Resistor Programmable Universal Active Filter Data Sheet

Description

The resistor programmable universal active filter is a CMOS chip that can be configured for Lowpass, Bandpass, Highpass, Elliptic, Notch or Allpass filters using external resistors. The filters come in one (8 pin) or two (16 pin) section versions. The device is a switched-capacitor filter using a topology that requires fewer pins and less power consumption than other switched-capacitor universal active filters. The clock to corner ratio as well as the Q are set by external resistors.

Depending on the filter type and response, from zero to nine external resistors are needed for each section. The sections may be cascaded to realize higher order filters.

The devices have a selectable nominal sample to corner ratio of either 50 to 1 or 100 to 1 and come in either a low power version (fo ‹ 3 kHz)or a higher power version (fo ‹ 20 kHz). With device current as low as 50 ua per section, the chip is ideal for low power and portable application. The devices are double sampled to reduce the clock frequency by a factor of two.

Features

Low Power Consumption
Low Voltage Operation 3.0V to 5.5V
Low Cost
Small Package Size 8 or 16 pin DIP or SOIC
Wide Q Range 0.5 to over 200
Wide Clock to Center/Corner Frequency Range 25:1 to over 200:1
Accurate Switched-Capacitor Technology

Applications

General Purpose Filtering
Portable Equipment
Instrumentation

Absolute Maximum Ratings

Power Supply Voltage	+6V
Storage Temperature	-60 to +150°C
Operating Temperture	0 to 70°C

Ordering Information

Part Number	Package	Operating Temperature
MSU1F1P	8 Pin DIP	0 - 70°C
MSU1F1S	8 Pin SOIC	0 - 70°C
MSU1F2P	8 Pin DIP	0 - 70°C
MSU1F2S	8 Pin SOIC	0 - 70°C
MSU1F3P	8 Pin DIP	0 - 70°C
MSU1F3S	8 Pin SOIC	0 - 70°C
MSU1F4P	8 Pin DIP	0 - 70°C
MSU1F4S	8 Pin SOIC	0 - 70°C
MSU2F1P	16 Pin DIP	0 - 70°C
MSU2F1S	16 Pin SOIC	0 - 70°C

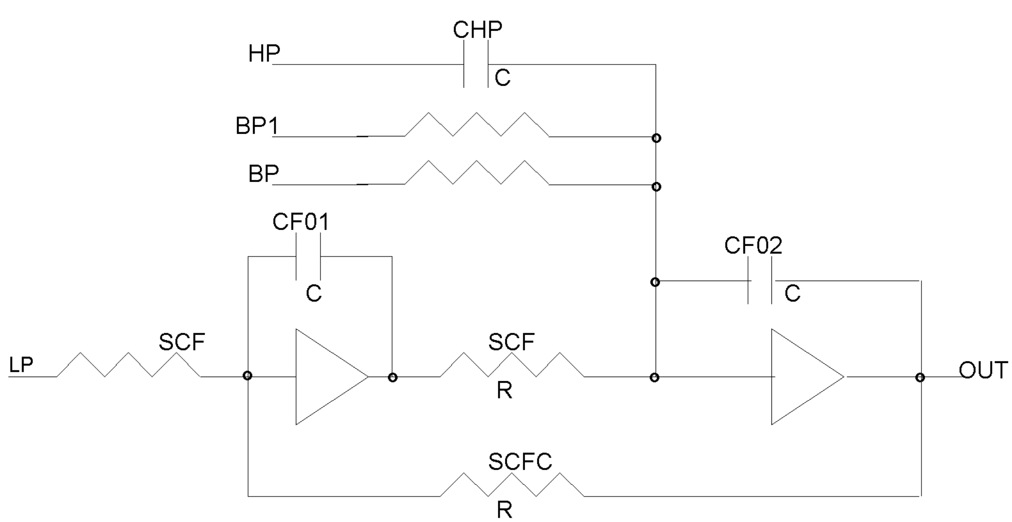
Electrical Characteristics

(VDD = +5V, T + 25 °C)

PARAMETER	SYMBOL	CONDITONS	MIN	TYP	MAX	UNITS
DC Specifications						
Operating Voltage	VDD		3.0	5.0	5.5	V
Supply Current	IDD	MSU2F1 PWR=1	100	200	300	µA
		MSU2F1 PWR=0	500	1000	2000	µA
		MSU1F1/3	50	100	200	µA
		MSU1F2/4	250	500	1000	µA
Output Impedance				700		Ω
Output Offset				20		mV
AC Specifications						
Output Swing			4.0	4.5		Vp-p
Input Impedance	Zin			1		MΩ
Nominal Clock to corner	Fo	MSU2F1 FO=1		25		
		FO=0		50		
		MSU1F1/2		25		
		MSU1F3/4		50		
Center/Corner Range		MSU2F1 PWR=1	3	6		kHz
note (1)		PWR=0	20	40		kHz
		MSU1F1/3	3	6		kHz
		MSU1F2/4	20	40		kHz
Clock Input Voltage	Ckin		0.1	note(2)	5	Vp-p

note(1): the sample to corner ratio is twice the clock to corner ratio
note(2): 100mV sine wave clock requires capacitive coupling, and fc‹100 kHz.

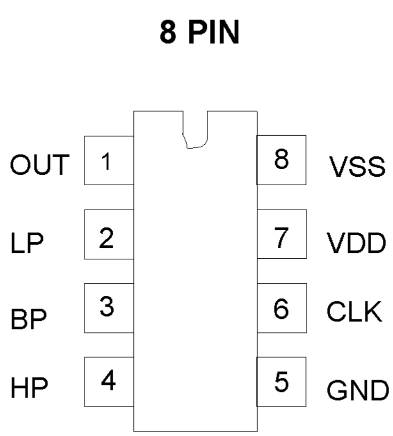
Block Diagram

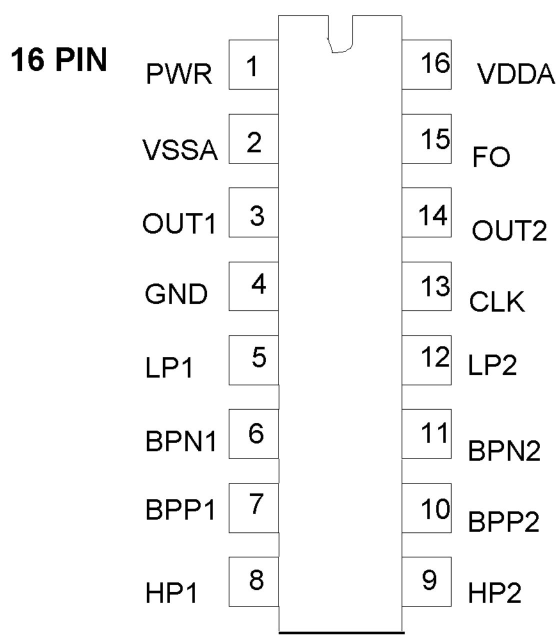


Pin Description

16 Pin	8 Pin		
1		PWR	Power Select Pin 0 = High 1 = Low
2	8	VSS	Negative Supply, Typically 0V for Single Supply, - 2.5 V for dual supply
3	1	OUT1	Section One Output
4	5	GND	Ground Reference, Typically 2.5V for Single Supply, OV for dual supply
5	2	LP1	Section One Lowpass Input
6	3	BPN1	Section One Negative Bandpass Input
7		BPP1	Section One Positive Bandpass Input
8	4	HP1	Section One High Pass Input
9		HP2	Section Two High Pass Input
10		BPP2	Section Two Positive Bandpass Input
11		BPN2	Section Two Negative Bandpass Input
12		LP2	Section Two Lowpass Input
13	6	CLK	Input Clock, CMOS Level, Typically 0 - 5V for single, supply 0 - 2.5V for dual supply
14		OUT2	Section Two Output
15		F0 note 1	Clock to Center/Corner, Select Pin, Low = 50 to 1 High = 25 to 1
16	7	VDD	Positive Supply, Typically 5V for single supply, 2.5V for dual supply

Pin Configuration



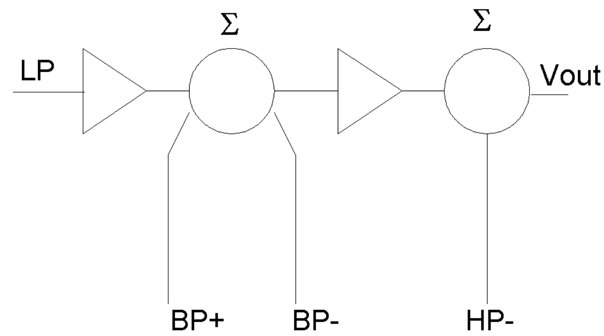


Resistor Programmable Universal Active Filter Data Sheet

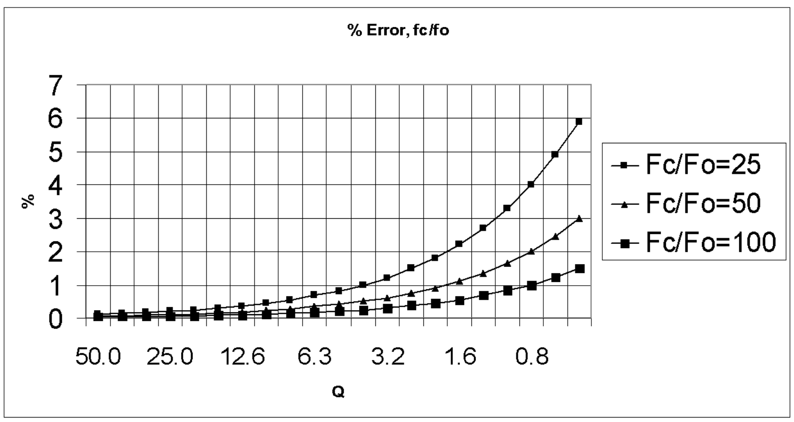
Filter Types Available

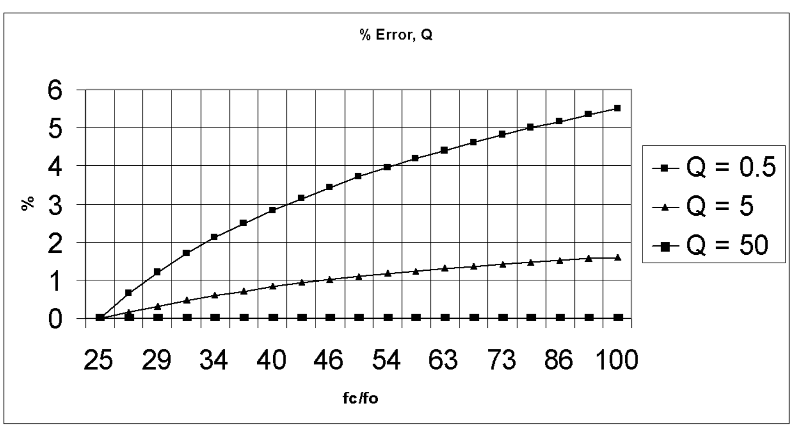
	MSU2F1	MSU1F2
Lowpass	yes	yes
Bandpass	yes	yes
Highpass	yes	yes
Lowpass eliptical	yes	yes
Highpass eliptical	yes	yes
Notch	yes	yes
Oscillator	yes	no
Allpass	yes	no
Biquad	yes	no

Block Diagram



Programming Non-Linearities





Transfer Functions

Lowpass

$$H(s) = \frac{-\omega_0^2}{S^2 + (\omega_0/Q)S + \omega_0^2}$$

Bandpass

$$H(s) = \frac{-(\omega_0/Q)S}{S^2 + (\omega_0/Q)S + \omega_0^2}$$

Highpass

$$H(s) = \frac{S^2}{S^2 + (\omega_0/Q)S + \omega_0^2}$$

Lowpass Elliptic

$$H(s) = \frac{(\omega_0/\omega_z)^2 S^2 + \omega_0^2}{S^2 + (\omega_0/Q)S + \omega_0^2}$$

Highpass Elliptic

$$H(s) = \frac{S^2 + (\omega_z/\omega_0)^2 \omega_0^2}{S^2 + (\omega_0/Q)S + \omega_0^2}$$

Notch

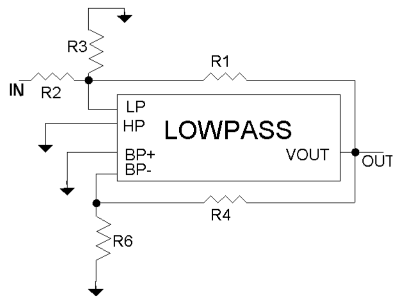
$$H(s) = \frac{S^2 + \omega_0^2}{S^2 + (\omega_0/Q)S + \omega_0^2}$$

Allpass

$$H(s) = \frac{S^2 - (\omega_0/Q)S + \omega_0^2}{S^2 + (\omega_0/Q)S + \omega_0^2}$$

NOTE: $\frac{f_c}{f_o} > 36$

For lowpass, lowpass elliptical, highpass elliptical, allpass and notch filters. This limitation due to the particular ratio of R_1 and R_2 and allows realizable values of R_3. Other minimum values of fc/fo can be obtained by using other values of R_1 and R_2 in the basic biquad equations.

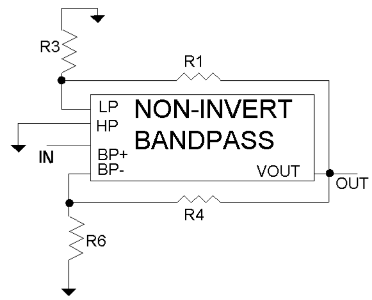


Assumption (1) $R_1 = R_2$; DC Gain = Unity

$$f_0 = \sqrt{K_1''}\ \frac{fc}{\propto} \qquad K_1'' = \frac{R_3}{R_1 + R_3}$$

$$Q = \frac{\sqrt{K_1''}}{K_2'} \qquad K_2' = \frac{R_6}{R_4 + R_6}$$

(1) If a gain other than unity is desired then gain = $\frac{R_1}{R_2}$ and K_1 from the biquad equations should be substituted for K_1''



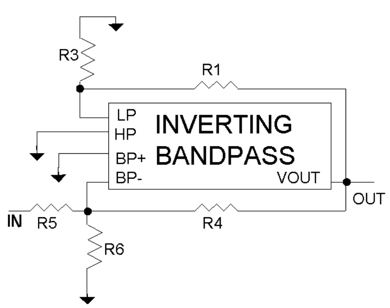
Gain(1) = $\frac{1}{K_2'}$

$$f_0 = \sqrt{K_1'}\ .\ \frac{fc}{\propto} \qquad K_1' = \frac{R_3}{R_1 + R_3}$$

$$Q = \frac{\sqrt{K_1'}}{K_2'} \qquad K_2' = \frac{R_6}{R_4 + R_6}$$

(1)Gain may be adjusted independent of G using the resistor divider described by K_5 from the biquad equations. Use the K_5 equation in place of K_2 for the gain equation only.

where $\propto$ = 25:1 or 50:1 depending upon the setting of fo.

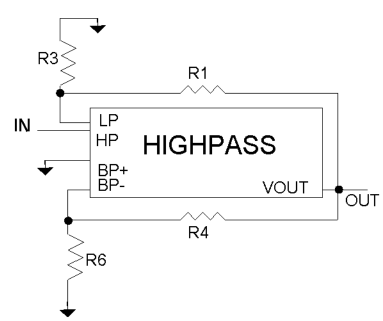


Assumption(1) $R_4 = R_5$; Gain = Unity

$$f_0 = \sqrt{K_1'}\ \frac{fc}{\propto} \qquad K_1' = \frac{R_3}{R_1 + R_3}$$

$$Q = \frac{\sqrt{K_1'}}{K_2''} \qquad K_2'' = \frac{R_6}{R_4 + 2R_6}$$

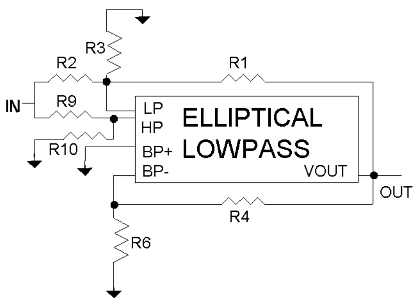
(1) For gains not equal to unity, gain = R_4/R_5 and K_2'' should be replaced with K_2 from the biquad equations.



Gain = Unity

$$f_0 = \sqrt{K_1'}\ \frac{fc}{\propto} \qquad K_1' = \frac{R_3}{R_1 + R_3}$$

$$Q = \frac{\sqrt{K_1'}}{K_2'} \qquad K_2' = \frac{R_6}{R_4 + R_6}$$



DC Gain (1) = Unity; R_1 = R2

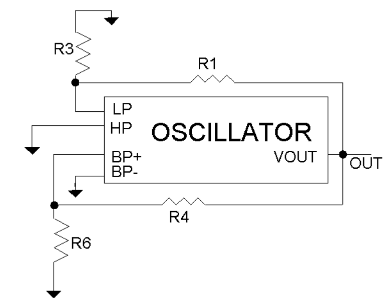
$f_0 = \sqrt{K_1} \cdot \frac{fc}{\alpha}$ $K_1 = \frac{R_3}{R_1 + R_3}$

$Q = \frac{\sqrt{K_1}}{K_2}$ $K_2 = \frac{R_6}{R_4 + R_6}$

$f_z = \sqrt{\frac{1}{K_3}} \cdot f_0$ $K_3 = \frac{R_{10}}{R_9 + R_{10}}$

(1) For gain other than unity, gain = R1/R2 and K1 should be substituted for K1. The $\sqrt{1/K3}$ term should also be multiplied by the gain.

(2) where α is 25 or 50 depending upon the setting of fo



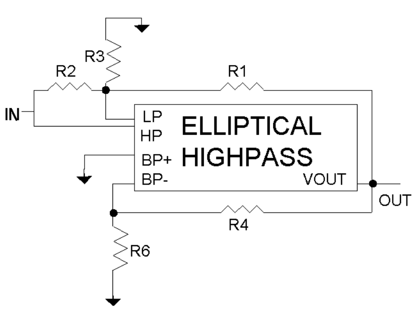
(1) $f_0 = \sqrt{\frac{R_3}{R_1 + R_3}} \cdot \frac{fc}{\alpha}$

(2) $\frac{R_4}{R_6} = 20$

(1) f_0 is also a function of the feedback coefficient defined by R_4 and R_6 and can vary considerably from the calculated value. For a fixed feedback coefficient, f_0 will not vary by more than plus or minus 1%.

(2) The distortion of the sine wave can be adjusted by varying this ratio.

(3) where α is 25 or 50 depending upon the setting of fo.



Gain = Unity

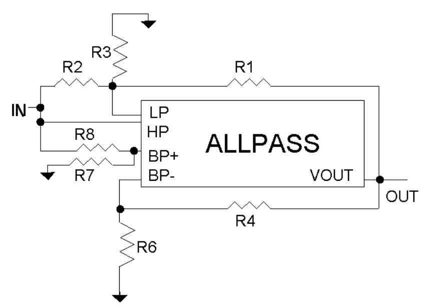
(1) $f_0 = \sqrt{K_1} \cdot \frac{fc}{\alpha}$

$Q = \frac{\sqrt{K_1}}{K_2}$ $K_1 = \frac{R_2R_3}{R_1R_2 + R_1R_3 + R_2R_3}$

$f_z = \sqrt{\frac{R1}{R_2}} \cdot f_0$ $K_2 = \frac{R_6}{R_4 + R_6}$

(1) For this case only, the resistor values R_1 and R_2 should be determined for f_z before the resistor values for f_0 (R_3) are calculated

(2) where α is 25 or 50 depending upon the setting of fo



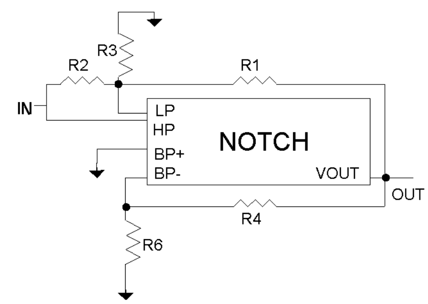
Gain = Unity; R_1 = R_2; R_7 = R_4; R_8 = R_6

$f_0 = \sqrt{K_1} \cdot \frac{fc}{\alpha}$ $K_1 = \frac{R_3}{R_1 + 2R_3}$

$Q = \frac{\sqrt{K_1}}{K_2}$ $K_2 = \frac{R_6}{R_4 + R_6}$

(1) where α is 25 or 50 depending upon the setting of fo.

Resistor Programmable Universal Active Filter
Data Sheet

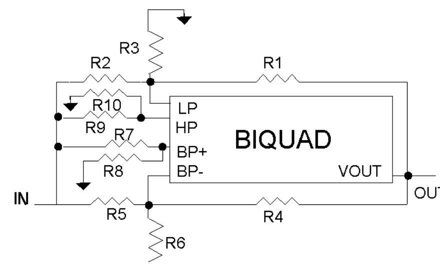


Gain = Unity; $R_1 = R_2$

$f_0 = \sqrt{K_1} \cdot \frac{fc}{\propto}$ $\quad K_1 = \frac{R_3}{R_1 + 2R_3}$

$Q = \frac{\sqrt{K_1}}{K_2}$ $\quad K_2 = \frac{R_6}{R_4 + R_6}$

where ∝ = 25:1 or 50:1 depending upon the setting of fo.



The biquad is the most general purpose filter type. By adjusting the values of K1 through K6, virtually any second order transfer function can be achieved. In some cases, it may be necessary to use an inverting op amp to achieve the correct polarity on these constants.

$$VOUT = VIN \frac{\left[-K_3S^2 - K_4S\frac{fc}{4} + K_5S\frac{fc}{4} - K_6\frac{fc^2}{16} \right]}{S^2 \quad K_2S\frac{fc}{4} + K_1\frac{fc^2}{16}}$$

$K_1 = \frac{R_2R_3}{R_1R_2 + R_1R_3 + R_2R_3}$ $\quad K_4 = \frac{R_4R_6}{R_4R_5 + R_4R_6 + R_5R_6}$

$K_2 = \frac{R_5R_6}{R_4R_5 + R_4R_6 + R_5R_6}$ $\quad K_5 = \frac{R_8}{R_7 + R_8}$

$K_3 = \frac{R_{10}}{R_g + R_{10}}$ $\quad K_6 = \frac{R_1R_3}{R_1R_2 + R_1R_3 + R_2R_3}$

MSU1F1/4,MSU2F1

Resistor Programmable Universal Active Filter

Data Sheet

Mixed Signal Integration
2157F O'Toole Avenue
San Jose, California 95131-1332
Phone: (408)-434-6305
Fax: (408)-434-6417

In western Pennsylvania, West Virginia, Ohio, Indiana, Kentucky and Michigan contact:

TechSide Sales
4068 Mount Royal Blvd.
Allison Park, Pennsylvania 15101
Telephone: 412-492-0777
Facsimile: 412-492-0780

In Mississippi, Alabama, Georgia South Carolina, North Carolina, and Tennessee contact:

Adeptronics
9694 Madison Boulevard Suite A-14
Madison, Alabama 35758
Telephone: 256-772-1922
Facsimile: 256-772-0323

In Arizona, Utah, Colorado, Montana, Wyoming, Idaho, and southern Nevada contact:
Nelco Electronix
6970 S. Holly Circle
Englewood, CO 80112
Telephone: 720-493-9630
Facsimile: 720-493-9631

In the San Francisco Bay Area contact:

CP Sales
P. O. Box 944
Soquel, California 95073
Telephone: 831-684-2464
Facsimile: 831-688-2629

In Taiwan contact:

Wintek Electronics Co., Ltd.
3F-3, No. 197, Sec 4, Nanking E Road
Taipei, Taiwan, R.O.C.
Telephone: 886-2-2712-5025
Facsimile: 886-2-2717-6960

In Hong Kong and the People's Republic of China contact:

Alphatron
2L, Cooke Street/F
G/F, Hung Hom
Kowloon Bay, Hong Kong
Telephone: 852-2303-1290
Facsimile: 852-2900-3616

In Korea contact:

H. B. Corp.
#1409, Seocho World Officetel,
1355-3, Seocho-Dong, Seocho-Ku,
Seoul, Korea 137-070
Telephone: (02)3472-3450
Facsimile: (02)3472-3458

In Singapore, Indonesia and Malaysia contact:

EXER Technologies (S) PTE LTD
45 Kaki Bukit Industrial Terrace
Singapore 416125
Telephone: (65)-6-747-9669
Facsimile: (65)-6-749-9669

In India contact:

WPI International (I) Pvt. Ltd.
405, Gateway Plaza
Hiranandani Gardens
Powai, Bombay 400 076
Telephone: 0091 22 570 5093
Facsimile: 0091 22 570 0594

In Israel contact:

Phoenix Technologies Ltd.
3 Gavish St.
Kfar-Saba, 44424
Israel
Telephone: 09-764-4800
Facsimile: 09-764-4801

In the United Kingdom contact:

Electronics 2000 Ltd.
Unit 4, Falcon Business Park
Ivanhoe Road, Finchampstead
Wokingham, Berks, RG40 4QQ
Telephone: 44-7074-432000
Facsimile: 44-7074-432329

Catch our web site at "http://www.mix-sig.com"

Send us e-mail at "info@mix-sig.com"

STANDARD PRODUCTS

MSGEQ5A	Five Band Graphic Equalizer
MSGEQ7	Seven Band Graphic Equalizer
MSHFS1-6	Selectable High Frequency LP/BP Filter
MSFS1-6	Selectable Lowpass/Bandpass Filter
MSCAHF	Selectable High Frequency Active Lowpass/Bandpass Filter
MSU1F1-4, MSU2F1	Resistor Programmable Universal Active Filter
MSU1HF1-4, MSU2HF1	High Frequency Resistor Programmable Universal Active Filter
MSELP	Switched Capacitor Elliptic Lowpass Filter with Op Amps
MSNBLP	Switched Capacitor Butterworth Lowpass Filter
MSLE/B/C5L/M	Switched Capacitor General Purpose Lowpass Filter
MS2LFS	Dual Selectable Low Voltage Lowpass/Bandpass Filter
MSHN1-6	Selectable High Pass/Notch Filter
MSRAAF	Resistor Programmable Active Audio Filter
MSRAHF	Resistor Programmable Active High Frequency Filter
MS2CAP	Two Channel Audio Processor
MS6CAP	Six Channel Audio Processor