

# Design and Analysis of Digital IIR, Fir Bandpass Filter using DSK6713 Kit



V. Rajendra Chary, M. Shiva Kumar, A. Ramakrishna Raju, M. Sandhya

**Abstract:** A digital filter is advantageous over analog filter. Some of its advantages are less complexity, flexibility, portability when compared with analog filters. In this paper, the design of digital IIR and FIR band pass filter is done using DSK6713 hardware kit, the software used is code composer studio 6.0.1. This code composer studio 6.0.1 is used to write the code in c language, which is then dumped on to DSK6713 kit, fda tool of matlab is used for designing coefficients for IIR and FIR filter. Further, the detailed design steps are illustrated in this paper.

**Keywords:** band pass filter, code composer studio, DSK6713, FIR filter, IIR filter.

## I. INTRODUCTION

The digital filter is very accurate and has linear phase (FIR filter). They are easy to simulate and design. Also adaptive filtering is possible. Analog to Digital conversions and vice-versa can be done easily for a digital filter [1]. A digital filter can be implemented using DSP processor. When compared with digital filter, analog filter is less accurate and adaptive filtering is a difficult task. Programmable coefficients are possible in digital filters but not in analog filters. The FIR filter response is computed by its present and previous values of input signals. This type of filter is non-recursive. The transfer function of FIR filter consists of zeros only. As a result, there is less probability for the filter to be unstable. A FIR filter, as its name indicates has finite impulse response. Coming to IIR filters, its response is computed by present and previous values of inputs and outputs. These filters are of recursive type. The transfer function of FIR and IIR filter contains both zeros and poles, so there is a probability of filter becoming unstable if not designed properly [2]. DSK6713 is a low cost development platform that allows researchers to evaluate and develop DSP applications. DSK6713 contains onboard USB emulator,

SDRAM, ROM, AIC CODEC for ADC and DAC embedded JTAG emulation support. DSP industry's first fully developed IDE tool is code composer studio. It has DSP specific libraries and functions that make debugging and execution faster.

CC Studio provides many chip support library files for linking the basic operations of on-chip CODEC, DIP switches, LED lights and many other components of DSK6713.

The remaining part of the paper is organized as follows: TMS320C6713 DSP KIT is discussed in section II. CODE COMPOSER STUDIO V6.0.1 is explained in section III. DESIGN OF FILTER is discussed in section IV. IMPLEMENTATION AND RESULTS are discussed in section V. APPLICATIONS are discussed in section VI. We conclude in section VII.

## II. TMS320C6713 DSP KIT

The DSK [3] comes with a full package of on-board devices that is suitable for wide variety of Application environments.

The main features:

- A Texas Instruments TMS320C6713 DSP operating at 225 MHz.
- An AIC23 stereo codec.
- 4 user accessible LEDs and DIP switches.
- 16 MBs of synchronous DRAM.
- 512 KBs of non-volatile Flash memory (256 KBs usable in default configuration).
- Software board configuration through registers implemented in CPLD.
- Single voltage power supply (+5V).
- Configurable boot options.
- Standard expansion connectors for daughter card use.
- JTAG emulation through on-board JTAG emulator with USB host interface or external emulator.

The figure 1 illustrates the block diagram of DSK6713 kit. This consists of 32-bit EMIF for the SDRAM and daughter card expansion interface. The AIC23 CODEC is used for transmitting and receiving signals. This audio input/output can be done through a 3.5mm audio jack that connects to microphone in, line in, line out and headphone output. McBSP0 is used for codec control interface and McBSP1 is used for data transmission [4].

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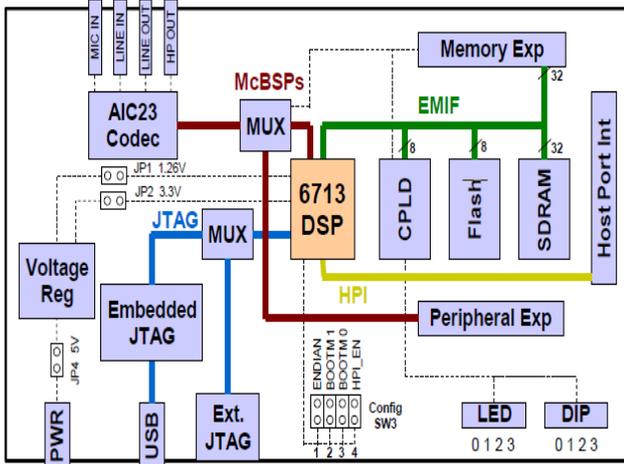


Figure 1. DSK6713 block diagram

Either microphone-in or line-in can be connected to codec for input signal and either headphone-out or line-out can be connected for the purpose of output. The line-out is a fixed gain and the headphone is an adjustable gain connector. To provide a user with interactive feedback the DSK provides with 4 DIP switches and 4 LEDs. The board is powered on by an external 5V power supply. The voltage regulator onboard provides 1.26V as DSP core voltage, 3.3V analog and 3.3V digital voltages [5].

The DSK can be programmed and communicated by CC studio through an embedded JTAG emulator with a USB host interface. Fig 2 shows physical layout of DSK6713. Spectrum Digital designs and manufactures the board, where as the C6713, which performs core DSP related operations is from Texas Instruments [6].

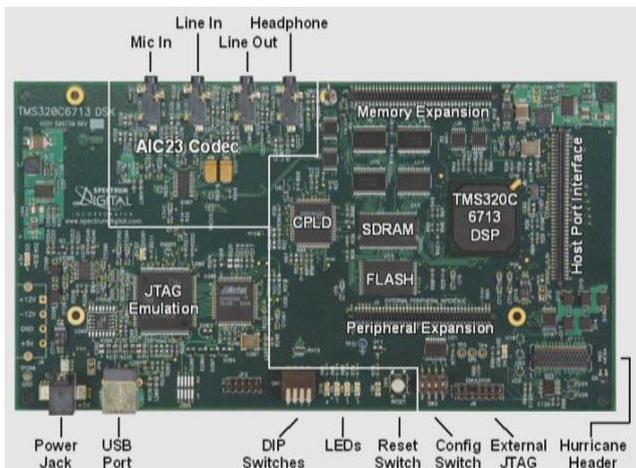


Figure 2. DSK6713 kit

**Board Layout:**

The C6713 DSK is a 8.75 x 4.5 inch (210 x 115 mm.) multi-layer board which is powered by an external +5 volt only power supply. Figure 3 shows the layout of the C6713 DSK.

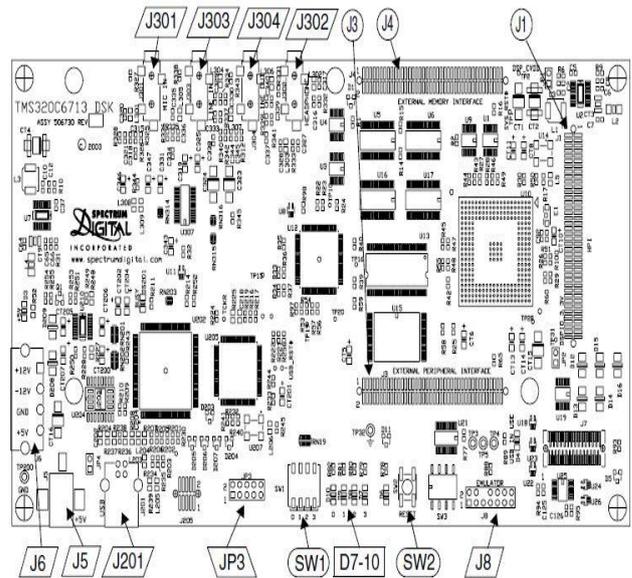


Figure 3. DSK6713 Board Layout

In DSP operations the most extensively used operation is MAC (Multiply and Accumulate) [7]. This operation is inbuilt and can be performed as a single instruction using 6713 DSK. The AIC23 codec chip is usually a 2-channel audio input output device.

**III. CODE COMPOSER STUDIO V6.0.1**

In this section, we will discuss the procedural steps of CC Studio v6.0.1.

**Step 1:** Double click on code composer studio short cut icon, then create location for workspace and click on OK.

**Step 2:** Go to project and select new ccs project, following window present in figure 4 will be displayed. Give the required inputs such as project name, kit specifications and click on OK.

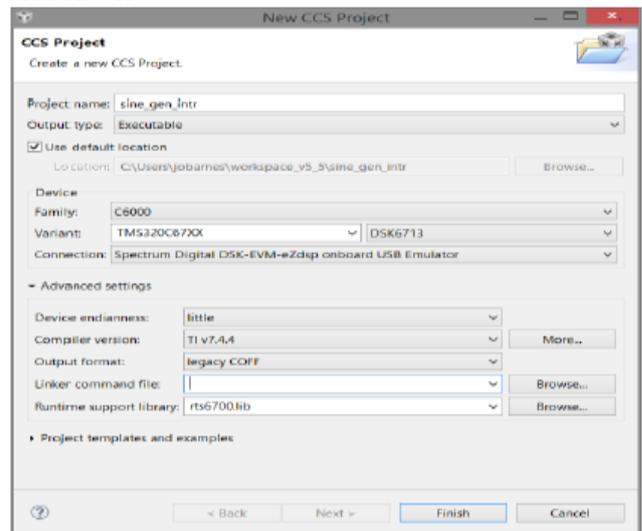


Figure 4. Create a new CCS project

**Step 3:** Go to project properties window. Click on the project name. -> Project -> Properties.



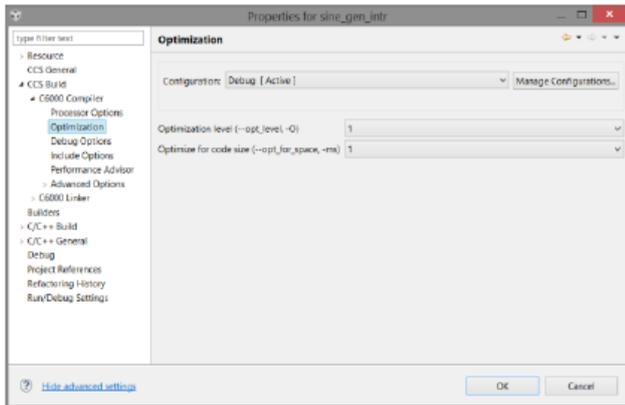


Figure 5. Project properties window

**Step 4:** Select the Target processor version. Go to Build and C6000 Compiler and Processor option. Enter 6700 in the blank space.

**Step 5:** Setting optimization level=1: Go to Build and C6000 Compiler and Optimization and set the value to 1.

**Step 6:** To select Include Options: Go to Build and C6000 Compiler and Include Options [5]. The window shows two blank spaces, to which the proper paths need to be added. The first path is added by the CCS, which points to the core library functions. The second path points to the board and chip support libraries. These include files and chip support library files are as shown in Fig 6.

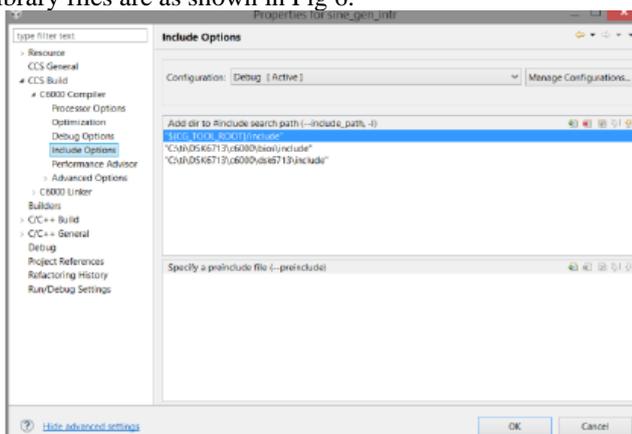


Figure6. Include settings window

**Step 7:** Select the predefined symbols. Go to Build - C6000 Compiler - advanced options - Predefined Symbols. Enter CHIP\_6713 to the pre-defined name blank space.

**Step 8:** Linking the paths: Go to Properties – Build - C6000 Linker - File Search Path. Add “libc.a”, “csl6713.lib”, “dsk6713bsl.lib” to the top panel.

**Step 9:** Now type the program in the source file and save it.

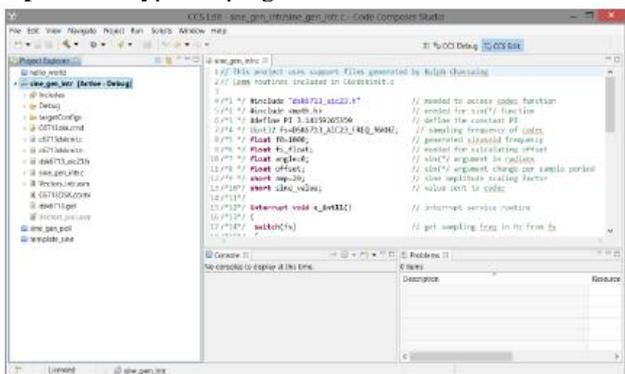


Figure 7. CCS edit window

**Step 10:** Go to Project >Build project. If there are any errors in the code, errors will be displayed at bottom(console window),rectify the errors and go to next step, if there are no errors after building the code, directly go to next step

**Step 11:** Run →Debug.

**Step 12:** After the program is loaded successfully, click Run→Terminate the program

**Step 13:** After terminating the program hear the output from MICOUT (Headphone or speakers or line out is connected)

#### IV. DESIGN OF FILTER

##### A. IIR filter design specifications:

- Sampling frequency = 50 KHz
- Stop band frequency1 = 500 Hz
- Pass band frequency1 = 1 KHz
- Pass band frequency2 = 3 KHz
- Stop band frequency2 = 4KHz

The coefficients of IIR filter are designed from MATLAB using fda tool, which generates the filter coefficients. The coefficients obtained from fda tool is stored in a file (for eg. “bpiirfilter.cof”). Figure 8 shows the fda tool window of MATLAB used to design IIR filter for given specifications.

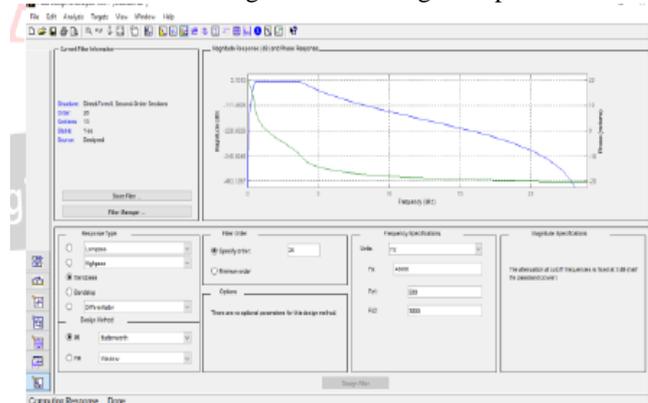


Figure 8.IIR filter magnitude and phase response

The pole-zero plot is illustrated in figure 9 for an IIR filter for the given specifications.

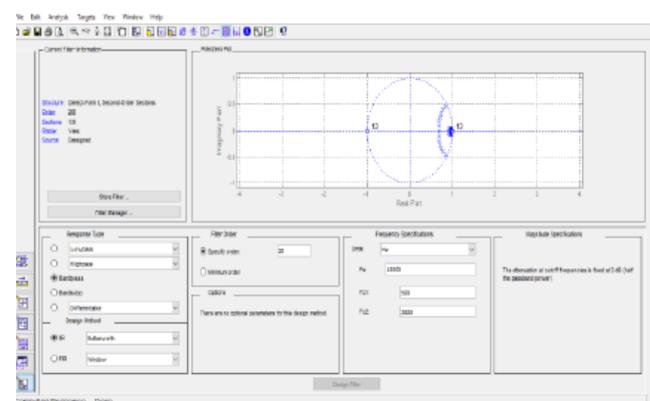
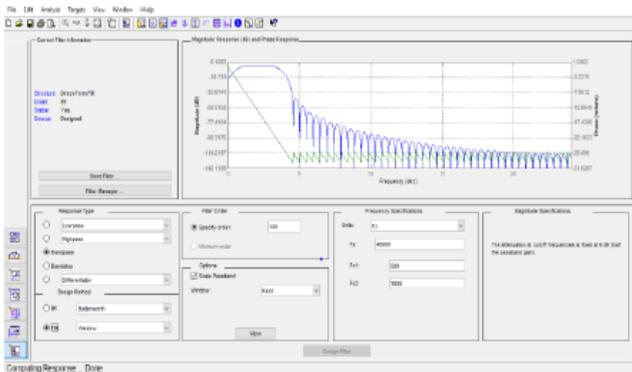


Figure 9.IIR filter pole-zero plot

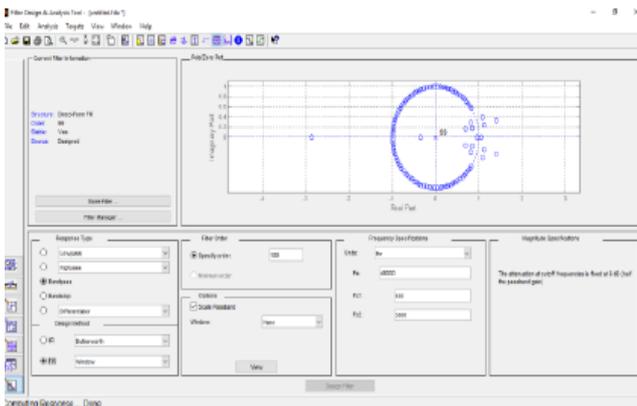
**B. FIR filter design specifications:**

- Sampling frequency = 50 KHz
- Stop band frequency1 = 500 Hz
- Pass band frequency1 = 1 KHz
- Pass band frequency2 = 3 KHz
- Stop band frequency2 = 4 KHz

The coefficients of FIR filter for these above specifications obtained from matlab using fda tool is stored in the file (for eg. “bpfirfilter.cof”). Fig 10 and 11 shows the fda tool screen for designing of FIR filter along with frequency response and its pole-zero plot.



**Figure 10.FIR filter magnitude and phase response**

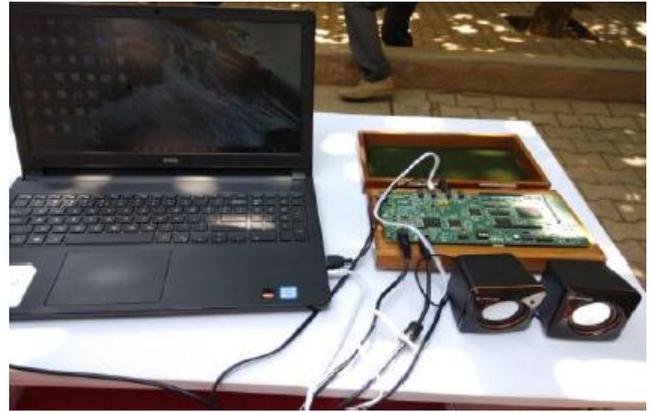


**Figure 11.FIR filter pole-zero plot**

**V. IMPLEMENTATION AND RESULTS**

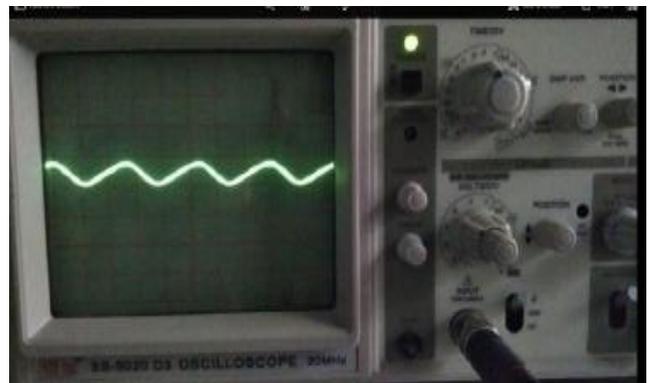
The designed filter coefficients are used in C code which is run on cc studio and then dumped on the DSK6713 processor along with all supporting files. Figure 12 shows the real-time implementation of the work.

The audio input is given to LINE\_IN and filtered output is taken from LINE\_OUT. Either a sine wave from the signal generator or an audio input can be given as input signal and the output can be seen on a CRO for observing the amplitude levels in pass band and stop band regions of the filter by varying the input signal frequencies or it can be heard through a pair of speakers.



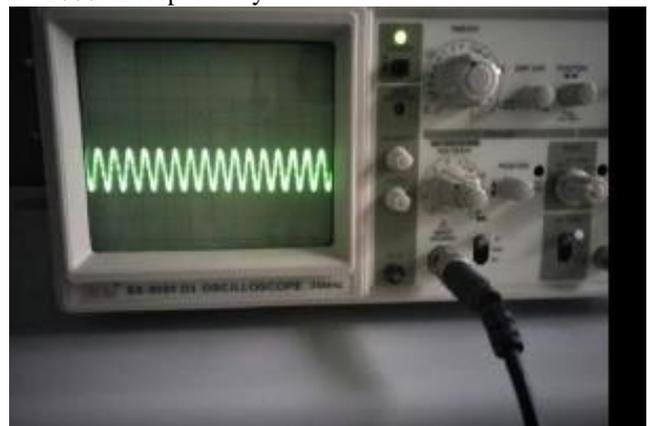
**Figure 12. Real time Implementation**

An input sine wave signal with 1Vpp and variable frequency range is set for illustration. The results of filter outputs are shown in following figures for the different cases.



**Figure 13.FIR filter output for input signal frequency=100Hz**

Figure 13 and 14 gives the stop band and pass band operations of FIR filter for input signal frequency of 100Hz and 2000Hz respectively.



**Figure 14.FIR filter output for input signal frequency=2000Hz**

Figure 15 and 16 gives the stop band and pass band operations of IIR filter for input signal frequency of 2KHz and 4KHz respectively.

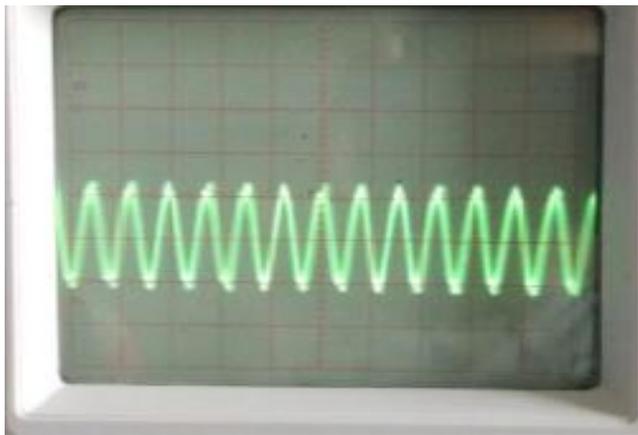


Figure 15. IIR filter output for input signal frequency= 2KHz



Figure 16. IIR filter output for input signal frequency= 4KHz

From the above results, we observe that FIR filter gives better performance when compared with IIR filter with respect to distortion and attenuation levels.

## VI. APPLICATIONS

A DSK6713 can be used for direct programming applications from simulink using embedded c code compiler process. This kit is also found important in audio echo, filtering, speaker recognition and many other fields.

Digital filters have wide area of applications in communication field for removing signal harmonics, noise and interferences.

## VII. CONCLUSION

In this paper, the DSK6713 kit features along with procedural steps using cc studio v6.0.1 are discussed. The band pass FIR and IIR filter outputs are verified for different input specifications. From the illustrations, we conclude that a FIR filter are always (or almost) stable and provides distortion-less output signal in its pass band region where as stability is the major problem in IIR filter. From the Implementation and Results, it is clear that IIR filter offers less attenuation level and FIR filter offers high attenuation levels in the stop band region.

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## REFERENCES

1. R. Chassaing, D. Reay, "Digital Signal Processing and Applications with the TMS3206713 and TMS320C6416 DSK", 2nd edition, John Wiley, 2008.
2. Ramesh Babu, "Digital Signal Processing", Sixth edition
3. TMS320C6713 DSK Technical Reference, SPECTRUM DIGITAL, INC
4. Nasser K, Namjin K, "Real-time Digital Signal Processing based on TMS320C6000", ISBN-0-7506-7830-5
5. N. Wong and C. U. Lei, "IIR approximation of FIR filters via discrete-time vector fitting," *IEEE Trans. Signal Process.*, vol. 56, no.3, pp. 1296–1302, Mar. 2008.
6. <http://www.ti.com/tool/TMDSEMU100V2U-14T>
7. A. Krukowski and I. Kale, "DSP System Design: Complexity Reduced IIR Filter Implementation for Practical Applications", Kluwer, Norwell, MA, 2003.