

# EPR Simulator 3.3

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## Description

*EPR simulator* is a standalone application demonstrating the basics of EPR spectroscopy. It is written in *MATLAB*, using some functions of the [EasySpin](#) package.

## Requirements

- Windows 10+ / Mac OS / Linux
- *MATLAB Runtime* libraries, version R2023b (23.2)

## Installation

*EPR Simulator* doesn't require an installation on your system, the portable version is provided. It is required though to install the *MATLAB Runtime* libraries, which are available online:

<https://www.mathworks.com/products/compiler/matlab-runtime.html>

## How to use the EPR Simulator package

### Interface

There are several panels in the main window of the *EPR Simulator*.

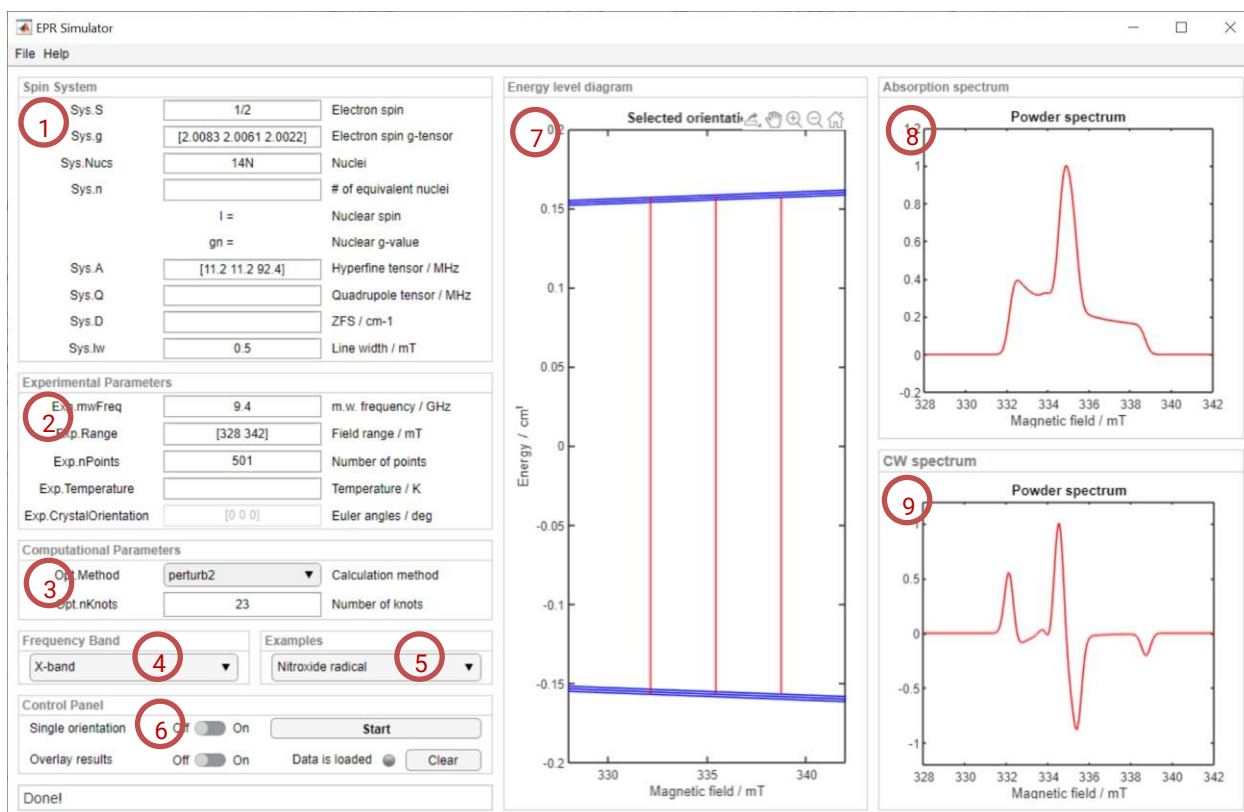
**PANELS 1-3** are used to set up the spin system, experimental and computational parameters. Here the labels used for different spin system elements are the same as those used in the *EasySpin* package.

**PANEL 4** allows you to select the resonance frequency. Note that it changes the experimental range = [Hmin Hmax], which is only adjusted for only '**NITROXIDE RADICAL**' example).

**PANEL 5** provides a selection of examples; each option loads a set of preassigned parameters.

With the '**CONTROL PANEL**' (**PANEL 6**) you can run EPR spectra simulations, which will be plotted in **PANELS 7-9**.

More details about each panel you will find below.



## Spin system parameters

EPR Simulator	EasySpin	Example	Description
<b>Sys.S</b>	Sys.S	0.5	Electronic spin quantum number
<b>Sys.g</b>	Sys.g	[2.01 2.004 2.001]	g-tensor
<b>Sys.Nucs</b>	Sys.Nucs	'14N'	Type of nucleus
<b>Sys.n</b>	Sys.nNucs	2	Number of equivalent nuclei
<b>I</b>	-	1	Nuclear spin quantum number
<b>gn</b>	-	0.40376	Nuclear g-value
<b>Sys.A</b>	Sys.A	[10 10 90]	Hyperfine tensor / MHz
<b>Sys.Q</b>	Sys.Q	[Q η]	Quadrupole tensor ( $I > 1/2$ ) / MHz
<b>Sys.D</b>	Sys.D	[D E]	Zero-field splitting ( $S > 1/2$ ) / $\text{cm}^{-1}$
<b>Sys.lw</b>	Sys.lw	0.5	EPR linewidth / mT

## Experimental parameters

EPR Simulator	EasySpin	Example	Description
<b>Exp.mwFreq</b>	Exp.mwFreq	9.4	Resonance frequency / GHz
<b>Exp.Range</b>	Exp.Range	[320 340]	Field range / mT
<b>Exp.nPoints</b>	Exp.nPoints	501	Number of points in spectrum
<b>Exp.Temperature</b>	Exp.Temperature	298	Temperature / K
<b>Exp.CrystalOrientation</b>	Exp.CrystalOrientation	[0 90 0]	Orientation selection* / deg



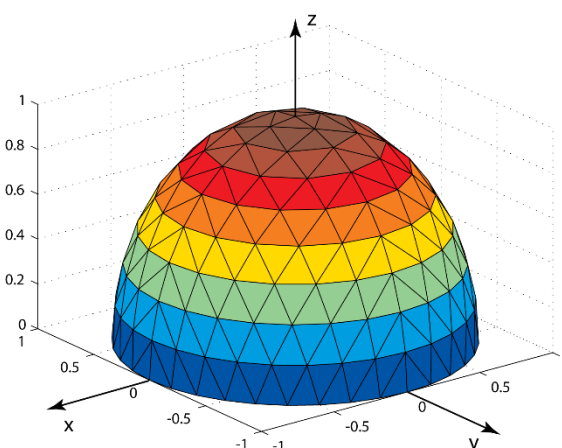
there are different options for orientation selection, for example Exp.CrystalOrientation, for more details read EasySpin documentation. Number of points (**nPoints**) has to be sufficient, that the spectral resolution, defined as  $dH = (H_{\max} - H_{\min}) / (nPoints - 1)$ , is smaller than the EPR linewidth.

## Computational parameters

EPR Simulator	EasySpin	Example	Description
<b>Opt.Method</b>	Opt.Method	9.4	Resonance frequency / GHz
<b>Opt.nKnots</b>	Opt.nKnots	31	Number of knots

The number of knots parameter (**nKnots**) defines the grid over the unit sphere used to sample the orientation of the molecule in the magnetic field (laboratory frame). The input value defines a number of points on the segment of the sphere, where  $[\varphi \theta]$  take values from 0 to  $\pi/2$ .

For example, for  $nKnots = 10$  (shown in the figure on the right) the  $\theta$  step is  $90 / (nKnots - 1)$ , which equals 10 degrees. The corresponding  $\varphi$  angles are calculated in the same manner. The powder spectrum is an average over single orientation spectra of each knot on the grid.



## Examples

There are several basic examples (aka 'starting points') for a quick parameter reset:

<b>'Free electron'</b>	spin system of a free electron: $S=1/2$ , isotropic g-tensor;
<b>'1 Proton'</b>	spin system of one proton: $S=1/2$ ; 1 nucleus ( $^1\text{H}$ ), isotropic g- and hyperfine tensors;
<b>'2 Protons'</b>	spin system of two proton: $S=1/2$ ; 2 nuclei ( $^1\text{H}$ ), isotropic g- and hyperfine tensors;
<b>'Nitroxide radical'</b>	spin system of a nitroxide radical: $S=1/2$ ; 1 nucleus ( $^{14}\text{N}$ ), anisotropic g and hyperfine tensors;
<b>'Mn(III) ion'</b>	spin system: $S=2$ ; 1 nucleus ( $^{55}\text{Mn}$ ), anisotropic g-tensor, ZFS;
<b>'Fe(III) ion'</b>	spin system: $S=2.5$ ; $g=2$ , ZFS;

## Control panel

The **'START'** button runs the calculations and plots energy level diagram and simulated EPR spectra, both the absorption and CW.



Note that the energy level diagram is calculated only for the orientation listed in the experimental panel, if the orientation is not given – it takes default values [0 0 0].

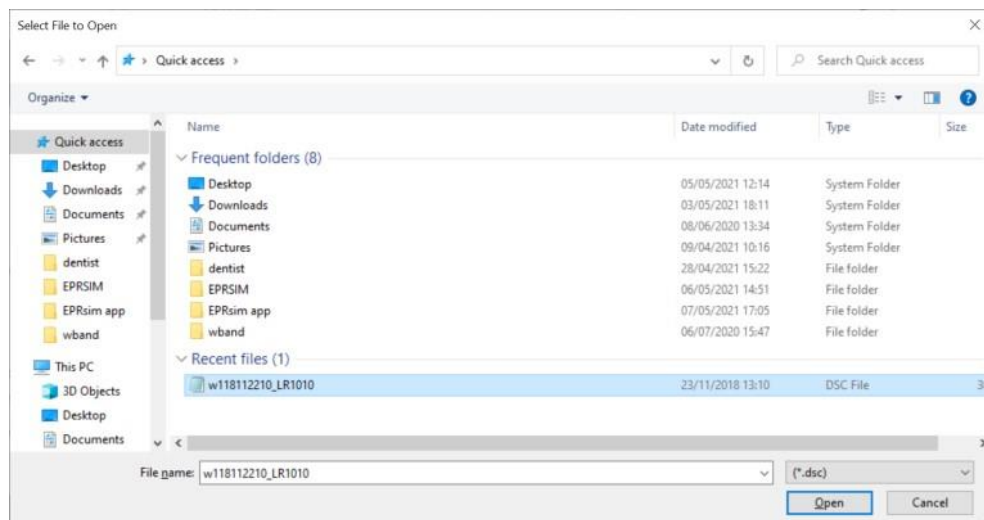
There are also two additional options that can be switched **ON** and **OFF**:

**'SINGLE ORIENTATION'** when selected – the program calculates spectrum of only one orientation as opposed to the whole powder spectrum. This could be used for simulating single crystal type EPR spectra.

**'OVERLAY RESULTS'** when selected this retains previously calculated spectra on the plot. This mode is useful for making figures with several single orientation spectra or when you wish to compare energy level diagrams for different resonance frequencies or orientations.

## Loading experimental data

To load an experimental spectrum select the **FILE -> LOAD** menu. Select the desired **\*.DSC** file and click the **OPEN** button.



## Saving parameters to a file

To save your parameters as a structure, select the **FILE -> SAVE** menu. All the spin, experimental and computational parameters will be then saved to the specified **\*.MAT** file, which can be used to import those into **MATLAB** environment for further calculations.

