

APPENDIX A

LISTING OF THE SOURCE CODE

function varargout = firrec(varargin)

```
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',    mfilename, ...
                  'gui_Singleton', gui_Singleton, ...
                  'gui_OpeningFcn', @firrec_OpeningFcn, ...
                  'gui_OutputFcn', @firrec_OutputFcn, ...
                  'gui_LayoutFcn', [], ...
                  'gui_Callback', []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end
if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

function firrec_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);
function varargout = firrec_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;
setappdata(gcf, 'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
cf = str2num(get(hObject, 'String'));
if(( cf > 1) | (cf < 0))
    set(hObject, 'String', 0);
    errordlg('cutoff frequency must be between 0 and 1','Error ');
end
```

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data = getappdata(gcf, 'UserData');
data.cf = cf;
setappdata(gcf, 'UserData', data);
function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=ones(1,data.N+1);    %Rectangular window
b = fir1(data.N,data.cf,w)
freqz(b,1,1024);
xlabel('Normalized frequency');
ylabel('Gain, dB');

function listbox1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox1_Callback(hObject, eventdata, handles)

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=ones(1,data.N+1);    %Rectangular window
b = fir1(data.N,data.cf,w)
set(handles.listbox1, 'String', b);

function varargout = firkai(varargin)

function firkai_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);
% --- Outputs from this function are returned to the command line.

function varargout = firkai_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;
setappdata(gcf, 'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
cf = str2num(get(hObject, 'String'));
if(( cf > 1) | (cf < 0))

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        set(hObject, 'String', 0);
        errordlg('cutoff frequency must be between 0 and 1','Error ');
    end

    data = getappdata(gcf, 'UserData');
    data.cf = cf;
    setappdata(gcf, 'UserData', data);

function edit4_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit4_Callback(hObject, eventdata, handles)
beta = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.beta = beta;
setappdata(gcf, 'UserData', data);

function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=kaiser(data.N+1,data.beta);%Kaiser window
b = fir1(data.N,data.cf,w)
freqz(b,1,1024);
xlabel('Normalized frequency');
ylabel('Gain, dB');
function edit5_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit5_Callback(hObject, eventdata, handles)
function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=kaiser(data.N+1,data.beta);%Kaiser window
b = fir1(data.N,data.cf,w)
set(handles.edit5, 'String', b);
function varargout = firbla(varargin)

function firbla_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

function varargout = firbla_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;

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setappdata(gcf,'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
cf = str2num(get(hObject,'String'));
if(( cf > 1) | (cf < 0))
    set(hObject,'String', 0);
    errordlg('cutoff frequency must be between 0 and 1','Error ');
end
data = getappdata(gcf, 'UserData');
data.cf = cf;
setappdata(gcf, 'UserData', data);
function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=blackman(data.N+1); %Blackman window
b = fir1(data.N,data.cf,w)
freqz(b,1,1024);
xlabel('Normalized frequency');
ylabel('Gain, dB');

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=blackman(data.N+1);
b = fir1(data.N,data.cf,w)
set(handles.listbox1, 'String', b);

function listbox1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox1_Callback(hObject, eventdata, handles)
function varargout = firhan(varargin)

function firhan_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

function varargout = firhan_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject,'String'));
data = getappdata(gcf, 'UserData');

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data.N = N;
setappdata(gcf, 'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
cf = str2num(get(hObject, 'String'));
if(( cf > 1) | (cf < 0))
    set(hObject, 'String', 0);
    errordlg('cutoff frequency must be between 0 and 1','Error ');
end

data = getappdata(gcf, 'UserData');
data.cf = cf;
setappdata(gcf, 'UserData', data);

function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=hann(data.N+1);      %Hanning window
b = fir1(data.N,data.cf,w)
freqz(b,1,1024);
xlabel('Normalized frequency');
ylabel('Gain, dB');

function listbox1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox1_Callback(hObject, eventdata, handles)

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
w=hann(data.N+1);      %Hanning window
b = fir1(data.N,data.cf,w)
set(handles.listbox1, 'String', b);

function varargout = IIRell(varargin)

function IIRell_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

function varargout = IIRell_OutputFcn(hObject, eventdata, handles)

varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else

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        set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
    end

function edit1_Callback(hObject, eventdata, handles)
    N = str2num(get(hObject, 'String'));
    data = getappdata(gcf, 'UserData');
    data.N = N;
    setappdata(gcf, 'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
    Rp = str2num(get(hObject, 'String'));
    data = getappdata(gcf, 'UserData');
    data.Rp = Rp;
    setappdata(gcf, 'UserData', data);

function edit4_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit4_Callback(hObject, eventdata, handles)
    Wn = str2num(get(hObject, 'String'));
    data = getappdata(gcf, 'UserData');
    data.Wn = Wn;
    setappdata(gcf, 'UserData', data);

function edit5_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit5_Callback(hObject, eventdata, handles)
    Rs = str2num(get(hObject, 'String'));
    data = getappdata(gcf, 'UserData');
    data.Rs = Rs;
    setappdata(gcf, 'UserData', data);

function pushbutton1_Callback(hObject, eventdata, handles)
    data = getappdata(gcf, 'UserData');
    [b,a] = ellip(data.N,data.Rp,data.Rs,data.Wn);
    disp(b)
    disp(a)
    w= 0:0.01/pi:pi;
    h = freqz(b,a,w);
    plot (w/pi,20*log10(abs(h)));grid;
    xlabel('\omega/\pi'); ylabel('Gain, dB');

function listbox1_CreateFcn(hObject, eventdata, handles)

```

```

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox1_Callback(hObject, eventdata, handles)

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = ellip(data.N,data.Rp,data.Rs,data.Wn);
set(handles.listbox1, 'String', b);

function listbox3_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox3_Callback(hObject, eventdata, handles)

function pushbutton3_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = ellip(data.N,data.Rp,data.Rs,data.Wn);
set(handles.listbox3, 'String', a);

function varargout = IIRch(varargin)

function IIRch_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

function varargout = IIRch_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;
function edit1_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;
setappdata(gcf, 'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)

```

```

Rp = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.Rp = Rp;
setappdata(gcf, 'UserData', data);

function edit4_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit4_Callback(hObject, eventdata, handles)
Wn = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.Wn = Wn;
setappdata(gcf, 'UserData', data);

function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = cheby1(data.N,data.Rp,data.Wn,'high');
disp(b);
disp(a)
w= 0:0.01/pi:pi;
h = freqz(b,a,w);
plot (w/pi,20*log10(abs(h)));grid;
xlabel('\omega/\pi'); ylabel('Gain, dB');

function listbox1_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox1_Callback(hObject, eventdata, handles)

function listbox2_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox2_Callback(hObject, eventdata, handles)

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = cheby1(data.N,data.Rp,data.Wn,'high');
set(handles.listbox1, 'String', b);

function pushbutton3_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = cheby1(data.N,data.Rp,data.Wn,'high');
set(handles.listbox2, 'String', a);

```


function varargout = IIRblp(varargin)

```
function IIRblp_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);
```

```
function varargout = IIRblp_OutputFcn(hObject, eventdata, handles)
```

```
varargout{1} = handles.output;
```

```
function edit1_CreateFcn(hObject, eventdata, handles)
```

```
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
```

```
function edit1_Callback(hObject, eventdata, handles)
```

```
N = str2num(get(hObject,'String'));
data = getappdata(gcf,'UserData');
data.N = N;
setappdata(gcf,'UserData', data);
```

```
function edit2_CreateFcn(hObject, eventdata, handles)
```

```
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
```

```
function edit2_Callback(hObject, eventdata, handles)
```

```
fc= str2num(get(hObject,'String'));
data = getappdata(gcf,'UserData');
data.fc = fc;
setappdata(gcf,'UserData', data);
```

```
function edit4_CreateFcn(hObject, eventdata, handles)
```

```
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
```

```
function edit4_Callback(hObject, eventdata, handles)
```

```
fs = str2num(get(hObject,'String'));
data = getappdata(gcf,'UserData');
data.fs = fs;
setappdata(gcf,'UserData', data);
```

```
function pushbutton1_Callback(hObject, eventdata, handles)
```

```
data = getappdata(gcf,'UserData');
[b,a] = butter(data.N,data.fc/(0.5*data.fs));
freqz(b,a,128,data.fs)
% xlabel('Normalized frequency');
ylabel('Gain, dB');
y = [b; a];
```

```

fid = fopen('blp.cff','w');
fprintf(fid,'%4.14f   %2.14f\n',y);
fclose(fid)

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = butter(data.N,data.fc/(0.5*data.fs));
set(handles.listbox1, 'String', b);

function pushbutton3_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = butter(data.N,data.fc/(0.5*data.fs));
set(handles.listbox2, 'String', a);

function listbox1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox1_Callback(hObject, eventdata, handles)

function listbox2_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox2_Callback(hObject, eventdata, handles)

function varargout = IIRbhp(varargin)

function IIRbhp_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

function varargout = IIRbhp_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;
setappdata(gcf, 'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc

```

```

    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
fc= str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.fc = fc;
setappdata(gcf, 'UserData', data);

function edit4_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit4_Callback(hObject, eventdata, handles)
fs = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.fs = fs;
setappdata(gcf, 'UserData', data);

function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = butter(data.N,data.fc/(0.5*data.fs),'high');
freqz(b,a,128,data.fs)
ylabel('Gain, dB');
y = [b; a];
fid = fopen('bhp.cff','w');
fprintf(fid,'%4.14f    %2.14f\n',y);
fclose(fid)

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = butter(data.N,data.fc/(0.5*data.fs),'high');
set(handles.listbox1, 'String', b);

function pushbutton3_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[b,a] = butter(data.N,data.fc/(0.5*data.fs),'high');
set(handles.listbox2, 'String', a);

function listbox1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox1_Callback(hObject, eventdata, handles)

function listbox2_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));

```

```

end

function listbox2_Callback(hObject, eventdata, handles)

function varargout = IIRbu(varargin)
function IIRbu_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);
function varargout = IIRbu_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;
function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;
setappdata(gcf, 'UserData', data);
function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit2_Callback(hObject, eventdata, handles)
W1= str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.W1 = W1;
setappdata(gcf, 'UserData', data);

function edit4_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit4_Callback(hObject, eventdata, handles)
W2 = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.W2 = W2;
setappdata(gcf, 'UserData', data);

function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
M=data.N/2;
Wn=[data.W1 data.W2]
[b,a] = butter(M,Wn);
disp(b)
disp(a)
w= 0:0.01/pi:pi;
h = freqz(b,a,w);
gain = 20*log10(abs(h));
plot (w/pi,gain);grid;
xlabel('Normalized frequency'); ylabel('Gain, dB');

```

```

function pushbutton2_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
M=data.N/2;
Wn=[data.W1 data.W2]
[b,a] = butter(M,Wn);
set(handles.listbox1, 'String', b);

function pushbutton3_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
M=data.N/2;
Wn=[data.W1 data.W2]
[b,a] = butter(M,Wn);
set(handles.listbox2, 'String', a);

function listbox1_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function listbox1_Callback(hObject, eventdata, handles)

function listbox2_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function listbox2_Callback(hObject, eventdata, handles)

function varargout = IIRimpv(varargin)
function IIRimpv_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

function varargout = IIRimpv_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;
setappdata(gcf, 'UserData', data);

function edit2_CreateFcn(hObject, eventdata, handles)

if ispc
    set(hObject,'BackgroundColor','white');
else

```

```

    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit2_Callback(hObject, eventdata, handles)
Wn= str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.Wn = Wn;
setappdata(gcf, 'UserData', data);

```

```

function edit4_CreateFcn(hObject, eventdata, handles)

```

```

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit4_Callback(hObject, eventdata, handles)
Fs = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.Fs = Fs;
setappdata(gcf, 'UserData', data);

```

```

function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[num,den]=butter(data.N,data.Wn,'s');
%
%      Convert analogue filter into Discrete IIR filter
%
[b, a]=impinvar(num, den, data.Fs);          %Determine coeffs of IIR filter
subplot(2,1,2)                               % Plot magnitude freq. response
[h, omega]=freqz(b, a, 512);
mag = 20*log10(abs(h))
plot(omega/pi,mag);grid;
xlabel('Normalized Frequency ')
ylabel('Gain dB')

```

```

function varargout = IIRbil(varargin)

```

```

function IIRbil_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

```

```

function varargout = IIRbil_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

```

```

function edit1_CreateFcn(hObject, eventdata, handles)

```

```

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit1_Callback(hObject, eventdata, handles)
N = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.N = N;
setappdata(gcf, 'UserData', data);

```

```

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
Wn= str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.Wn = Wn;
setappdata(gcf, 'UserData', data);

function edit4_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit4_Callback(hObject, eventdata, handles)
Fs = str2num(get(hObject, 'String'));
data = getappdata(gcf, 'UserData');
data.Fs = Fs;
setappdata(gcf, 'UserData', data);

function pushbutton1_Callback(hObject, eventdata, handles)
data = getappdata(gcf, 'UserData');
[num,den]=butter(data.N,data.Wn,'s');
%
% Convert analogue filter into Discrete IIR filter
%
[b, a]=bilinear(num, den, data.Fs);           %Determine coeffs of IIR filter
disp(a)
disp(b)
subplot(2,1,2)                               % Plot magnitude freq. response
[h, omega]=freqz(b, a, 512);
mag = 20*log10(abs(h))
plot(omega/pi,mag);grid;
xlabel('Normalized Frequency ')
ylabel('Gain dB')

function dfd(fcn)

if nargin == 0
    fcn = 'makeGUI';
end

switch fcn

case 'makeGUI'

    % ===Create main figure=====

    fig = figure('Position',centerfig(660,630),...
        'Resize','on',...
        'NumberTitle','off',...
        'Name','Digital Filter Design',...
        'Interruptible','off',...

```

```

'Menubar','none',...
'Color',get(0,'DefaultUIControlBackgroundColor'));

%====A menu=====
f = uimenu(gcf,'Label','FIR Design');
    uimenu(f,'Label','by Rectangular window','Callback','firrec');
    uimenu(f,'Label','by kaiser window','Callback','firkai');
    uimenu(f,'Label','by Blackman window','Callback','firbla');
    uimenu(f,'Label','by hanning window','Callback','firhan');
m = uimenu(gcf,'Label','IIR Design');
    uimenu(m,'Label','Elliptic','Callback','IIRell');
    uimenu(m,'Label','Chebyshev','Callback','IIRch');
    uimenu(m,'Label','Butterworth lowpass ','Callback','IIRblp');
    uimenu(m,'Label','Butterworth highpass ','Callback','IIRbhp');
    uimenu(m,'Label','Butterworth bandpass ','Callback','IIRbu');
    uimenu(m,'Label','Impulse Invariance Method','Callback','IIRimpv');
    uimenu(m,'Label','Bilinear Transformation Method','Callback','IIRbil');
e = uimenu(gcf,'Label','End Program');
    uimenu(e,'Label','Quit','Callback','close',...
        'Accelerator','C');

%      'Separator','on','Accelerator','Q');
end

%====A utility to center the window on the screen=====
function pos = centerfig(width,height)
screen_s = get(0,'ScreenSize'); % Find the screen size in pixels
pos = [screen_s(3)/2 - width/2, screen_s(4)/2 - height/2, width, height];

```


Digital filter design

Digital filter design requires the use of both frequency domain and time domain techniques. This is because filter design specifications are often given in the frequency domain, but filters are usually implemented in the time domain with a difference equation. Typically, frequency domain analysis is done using the Z-transform and the discrete-time Fourier Transform (DTFT). In general, a linear and time-invariant causal digital filter with input $x(n)$ and output $y(n)$ may be specified by its difference equation)

$$y(n) = \sum_{i=0}^{N-1} b_i x(n-i) - \sum_{k=1}^M a_k y(n-k) \quad (1)$$

where b_i and a_k are coefficients which parameterize the filter. This filter is said to have N zeros and M poles. Each new value of the output signal, $y(n)$, is determined by past values of the output, and by present and past values of the input. The impulse response, $h(n)$, is the response of the filter to an input of $\delta(n)$ and is therefore the solution to the recursive difference equation

$$h(n) = \sum_{i=0}^{N-1} b_i \delta(n-i) - \sum_{k=1}^M a_k h(n-k) \quad (2)$$

There are two general classes of digital filters: infinite impulse response (IIR) and finite impulse response (FIR). The FIR case occurs when $a_k = 0$, for all k . Such a filter is said to have no poles, only zeros. In this case, the difference equation (2) becomes

$$h(n) = \sum_{i=0}^{N-1} b_i \delta(n-i) \quad (3)$$

Since (3) is no longer recursive, the impulse response has finite duration N . In the case where $a_k \neq 0$, the difference equation usually represents an IIR filter. In this case, (2) will usually generate an impulse response which has non-zero values as $n \rightarrow \infty$. The Z-transform is the major tool used for analyzing the frequency response of filters and their difference equations. The Z-transform of a discrete-time signal, $x(n)$, is given by

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

The DTFT may be thought of as a special case of the Z-transform where z is evaluated on the unit circle in the complex plane.

$$\begin{aligned}
X(e^{j\omega}) &= X(z)|_{z=e^{j\omega}} \\
&= \sum_{n=-\infty}^{\infty} x(n)e^{-j\omega n}
\end{aligned}$$

From the definition of the Z-transform, a change of variable $m = n - K$ shows that a delay of K samples in the time domain is equivalent to multiplication by z^{-K} in the Z-transform domain

$$X(n-k) \xleftrightarrow{Z} \sum_{n=-\infty}^{\infty} x(n-k)z^{-n}$$

$$X(n-k) = \sum_{m=-\infty}^{\infty} x(m)z^{-(m+k)}$$

$$X(n-k) = z^{-K} \sum_{m=-\infty}^{\infty} x(m)z^{-m}$$

$$X(n-k) = z^{-K} X(z)$$

We may use this fact to re-write Eq. (1) in the Z-transform domain, by taking Z-transforms of both sides of the equation:

$$Y(z) = \sum_{i=0}^{N-1} b_i z^{-i} X(z) - \sum_{k=1}^M a_k z^{-k} Y(z)$$

$$Y(z) \left(1 + \sum_{k=1}^M a_k z^{-k} \right) = X(z) \sum_{i=0}^{N-1} b_i z^{-i}$$

$$H(z) \triangleq \frac{Y(z)}{X(z)} = \frac{\sum_{i=0}^{N-1} b_i z^{-i}}{1 + \sum_{k=1}^M a_k z^{-k}}$$

From this formula, we see that any filter which can be represented by a linear difference equation with constant coefficients has a rational transfer function (i.e. a transfer function which is a ratio of polynomials). From this result, we may compute the frequency response of the filter by evaluating $H(z)$ on the unit circle:

$$H(e^{j\omega}) = \frac{\sum_{i=0}^{N-1} b_i e^{-j\omega i}}{1 + \sum_{k=1}^M a_k e^{-j\omega k}}$$