Experiment # 2 - Filters

Supplement

1. **Modifying the Digital Filter in Real-Time**

   The objective of this part is to verify the output of a signal travelling through a band-pass channel. In this part of the experiment, keep your input signal as a 1.5KHz square wave, $1V_{pp}$. You can think of this signal as the signal "containing" your information. You will pass this signal through two different channels. You will switch between the filters by writing the coefficients of the filters directly from `Matlab` to the memory location of the target hardware in which they are to be stored.

   The software packages in use here allow for the designer to access, read and write contents in memory while the processor runs. This is to say that if you have two different sets of coefficients (usually stored as a vector in `Matlab`), you can build one filter model and test different sets of coefficients for that same model, provided that you are using filters of the same order. The **order** of a digital filter. For this case, the order of your filter will be the number of the coefficients of the numerator plus one. In this part of the experiment, you are required to modify the coefficients of your filter directly on the memory of your DSP platform while it runs. This is done by "exporting" the filter coefficients from the filter design tool into `Matlab` and then to the memory of the target hardware.

   Since you have a low pass filter already designed and running, you will substitute the existing coefficients by those of a new filter, which will be a band-pass filter. Notice that when you "export" coefficients from the filter design tool, you will be required to specify names for a *numerator* and for a *denominator*. The *numerator* will hold the coefficients that you are interested in. For an FIR filter, they represent the discrete-time impulse response of the filter you have designed,and the length of this *numerator* is the order you chose for your filter, plus one. In your case, the *denominator* is always one.

   The tricky task for this part of your lab is to identify where the original coefficients are stored in memory, so that one can read from and write to that location (search for "rtP" on your project in CCS). Having identified where is the location of the data you wish to modify, use the commands "read" and "write" from within `Matlab` to execute your task. First, however, re-design your band-pass filter according to the specifications given in the first section. Then, utilize the File/Export tool in the Digital Filter Design block to send the coefficients into a vector (a variable) in the `Matlab` workspace (call the *numerator* variable "bpf").

   On the `Matlab` command window, type "who" to assure that your new coefficients are there. With the system running, read the coefficients that are residing in memory, by typing on the command window:

```
lpf=read(CCS_Obj,address(CCS_Obj,'rtP'),'double',order_plus_one)
length(lpf)
```

By "length of filter plus one", it is meant **a value** that represents the number of filter coefficients stored in memory. These coefficients, for an FIR filter, represent the *numerator* of the filter transfer function. You have now created the variable "lpf" in `Matlab`. Then, write the **new** coefficients into memory by typing:

```
write(CCS_Obj,address(CCS_Obj,'rtP'),double(bpf))
```

Your **band-pass filter** is running now. You can use the program provided in the previous section to verify the results in the frequency domain. If you want to return to the original low-pass filter, you can type:

```
write(CCS_Obj,address(CCS_Obj,'rtP'),double(lpf))
```

Note that "lpf" was the name of the variable you created when you read the coefficients from memory.

Having done all that, answer the questions below.

- *Draw below the outputs (time domain) for the two filters.*

- *What fundamental limit does the bandwidth of the communication channel impose on the binary data being sent through it? Identify one or more measures to be taken in order to compensate for the limitations of the communication channel.(this question is to get you thinking about ECE417)*