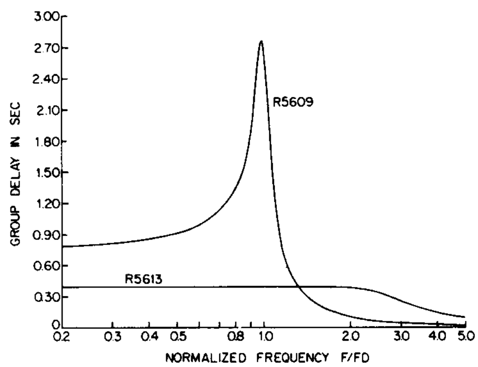

Figure 6. Group delay of R5609 and R5613 switched-capacitor filter.

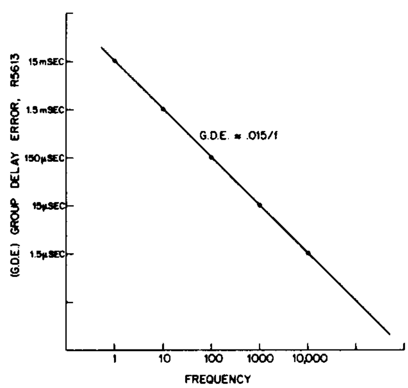

Figure 7. Group delay error, R5613.

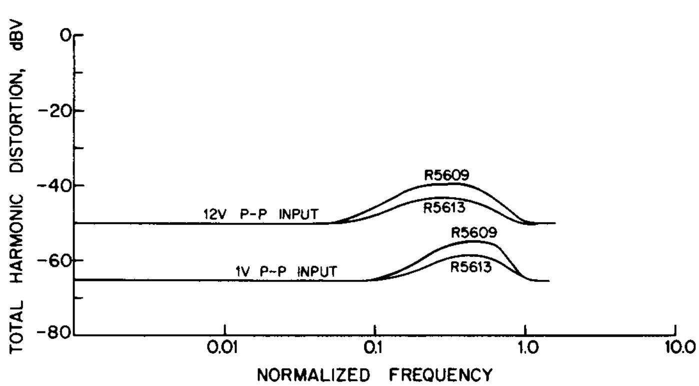

Figure 8. Total harmonic distortion. (R5609, R5613)

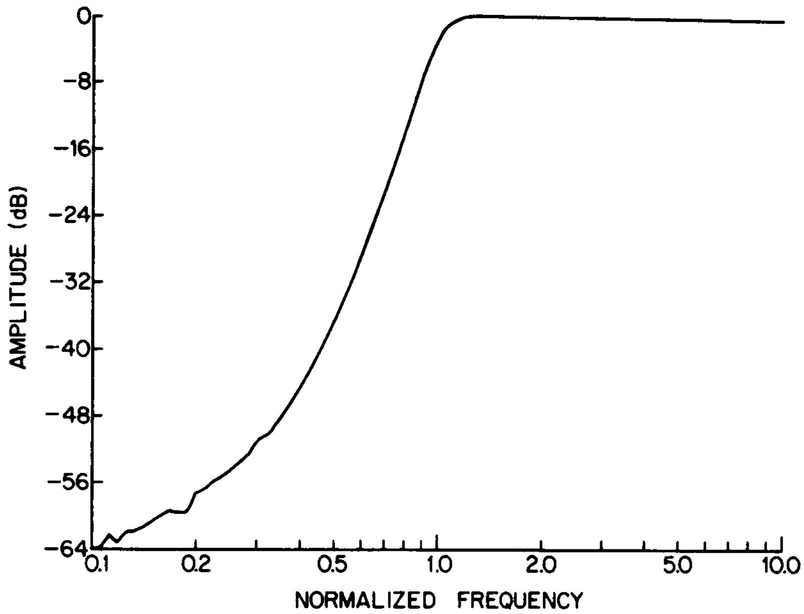

Figure 9. Frequency response of R5611 high-pass filter.

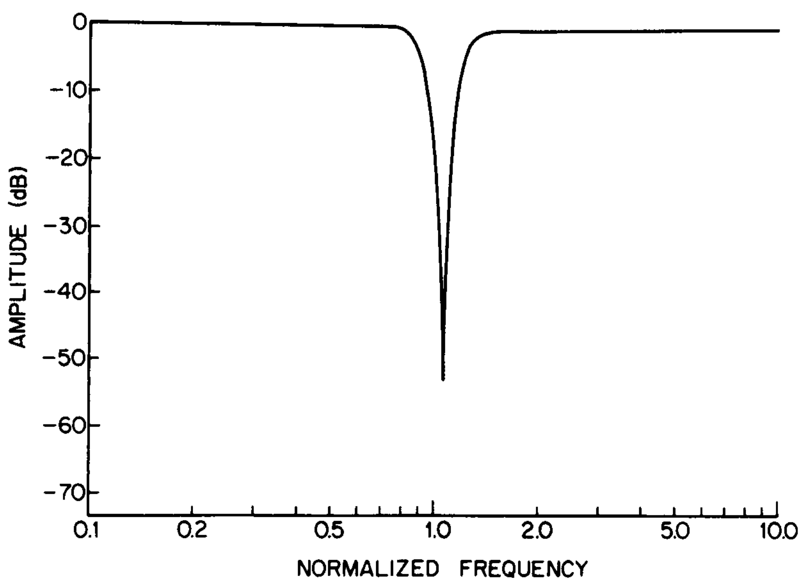

Figure 10. Frequency response of R5612 notch filter.

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