Contents

make sure that field_init has been called

```
eval('field_init(0)','1;')
```

```
*---------------------------------------------------------*
*                                                         *
*                      F I E L D   I I                    *
*                                                         *
*              Simulator for ultrasound systems           *
*                                                         *
*             Copyright by Joergen Arendt Jensen          *
*    Version 3.24, May 12, 2014 (Matlab 8.20 version)     *
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*---------------------------------------------------------*
```

DEFINE ARRAY

```
c = 1540;                    % Speed of sound
f0 = 2.5e6;                  % Transducer center frequency [Hz]
fs = 50e6;                  % Sampling frequency [Hz]
lambda = c/f0;               % Wavelength
element_height = 13/1000;    % Height of element [m] (elevation direction)
pitch = 0.290/1000;          % Distance between element centers
kerf = 0.025/1000;           % Width of fill material between the ceramic elements
element_width = pitch-kerf; % Element width [m] (azimuth direction)
Rfocus = 60/1000;            % Elevation lens focus (or radius of curvature, ROC)
focus = [0 0 60]/1000;       % Fixed emitter focal point [m] (irrelevant for single element
 transducer)
N_elements = 64;             % Number of physical elements in array
N_sub_x = 5;                 % Element sub division in x-direction
N_sub_y = 15;                % Element subdivision in y-direction
apodTx = 0;                  % Transmit apodization. 0:boxcar, 1:Hanning, 2:Cosine-tapered
```

```
0.3
apodRx = 0;                 % Receive apodization. 0:boxcar, 1:Hanning, 2:Cosine-tapered 0
.3
dynamic_receive_focus = 1;  % Enable dynamic receive focusing.
simType = 'txrx';             % Simulation type. Transmit:'tx', receive:'rx', pulse-echo:'
txrx'
```

GENERATE TRANSMIT AND RECEIVE APERTURE

```
emit_aperture = xdc_focused_array (N_elements, element_width, element_height, kerf, Rfocus
, N_sub_x, N_sub_y, focus);
receive_aperture = xdc_focused_array (N_elements, element_width, element_height, kerf, Rfo
cus, N_sub_x, N_sub_y, focus);

eval('close(1)','1;')
% figure(1)
% show_xdc_geir(emit_aperture, 1);
% axis equal; view(3)
% h_txAp = gcf;
```

SET THE IMPULSE RESPONSE AND EXCITATION OF THE TRANSMIT AND RECEIVE APERTURE

```
t_ir = -2/f0:1/fs:2/f0;
Bw = 0.6;
impulse_response=gauspuls(t_ir,f0,Bw);
set_sampling(fs);
xdc_impulse (emit_aperture, impulse_response);
xdc_impulse (receive_aperture, impulse_response);
```

```
Warning:  Remember to set all pulses in apertures for the new sampling frequency
```

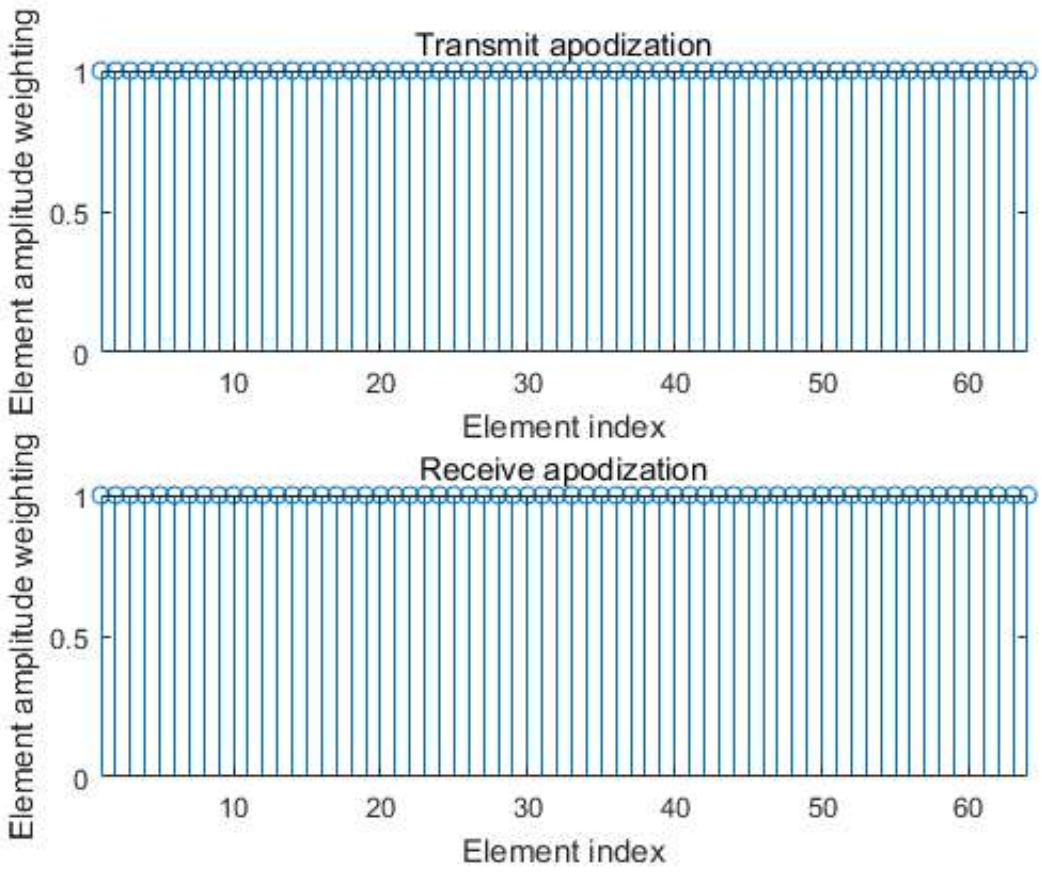
SET THE EXCITATION OF THE TRANSMIT APERTURE

```
ex_periods = 1.5;
t_ex=(0:1/fs:ex_periods/f0);
excitation=square(2*pi*f0*t_ex);
xdc_excitation (emit_aperture, excitation);
```

DEFINE APODIZATION FOR THE EMIT APERTURE

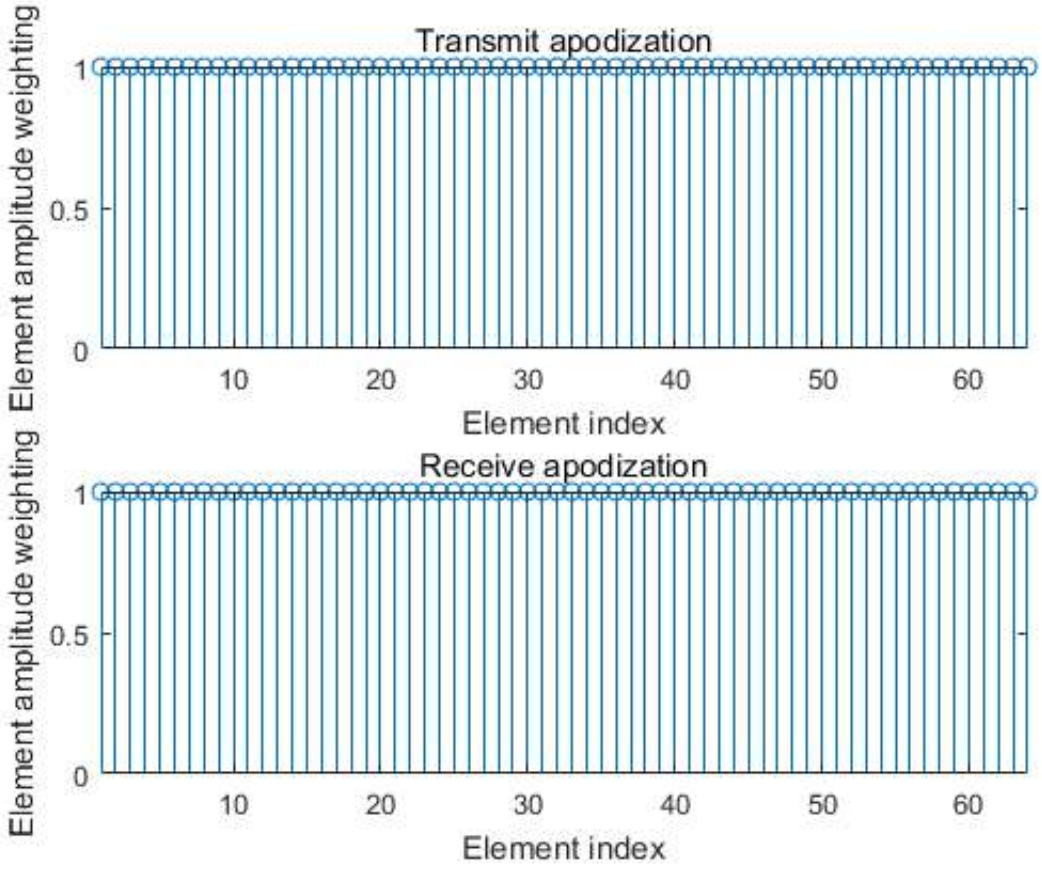
```
switch apodTx
    case 0
        apo_emit = ones(1,N_elements);   % Rectangular apodization
    case 1
        apo_emit = hanning(N_elements)'; % Hanning apodization on the emit-apperture
    case 2
        apo_emit = tukeywin(N_elements,  0.3)'; % Cosine-tapered apodization
end
xdc_apodization(emit_aperture, 0, apo_emit);
figure(2)
subplot(211)
stem(apo_emit);
```

```
title('Transmit apodization');
xlabel('Element index');
ylabel('Element amplitude weighting');
axis tight
ylim([0 1]);
```



DEFINE APODIZATION FOR THE RECEIVE APERTURE

```
switch apodRx
    case 0
        apo_receive = ones(1,N_elements);    % Rectangular apodization
    case 1
        apo_receive = hanning(N_elements)'; % Hanning apodization on the emit-apperture
    case 2
        apo_receive = tukeywin(N_elements,  0.3)'; % Cosine-tapered apodization
end
xdc_apodization(receive_aperture, 0, apo_receive);
figure(2)
subplot(212)
stem(apo_receive);
title('Receive apodization');
xlabel('Element index');
ylabel('Element amplitude weighting');
axis tight
ylim([0 1]);
```



DEFINE MEASUREMENT POINTS

```
measDepthStart = 5/1000;     % Start depth along z-axis to place measurement points
measDepthEnd = 150/1000;     % End depth along z-axis to place measurement points
xStart = -15/1000;       % Start position of measurement points in x direction
xEnd = 15/1000;          % End position of measurement points in x direction

Nmpx = 81;
Nmpz = 59;
mx = linspace(xStart,xEnd,Nmpx)';
my = zeros(Nmpx*Nmpz, 1);
mz = linspace(measDepthStart,measDepthEnd,Nmpz)';
[X,Z] = meshgrid(mx,mz);
measurement_points = [X(:),my,Z(:)];
% figure(h_txAp);
% hold on;
% plot3(measurement_points(:,1)*1000,measurement_points(:,2)*1000,measurement_points(:,3)*
1000, 'o', 'linewidth', 6)
% axis tight
```

CALCULATE PRESSURE OR SENSITIVITY

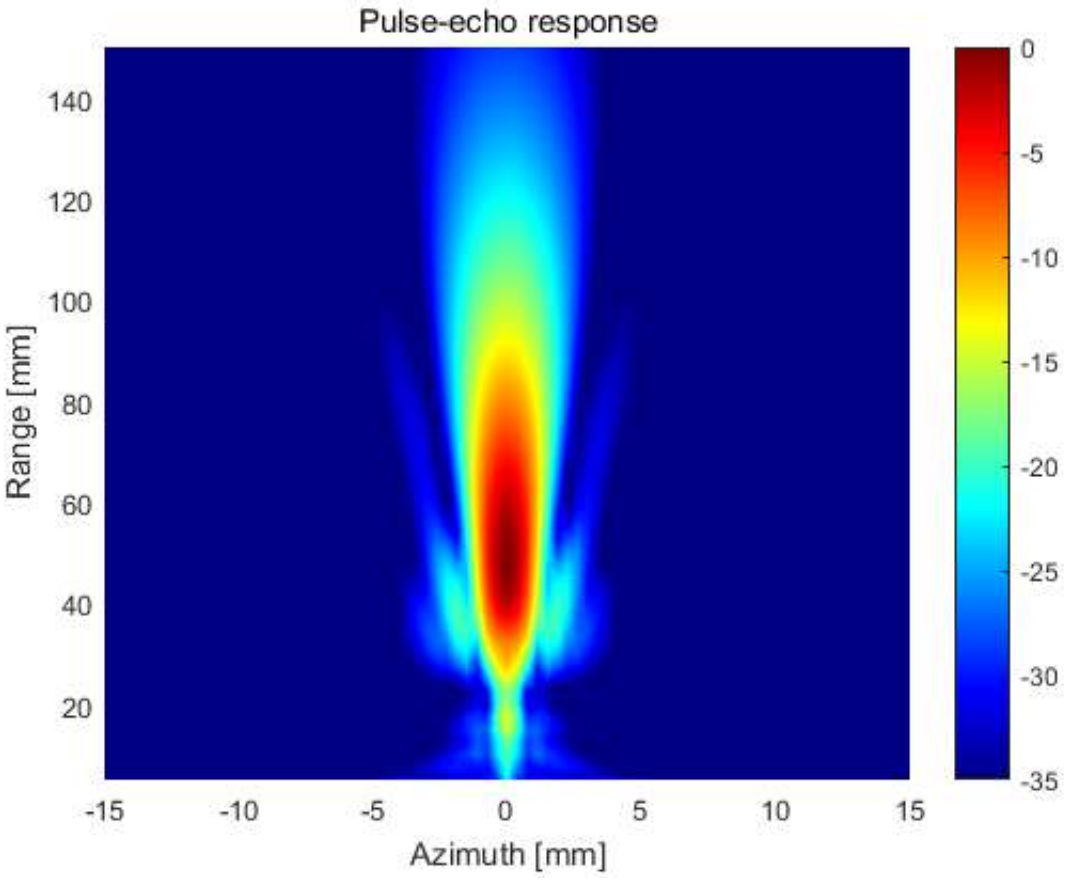
```
switch simType
    case 'tx'
        disp('Calculating transmit pressure');
        [simData, startTime] = calc_hp(emit_aperture, measurement_points);
        figTitle = 'Transmit pressure field';
    case 'rx'
        disp('Calculating receive sensitivity');
        if dynamic_receive_focus
            xdc_dynamic_focus(receive_aperture, 0, 0, 0)
        end
```

```
        [simData, startTime] = calc_hp(receive_aperture, measurement_points);
        figTitle = 'Receive sensitivity';
    case 'txrx'
        disp('Calculating pulse-echo response');
        if dynamic_receive_focus
            xdc_dynamic_focus(receive_aperture, 0, 0, 0)
        end
        [simData, startTime] = calc_hhp(emit_aperture, receive_aperture, measurement_point
s);
        figTitle = 'Pulse-echo response';
end
```

```
Calculating pulse-echo response
 3 seconds used for the calculation
```

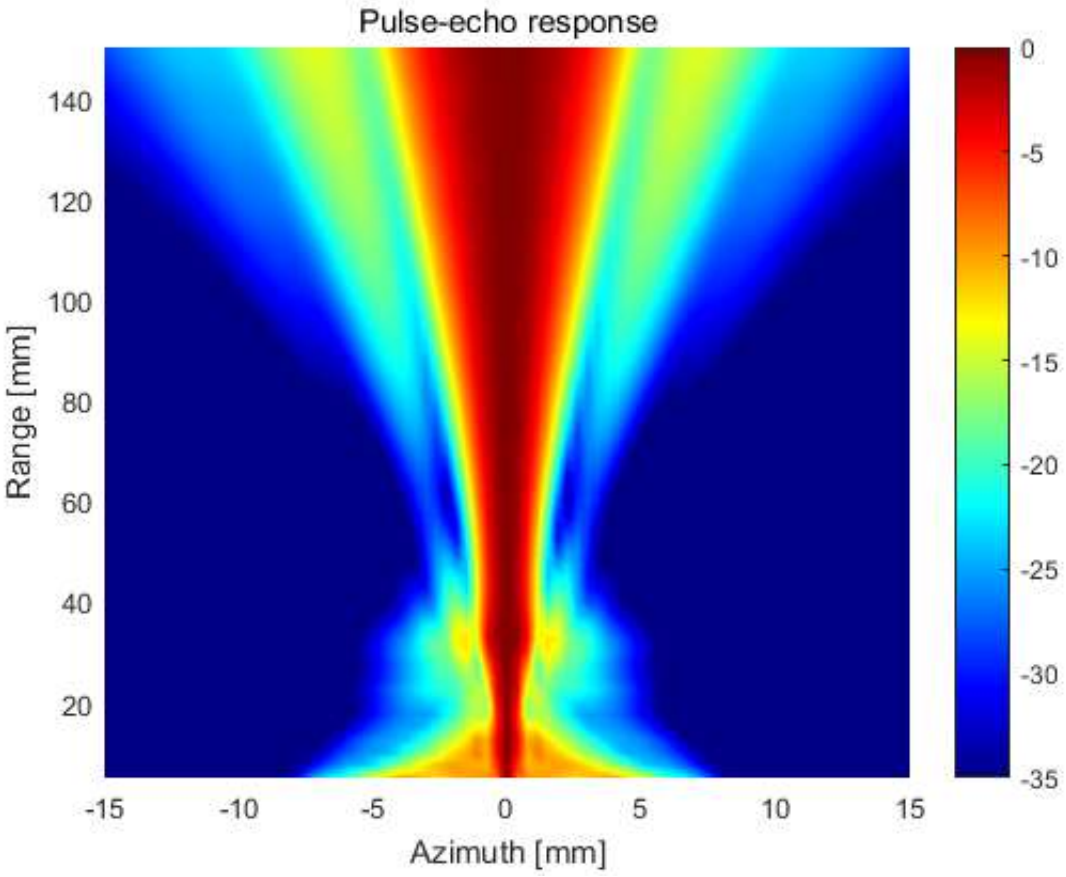
PLOT RESULTS

```
figure(4)
bp = sqrt(mean(simData.^2));
bp = reshape(bp, Nmpz, Nmpx);
bp=bp/max(bp(:));
pcolor(mx*1000, mz*1000, 20*log10(bp));
shading interp
title(figTitle)
xlabel('Azimuth [mm]');
ylabel('Range [mm]');
caxis([-35 0]); % Set dynamic range
colormap(jet(256));
colorbar
```



PLOT BP NORMALIZED AT EACH DEPTH

```
figure(5)
bp= bp./repmat(max(bp')', 1,Nmpx);
pcolor(mx*1000, mz*1000, 20*log10(bp));
shading interp
title(figTitle)
xlabel('Azimuth [mm]');
ylabel('Range [mm]');
caxis([-35 0]); % Set dynamic range
colormap(jet(256));
colorbar
```



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