Analyzing Code Generated from a Simulink* Model

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EECS 461: Embedded Control Systems

* Matlab 2018a

Introduction

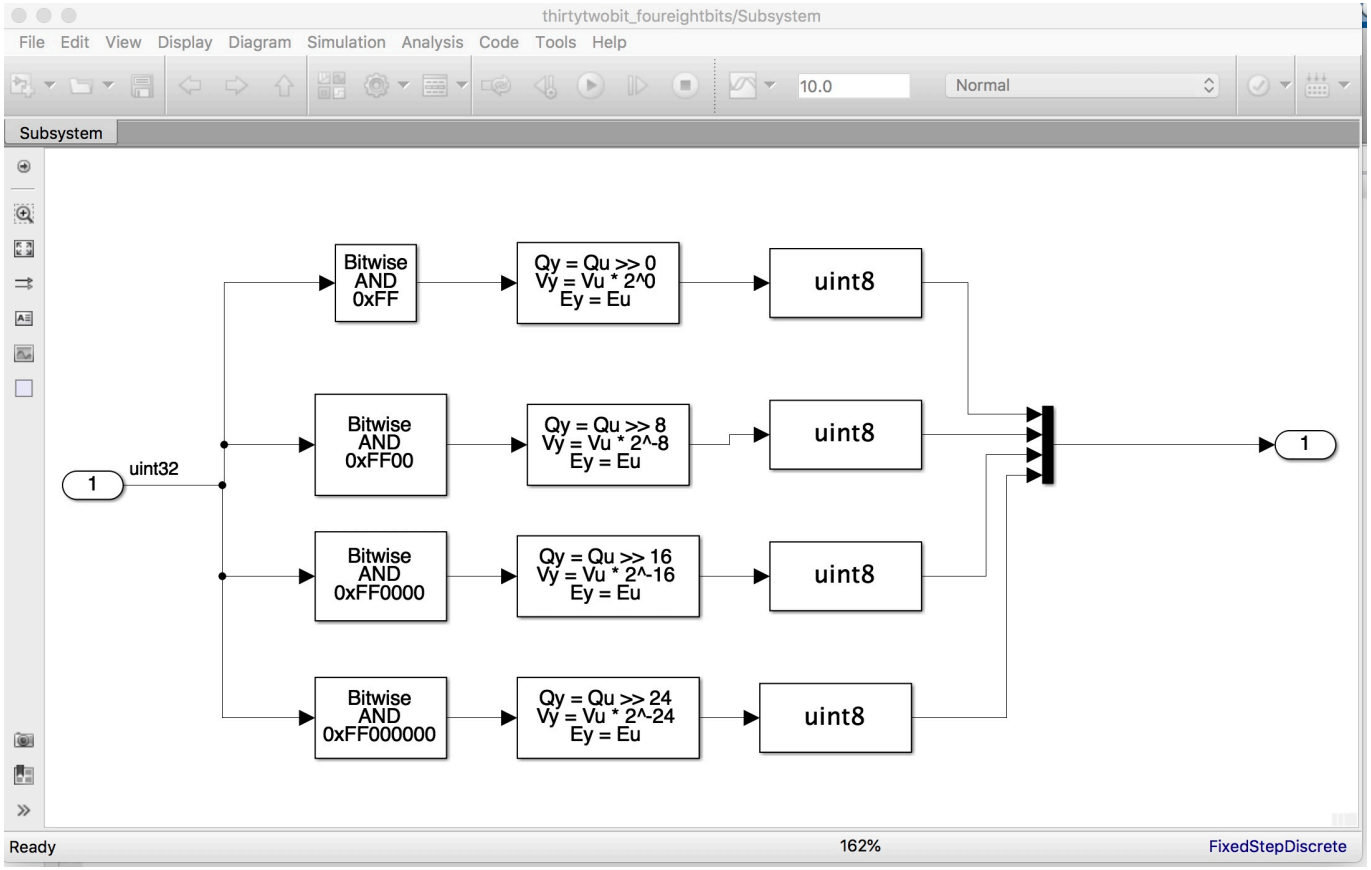
- This set of slides will show you how generate C code from a simple Simulink model, and analyze the generated code using Embedded Coder utilities.

- In particular, we will use the **traceability** feature to move back and forth from the Simulink blocks to the code generated from them.

- We will use Matlab 2018a, which is the version of Matlab used in the EECS461 lab.

- The slides were made with a Mac – the menus on a PC may look a little different.

Convert 32-bit Integer to 8-bit Integers



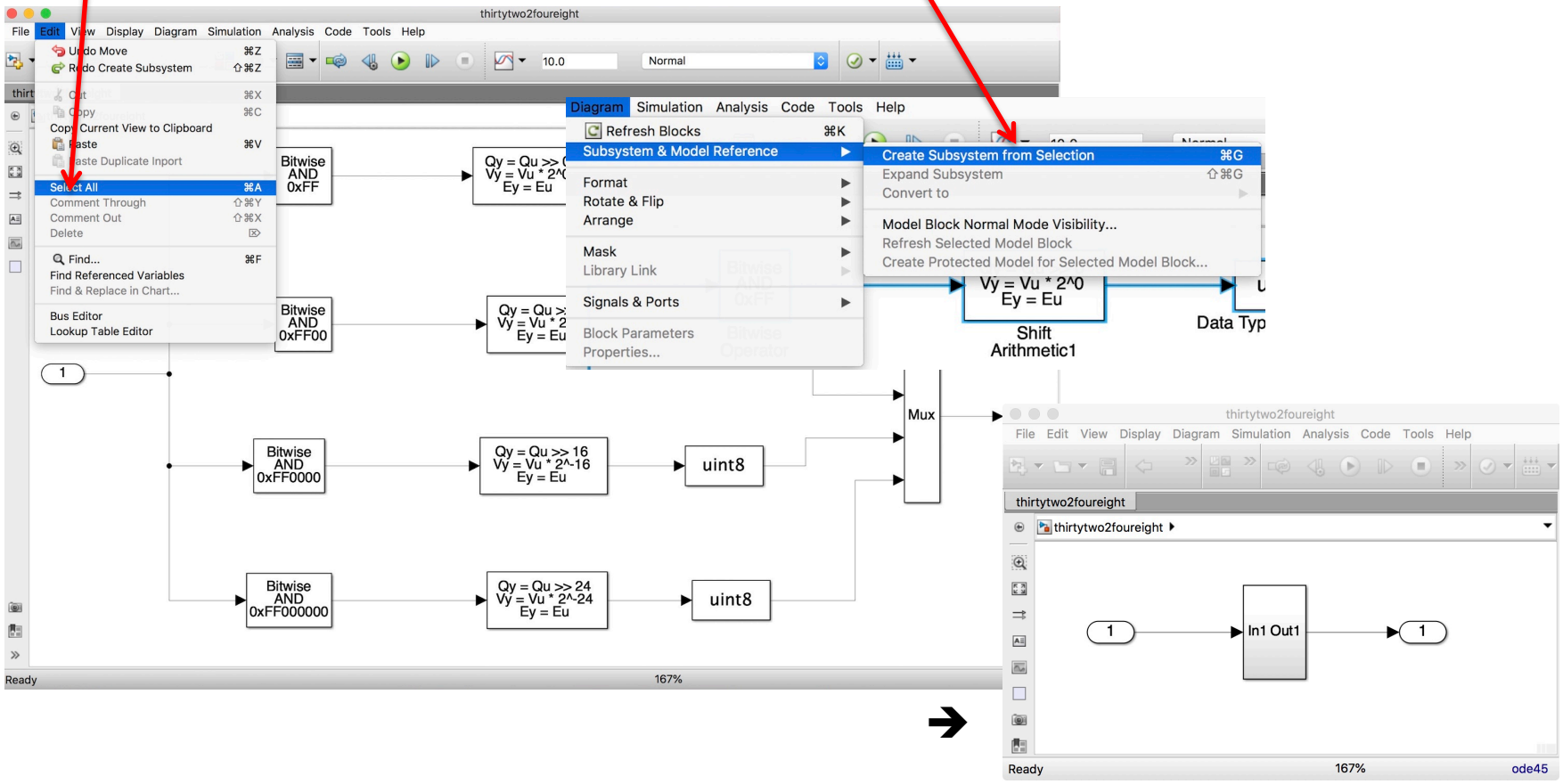
Create a Simulink model of the system depicted in Figure 3 of the handout “Simulink Models for Autocode Generation”. This model takes one 32-bit integer as input and breaks it into four 8-bit integers.

Make a Subsystem

From the Edit and Diagram menus:

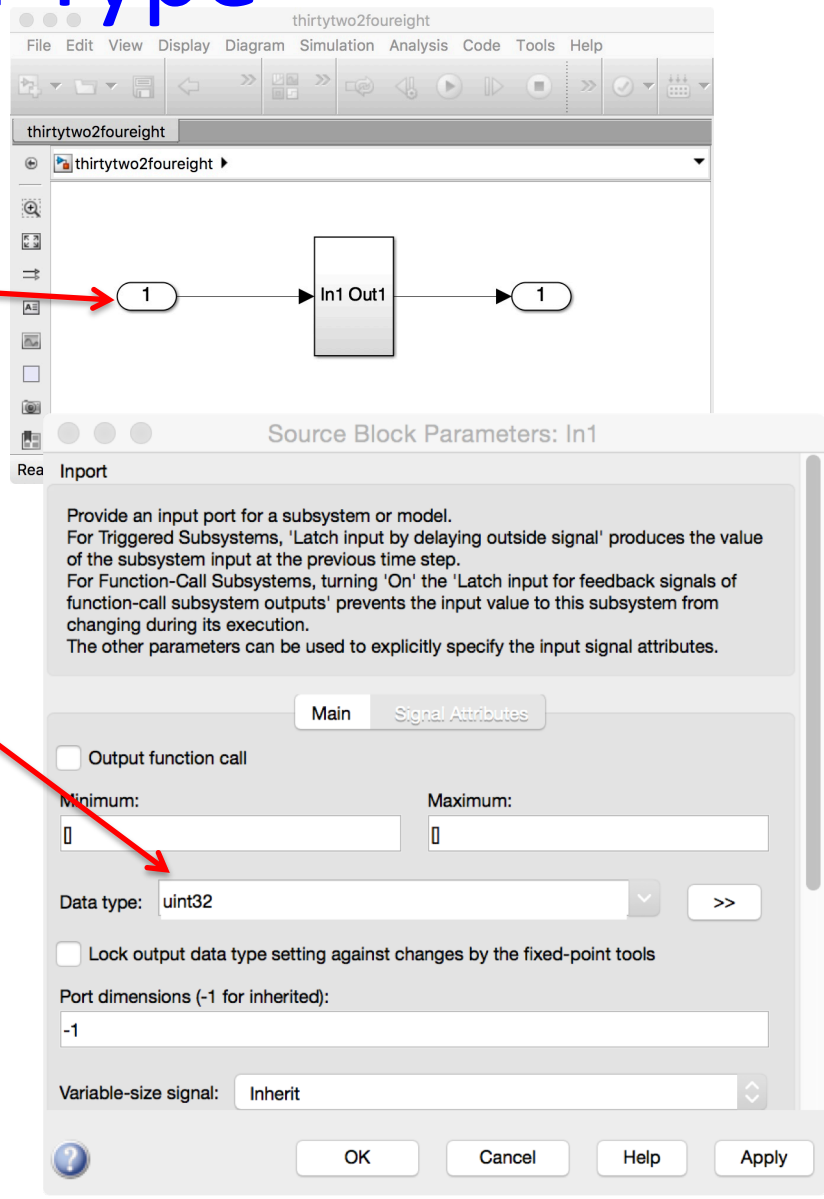
Edit/Select All

Diagram/Subsystem & Model Reference/Create Subsystem from Selection

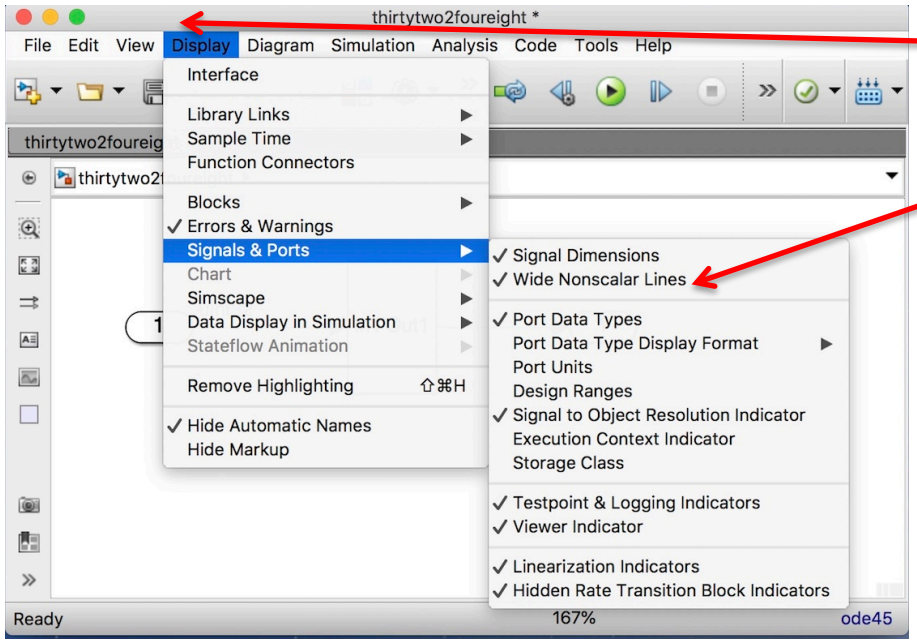


Input Data Type

- Double-click Input Port
- Set data type to `uint32` in the Signal Attributes Menu



Display Data Types



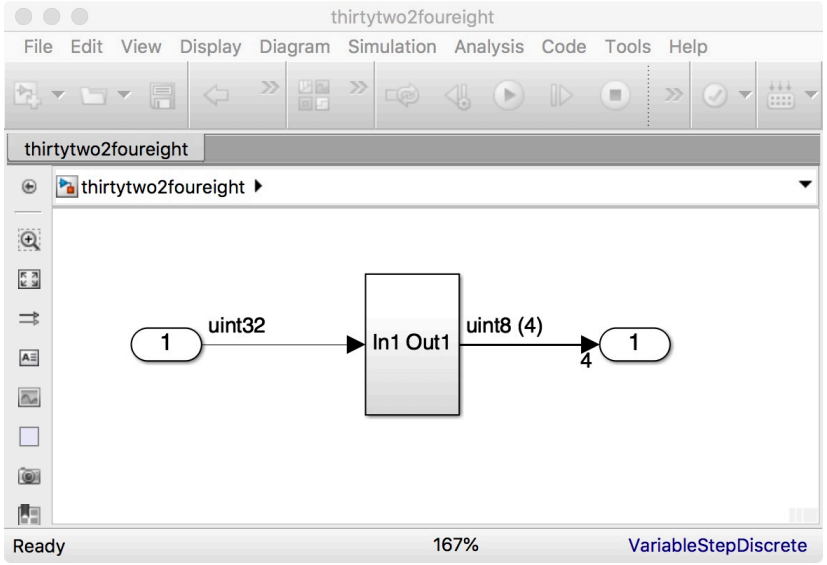
- Under the Display Menu, select

Display/Signals & Ports/Signal Dimensions
Display/Signals & Ports/Wide Nonscalar Lines
Display/Signals & Ports/Port Data Types

- You may need to run the model

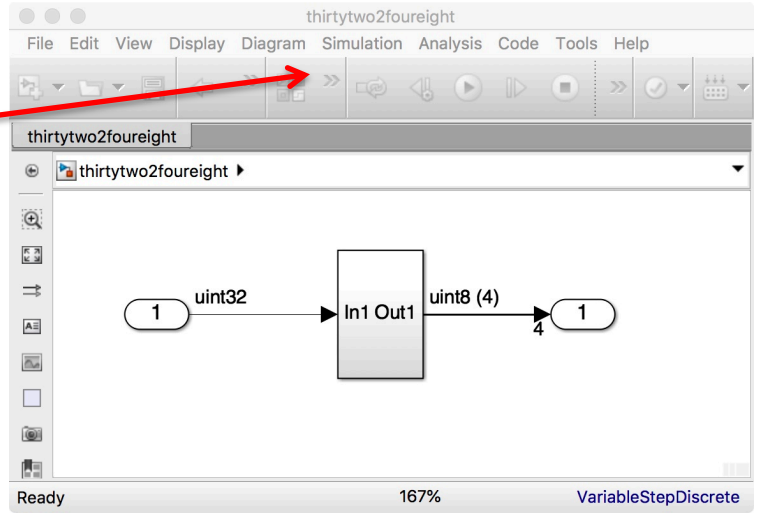
in order to see the update

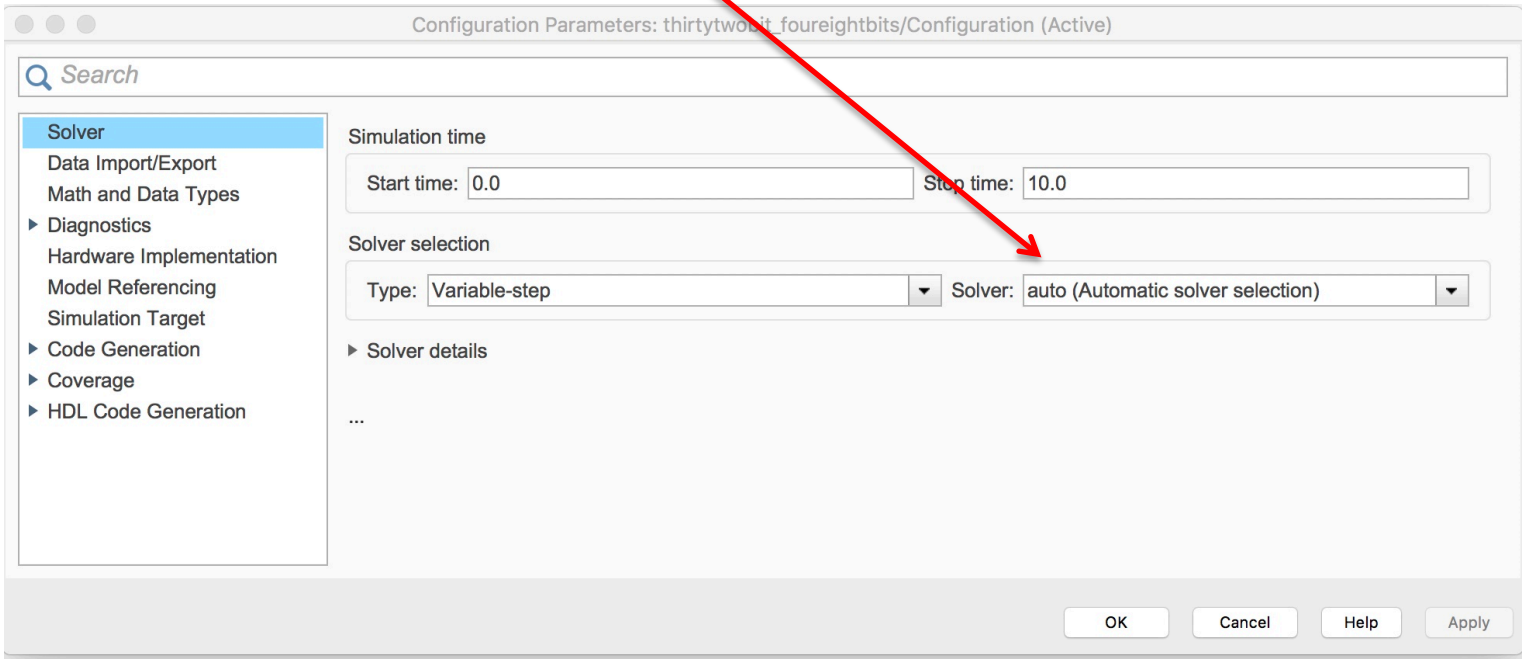
➔



Solver Options

In the
Simulation/Model Configuration Parameters/Solver Menu, select “Fixed Step” solver and “discrete (no continuous states)”

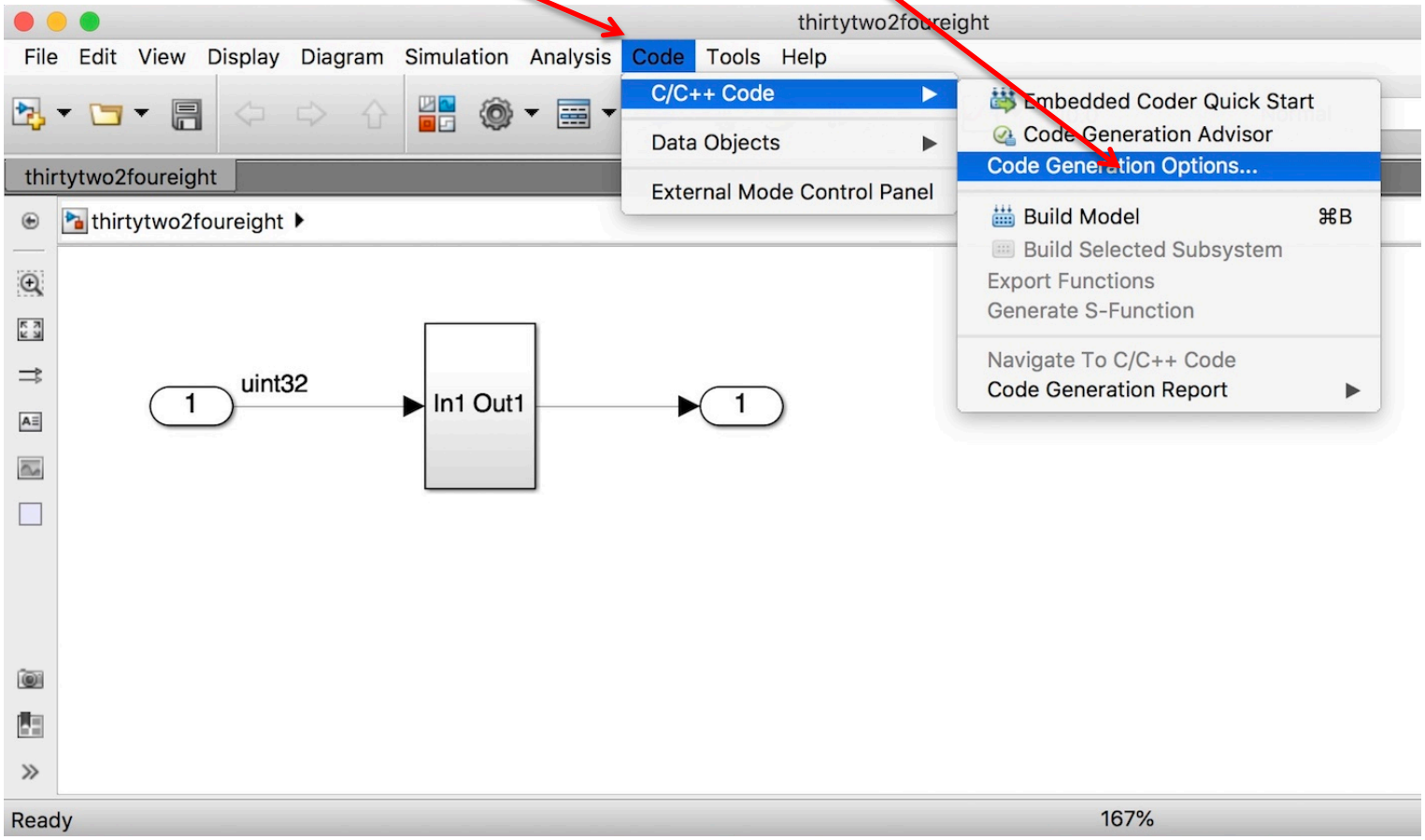




Options for Code Generation

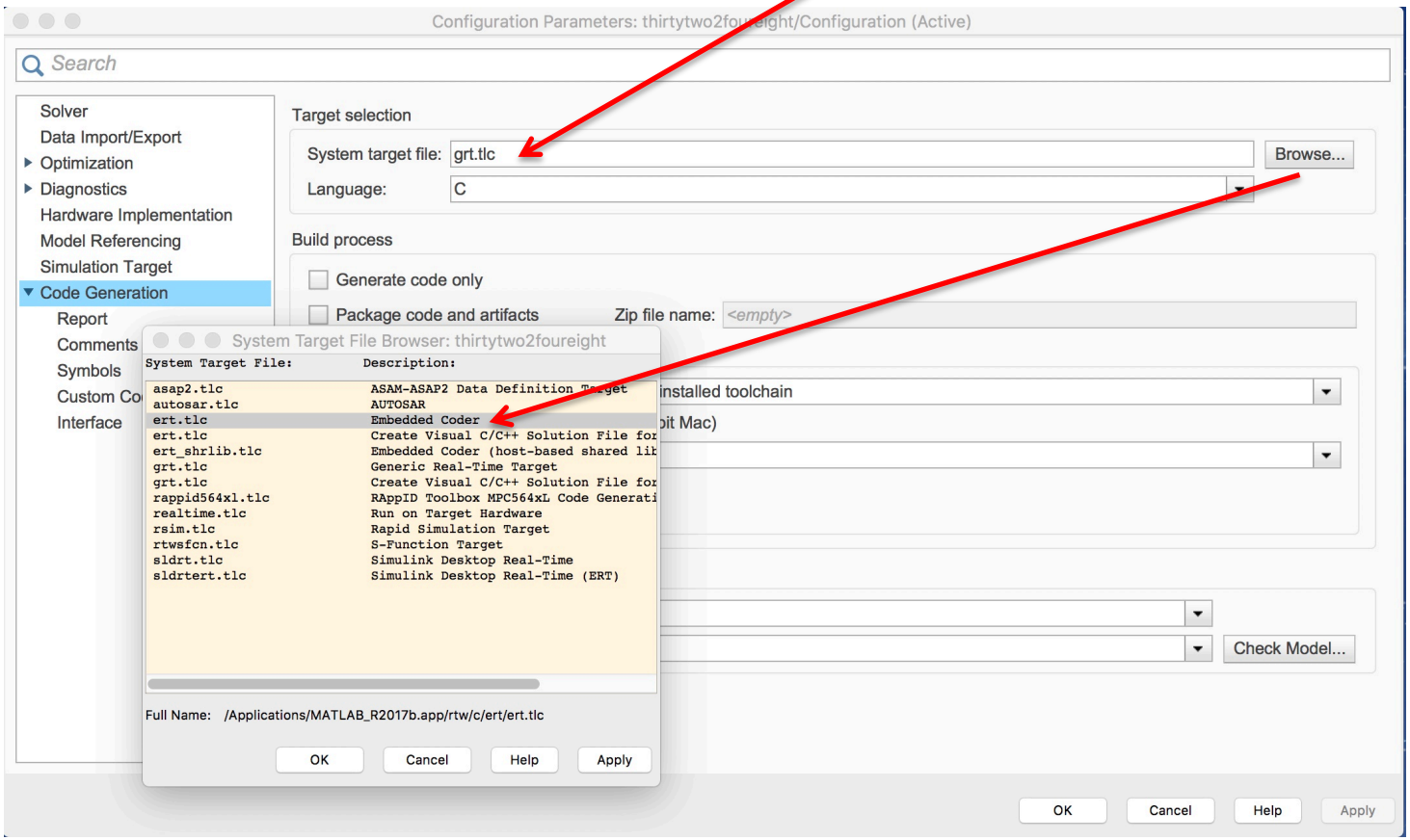
From the Code Menu, select:

Code/C/C++ Code/Code Generation Options…



Options Window

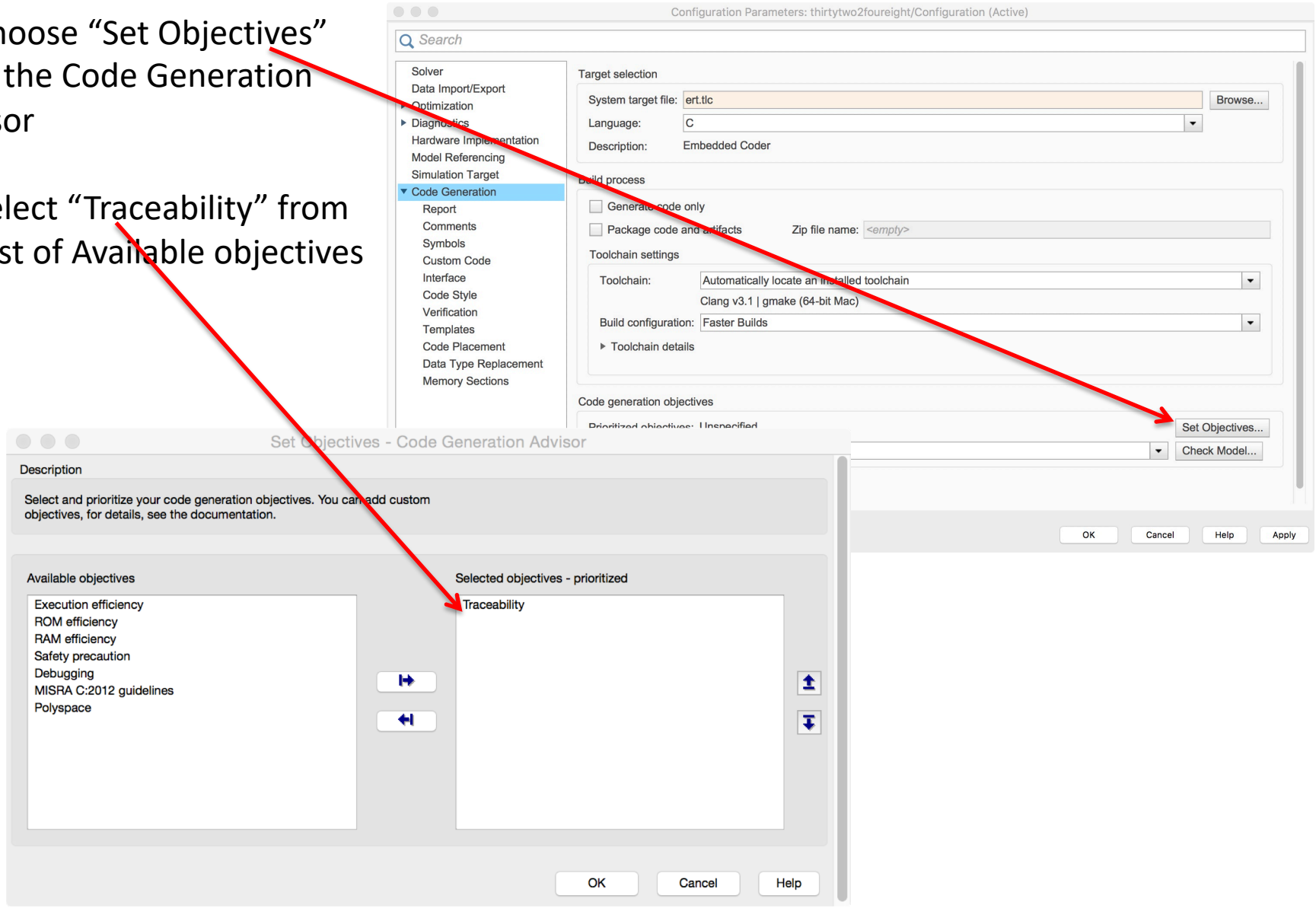
The default target option is “Generic Real-Time Target”, `grt.tlc`
For more efficient code and additional features, Browse to select “Embedded Coder “, `ert.tlc`



Embedded Coder Options

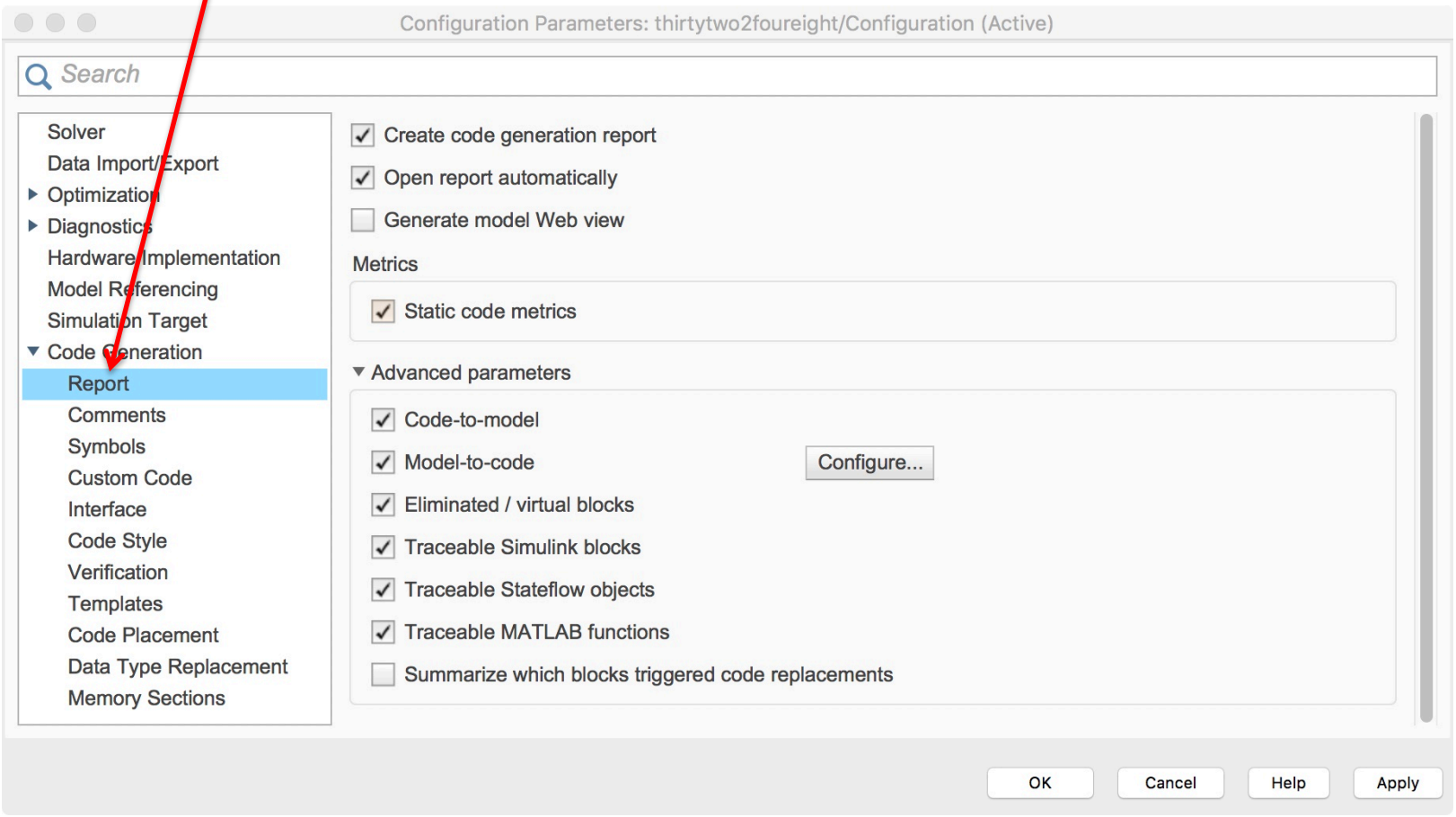
- Choose “Set Objectives” from the Code Generation Advisor

- Select “Traceability” from the list of Available objectives



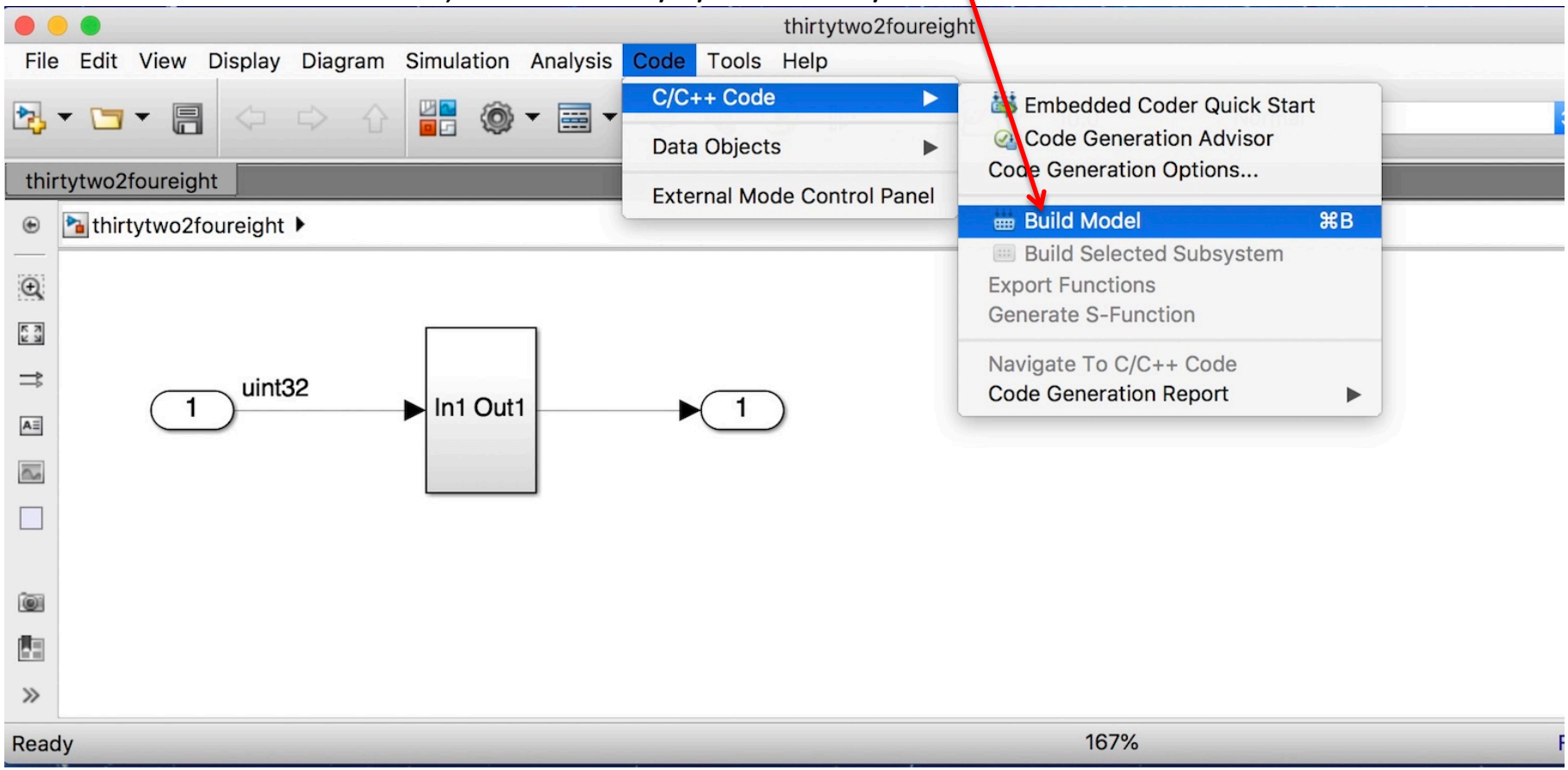
Report Options

Select Code Generation/Report and check the indicated options.



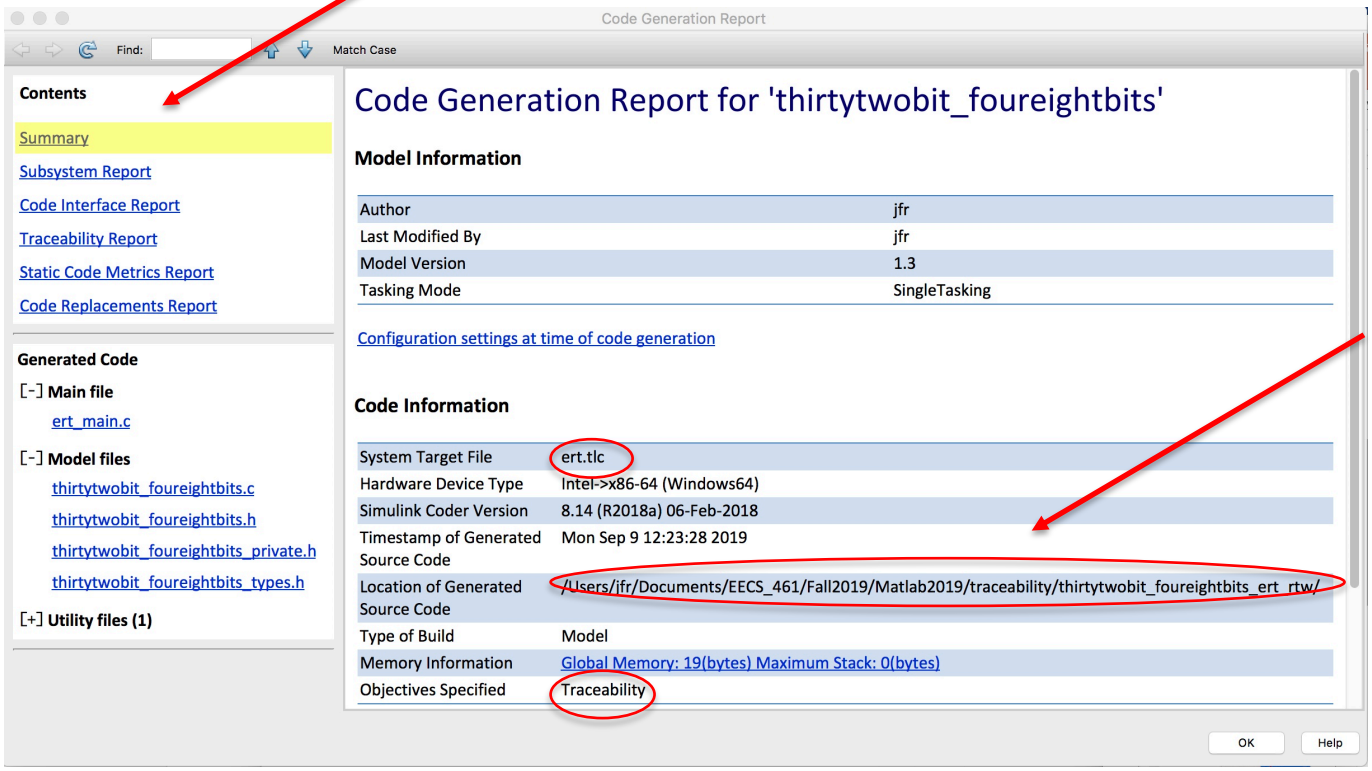
Generate C Code

- To generate C code, we must “Build” the model
- **Be sure the Matlab working directory is the same directory that contains the Simulink model!!!!!**
- Under the Code Menu, select Code/C/C++ Code/Build Model



Code Generation Report

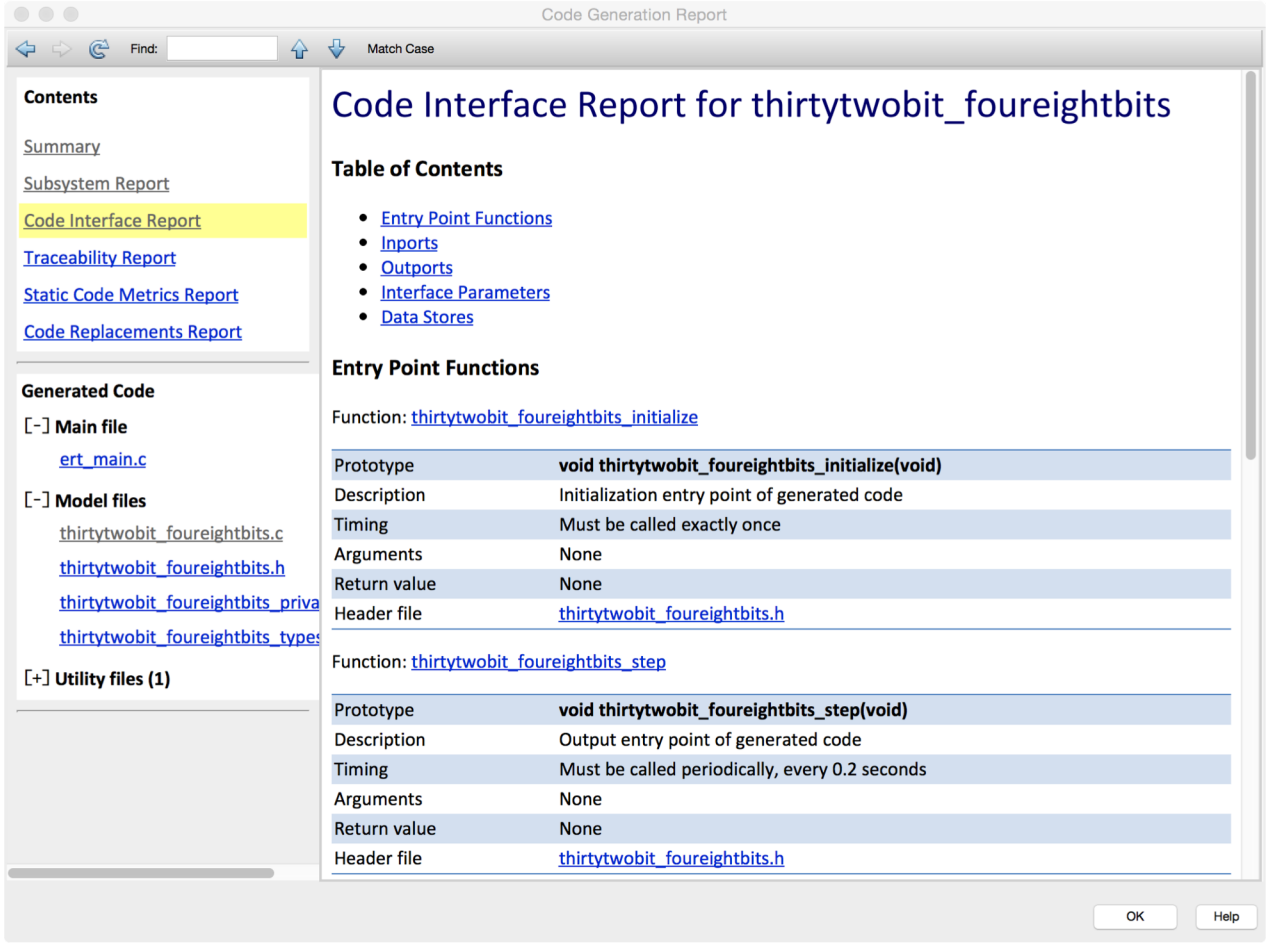
- If the Build is successful, a Code Generation Report window will open
- Note the many menus - we will take a look at some of these.



- Information about the model settings

Code Interface Report

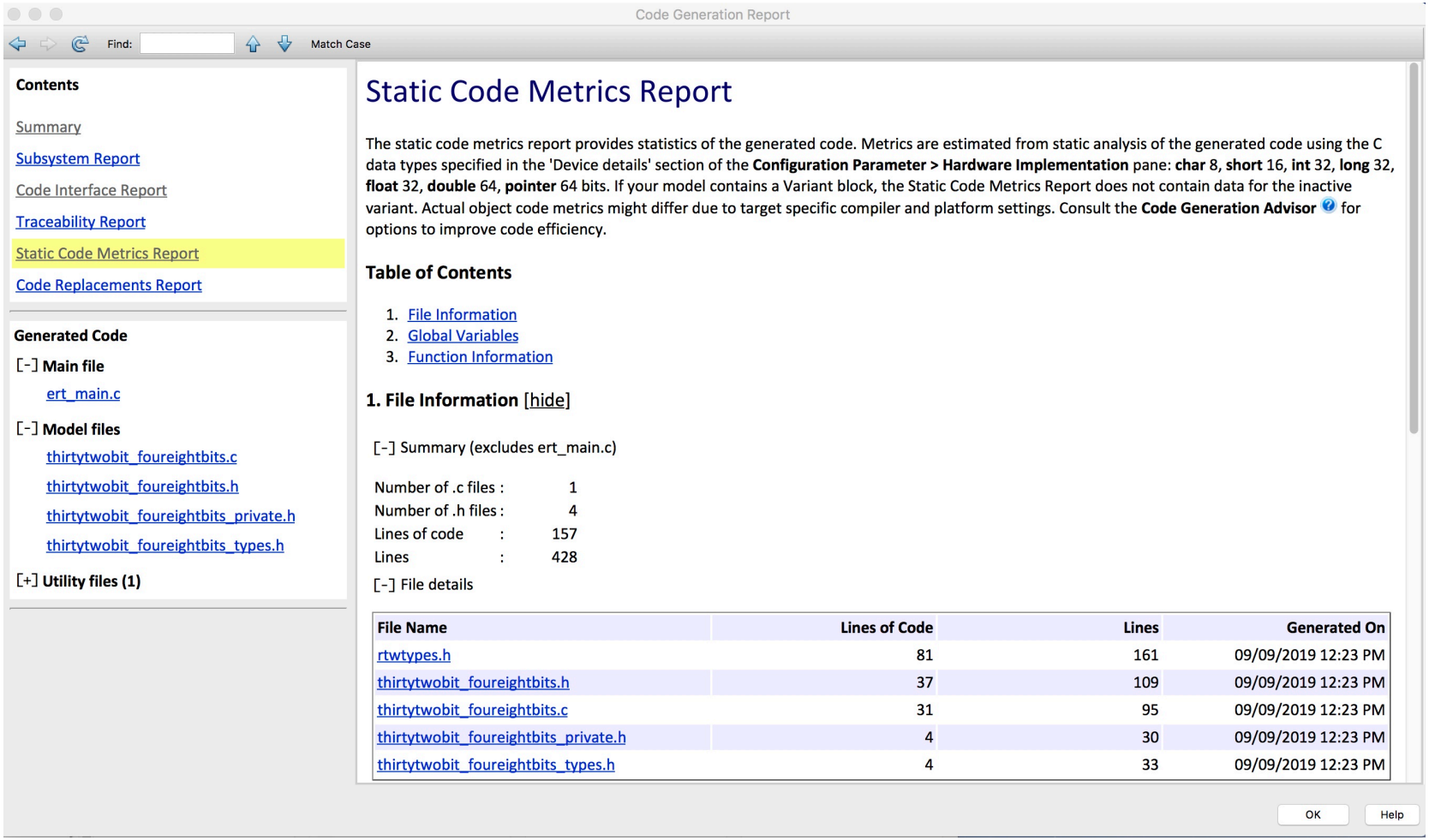
Describes the generated functions, their arguments, and how often they are executed



Q: why does the function `thirtytwo bit_foureightbits_step` execute every 0.2 seconds?

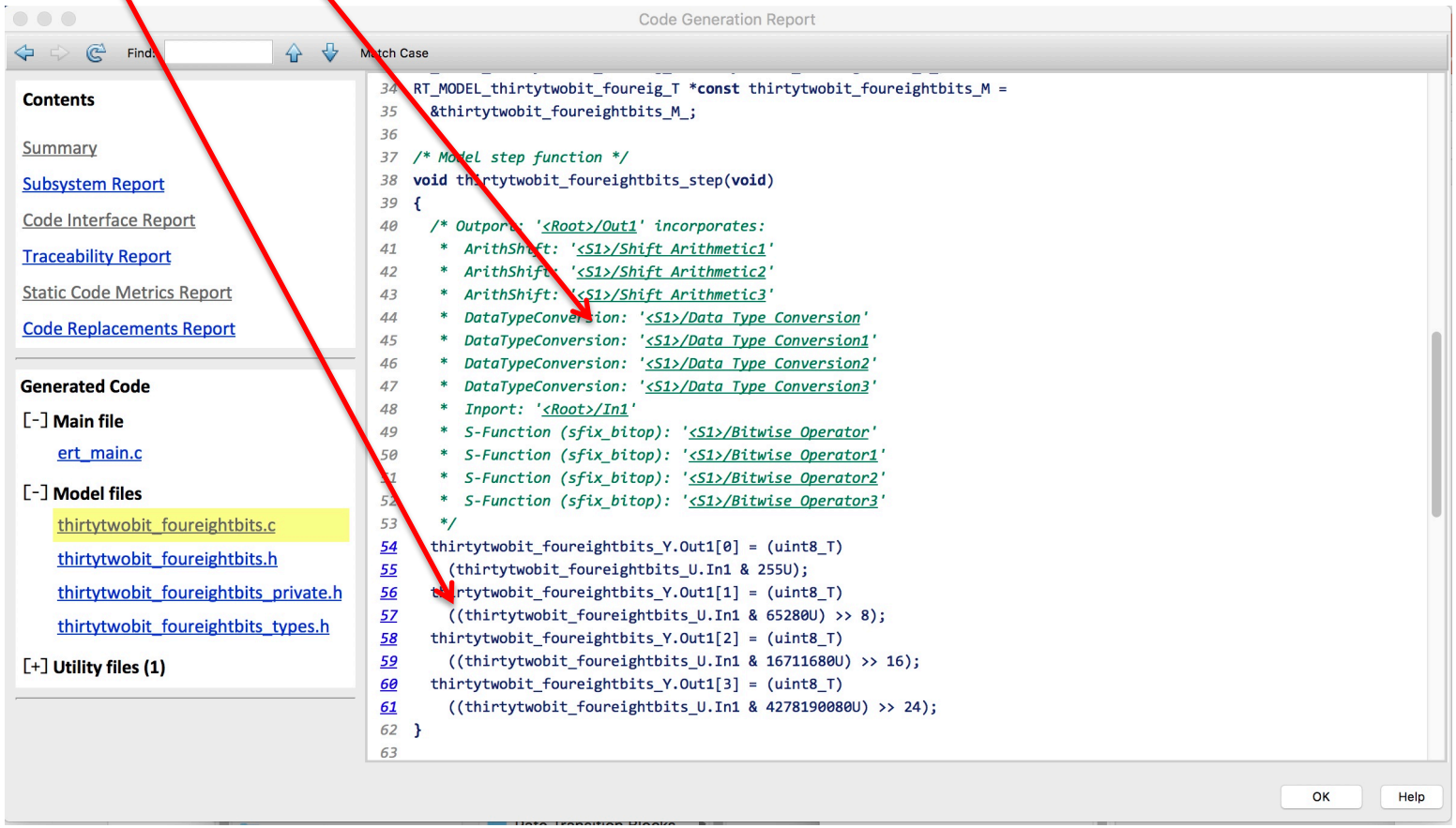
Static Code Metrics Report

- Number of lines of code in the generated `.c` and `.h` files
- Total lines of code, including comments



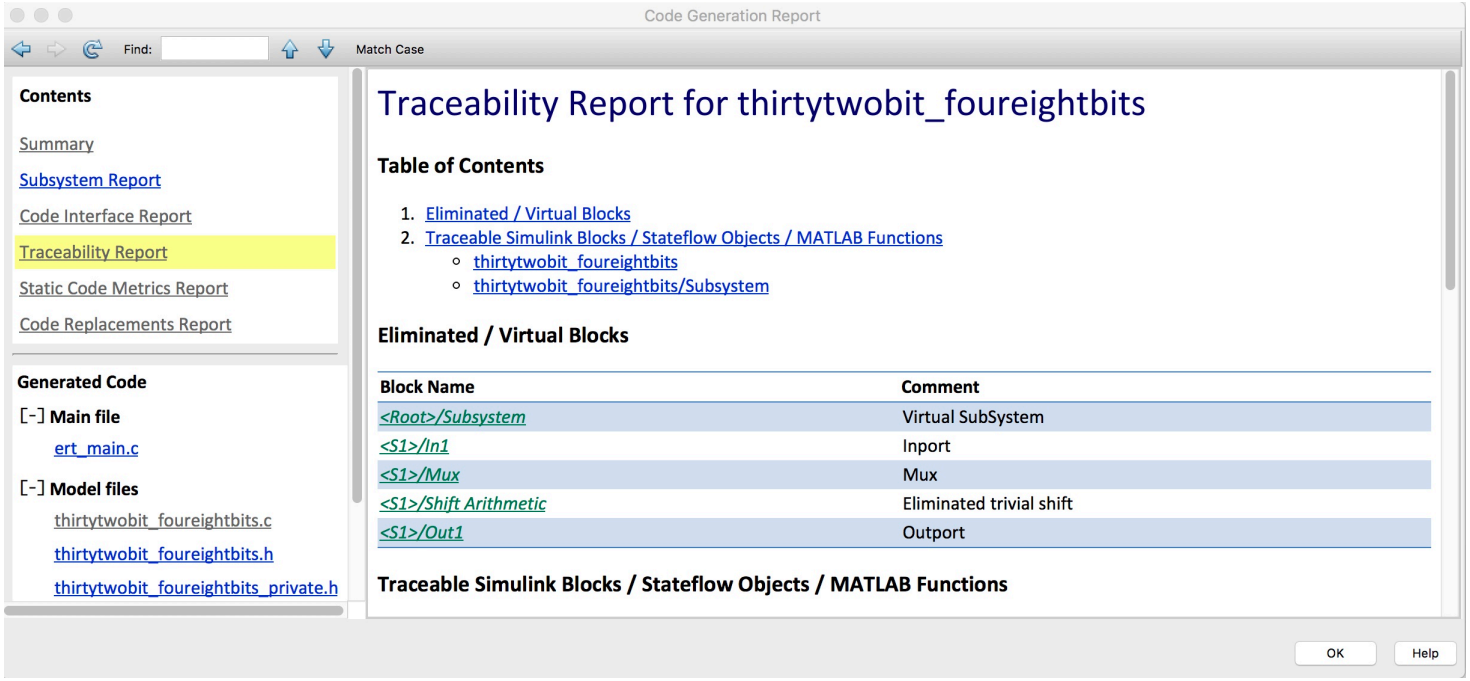
Function Definitions

- Function definitions are found in `thirtytwobitto8bit.c`
- The function `thirtytwobitto8bit_step` performs the desired bit manipulations
- C code for bit masking and shifting
- Simulink blocks implemented in C code
- Note the block *<S1>/Shift Arithmetic* is not on the list



Traceability Report: Eliminated Blocks

Certain Simulink blocks are used only to improve model readability, and do not affect the generated code. These are eliminated (in this case, the subsystem block, Mux block, and redundant input and output port blocks)



Why is the Shift Arithmetic block eliminated?

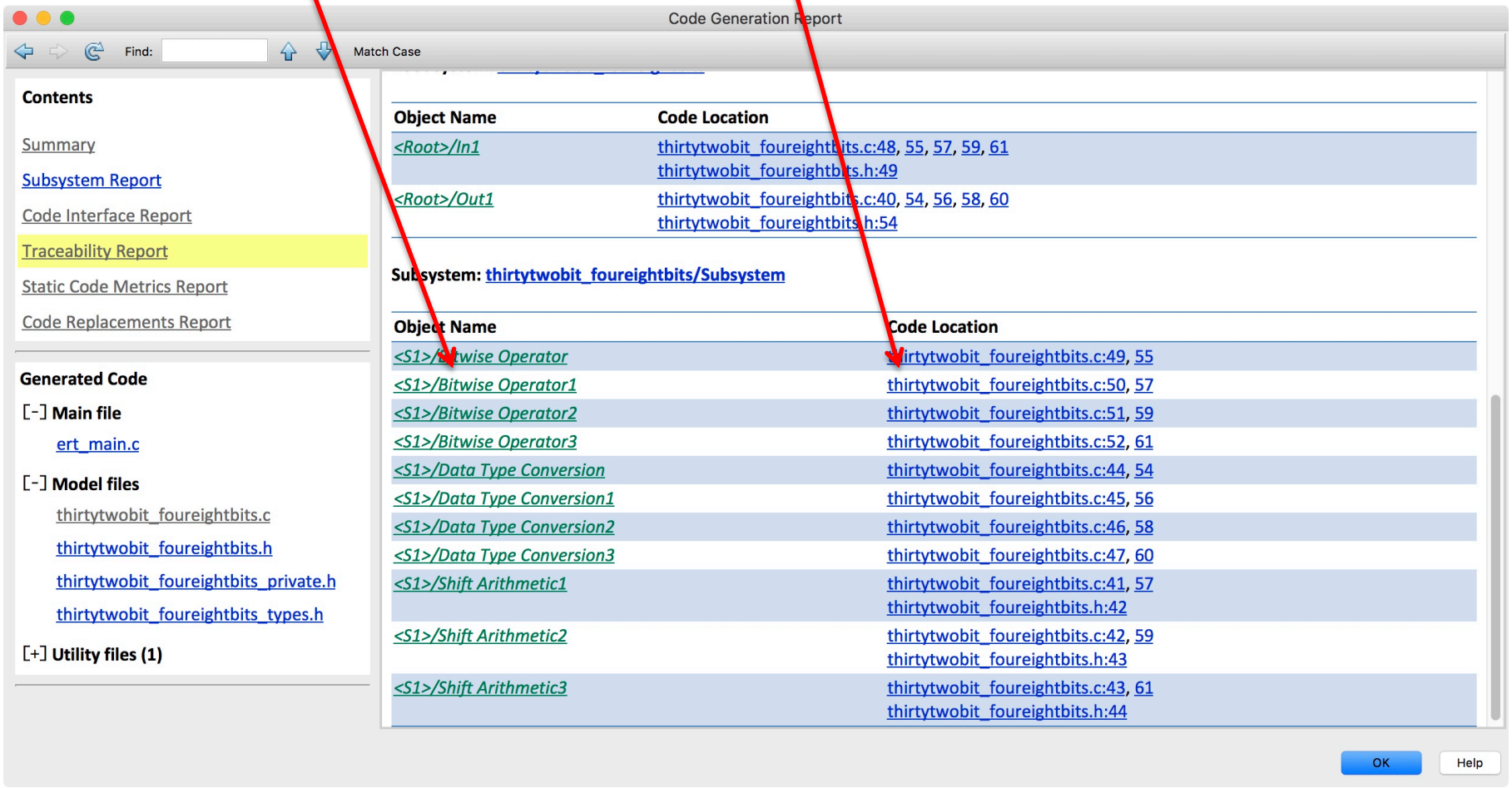
<Root>: Top Level Simulink diagram

<S1>: Subsystem that contains the rest of the Simulink blocks

Traceability Report: Blocks to Code

Simulink block name

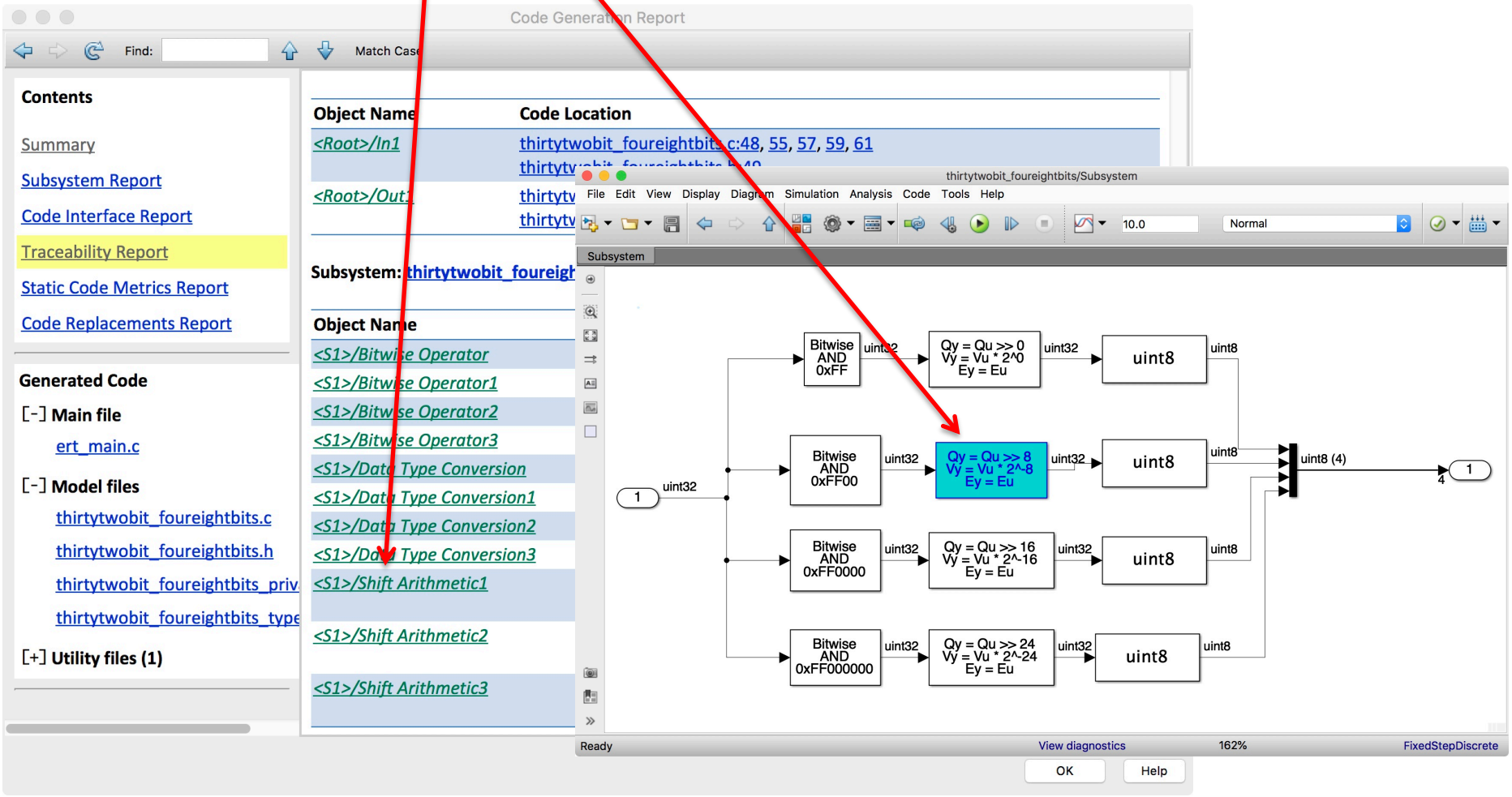
Lines of code in associated .c and .h files



Q: why are there only lines of code for three `<S1>/Shift Arithmetic` blocks in the file `thirtytwobittofourbit.c`?

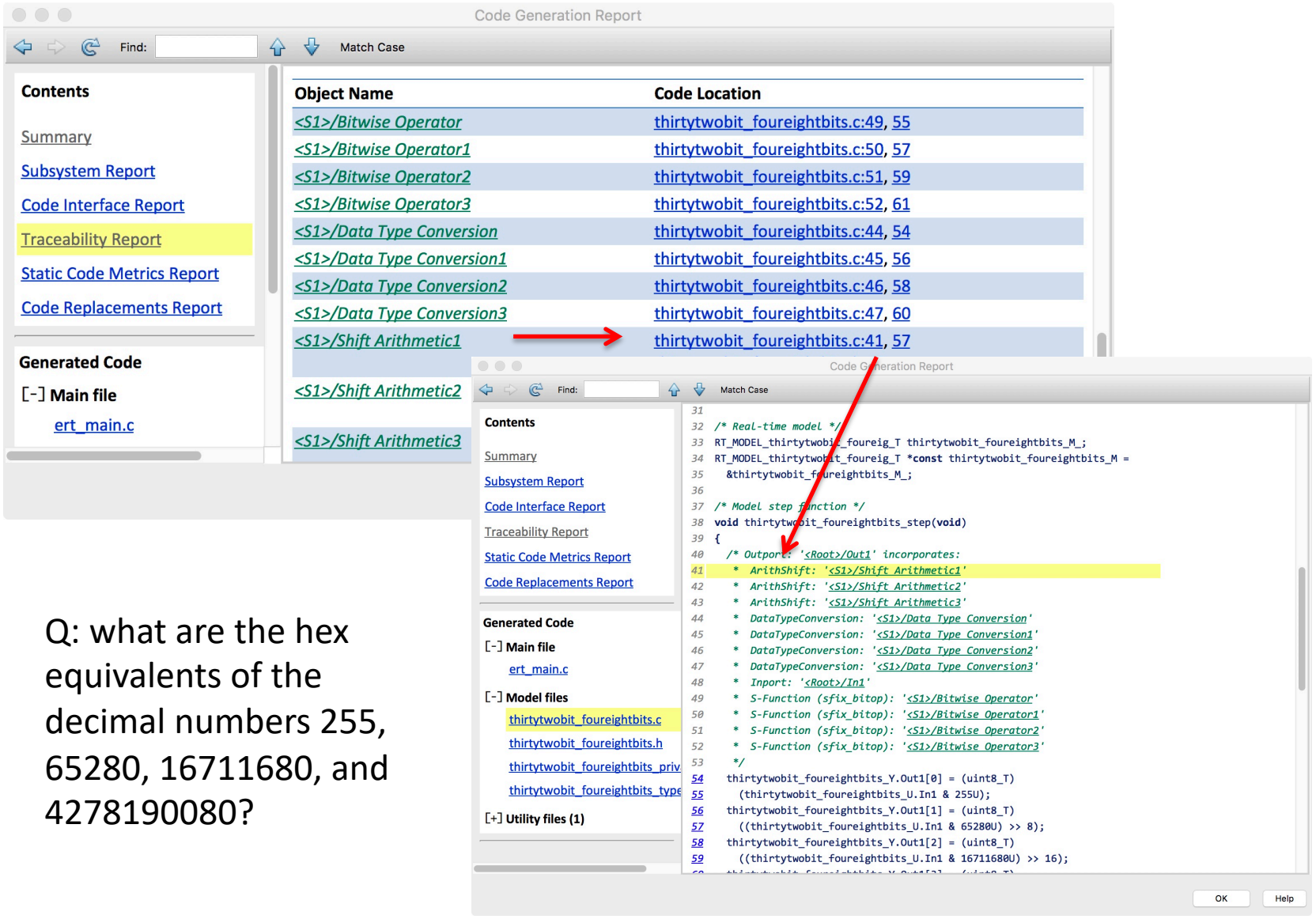
Traceability

Click on block name `< S1>/Shift Arithmetic`
Corresponding Simulink block is highlighted



Traceability: .c file

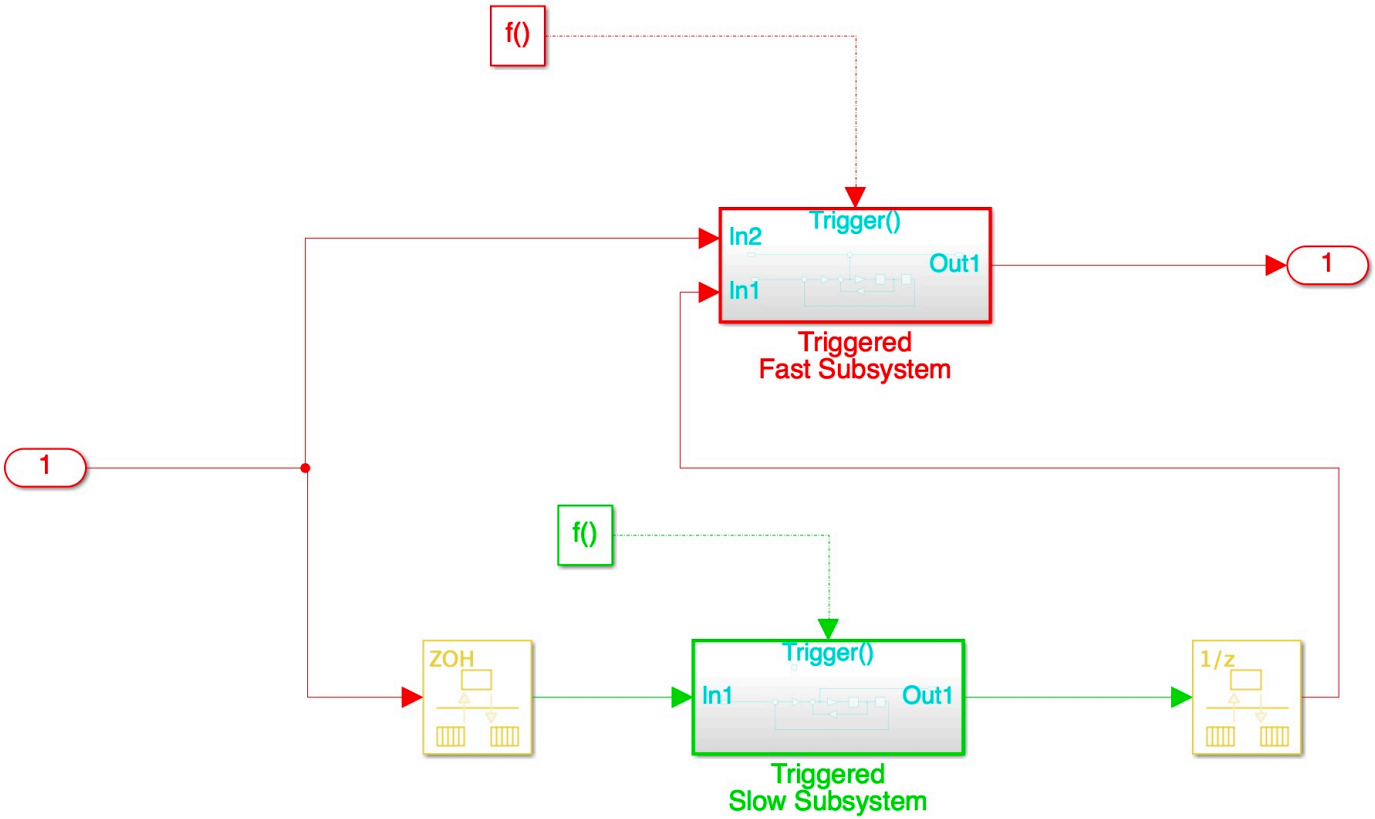
- Click on .c filename name next to Simulink block name
- Location of C code for that block is shown



Q: what are the hex equivalents of the decimal numbers 255, 65280, 16711680, and 4278190080?

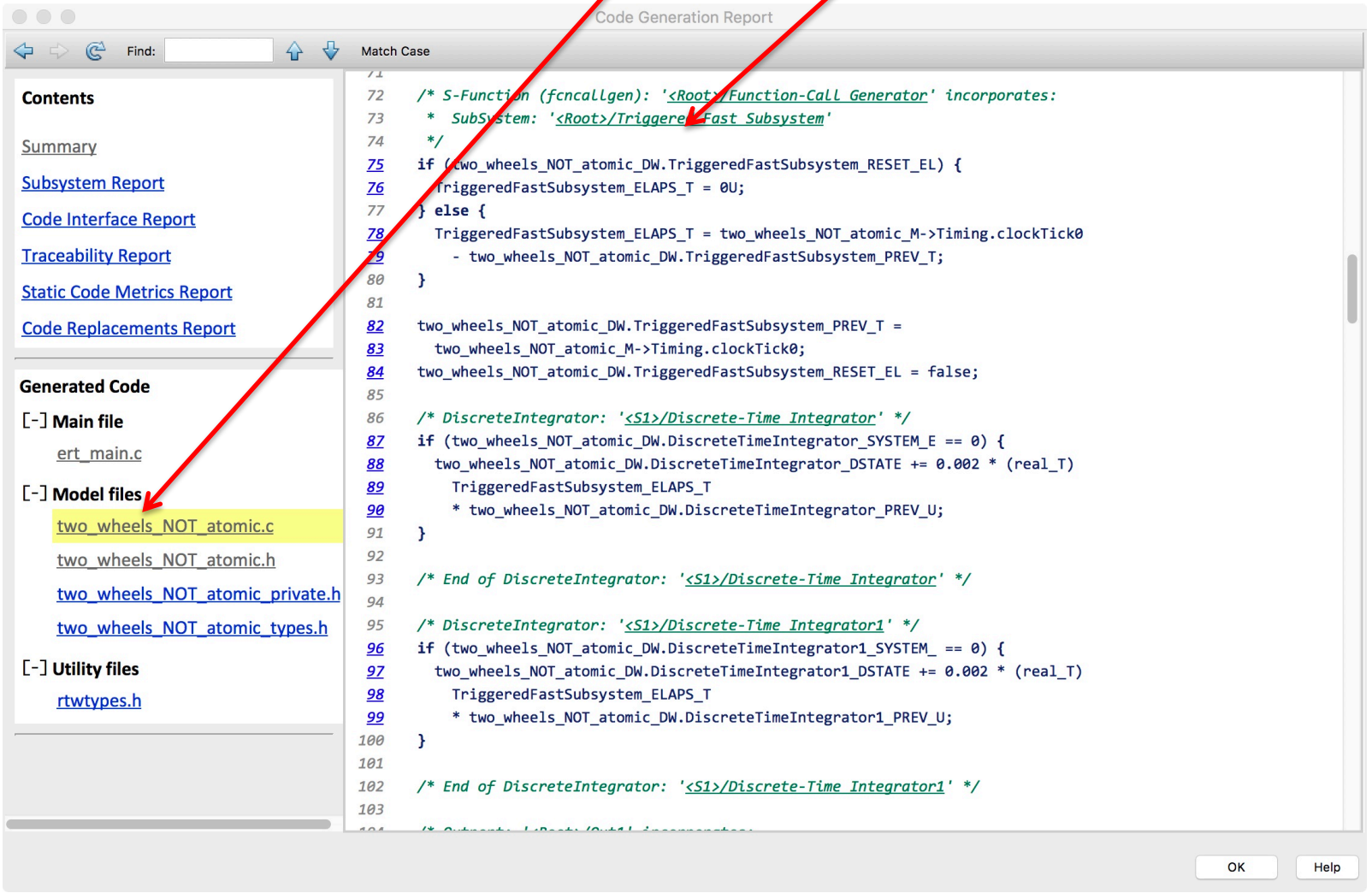
Atomic Subsystems

- Sometimes it is useful to have a separate file generated for each subsystem in a model.
  - For example, it makes the code easier to read.
  - In order to do this, you need to specify each subsystem as an “atomic unit”.
- Example: Two virtual wheels connected to the haptic wheel



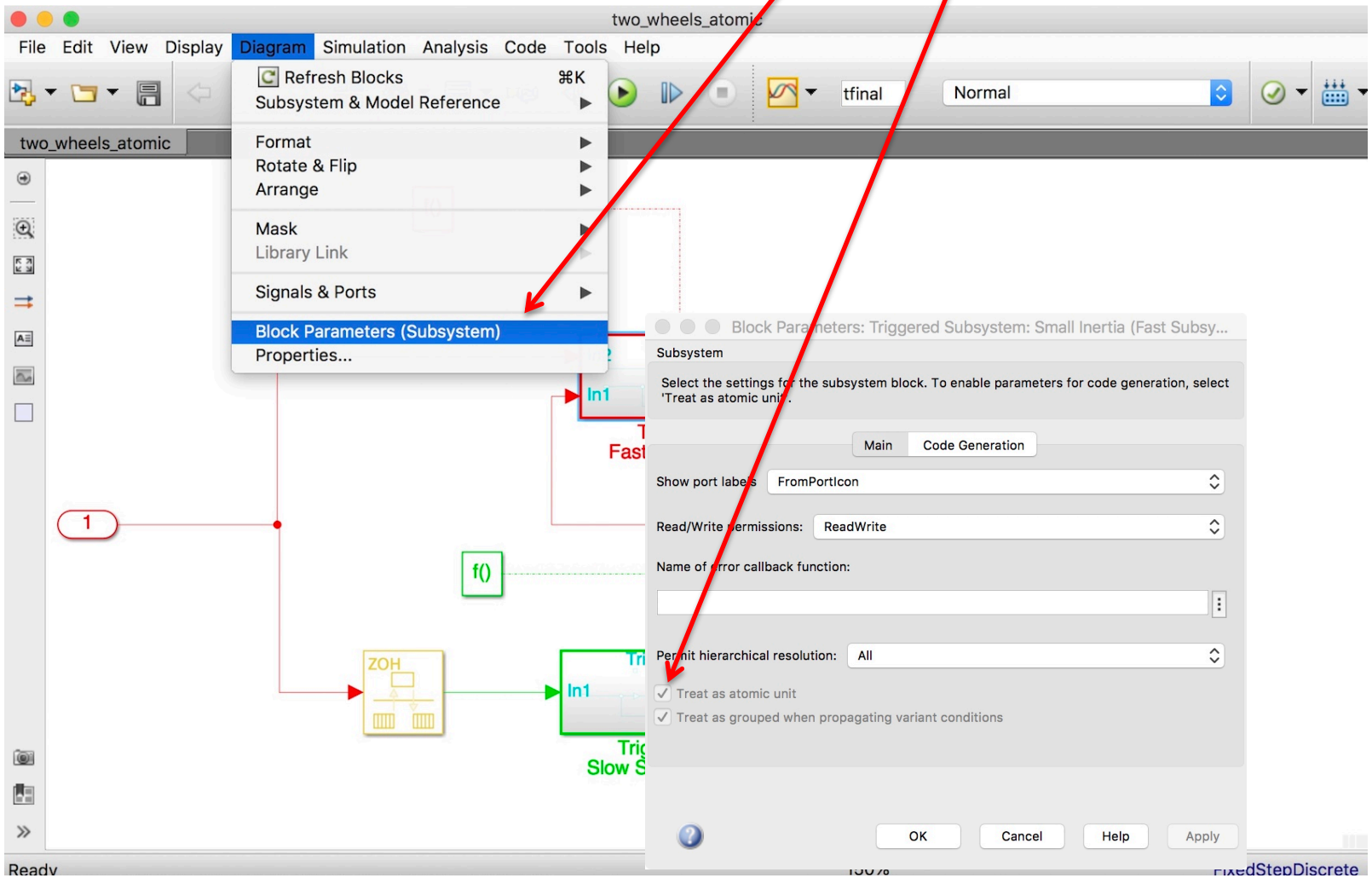
Default code (nonatomic subsystems)

- Default setting is for all code to be in one file, including separate functions to update both subsystems, e.g., the code to update the fast subsystem



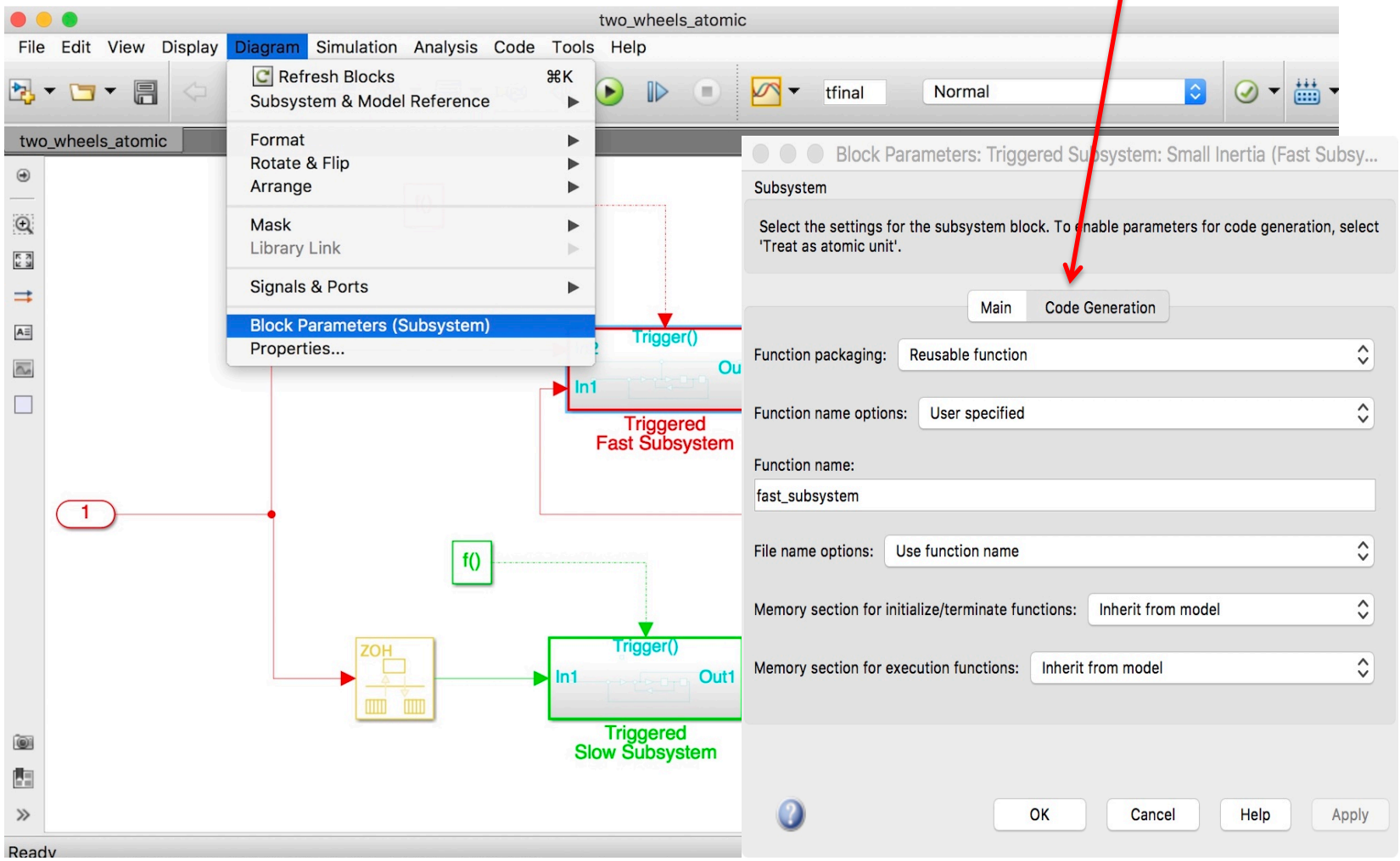
Making subsystems atomic

- Select a subsystem, and navigate to the menu Diagram/Block Parameters (Subsystem)/Main
- For a Triggered Subsystem block, the ”Treat as atomic unit” box will be automatically checked and grayed out.



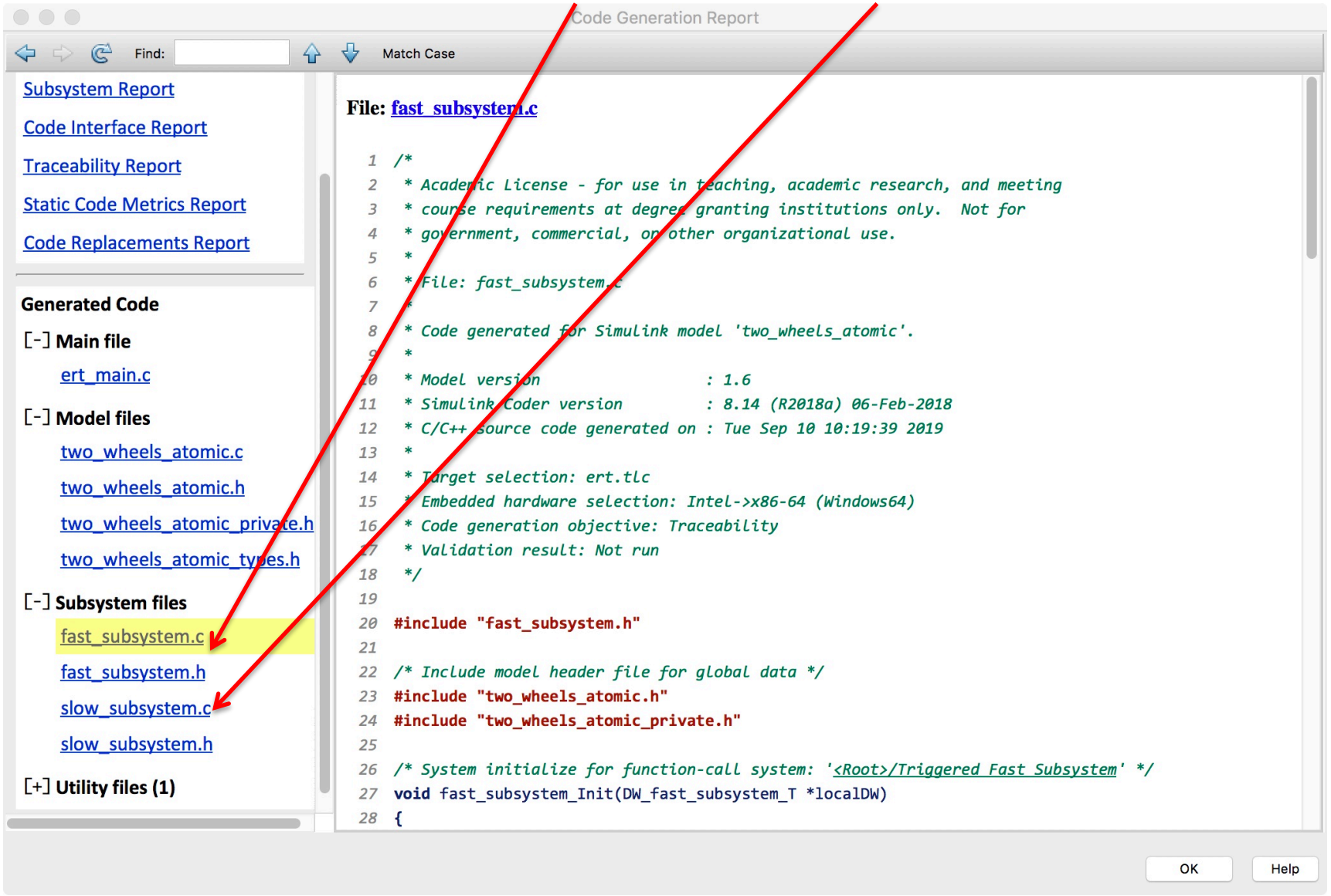
Name the function

- From the menu Diagram/Block Parameters (Subsystem)/Code Generation
- Select “Reusable function” and “User specified” function name
- Name the function, and specify “Use function name” for the file name



Code with atomic subsystems

- Separate functions and files “fast_subsystem” and “slow_subsystem”



Triggered and Atomic Subsystems

There are several ways to make a subsystem that is both triggered and atomic:

- Use a Triggered Subsystem block from the Ports & Subsystems menu of the Simulink Library Browser.
  - This block with automatically be atomic and triggered.

- Use an Atomic Subsystem block from the Ports & Subsystems menu of the Simulink Library Browser.
  - This block will automatically be atomic. Add a Trigger block to make it triggered.

- Use a regular Subsystem block either from the Ports & Subsystems menu of the Simulink Library Browser, or by using the “Create Subsystem from Selection” option from the Subsystem & Model Reference menu of a Simulink diagram.
  - Make the subsystem atomic by checking the “Treat as atomic unit box” of the Diagram/Block Parameters (Subsystem)/Main menu and then add a Trigger block. to the subsystem.
  - Make the subsystem triggered by adding a Trigger and then make the subsystem atomic by checking the “Treat as atomic unit box” of the Diagram/Block Parameters (Subsystem)/Main menu.

    NOTE: In Matlab 2018a this last option will cause the “atomic unit” box to be grayed out but not checked. This is a bug. THE SUBSYSTEM IS STILL ATOMIC!