



Digital Filter Demo for the Ez-Kit Lite

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This DSP EZ-Note describes a simple digital filter demonstration using the ADSP-2181 Ez-Kit Lite development board (ADDS-21XX-EZ-LITE.) This board is a low-cost evaluation/development board based on the ADSP-2181 digital signal processor (DSP.) It is assumed that a "default" installation of the Ez-Kit Lite software (included with the development kit) has been performed. This software includes the assembler, linker, simulator and prom splitter programs as well as a Windows based monitor program and various sample applications.

One of the included demonstration applications is a finite impulse response (FIR) filter program. This program implements various 256-tap FIR bandpass filters. The input to the filter can be either from the A/D converter of the on-board AD1847 codec or from a white noise audio sequence generated by the DSP. The various input sources and filters are selected by "clicking" on the appropriate buttons.

The source code for the FIR digital filter application is contained in the directory:

```
C:\ADI-DSP\21xx\EZKITL\2181\DSP\FIRDEMO
```

The DSP source file is FIRDEMO.DSP. The filter coefficients for the four FIR filters is contained in the files: FIR1.DAT, FIR2.DAT, FIR3.DAT and FIR4.DAT. The .INIT assembler directive is used to initialize the coefficient buffers with the filter coefficient values. For example, the lines:

```
.const      taps=256;
.var/pm/circ fir1_coefs[taps];
.init       fir1_coefs: <fir1.dat>;
```

are used by the assembler and linker tools to create and initialize the first filter coefficient buffer. The filter coefficient files are simple ASCII text files with filter coefficients stored as hex constants, one per line.

A simple DOS-based filter coefficient generator program (EZ-FIR.EXE) is available on the Analog Devices bulletin board. This program creates coefficient files in the format required by the linker. The EZ-FIR.EXE program can be used to generate a new set of filter coefficients. These coefficients can then be incorporated in the

FIRDEMO.DSP program by simply running the FIRDEMO.BAT file contained in the ..\FIRDEMO directory. This batch file assembles and links the FIRDEMO application and places the DSP executable file in the appropriate directory for use by the Ez-Kit Lite Monitor program. It is then possible to test the new filter by simply selecting the FILTER demo application which downloads the FIRDEMO.EXE DSP program to the Ez-Kit Lite board. Once the filter program has been downloaded to the Ez-Kit Lite board, the new filter can be activated by clicking on the appropriate button corresponding to the set of new filter coefficients.

The following steps outline the procedure for creating and testing a new digital filter:

- 1) Copy the EZ-FIR.EXE filter coefficient generator DOS program to the FIRDEMO directory (the default Ez-Kit Lite software installation would create the following path: C:\adi_dsp\21xx\ezkitl\2181\dsp\firdemo).
- 2) Create a "DOS box" by double-clicking on the MS-DOS prompt icon from the program manager window (or you may create the new coefficients from DOS before entering Windows).
- 3) Change to the FIRDEMO directory (an exercise in typing in long paths.) This can be done by typing:

```
CD \ADI-DSP\21xx\EZKITL\2181\DSP\FIRDEMO
```

4) As an example, we will design a low-pass filter with a cut-off frequency of 400 Hz. The FIRDEMO.DSP source code implements four bandpass filters with the filter coefficients stored in the data files FIR1.DAT, FIR2.DAT, FIR3.DAT and FIR4.DAT. If we create a new set of coefficients and place it in the appropriately named file, then the filter can be activated by selecting the corresponding "button" in the FILTERS demo of the Ez-Kit Monitor program. We will use the fourth set of filter coefficients for our new filter. To keep the original bandpass filter coefficients, we will copy them to another file:

```
COPY FIR4.DAT OLDFIR4.DAT
```

- 5) Run the EZ-FIR.EXE program. This is done by typing: **EZ-FIR**

The main menu of the filter design program should be displayed.

6) The following entries should be made in response to the program prompts:

Digital Filter Menu

- 1 ... Low pass filter
- 2 ... High pass filter
- 3 ... Band pass filter
- 4 ... Band stop filter
- 5 ... Hilbert transformer
- 6 ... Differentiator

Please enter filter type [1-6]: **1**

Window Types

- 1 ... Rectangular window
- 2 ... Triangular window
- 3 ... Hanning window
- 4 ... Hamming window
- 5 ... Generalized Hamming window
- 6 ... Kaiser-Bessel window

Please enter window type [1-6]: **1**

Enter filter length (max. 256): **256**

Enter sampling frequency in Hertz: **8000**

Enter cut-off frequency in Hertz: **400**

Enter filter gain factor [1]: **1**

Enter file name to store FIR filter design: **fir4.txt**

(The FIRDEMO program implements a 256-tap FIR filter. The AD1847 codec on the Ez-Kit Lite board is initialized to an 8000Hz sampling rate by the FIRDEMO program.)

Upon completion the EZ-FIR program creates two files. The file FIR4.TXT is an ASCII file which contains information about the filter and a listing of the filter coefficients (in both decimal, 16-bit quantized and 1.15 format.) These files can be viewed with the DOS edit program or by typing:

```
more<fir4.txt
```

to view the filter design information, or

```
more<fir4.dat
```

to view the actual filter coefficient data file.

7) To rebuild the FIRDEMO application type:

```
FIRDEMO.BAT
```

This invokes the 21xx assembler and linker producing a new DSP executable application containing the new filter coefficients. The FIRDEMO.BAT file contains the following assembler and linker command lines:

```
asm21 firdemo -2181  
ld21 firdemo -a ..\ezkit_lt -e ..\..\firdemo.exe
```

The -e switch creates the application named firdemo.exe and places it in the appropriate directory so that the monitor program can find it. (this is the directory: \ADI_DSP\21XX\EZKITL\2181\).

8) We are now ready to test the new filter. Start up the Ez-Kit Lite Monitor program from Windows (or you may use the "ALT-TAB" key sequence to switch to the monitor if it is already running under Windows.)

9) Select the FILTER demo by clicking on the FILTER demo button if the list of demos is displayed or by selecting the "Filtering" option under the DEMO menu item. This causes the new FIRDEMO.EXE program to be downloaded to the Ez-Kit Lite board. The monitor automatically starts execution of the program after downloading.

10) The list of filters and selection buttons should now be displayed. Select the "noise input" option to have the DSP generate a noise sequence for testing the filters. The button options for the first three filters should be unchanged (various bandpass filters.) But filter number four now selects the new filter coefficients generated by EZ-FIR. These were incorporated into FIRDEMO.EXE when the linker read in the FIR4.DAT filter coefficient file. If all has gone well, you should hear a low-pass filtered noise signal.

11) You can exit the filter demo and return to the main monitor screen. Then you can repeat the process by using the "ALT-TAB" key sequence to go to the DOS box and run the EZ-FIR program again to create a new filter. Just remember to select the correct sampling rate and number of points, etc. After EZ-FIR completes, run the FIRDEMO.BAT to rebuild the application. You can then "ALT-TAB" back to the monitor and select the FILTER demo again and test the new filter.

This simple example demonstrates some of the capabilities of the 21XX development tools and the Ez-Kit Lite board. New filters can be designed and tested without changing the source code. All filter coefficients are stored in the data files and the appropriate arrays are initialized by the linker. The C source code for the EZ-FIR program is also available on the bulletin board.

The source code for the DSP program (FIRDEMO.DSP) could also be modified to change sampling rates, the number of filter taps or to add windowing as desired. For more information about digital filters refer to the 21XX Applications Vol. 1 manual.

