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Internship report

Simulation of the Smith-Purcell radiation and designing stepper motor control system

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Smith-Purcell Radiation

Smith-Purcell Radiation (SPR) is radiation that is caused by a charged particle passing near a periodical conductive grating. It can be used as the source of the radiation in millimeter range or as a bunch profile measurement method.

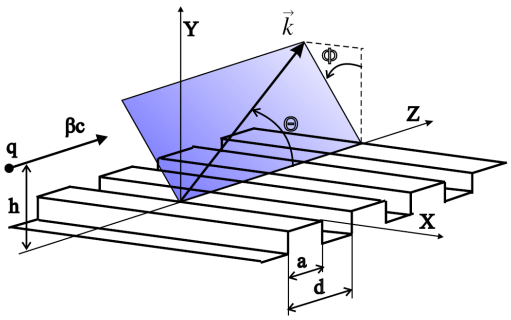

Figure 1: Volume grating

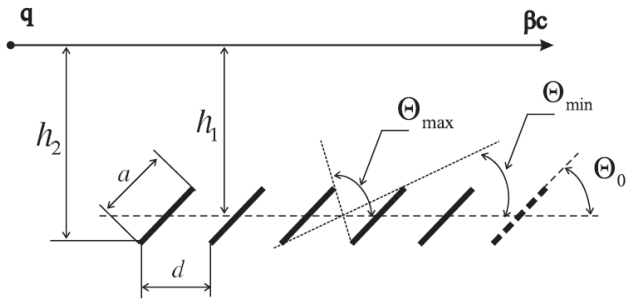

Figure 2: Thin strip grating

Simulation of SPR

The task was to make a program for simulating SPR models in the MATLAB and make simulations for SPESO and E 203 experiments.

For the simulation I used incoherent (intensity of radiation is proportional to the number of the particles in a bunch) models: surface current model (SC), resonant diffraction resonation (RDR) [2] and transition radiation model (TR) [1], which describe SPR in the Pre-Wave zone, firs two are describing Smith-Purcell radiation at the long distances, and the last one is good at short distances from the grating.

Using these models, I made a program that calculated Intensity or Intensity per solid angle of energy of the SPR for different parameters. To check if my simulation is right I put parameters from [1] and [2] in my program and compared its plots with the ones in the articles, and almost all of the plots are in agreement with each other. There are some disagreements, but theyre could be easily explained. After this I made simulations using parameters from SPESO and E 203 experiments and, using this data made plots, to compare three models for these experiments. For each Θ there are four combinations of models describing Φ-distribution of intensity per solid angle.

For convenience I made web-pages [8], where for each parameter set there is four combinations of plots in row and 14 rows for each Θ from 40 to 140 degree with the step of 10 degree. Like this, you can easily see evolution of models with increasing Θ. On the plots you can see blue line RDR model, blue dashed line SC model, light green line far(TR model, with assumption, that distance from the grating is infinite) model and red line full(TR) model.

So, at the end we have program that calculates incoherent SPR intensity or intensity per solid angle with any parameters for three models. For now this program is configured to makeΦ distributions for different Θ and other parameters and at the same time it makes

html-pages to easily compare data for different Θ. It is very easy to start simulations for the new set of parameters and for this you dont need to change code and you can do this with a command line.

Step motors

Step motor is device that could move its rotor at precise positions and stay in this positions without having feedback sensors. Thats why these devices are popular in the applications where you need to move something at defined position.

Step motor control system

My second task was to make a system that would be able to move target of the E 203 experiment.

It was decided, that for the motor drivers we will use WAGO 750-671 [5] and WAGO 750-673 [6] modules and WAGO 750-880 [4] PLC will be used as controller that could be connected to a PC with an Ethernet cable.

First thing I did is learned how to make programs in the CodeSys 2.3 software. Then with the help of it I tested the motor drivers and motor RS 432-827 with standard libraries for moving step motors that are available free on the WAGO site.

Standard communication, programming and debugging of the controller and stepper drivers has been done through the Ethernet in the CodeSys environment, so next thing I did is run the TCPIP server on the controller, so it can create connection by TCP/IP protocol with external devices, thats trying to connect to it.

One requirement in the task was to be able to control motor by MATLAB. To do this I used the socket communication in the MATLAB and made a set of commands for controller with the help of which it is possible to control the stepper drivers. Using this commands I made scripts in the MATLAB to enable/disable drivers, to move the motor at the precise position or to change speed, target position, acceleration of the motor etc., or to get the current position of the motor, or status of the digital inputs.

Having done that, I checked how it works by trying it on the RS 432-827 and 23HT18C230 motors and WAGO 750-671 and WAGO 750-673 motor drivers. Making sure that everything worked right and motor wasnt damaged, we connected this to the E 203 installation and tested the system using WAGO 750-673 driver with the 23HT18C230 motor.

WAGO 750-673 has 6 digital inputs, 2 of them we used as the limit switches(back and front) that will stop motor so it wont go out of the borders, one is the reference button, that indicates that motor is at the reference position, and one emergency input, that will turn off the motor, before it breaks something. Using this inputs I made a program that will go from the back limit switch to the reference point and back to the back limit switch. This cycle changes the grating of the target, so to ensure that the grating rotates without errors and motor works right we made 100 such cycles, we installed IP cameras, so they will take pictures at the reference and limit points [7], and made movies of the carousel rotation. And recently we successfully made these rotations in the vacuum [9].

The result of this work is the working system to control step motors using WAGO stepper drivers. Its also possible to use several stepper drivers at the same time, so you can control more than one motor, its can be easily done on the hardware and on the software side. The system has been tested and ready to work.

Plans for the future

As for the SPR Im planning to add possibility to calculate Pre-Wave model for blazing angles (θ_0) different from zero. Add some styling to the web-pages, so they will be faster to load and easier to navigate.

Thanks

Thanks to my supervisor Nicolas Delerue, LAL, V. N. Karazin Kharkiv National University, all my family and friends, for giving me support and possibility to go on this Internship, I liked it very much!

References

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