mt360_ur7_7_3_1 Wave Polarization

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Title

```
Authors: Ulaby and Ravaioli
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Description

The electric field of a plane wave is given by

$$E(z,t) = \hat{x}\sin(\omega t - kz) + \hat{y}2\cos(\omega t - kz)$$

This assignment has an interactive plot which allows you to control

- Ex_mag - The x component magnitude of the electric field, V/m
- Ey_mag - The y component magnitude of the electric field, V/m
- Ex_phase - The x component phase in reference of cosine in degrees. Thus to get a sin wave the phase needs to be set to -90 degrees.
- Ey_phase - The y component phase in reference of cosine in degrees. Thus to get a -sin wave the phase needs to be set to 90 degrees.
- t - Represents time from t = 0 to t = 40ns. The wave number is set such that a full cycle passes in 40ns.

The interactive plot is at z = 0 propagating in the +z direction.

Exercise

1. Determine the polarization of the electric field shown above.
2. Adjust the parameters to obtain a LHC polarization.
3. Adjust the parameters to obtain a linear polarization that is out of phase.

Questions

1. What are the general conditions for Ex_mag, Ey_mag, Ex_phase, and Ey_phase for the following polarizations: linear in phase, linear out of phase, LHC, RHC, elliptical LH, elliptical RH.

Useful Information

No useful Information is provided to you.

Provided Code

```
function wave_polarization()
param

% x component magnitude of the electric field, V/m
var.Ex_mag = %INSET CODE HERE
% y component magnitude of the electric field, V/m
var.Ey_mag = %INSET CODE HERE
var.Ex_phase = %INSET CODE HERE     % x component phase, degrees
var.Ey_phase = %INSET CODE HERE     % y component phase, degrees
waveNumber = pi/6;   % Wave number of the electric plane wave
var.w = waveNumber/sqrt(P.Eo*P.Uo); % Frequency of the wave, rads
var.t = 0;                  % Time, s

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% The code below is provided to you. You do not need to modify it.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% The maximum of the x and y component of the electric field.
var.E_max = 2.4;

% The code below is used to create the interactive gui

f = figure(1);
clf();

var.ax = axes('Parent',f,'position',[0.1 0.5  0.8 0.4]);

% plot initial data
var.h = plot([1],[1],[1],[1]);
var = updatePlot(var);
legend('E trace','E current','location', 'NorthWest')
title('Wave Polarization')

% User interactive controls
Ex_mag_ctrl = uicontrol('Parent',f,'Style','slider',...
        'Position',[60,20,420,20],'value',var.Ex_mag,...
        'min',0,'max',var.E_max,'Callback',{@update_Ex_mag},...
        'Tag','slider1');
guidata(Ex_mag_ctrl,var);
Ey_mag_ctrl = uicontrol('Parent',f,'Style','slider',...
        'Position',[100,40,380,20],'value',var.Ey_mag,...
        'min',0,'max',var.E_max,'Callback',{@update_Ey_mag});
```

```
Ex_phase_ctrl = uicontrol('Parent',f,'Style','slider',...
         'Position',[100,60,380,20],'value',var.Ex_phase,...
         'min',-180,'max',180,'Callback',{@update_Ex_phase});
Ey_phase_ctrl = uicontrol('Parent',f,'Style','slider',...
          'Position',[100,80,380,20],'value',var.Ey_phase,...
          'min',-180,'max',180,'Callback',{@update_Ey_phase});
t_ctrl = uicontrol('Parent',f,'Style','slider',...
          'Position',[100,100,380,20],'value',var.t,...
          'min',0,'max',40,'Callback',{@update_t});

% controls to display slider names
Ex_mag_txt = uicontrol('Parent',f,'Style','text',...
       'Position',[0,20,100,20],'String','Ex_mag, V/m');
Ey_mag_txt = uicontrol('Parent',f,'Style','text',...
       'Position',[0,40,100,20],'String','Ey_mag, V/m');
Ex_phase_txt = uicontrol('Parent',f,'Style','text',...
        'Position',[0,60,100,20],'String','Ex_phase, deg');
Ey_phase_txt = uicontrol('Parent',f,'Style','text',...
        'Position',[0,80,100,20],'String','Ey_phase, deg');
t_txt = uicontrol('Parent',f,'Style','text',...
        'Position',[0,100,100,20],'String','t, ns');

% controls to display slider values
Ex_mag_disp = uicontrol('Parent',f,'Style','text',...
        'Position',[480,16,40,15],'String',...
        num2str(Ex_mag_ctrl.Value),'Tag','Ex_mag_disp');
Ey_mag_disp = uicontrol('Parent',f,'Style','text',...
        'Position',[480,37,40,15],'String',...
        num2str(Ey_mag_ctrl.Value),'Tag','Ey_mag_disp');
Ex_phase_disp = uicontrol('Parent',f,'Style','text',...
         'Position',[480,59,40,15],'String',...
         num2str(Ex_phase_ctrl.Value),'Tag','Ex_phase_disp');
Ey_phase_disp = uicontrol('Parent',f,'Style','text',...
         'Position',[480,80,40,15],'String',...
         num2str(Ey_phase_ctrl.Value),'Tag','Ey_phase_disp');
t_disp = uicontrol('Parent',f,'Style','text',...
         'Position',[480,100,40,15],'String',...
         num2str(t_ctrl.Value),'Tag','t_disp');

end

% Callback function when Ex_mag slider changes
function update_Ex_mag(hObject,callbackdata)
 handle = findobj('Tag','slider1');
 var = guidata(handle);
 var.Ex_mag = (hObject.Value);
 var = updatePlot(var);
 guidata(handle, var);
 Ex_mag_disp = findobj('Tag','Ex_mag_disp');
 set(Ex_mag_disp,'String',num2str(hObject.Value));
end

% Callback function when Ey_mag slider changes
function update_Ey_mag(hObject,callbackdata)
  handle = findobj('Tag','slider1');
```

```
  var = guidata(handle);
  var.Ey_mag = (hObject.Value);
  var = updatePlot(var);
  guidata(handle, var);
  Ey_mag_disp = findobj('Tag','Ey_mag_disp');
  set(Ey_mag_disp,'String',num2str(hObject.Value));
end

% Callback function when Ex_phase slider changes
function update_Ex_phase(hObject,callbackdata)
  handle = findobj('Tag','slider1');
  var = guidata(handle);
  var.Ex_phase = (hObject.Value);
  var = updatePlot(var);
  guidata(handle, var);
  Ex_phase_disp = findobj('Tag','Ex_phase_disp');
  set(Ex_phase_disp,'String',num2str(hObject.Value));
end

% Callback function when Ey_phase slider changes
function update_Ey_phase(hObject,callbackdata)
  handle = findobj('Tag','slider1');
  var = guidata(handle);
  var.Ey_phase = (hObject.Value);
  var = updatePlot(var);
  guidata(handle, var);
  Ey_phase_disp = findobj('Tag','Ey_phase_disp');
  set(Ey_phase_disp,'String',num2str(hObject.Value));
end

% Callback function when t slider changes
function update_t(hObject,callbackdata)
  handle = findobj('Tag','slider1');
  var = guidata(handle);
  var.t = (hObject.Value);
  var = updatePlot(var);
  guidata(handle, var);
  t_disp = findobj('Tag','t_disp');
  set(t_disp,'String',num2str(hObject.Value));
end

function var = updatePlot(var)

          % Calculate the x component
          Ex = var.Ex_mag*cos(var.w*var.t*1e-9+var.Ex_phase*pi/180);
          % calculate the y component
          Ey = var.Ey_mag*cos(var.w*var.t*1e-9+var.Ey_phase*pi/180);

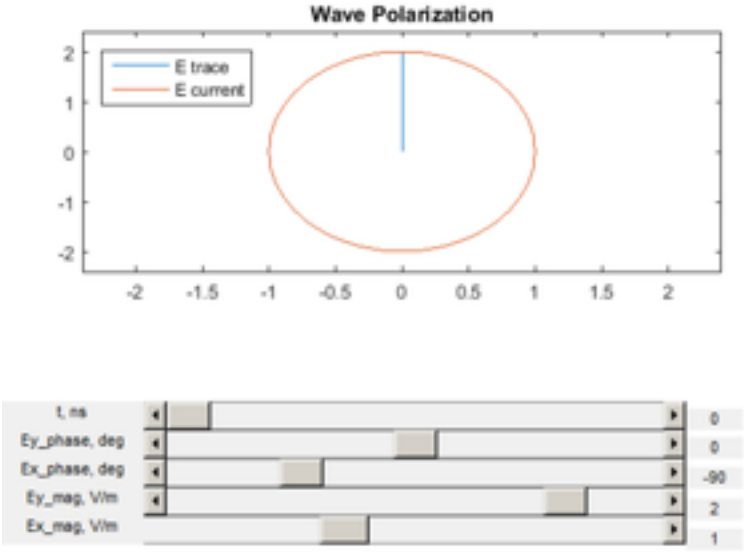
          % The trace, traces out the polarization of the electric field.
          pts = 20; % The trace plot has 2*pts points

          % x component trace
          Ex_trace = var.Ex_mag*cos((0:pi/pts:2*pi)+var.Ex_phase*pi/180);
          % y component trace
          Ey_trace = var.Ey_mag*cos((0:pi/pts:2*pi)+var.Ey_phase*pi/180);
```

```
        % Plots the figure
        set(var.h(1,1), 'XData',[0,Ex],'YData',[0,Ey]);
        set(var.h(2,1), 'XData',Ex_trace,'YData',Ey_trace);
        var.ax.YLim = ([-var.E_max,var.E_max]);
        var.ax.XLim = ([-var.E_max,var.E_max]);
```

```
end
```

Solution



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