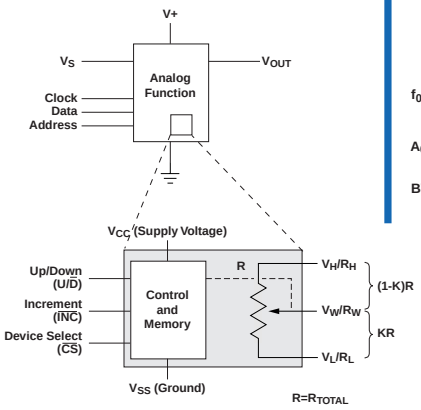
TECH BRIEF

The Premise

The computer has extended the capabilities of electronic products and systems by adding new dimensions of control, computation and programmability. The world of analog products, however, has not been able to take advantage of these advances. We can have the best of both worlds by combining Xicor digitally controlled potentiometers (XDCPs™) with standard analog functions. The XDCP allows the designer to "computerize" the analog function by PUTTING ANALOG ON THE BUS!



If the parameters of the analog function are varied using the XDCP, and the XDCP is controlled by a microprocessor, then the analog function is now digitally controlled.

ANY analog function whose functional specification depends on resistance is a candidate for "computerization" using XDCPs!

HOW MANY WAYS CAN YOU USE A PROGRAMMABLE RESISTOR?

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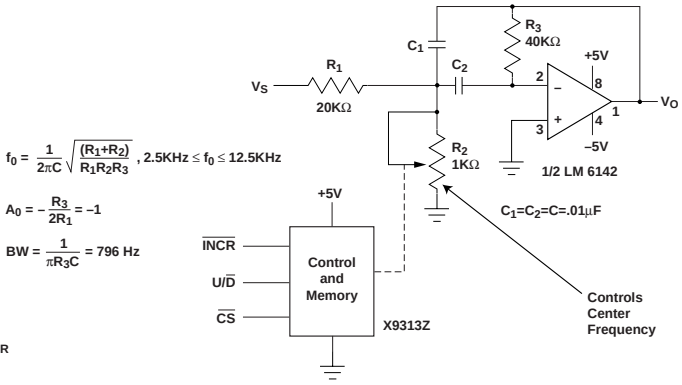
The Design: IMPLEMENTING PROGRAMMABLE BANDPASS FILTERS USING XDCPs

A common requirement in many signal processing applications is a bandpass filter network to precondition an input signal to a desired range of frequencies. Traditionally, this circuit has been implemented using basic analog building blocks (e.g. operational amplifiers) in conjunction with fixed resistors and capacitors to set the center frequency (f_0) of the bandpass filter.

The figure below shows a programmable infinite gain multiple feedback (IGMF) bandpass filter. These filters are characterized by a fixed, five component configuration.



$f_0 = \frac{1}{2\pi C}\sqrt{\frac{(R_1+R_2)}{R_1R_2R_3}}$, 2.5KHz ≤ f_0 ≤ 12.5KHz

$A_0 = -\frac{R_3}{2R_1} = -1$

$BW = \frac{1}{\pi R_3 C} = 796$ Hz

For this circuit, the gain V_0/V_S is given by

$$\frac{V_0}{V_S} = \frac{-s/R_1C}{s^2 + s(2/R_3C) + (R_1+R_2)/R_1R_2R_3C^2} = \frac{-A_0s(2\pi f_0/Q)}{s^2 + s(2\pi f_0/Q) + 2\pi f_0^2}$$

where A_0, f_0 and Q represent the passband gain, characteristic frequency and figure of merit, respectively. A problem common to most second order, active filters is the dependence of each of the filters parameters on the values of all or most circuit components. Ideally, one component would control a single parameter.

As the equation below shows, the filter center frequency f_0 controlled by R_2 is independent of gain A_0, and bandwidth.

$$f_0 = \frac{1}{2\pi C}\sqrt{\frac{R_1+R_2}{R_1R_2R_3}}, \quad 2.5\text{KHz} \le f_0 \le 12.5\text{KHz}$$

where R_2 is an XDCP, and R_1 and R_3 are fixed resistors used to set the gain and passband bandwidth of the filter. Hence, varying XDCP R_2 will change the center frequency, but not the gain or bandwidth of the filter.

A Xicor Design Education Series

Xicor Mixed Signal Products-Digitally Controlled Potentiometers

PRODUCT	DESCRIPTION	PKG CODE*	TEMP RANGE	IC (mA)	ISB (µA)	V_H/V_L	V+	V-	DATA SHEET	SAMPLES	PRODUCTION
Quad 256 Tap											
X9250U,T	Quad 256 tap XDCP, low power, SPI interface, dual supply	S24	C,I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9258U,T	Quad 256 tap XDCP, low power, two-wire interface, dual supply	S24	C,I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
Quad 64 Tap											
X9241Y,W U,M	Quad 64 tap XDCP, two-wire interface, single supply	P(20) S(20),V(20)	C,I	3	500	-5.5V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9400Y,W	Quad 64 tap XDCP, low power, SPI interface, dual supply	S24, V24	C,I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9401W	Quad 64 tap XDCP, low power, SPI interface, single supply	S24, V24	C,I	0.4	1	0V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9408Y,W	Quad 64 tap XDCP, low power, two-wire interface, dual supply	S24, V24	C,I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9409W	Quad 64 tap XDCP, low power, two-wire interface, single supply	S24, V24	C, I	0.4	1	0V to +5.5V	N/A	N/A	NOW	NOW	NOW
Dual 64 Tap											
X9221Y, W,U	Dual 64 tap XDCP, two-wire interface, single supply	P(20) S(20)	C,I	3	500	-5.5V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9410Y,W	Dual 64 tap XDCP, low power, SPI interface, dual supply	S24, V24	C,I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9411W	Dual 64 tap XDCP, low power, SPI interface, single supply	S24, V24	C,I	0.4	1	0V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9418Y,W	Dual 64 tap XDCP, low power, two-wire interface, dual supply	S24, V24	C,I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to +5.5V	NOW	NOW	NOW
X9419W	Dual 64 tap XDCP, low power, two-wire interface, single supply	S24, V24	C,I	0.4	1	0V to +5.5V	N/A	N/A	NOW	Q4	Q1/00
Single 100 Tap											
X9C102	Single 100 tap XDCP, 1k Ω increment/decrement interface, single supply	P, S	C, I	3	500	-5.5V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9C103	Single 100 tap XDCP, 10k Ω increment/decrement interface, single supply	P, S	C, I	3	500	-5.5V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9C104	Single 100 tap XDCP, 100k Ω increment/decrement interface, single supply	P, S	C, I	3	500	-5.5V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9C303	Single 100 tap XDCP, 32k Ω increment/decrement interface, single supply	P, S V8	C, I	3	500	-5.5V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9C503	Single 100 tap XDCP, 50k Ω increment/decrement interface, single supply	P, S	C, I	3	500	-5.5V to +5.5V	N/A	N/A	NOW	NOW	NOW
X9312W, Z,T	Single 100 tap XDCP, 1k Ω increment/decrement interface, 0-15V terminal voltage single supply	P, S, No V	C, I	3	1000	0 to +15V	N/A	N/A	NOW	NOW	NOW
X9317W,U	Single 100 tap XDCP, low power increment/decrement interface, single supply	P, S8 V8	C, I	0.4	1	0V to +5.5V	N/A	N/A	NOW	NOW	NOW
Single 64 Tap											
X9420Y,W	Single 64 tap XDCP, low power SPI interface, dual supply	S16, V14	C, I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9421W	Single 64 tap XDCP, low power SPI interface, single supply	S16, V14	C, I	0.4	1	0V to +5.5V	N/A	N/A	NOW	Q4	Q1/00
X9428Y,W	Single 64 tap XDCP, low power two-wire interface, dual supply	S16, V14	C, I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9429W	Single 64 tap XDCP, low power two-wire interface, single supply	S16, V14	C, I	0.4	1	0V to +5.5V	N/A	N/A	NOW	Q4	Q1/00
Single 32 Tap											
X9313Z, W,U	Single 32 tap XDCP, increment/decrement interface single supply	M, P, S	C, I C	3	500	-5V to +5V	N/A	N/A	NOW	NOW	NOW
X9315W,N	Single 32 tap XDCP, low power increment/decrement interface, single supply	M, P, S(8)	C, I	0.4	1	0V to +5.5V	N/A	N/A	NOW	NOW	NOW
Single 16 Tap											
X9116W	Single 16 tap XDCP, low power increment/decrement interface, single supply	S8, M8	C, I	0.4	1	0V to +5.5V	N/A	N/A	NOW	NOW	NOW
32 Tap PushPots											
X9511W,Z	Single 32 tap pushpot XDCP, pushbutton interface, single supply	P, S	C, I	3	500	-5V to +5V	N/A	N/A	NOW	NOW	NOW
Comparators											
X9440Y,W	Dual smart comparator with dual 64 tap XDCP, low power SPI interface, dual supply	S24, V24	C, I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9448Y,W	Dual smart comparator with dual 64 tap XDCP, low power two-wire interface, dual supply	S24, V24	C, I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
64 tap operational amplifiers											
X9430W	Dual operational amplifier with dual 64 tap XDCP, low power SPI interface, dual supply	S24, V24	C, I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW
X9438W	Dual operational amplifier with dual 64 tap XDCP, low power two-wire interface, dual supply	S24, V24	C, I	0.4	1	-5.5V to +5.5V	+2.7V to +5.5V	-2.7V to -5.5V	NOW	NOW	NOW

***PKG Codes: M=MSOP, P=PDIP, S=SOIC, V=TSSOP**
Resistor Values (Ohms): Z=1K, Y=2K, W=10K, U=50K, T=100K, M=2K, 10K, 10K, 50K, N=500K

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