MAX21001V

Simulink model short guide

Date : **Oct/30/2013**
Revision : **1.0**

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1. GENERAL DESCRIPTION

The MAX21001V Simulink model is a black-box base-band model, which emulates the behavior of the MAX21001V device in the Simulink environment.
The model takes as input the mechanical roll, pitch and yaw rates around the sensitive axes (expressed in °/s). As a result of the simulation, corresponding digital outputs expressed in LSBit unit are produced.

Range and resolution of the device outputs are set to nominal values as indicated in the relevant datasheet.

Sensor elements frequency response and internal digital filtering are modeled. Besides, internal analog and digital saturations are emulated, together with typical noise level on the outputs.

The model is also capable of emulating tolerances on offset and sensitivity of roll, pitch and yaw rates and temperature coefficients (TCs) of offset and sensitivity. This is done by a set of simulation parameters which can be changed by the user at each simulation run.

In order to make the Simulink model easy to use, at least in a standard environment, general purpose test-benches are provided in which the MAX21001V block is instanced. Input signals are automatically taken from a text file with fixed format. Output signals are automatically plotted and stored in a text file with fixed format. Input and output file names can be user-defined, and hence considered simulation parameters.

Furthermore, the sampling frequency of the outputs is parameterized so that the frequency of the requests on the SPI interface at application level can be emulated.

1.1 Files description

The following files are necessary for the correct functionality of the Simulink model.

- **MAX_21001V_sensor_lib.mdl**:
  Simulink library including basic building blocks of the MAX21001V systems and MAX21001V top level block; in particular the top level block is named MAX_21001V_model.

- **tb_MAX_21001V_sensor_model.mdl**:
  basic test-bench instantiating the MAX_21001V_model block, taking input from text file and storing outputs on text file.

- **MAX_21001V_model_parameters.m**:
  simulation parameters file (automatically run in the MAX21001V Simulink test-bench).

- **MAX_21001V_tb_initialization.m**, MAX_21001V_tb_save_outputs.m:
  these functions are automatically run inside the model test-benches during the simulation for proper initialization of the variables used during the simulation and for proper output plotting and storing.

2. SIMULATION

2.1 Simulation flow

The basic flow to run a simulation using the MAX21001V Simulink model is described by the following operations:

- prepare an input file in the correct format with desired input signals
- edit the file MAX_21001V_model_parameters.m (if necessary) to set simulation parameters values, including input and output files names (with path)
- open tb_MAX_21001V_sensor_model.mdl, if you want to simulate the MAX21001V device
- run the simulation
- the output signals are automatically plotted versus time in standard Matlab plots; the output text file is automatically created with the chosen file name and path

2.2 Simulation parameters

The user of the MAX21001V Simulink model has the opportunity to define the value of some simulation parameters.
Parameters are related to:

- the device behavior and configurability
- the physical environment
- the simulation input/output

Some of these basic parameters are listed below. In order to modify their value it is sufficient to directly edit the MAX_21001V_model_parameters.m file.
So the user should, if necessary, edit and save the parameters file, before running the Simulink simulation.

Input file (infile = './Inputs/file_name';):
this is the name and path of the input file used for the simulation (see later for some more info on the input file format).

Output file (outfile = './Outputs/file_name';):
this is the name and path of the text file in which the user wants to store the output data (see later for some more info about the output file format).

SPI_sampling_period:

this is the sampling period of the output signals through SPI interface expressed in seconds. Output data will be plotted and stored using this sampling period.

Change the gyro output range (resolution):

the resolution of the digital outputs of the MAX21001V is programmable by the user through the specified registers interface. Concerning the resolution of the gyro outputs, the default setting for this version of the Simulink model is 240 LSB/dps, which corresponds to a range of +/- 125 dps. These values can be changed by simply editing the file 'MAX_21001V_model_parameters.m'. The parameter name for these settings is '**gyro_LSB_per_deg**'.

Other parameters:

the gyro bias (offset) and scale factor (sensitivity) errors can be added to simulate the behavior of a real device. Each error is split in two parameters: a base error that is due to intrinsic device precision and en error due to the ambient temperature variation. The maximum value of each parameter is indicated in the file comments. The ambient temperature must be specified at the beginning of the parameters file and a temperature difference (used in the model) is calculated as difference with an ambient temperature of 25 Celsius degrees. Also the cutoff frequencies of low-pass (LP) and high-pass (HP) output filters can be configured by the user, as well as the possibility to enable or disable (default) the HP filter.

Please contact Maxim Integrated for a complete description of the parameters included in the file 'MAX_21001V_model_parameters.m'.

2.3 Input and output file formats

The input file format is very simple. The text file has a few lines of header where the user can put information about the input signals and then the inputs are specified as a table with time in the first column, input roll, pitch and yaw rates in the second, third and fourth column, respectively. All angular rates have to be expressed in °/s (dps). Below, an example of the first lines of an input text file is reported.

MAX21001V - Simulink model simulation input file
Input Title : angular rate frequency sweep
Duration : 2s
Description : X: 50dps @ (10:110)Hz; Y: 100dps @ (10:110)Hz; Z: 20dps @ 20Hz
Other notes : .

time(s)	gyro_x(dps)	gyro_y(dps)	gyro_z(deg/s)
0.000000000e+000	0.0000000e+000	0.0000000e+000	0.0000000e+000
1.000000000e-004	3.1432998e-001	6.2865996e-001	2.5132080e-001
2.000000000e-004	6.2899309e-001	1.2579862e+000	5.0260191e-001
3.000000000e-004	9.4397680e-001	1.8879536e+000	7.5380365e-001
4.000000000e-004	1.2592685e+000	2.5185370e+000	1.0048864e+000
5.000000000e-004	1.5748555e+000	3.1497110e+000	1.2558104e+000
6.000000000e-004	1.8907251e+000	3.7814501e+000	1.5065361e+000
7.000000000e-004	2.2068643e+000	4.4137286e+000	1.7570239e+000
8.000000000e-004	2.5232603e+000	5.0465206e+000	2.0072343e+000
9.000000000e-004	2.8399000e+000	5.6798001e+000	2.2571277e+000
1.000000000e-003	3.1567705e+000	6.3135409e+000	2.5066647e+000
1.100000000e-003	3.4738584e+000	6.9477167e+000	2.7558058e+000
1.200000000e-003	3.7911505e+000	7.5823011e+000	3.0045118e+000
1.300000000e-003	4.1086336e+000	8.2172673e+000	3.2527433e+000
1.400000000e-003	4.4262942e+000	8.8525885e+000	3.5004612e+000
1.500000000e-003	4.7441189e+000	9.4882378e+000	3.7476263e+000
1.600000000e-003	5.0620941e+000	1.0124188e+001	3.9941996e+000
1.700000000e-003	5.3802061e+000	1.0760412e+001	4.2401422e+000

The produced output text file format is very similar to the input one. Input file name, output file name and output SPI sampling rate used for the simulation are reported in the header lines. Here below is an example of the first lines of an output file.

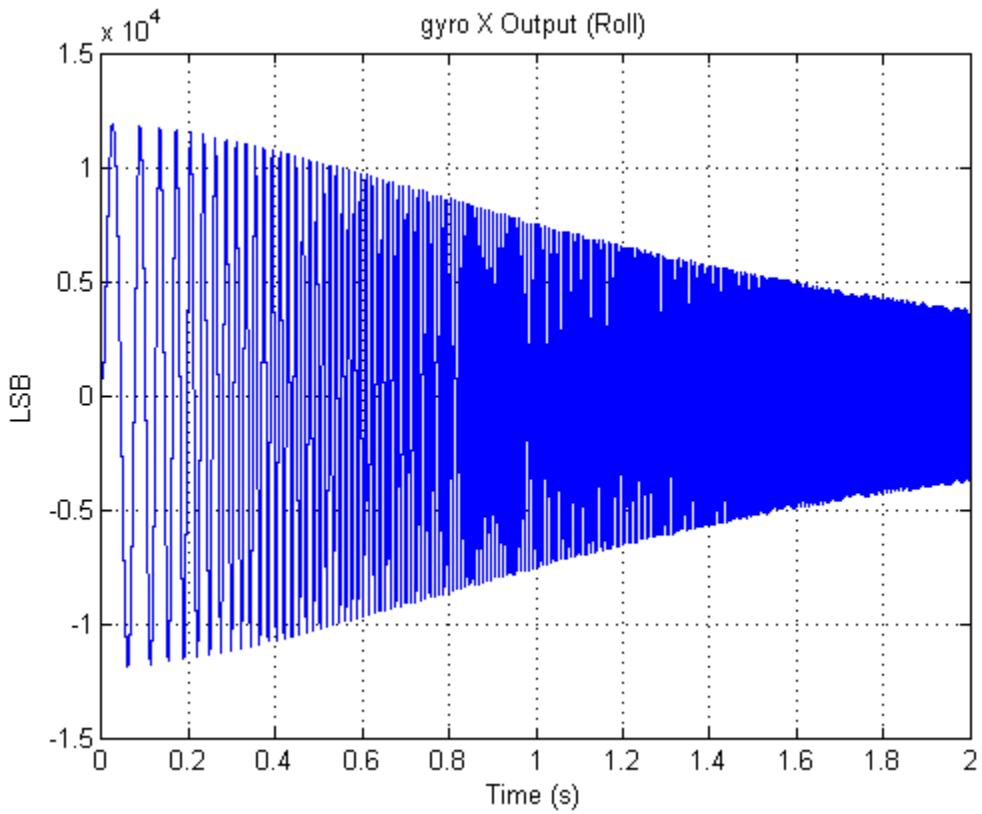
MAX21001V Simulink model simulation output file
Input file name: ./Inputs/mech_input_allzero.source
Output file name: ./Outputs/sim1.out
Output SPI sampling rate: 0.000100 s
Output unit: LSBs

time(s)	gyro_x(LSB)	gyro_y(LSB)	gyro_z(LSB)
0.000000	0	0	0
0.000100	0	0	0
0.000200	0	0	0

0.000300	0	0	0
0.000400	0	0	0
0.000500	0	0	0
0.000600	0	0	0
0.000700	0	0	0
0.000800	0	0	0
0.000900	0	0	0
0.001000	-1	0	-1
0.001100	-1	0	-1
0.001200	-1	0	-1
0.001300	-1	0	-1
0.001400	-1	0	-1
0.001500	-3	4	1
0.001600	-3	4	1
0.001700	-3	4	1
0.001800	-3	4	1
0.001900	-3	4	1
0.002000	-9	4	-2
0.002100	-9	4	-2
0.002200	-9	4	-2
0.002300	-9	4	-2
0.002400	-9	4	-2
0.002500	-14	1	-4
0.002600	-14	1	-4
0.002700	-14	1	-4

3. SIMULATION EXAMPLE

The model was tested with a sine sweep form 10 to 110 Hz, 100 dps of amplitude for the gyro roll rate. This allows verifying the sensitivity and the bandwidth of the system.



4. REVISION HISTORY

Revision	Change	Date	Author
1.0	Initial version	Oct/30/2013	G. De Sandre