uM-FPU64 IDE
Integrated Development Environment

User Manual
Release 411

Micromega Corporation

Introduction

The uM-FPU64 Integrated Development Environment (IDE) software provides a set of easy-to-use tools for developing applications using the uM-FPU64 floating point coprocessor. The IDE runs on Windows XP, Vista and Windows 7, and provides support for compiling, debugging, and programming the uM-FPU64 floating point coprocessor.

Main Features

Compiling

- built-in code editor for entering FPU source code
- source window tab processing and auto-indent
- FPU code can be written in compiled code or assembler code
- compiler generates code for FPU functions or customized to the selected microcontroller
- target description files provide for most commonly used microcontrollers
- users can create target description files for customized code generation
- FPU code can be programmed to Flash memory or copied to the microcontroller program

Debugging

- instruction tracing
- contents of all FPU registers can be displayed in various formats
- display windows for Flash memory, RAM, and matrices
- serial output can be displayed by IDE
- breakpoints and single-step execution
- conditional breakpoints using auto-step capability
- symbol definitions from compiler used for instruction trace and display windows
- numeric conversion tool for 32-bit and 64-bit floating point and integer values

Programming Flash Memory

- built-in programmer for storing user-defined functions in Flash memory
- memory map display for Flash memory
- graphic interface for setting parameter bytes stored in Flash

Further Information

The following documents are also available:

uM-FPU64 Datasheet	provides hardware details and specifications
uM-FPU64 Instruction Set	provides detailed descriptions of each instruction

Check the Micromega website at www.micromegacorp.com for up-to-date information.

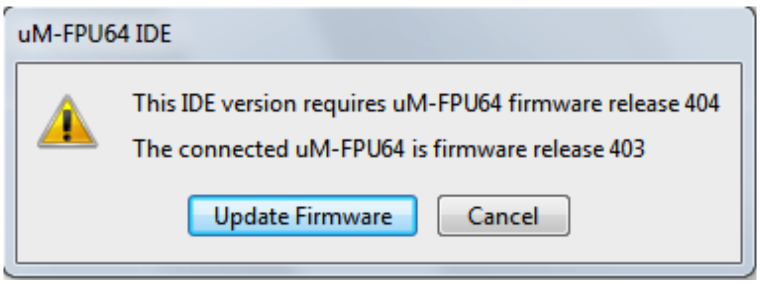
Table of Contents

Installing the uM-FPU64 IDE Software

The uM-FPU64 IDE software can be downloaded from the Micromega website at:
http://www.micromegacorp.com/umfpu64-ide.html
The download is called *uM-FPU64 IDE xxx.zip* (where *xxx* is the release number e.g. *r406*). Double-click or unzip the file, then open the folder, and run the installer called *uM-FPU64 IDE setup.exe*. The software is installed in the *Program FIles (x86)> Micromega* folder, and the Start Menu entry is *Micromega*.

Upgrading the uM-FPU64 Firmware

New versions of the uM-FPU64 IDE software may require that the uM-FPU64 firmware be upgraded to be compatible with new features and the code generated by the compiler. If the IDE is connected to the FPU when it is started, a version command will be sent automatically to check if the firmware requires updating. The check is also done whenever the version command is executed or the Flash is programmed. If an update is required, the following dialog will appear.



See the description of the ***Firmware Update…*** menu item in the ***Tools*** menu for additional information on firmware upgrades. The required firmware files are included in the uM-FPU IDE installation.

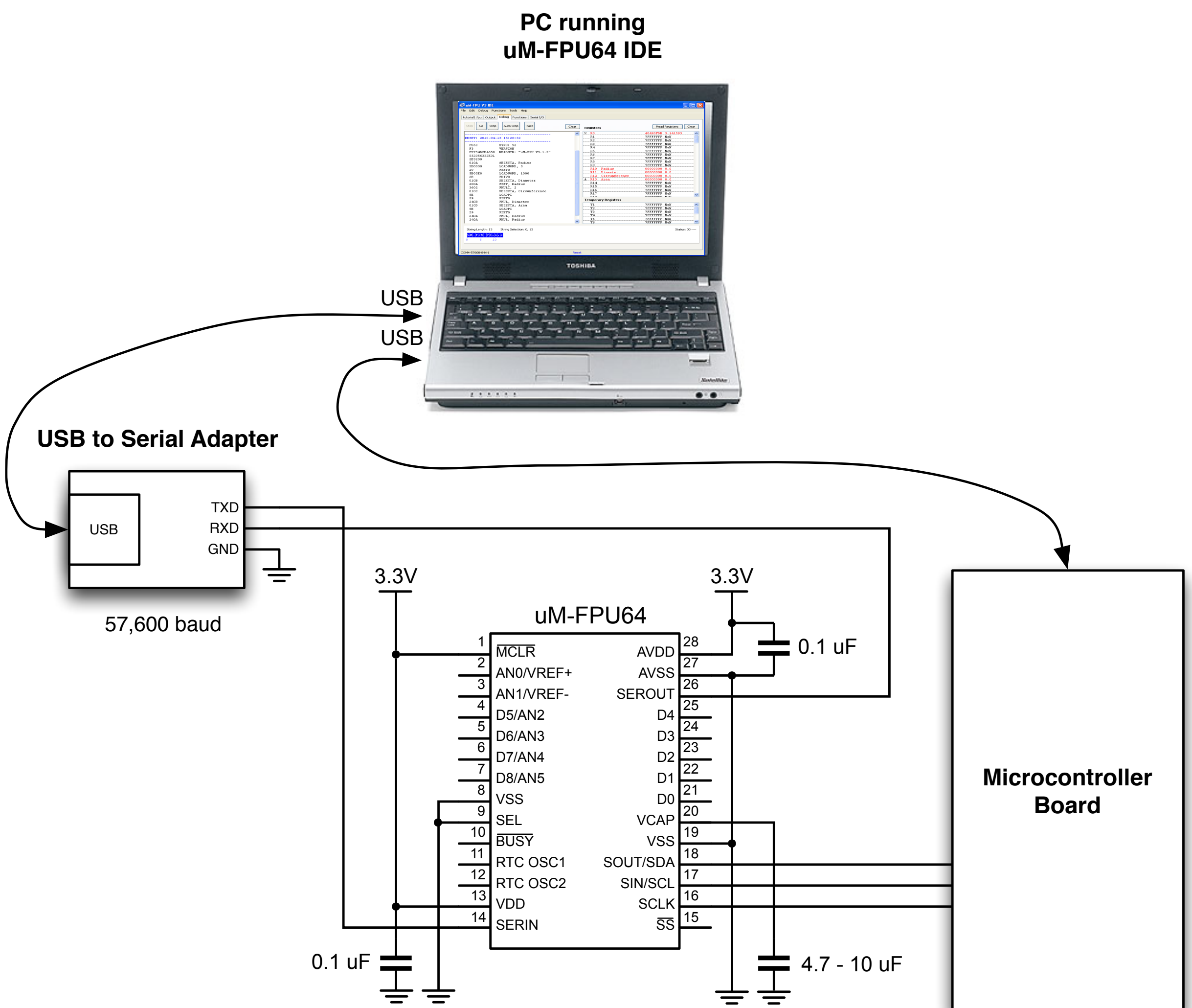
Connecting to the uM-FPU64 chip

Compiling can be done without a serial connection, but a serial connection between the computer running the IDE and the uM-FPU64 chip is required for debugging and programming. For recent computers, the easiest way to add a serial connection is using a USB to Serial adapter. Older computers with serial ports, or USB to RS-232 adapters require a level converter (e.g. MAX232). The uM-FPU64 chip requires a non-inverted serial interface operating at the same voltage as the FPU (i.e. if the FPU is operating at 3.3V, the serial interface must be a 3.3V interface). The IDE communicates with the uM-FPU64 chip at 57,600 baud, using 8 data bits, no parity, one stop bit, and no flow control.

Examples of suitable USB to Serial adapters include:

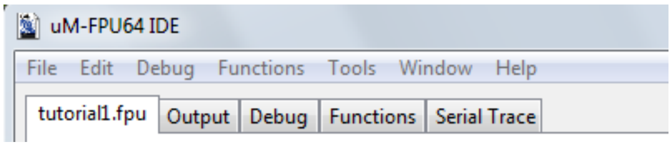
Sparkfun	FTDI Basic Breakout - 3.3V	http://www.sparkfun.com/
Parallax	Parallax PropPlug	http://www.parallax.com/

Connection Diagram



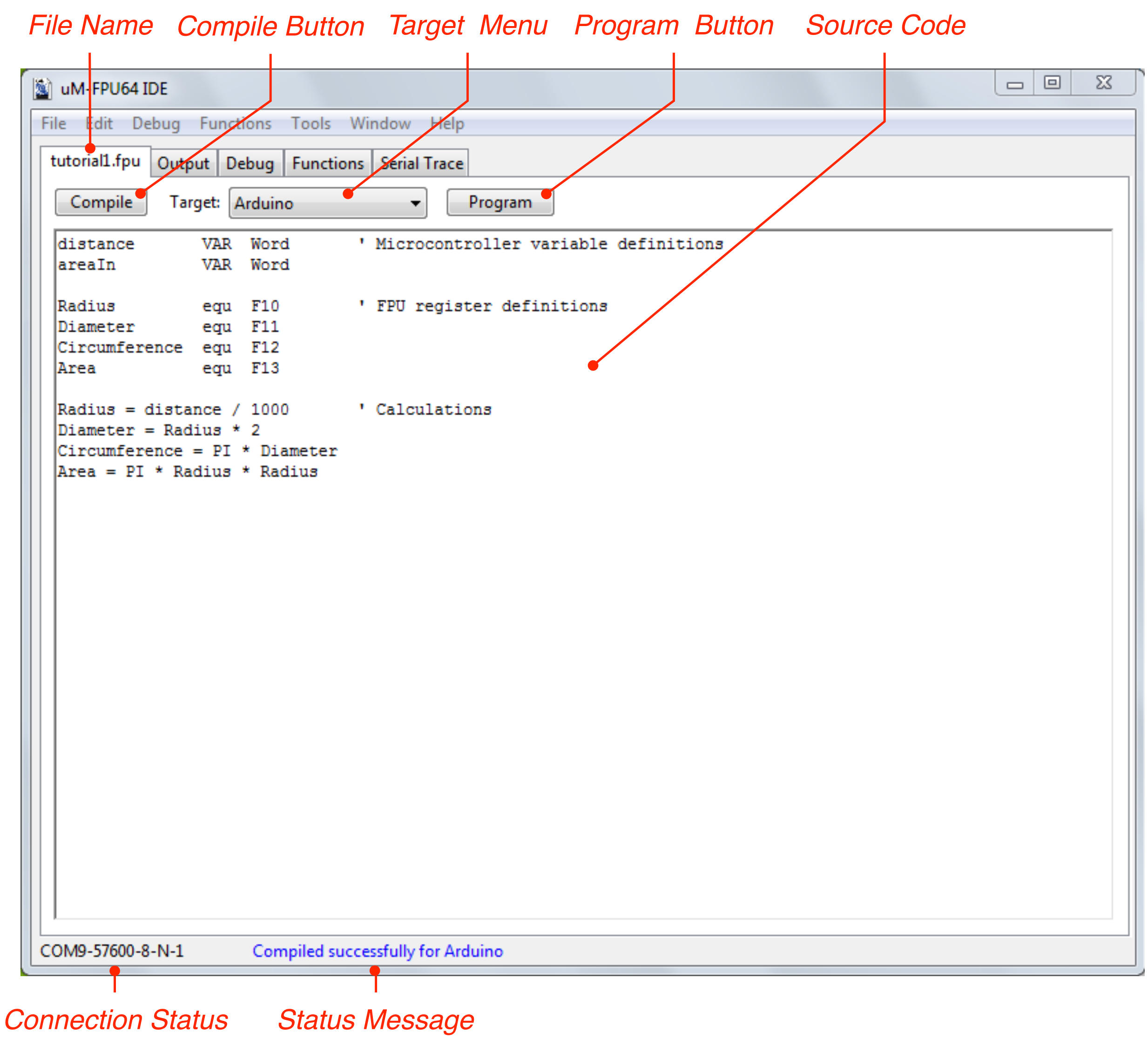
Overview of uM-FPU64 IDE User Interface

The main window of the IDE has a menu bar, and a set of tabs attached to five different windows. Clicking a tab will display the associated window.



Source Window

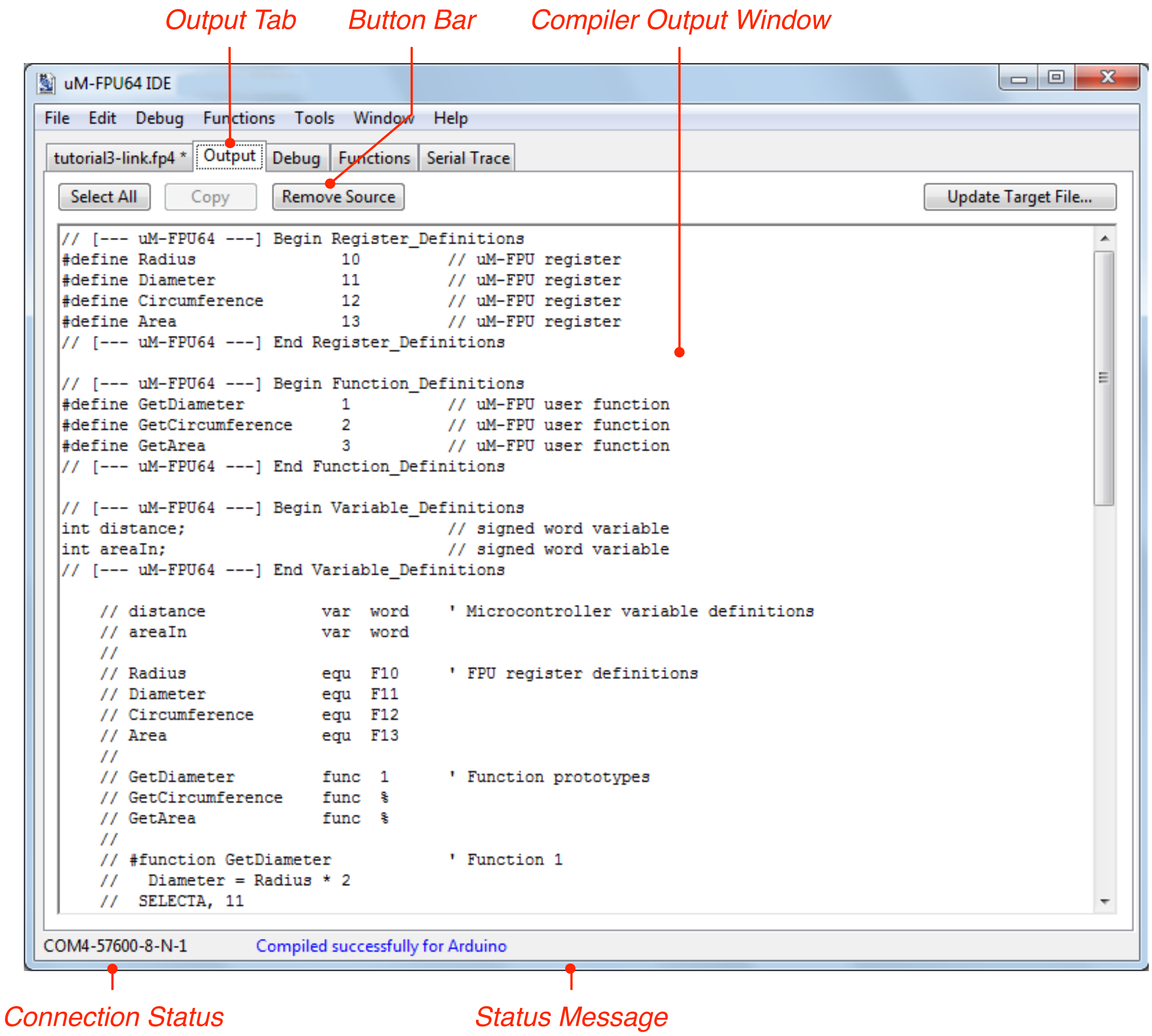
The ***Source Window*** is the leftmost tab, and the filename of the source file is displayed on the tab. If the source file has not been previously saved, the name of the tab will be *untitled*. If the source file has been modified since the last save, an asterisk is displayed after the filename. The source file is stored as a text file with a default extension of *fpu*.



The ***Source Window*** is used to edit the source code and compile the source code. Pressing the ***Compile*** button will compile the code for the target selected by the ***Target Menu***. If an error occurs during compile, then an error message will be displayed as the ***Status Message***. All error messages are displayed in red.

Output Window

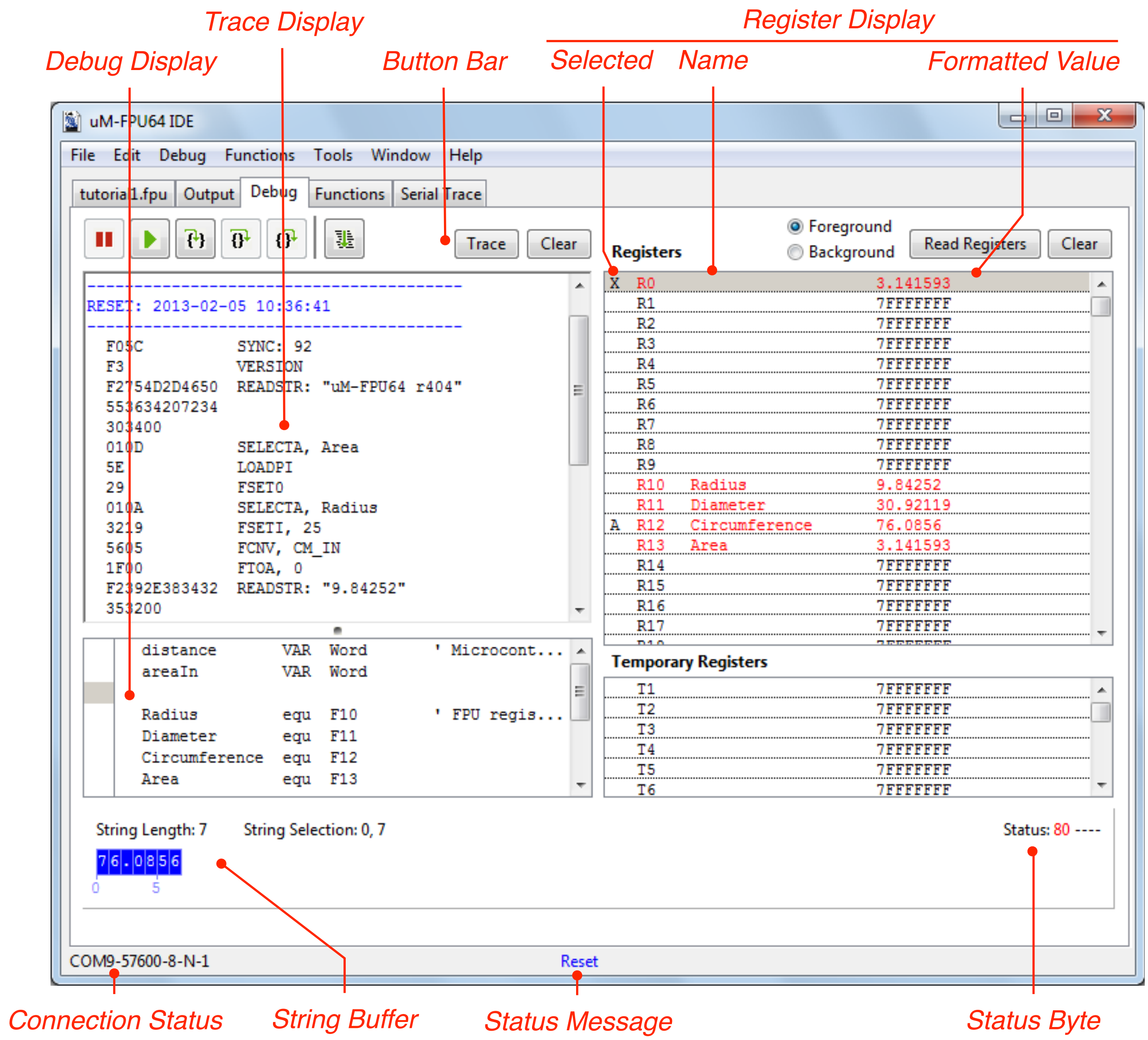
The ***Output Window*** is automatically displayed if the compile is successful. The status message will show that the compile was successful. All normal status messages are displayed in blue.



If the code was generated for a target microcontroller, the ***Select All*** and ***Copy*** buttons can be used to copy the code from the window so it can be pasted into the microcontroller program. Alternatively, the code can be copy-and-pasted a section at a time by doing a text selection and using the ***Copy*** button. The ***Remove Source*** button can be used to remove the source code lines that are included as comments. The ***Update Target File...*** button is used to update a target file with the generated code.

Debug Window

The ***Debug Window*** is used for debugging. It displays the instruction trace, reset and breakpoint information, and the contents of the FPU registers, string buffer and status value.



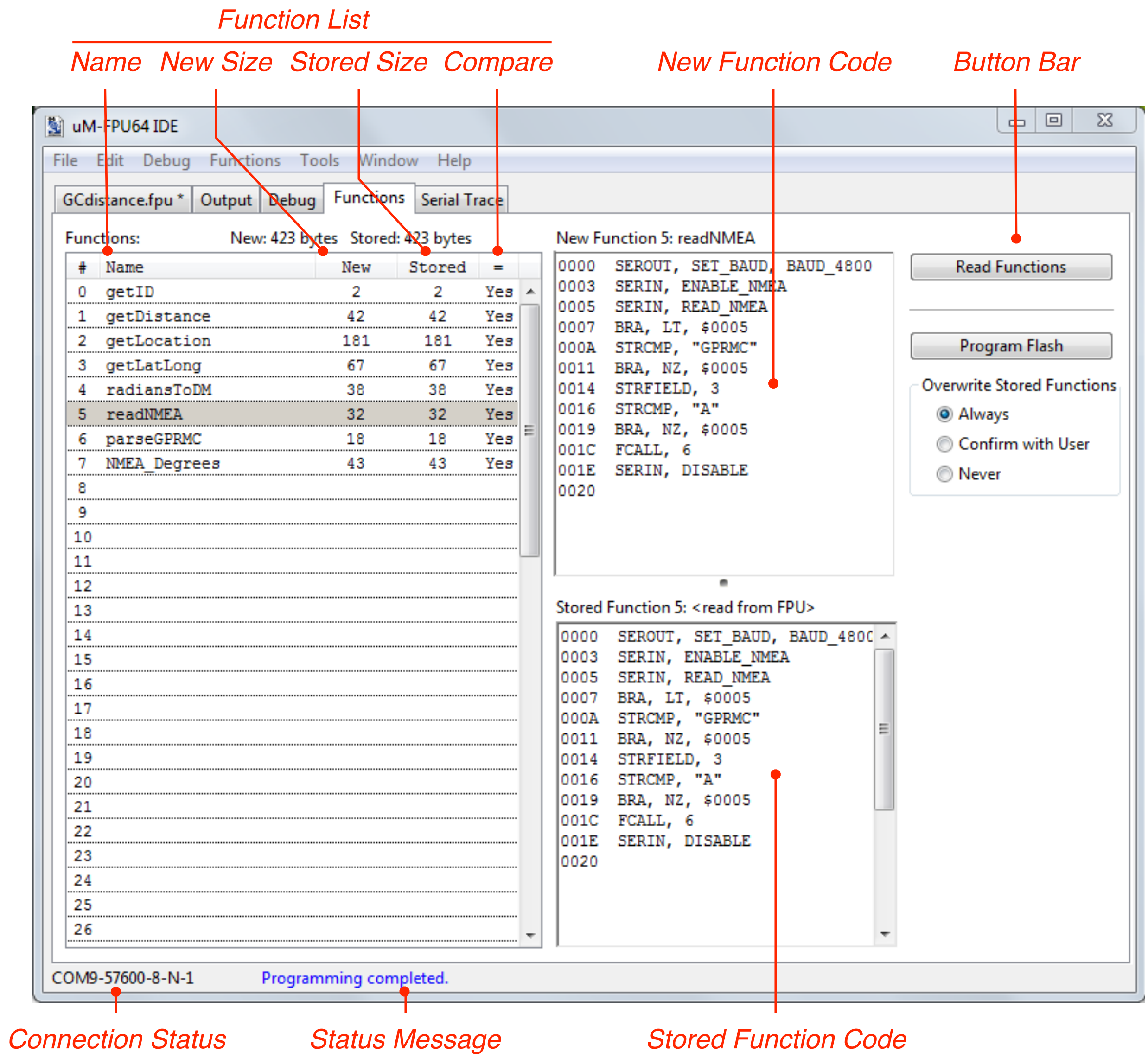
The ***Trace Display*** shows messages and instruction traces. The Reset message includes a time stamp, is displayed whenever a hardware or software reset occurs. Instruction tracing will only occur if tracing is enabled. This can be enabled at Reset by setting the ***Trace on Reset*** option in the ***Functions> Set Parameters...*** dialog, or at any time by by sending the **TRACEON** instruction.

The ***Debug Display*** provides support for source level debugging with hardware breakpoints.

The ***Register Display*** shows the value of all registers. Register values that have changed since the last update are shown in red. The ***String Buffer*** displays the FPU string buffer and string selection, and the ***Status Byte*** shows the FPU status byte and status bit indicators. The ***Register Display***, ***String Buffer***, and ***Status Byte*** are only updated automatically at breakpoints. They can be updated manually using the ***Read Registers*** button.

Functions Window

The ***Functions Window*** shows the function code for all new functions and stored functions. It also can be used to program the functions into Flash memory on the FPU.



The ***Function List*** provides information about each function defined by the compiler and stored on the FPU. The ***New Function Code*** displays the FPU instructions for compiled functions, and the ***Stored Function Code*** displays the FPU instructions for functions stored on the FPU. The ***Read Functions*** button is used to read the functions currently stored on the FPU, and the ***Program Functions*** button is used to program new functions to the uM-FPU64 chip.

Serial Trace Window

The ***Serial Trace Window*** shows a trace of the serial data exchanged between the IDE and the uM-FPU64 chip. It's provided mainly for diagnostic purposes.

Tutorial 1: Compiling FPU Code

This tutorial takes you through the process of compiling uM-FPU64 code for a few simple examples. Various IDE features are introduced as we go through the tutorial. For a more complete description of specific features, see the the *Reference Guide* sections later in this document.

This tutorial uses Arduino with a SPI interface as the target. If you're working with a different microcontroller or compiler, the procedures are the same, but the output code for the selected target will be different. The figure below shows the process of developing FPU code using the IDE.

Compiling uM-FPU64 code

uM-FPU64 IDE

tutorial1.fpu

```
distance       VAR  Word       ' Microcontroller variable definitions
areaIn         VAR  Word

Radius         equ  F10        ' FPU register definitions
Diameter       equ  F11
Circumference  equ  F12
Area           equ  F13

Radius = distance / 1000       ' Calculations
Diameter = Radius * 2
Circumference = PI * Diameter
Area = PI * Radius * Radius
```

Compile

Output window

```
//-------------------- uM-FPU Register Definitions -----------------------------
#define Radius  10                      // uM-FPU register
#define Diameter    11                  // uM-FPU register
#define Circumference   12              // uM-FPU register
#define Area    13                      // uM-FPU register

//-------------------- Variable Definitions -----------------------------------
int distance;                           // signed word variable
int areaIn;                             // signed word variable

//-------------------- Generated Code -----------------------------------------
    // distance       VAR  Word       ' Microcontroller variable definitions
    // areaIn         VAR  Word
    //
    // Radius         equ  F10        ' FPU register definitions
    // Diameter       equ  F11
    // Circumference  equ  F12
    // Area           equ  F13
    //
    // Radius = distance / 1000       ' Calculations
    Fpu.write(SELECTA, Radius, LOADWORD);
    Fpu.writeWord(distance);
    Fpu.write(FSET0, LOADWORD);
    Fpu.writeWord(1000);
    Fpu.write(FDIV0);
    // Diameter = Radius * 2
    Fpu.write(SELECTA, Diameter, FSET, Radius, FMULI, 2);
    // Circumference = PI * Diameter
    Fpu.write(SELECTA, Circumference, LOADPI, FSET0, FMUL, Diameter);
    // Area = PI * Radius * Radius
    Fpu.write(SELECTA, Area, LOADPI, FSET0, FMUL, Radius);
    Fpu.write(FMUL, Radius);
    //
```

Copy & Paste

Microcontroller Development Tool

tutorial1.bs2

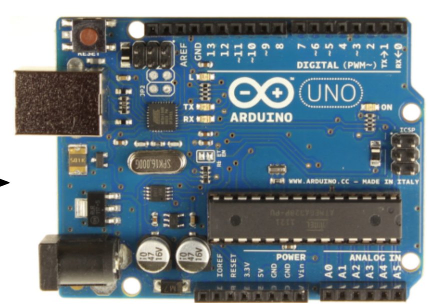
```
#include <SPI.h>
#include <Fpu64.h>
#include <FpuSerial64.h>

//-------------------- uM-FPU register definitions ---------------------------

#define DiameterIn      10         // diameter in inches
#define Circumference   11         // circumference
#define Area            12         // area
#define Pi              13         // constant pi

void setup()
{
  Serial.begin(9600);
  Serial.println("Sample");

  SPI.begin();
  Fpu.begin();

  if (Fpu.sync() == SYNC_CHAR)
    FpuSerial.printVersionln();
  else
  {
    Serial.println("FPU not detected");
    while(1) ; // stop if FPU not detected
  }
}

void loop()
{
  byte diameterCm;

  // Load constant for later use.
  Fpu.write(SELECTA, Pi, LOADPI, FSET0);

  // Get diameter in centimeters.  The value would typically come from a sensor
  // reading, but in this example an assumed value of 25 is used.
  diameterCm = 25;
  Serial.print("\r\nDiameter (cm):       ");
  Serial.println(diameterCm, DEC);

  // Convert inches to centimeters
  Fpu.write(SELECTA, DiameterIn, FSETI, diameterCm);
  Fpu.write(FCNV, 5);
  Serial.print("Diameter (in.):      ");
  FpuSerial.printFloatln(0);

  // circumference = diameter * pi
  Fpu.write(SELECTA, Circumference, FSET, DiameterIn);
  Fpu.write(FMUL, Pi);
  Serial.print("Circumference (in.): ");
  FpuSerial.printFloatln(0);

  // area = (diameter / 2)^2 * pi
  Fpu.write(SELECTA, Area, FSET, DiameterIn);
```

Program

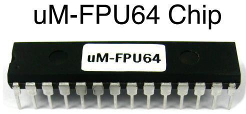
Steps

- Create FPU source code file
- Compile the FPU code
- Copy generated code to microcontroller program
- Compile microcontroller program
- Program the microcontroller

Microcontroller



uM-FPU64 Chip



Starting the uM-FPU64 IDE

Start the uM-FPU64 IDE program. The program will open to an empty ***Source Window*** with the filename set to *untitled*. Since we are using Arduino for this tutorial, use the ***Target Menu*** to select *Arduino–SPI*.

The ***Connection Status*** is shown at the lower left of the window**.** A connection is not required to use the compiler, it's only required for debugging and programming.

Entering a Simple Equation

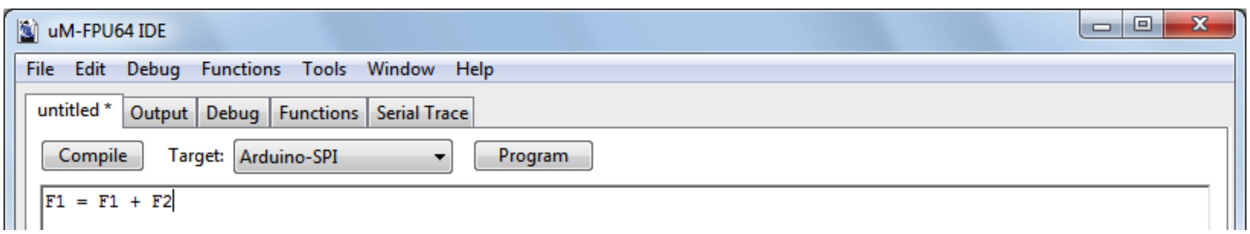
The uM-FPU64 IDE has predefined names for the registers in the FPU.

F0, **F1**, **F2**, … **F127** specifies registers 0 through 255, and that the register contains a floating point value
L0, **L1**, **L2**, … **L127** specifies registers 0 through 255, and that the register contains a long integer
U0, **U1**, **U2**, … **U127** specifies registers 0 through 255, and that the register contains an unsigned long integer

Using these pre-defined names, you can enter a simple equation directly. To add the floating point values in register 1 and register 2, and store the result in register 1, you can enter the following equation:

```
F1 = F1 + F2
```

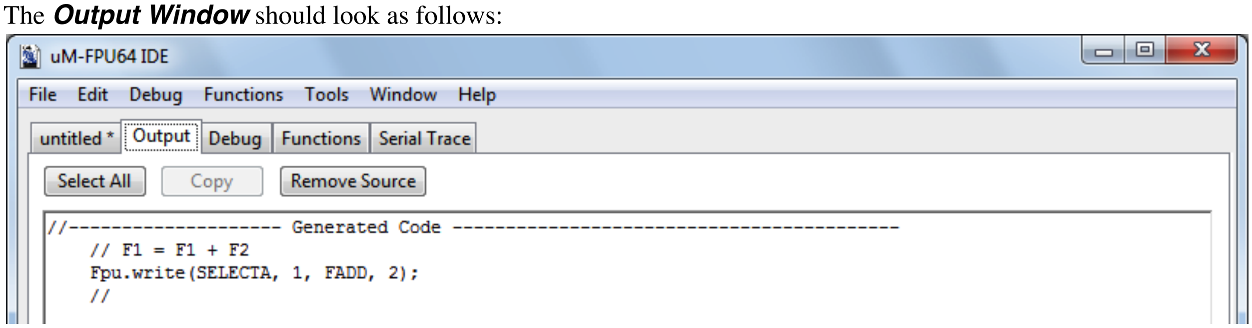
The ***Source Window*** should look as follows:



Notice that the status line at the bottom of the window now reads *Input modified since last compile*. This lets you know that you must compile to generate up-to-date output code. Click the ***Compile*** button. If the compile is successful, the ***Output Window*** will be displayed, and the status message will be *Compiled successfully for Arduino-SPI.*

If an error is detected, an error message will be displayed in red. If you get an error message, check that your input matches the ***Source Window*** above, then click the ***Compile*** button again.

The ***Output Window*** should look as follows:



The expression `F1 = F1 + F2` has been translated into Arduino code. The code selects FPU register 1 as register A, then adds the value of register 2 to register A. You've successfully compiled your first compile. (If you want to see the code generated for a different target, go back to the ***Source Window*** and select a different target from the ***Target Menu***.)

Defining Names

Math expressions can be easier to read when meaningful names are used. The IDE allows you to define names for FPU registers, microcontroller variables and constants.

Registers are defined using the **EQU** operator and one of the predefined register names. Microcontroller variables are defined using the **VAR** operator. For example, the following statements define TOTAL as a floating point value in register 1, and COUNT as a byte variable on the microcontroller.

```
TOTAL  EQU  F1
COUNT  VAR  BYTE
```

The following statement would generate code to read the value of COUNT from the microcontroller, convert it to floating point and add it to the TOTAL register.

```
TOTAL = TOTAL + COUNT
```

Sample Project

Suppose we have a distance measuring device that returns a number of pulses proportional to distance. It measures distance from 0 to 30 inches and returns 1000 pulses per inch. We intend to use this device to measure the radius of a circle, then calculate the diameter, circumference and area using the FPU. The results are displayed in units of inches to three decimal places.

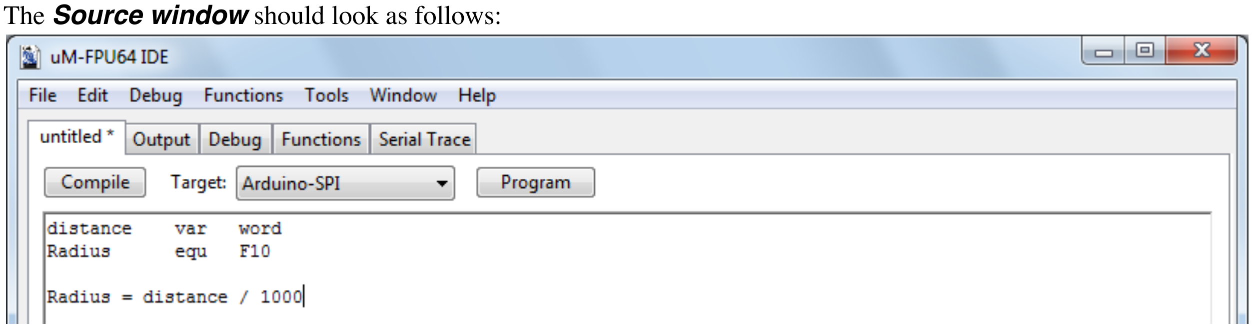
Calculating Radius

The number of pulses returned by the distance measuring device ranges from 0 to 30000 (30 inches x 1000 pulses per inch), so we will need to use a word variable to store the value on the microcontroller. Since results will be displayed in inches, we'll divide the distance value by 1000 once it's loaded to the FPU chip.

Create a new source file using the ***File> New...*** menu item, and enter the following code:

```
distance  VAR  word
Radius    EQU  F10

Radius = distance / 1000
```

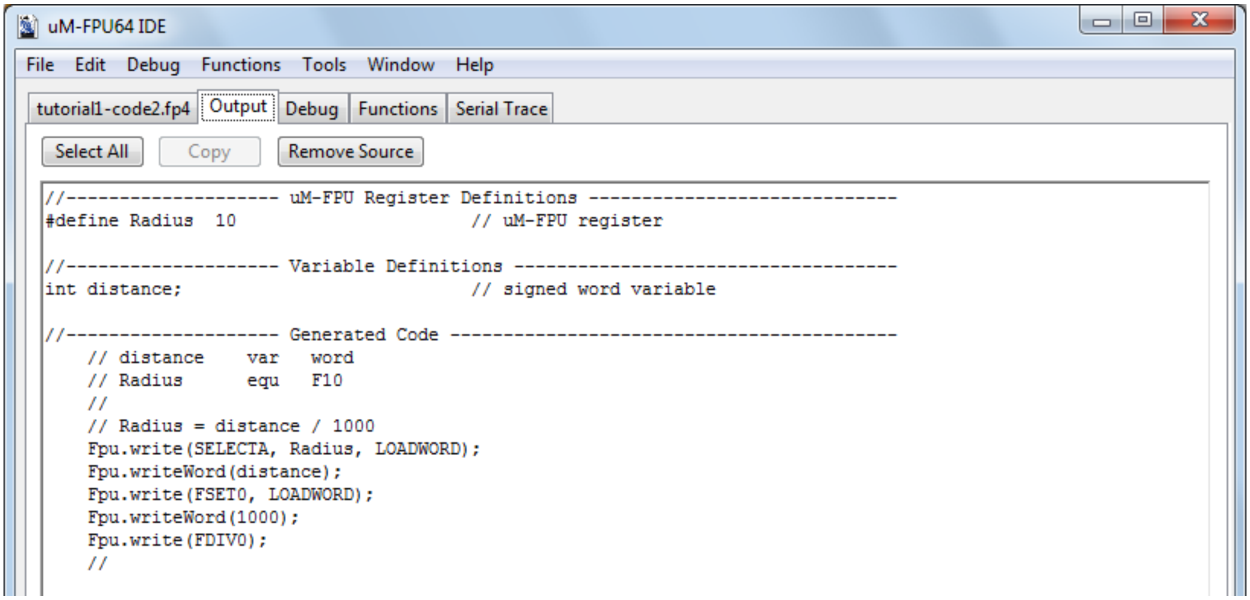
The ***Source window*** should look as follows:



Save the source file using the ***File> Save*** menu item. Save the file as *tutorial1* (with *.fp4* extension added automatically).

Click the ***Compile*** button.

The ***Output Window*** should look as follows:



The generated code does the following:

`SELECTA, Radius`
select the Radius register as register A

`LOADWORD, distance, FSET0`
load the 16-bit `distance` variable to the FPU, convert it to floating point, and store in Radius register

`LOADWORD, 1000, FDIV0`
load the floating point constant 1000, and divide the Radius register by that value

Copying Code to the Microcontroller Program

In this example we are using Arduino as the target, so open the Arduino software and open the following file: ***File> Examples> Fpu64> template***. Save a new copy of the *template* file.

Copy the *uM-FPU Register Definitions* and *Variable Definitions* from the ***Output Window*** and paste them at the start of the *template* program before the *setup()* method.

Copy the Generated Code from the ***Output Window*** and paste it in the *template* program inside the `loop()` method.

Since we don't actually have the sensor described, we'll enter a test value at the start of the program. Add the following line at the start of the `loop()` method.

```
distance = 2575;
```

To print the result, add the following lines immediately after the code you copied.

```
Serial.print("Radius: ");
FpuSerial.PrintFloat(0);
```

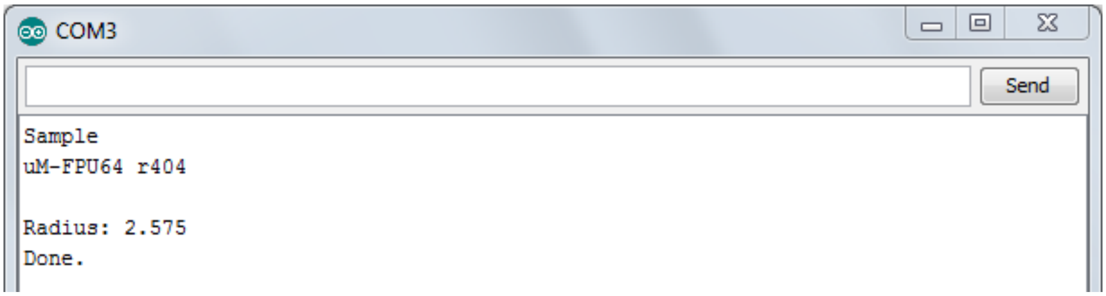
The `FpuSerial.PrintFloat` method displays the value of register A as a floating point number.

The main section of your Arduino program should look as follows:

```
#include <SPI.h>
#include <Fpu64.h>
#include <FpuSerial64.h>

//-------------------- uM-FPU Register Definitions -----------------------------
#define Radius  10                      // uM-FPU register

//-------------------- Variable Definitions ------------------------------------
int distance;                           // signed word variable

//-------------------- setup ---------------------------------------------------

void setup()
{
  Serial.begin(9600);
  Serial.println("Sample");

  SPI.begin();
  Fpu.begin();

  // Check for synchronization and display FPU version
  // (note: this is optional code)
  if (Fpu.sync() == SYNC_CHAR)
    FpuSerial.printVersionln();
  else
  {
    Serial.print("uM-FPU not detected");
    while(1) ; // stop if FPU not detected
  }
}

//-------------------- loop ----------------------------------------------------

void loop()
{
    distance = 2575;

//-------------------- Generated Code ------------------------------------------
    // distance    var   word
    // Radius      equ   F10
    //
    // Radius = distance / 1000
    Fpu.write(SELECTA, Radius, LOADWORD);
    Fpu.writeWord(distance);
    Fpu.write(FSET0, LOADWORD);
    Fpu.writeWord(1000);
    Fpu.write(FDIV0);
    //

    Serial.print("\r\nRadius: ");
    FpuSerial.printFloat(0);

  Serial.println("\r\nDone.");
  while(1) ;
}
```

Running the Program

Run the Arduino program. The following output should be displayed in the terminal window.



Calculating Diameter, Circumference and Area

Now that we have the initial program, let's add the calculations for diameter, circumference and area. Add the following register definitions in the start of the *tutorial1.fpu*:

```
Diameter       equ  F2
Circumference  equ  F3
Area           equ  F4
```

The area of a circle is twice the radius, so we add the following line to calculate diameter:

```
Diameter = Radius * 2
```

The circumference of a circle is equal to the value pi (π) times the diameter. The IDE has a pre-defined name for π, called PI, so you can simple enter the following line to calculate circumference:

```
Circumference = PI * Diameter
```

The area of a circle is equal to pi (π) times radius squared. The **`POWER`** function could use to calculate radius to the power of 2, but for squared values it's easier and more efficient to simply multiply the value by itself. Enter the following line to calculate the area:

```
Area = PI * Radius * Radius
```

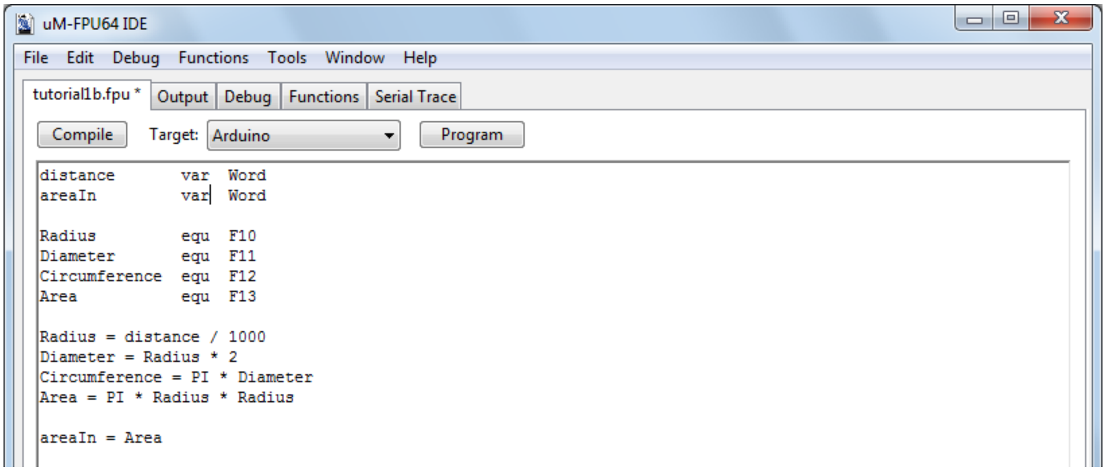
Finally, we'll read the `Area` value back to the microcontroller as a 16-bit integer and print the result. To do this we first add the following definition for the microcontroller variable:

```
areaIn         VAR  Word
```

Next, we add the following line to convert the `Area` value to long integer and send the lower 16-bits back to microcontroller.

```
areaIn = Area
```

The ***Source Window*** should look as follows:



Click the ***Compile*** button.

Copy Revised Code to the Microcontroller Program

Copy the *uM-FPU Register Definitions* and *Variable Definitions* from the ***Output Window*** and paste them at the start of the *template* program before the `setup()` method (replacing the previous definitions).

Copy the Generated Code from the ***Output Window*** and paste it in the *template* program inside the `loop()` method (replacing the previous code).

Add a `Serial.print` and `FpuSerial.printFloat` statement after each of the following values are calculated on the FPU: `Radius` , `Diameter`, `Circumference` and `Area`. `FpuSerial.printFloat(63)` is used to display the floating point values in a field six characters wide with digits to the right of the decimal point. For example:

```
Serial.print("Radius:        ");
FpuSerial.PrintFloat(63);
```

Add `Serial.print` statements for the Arduino variable `areaIn`.

```
Serial.print("\r\nareaIn:        ")
Serial.print(areaIn);
```

The main section of your Arduino program should look as follows:

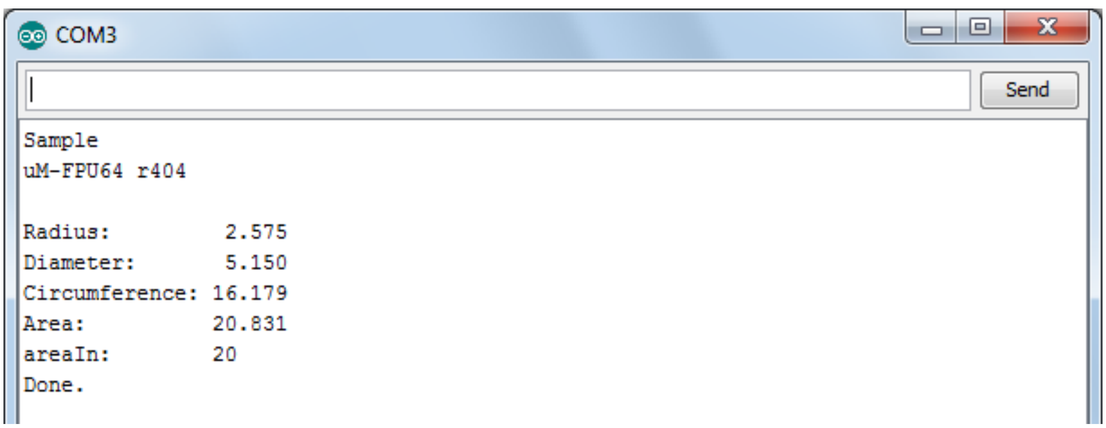
```
#include <SPI.h>
#include <Fpu64.h>
#include <FpuSerial64.h>

//-------------------- uM-FPU Register Definitions ------------------------------
#define Radius  10                      // uM-FPU register
#define Diameter    11                  // uM-FPU register
#define Circumference   12              // uM-FPU register
#define Area    13                      // uM-FPU register

//-------------------- Variable Definitions ------------------------------------
```

```
int distance;                            // signed word variable
int areaIn;                              // signed word variable

//-------------------- setup ------------------------------------------------

void setup()
{
  Serial.begin(9600);
  Serial.println("Sample");

  SPI.begin();
  Fpu.begin();

  // Check for synchronization and display FPU version
  // (note: this is optional code)
  if (Fpu.sync() == SYNC_CHAR)
    FpuSerial.printVersionln();
  else
  {
    Serial.print("uM-FPU not detected");
    while(1) ; // stop if FPU not detected
  }
}

//-------------------- loop -------------------------------------------------

void loop()
{
    distance = 2575;

//-------------------- Generated Code -----------------------------------------
    // distance       var  Word
    // areaIn         var  Word
    //
    // Radius         equ  F10
    // Diameter       equ  F11
    // Circumference  equ  F12
    // Area           equ  F13
    //
    // Radius = distance / 1000
    Fpu.write(SELECTA, Radius, LOADWORD);
    Fpu.writeWord(distance);
    Fpu.write(FSET0, LOADWORD);
    Fpu.writeWord(1000);
    Fpu.write(FDIV0);
    Serial.print("\r\nRadius:        ");
    FpuSerial.printFloat(63);

    // Diameter = Radius * 2
    Fpu.write(SELECTA, Diameter, FSET, Radius, FMULI, 2);
    Serial.print("\r\nDiameter:      ");
    FpuSerial.printFloat(63);

    // Circumference = PI * Diameter
    Fpu.write(SELECTA, Circumference, LOADPI, FSET0, FMUL, Diameter);
    Serial.print("\r\nCircumference: ");
    FpuSerial.printFloat(63);
```

```
    // Area = PI * Radius * Radius
    Fpu.write(SELECTA, Area, LOADPI, FSET0, FMUL, Radius);
    Fpu.write(FMUL, Radius);
    Serial.print("\r\nArea:          ");
    FpuSerial.printFloat(63);
    //
    // areaIn = Area
    Fpu.write(SELECTA, 0, FSET, Area, F_FIX);
    Fpu.wait();
    Fpu.write(LREADWORD);
    areaIn = Fpu.readWord();
    Serial.print("\r\nareaIn:        ");
    Serial.print(areaIn);
    //

  Serial.println("\r\nDone.");
  while(1) ;
}
```

Running the Revised Program

Run the Arduino program. The following output should be displayed in the terminal window:



`Area` is displayed as 20.831, but `areaIn` is displayed as 20. This is because when a floating point number is converted to a long integer it is truncated, not rounded. If you prefer the value to be rounded, then use the **`ROUND`** function before converting the number. In the FPU source file, replace:

```
   areaIn = Area
```

with:

```
   areaIn = round(area)
```

Compile the FPU code, copy and paste the new code to the Arduino program. Run the program again. The following output should now be displayed in the terminal window:

Saving the Source File

Use the ***File > Save*** command to save the file.

This completes the tutorial on compiling code for the uM-FPU64 chip. With the information gained from this tutorial, and more detailed information from the reference section, you should now be able to use the IDE to create your own programs.

Tutorial 2: Debugging FPU Code

This tutorial takes you through some examples of debugging FPU code using the uM-FPU64 IDE. We will use the Arduino program created in the previous tutorial for debugging.

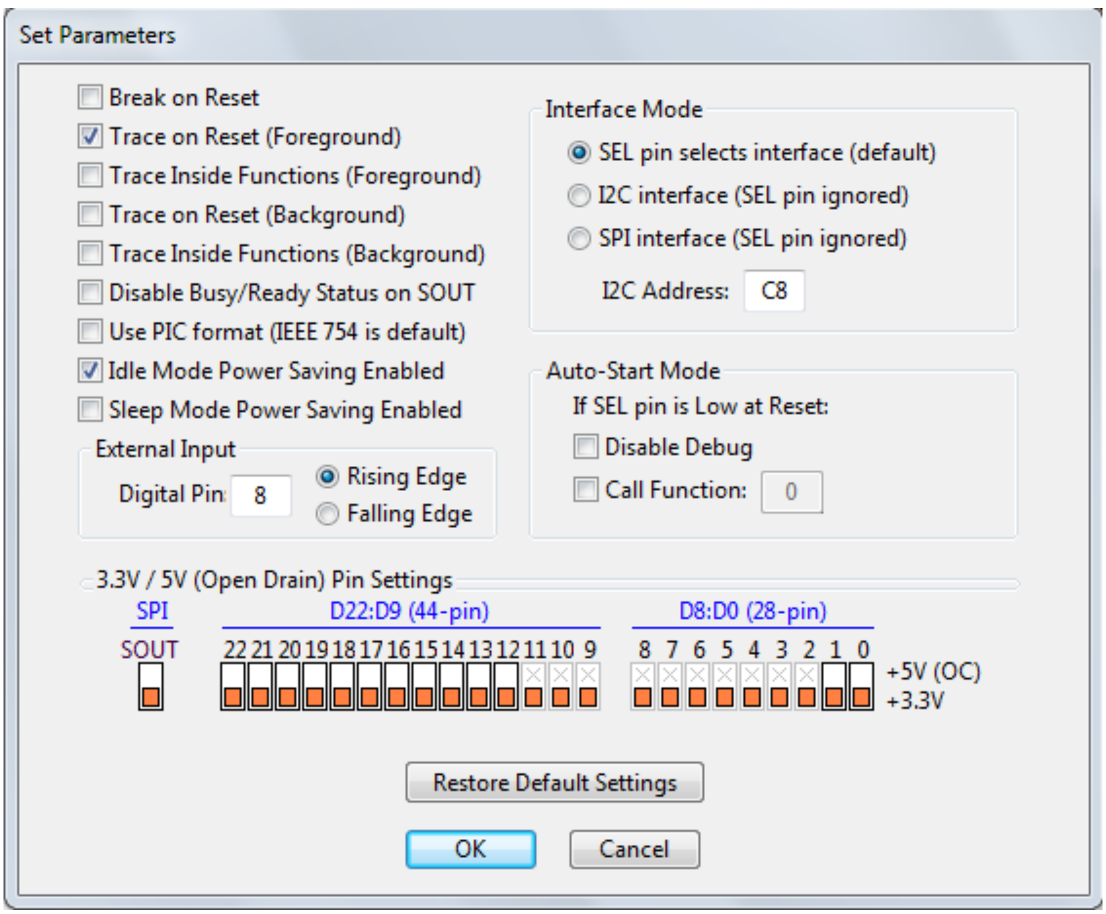
Making the Connection

For debugging, the uM-FPU64 IDE must have a serial connection to the uM-FPU64 chip. Refer to the section at the start of this document called *Connecting to the uM-FPU64 chip*.

Tracing Instructions

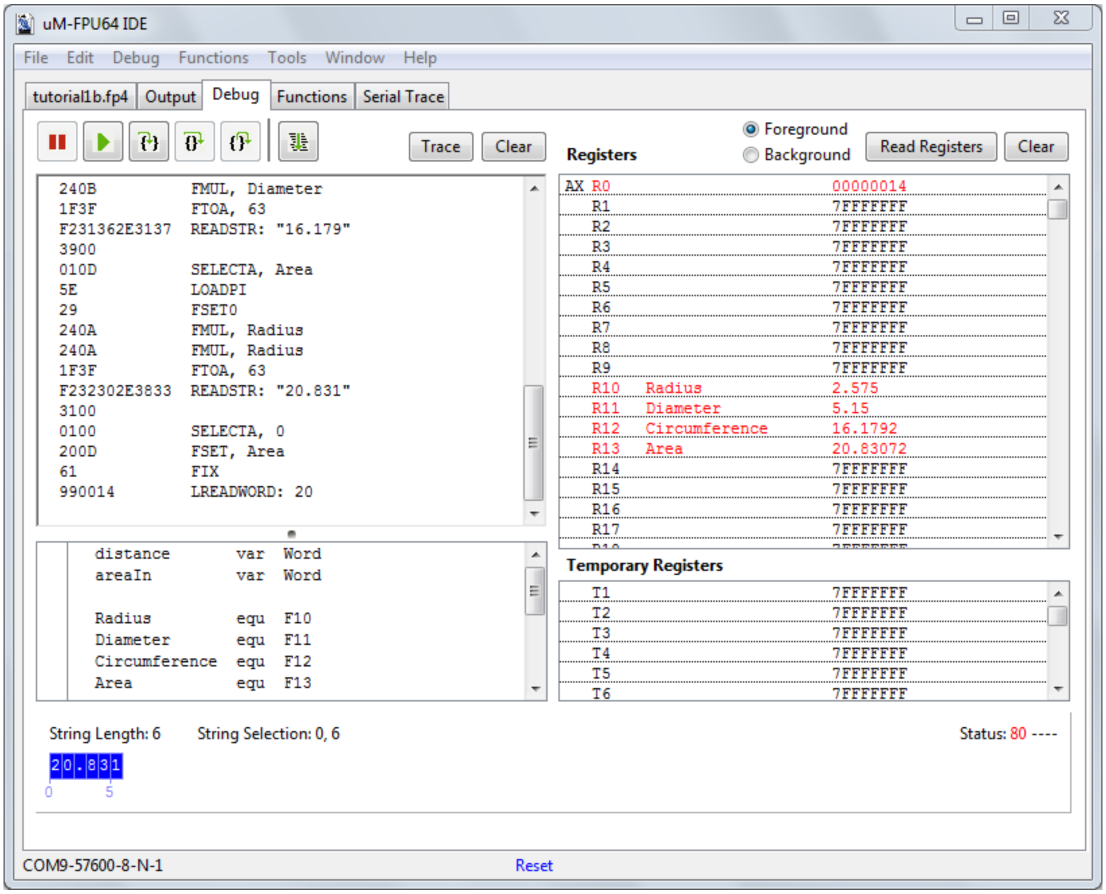
The ***Debug Window*** of the IDE can display a trace of all instructions as they are executed. By default, tracing is disabled. It can be enabled at Reset by setting the ***Trace on Reset (Foreground)*** option in the ***Functions> Set Parameters...*** dialog, or it can be turned on or off at any time by sending the **`TRACEON`** or **`TRACEOFF`** instruction.

For this tutorial we will use the ***Trace on Reset (Foreground)*** option. Select the ***Functions> Set Parameters...*** menu item, and enable the ***Trace on Reset (Foreground)*** option as shown below.



Select the ***Debug Window***, and click the ***Clear*** button above the ***Debug Trace*** to clear the trace area. Now run the *tutorial1* program that you developed in the previous tutorial. An instruction trace will be displayed in the ***Debug Trace*** area. After the program stops running, click the ***Read Registers*** button to update the ***Register Display, String Buffer, and Status***. Scroll up to the beginning of the ***Debug Trace.***

The ***Debug Window*** should look as follows:



The reset message is displayed at the top of the screen. Every time the FPU resets, a reset message is displayed with a time stamp. The instruction trace shows the hexadecimal bytes of the instruction on the left, followed by the disassembled instruction. If a source file has been compiled with symbol definitions, these symbols are used when displaying the instructions. For instructions that read data from the FPU, the trace will also display the data being sent.

Compare the instructions in the ***Debug Trace*** to the *tutorial1* program. Tracing is very useful for checking the actual sequence of instruction executed by the FPU. Many programming errors can often be found simply by examining the trace.

Breakpoints

A breakpoint stops execution of FPU instructions. A `BREAK` message is displayed in the ***Debug Trace*** and the ***Register Display, String Buffer, and Status*** are automatically updated. This enables you to examine the state of the FPU at that point, and then continue execution, or to single step through the code one instruction at a time.

To experiment with breakpoints, add the following statement to the *tutorial1* program at the start of the `loop()` method.

```
Fpu.write(F_BREAK);
```

Run the *tutorial1* program again. A breakpoint occurs immediately after printing the version string. By examining the ***Debug Window*** you can see the following:

- the debug trace shows the Reset message and a trace for all previously executed instructions
- the debug trace shows the `BREAK` message in red
- the version string is displayed in the string buffer
- the **AX** beside register 0 shows that it's currently selected as register A and register X
- register 0 is displayed in red to indicate it has a new value
- the value in register 0 is the version code
- all other registers are NaN (Not-a-Number)

Single Stepping

By single stepping through the FPU code you can see exactly what's happening. The following example steps through a few instructions.

Click the ***Step*** button (or type the Enter button) to single step. The ***Debug Window*** will change as follows:

- the debug trace shows the **SELECTA,Radius** instruction and the `BREAK` message
- the **A** beside register 10 shows that it's now selected as register A
- register 0 is displayed in black since it hasn't changed since the last breakpoint
- To experiment with breakpoints and single stepping, add the following line to your program at a spot that you want a breakpoint to occur at.

Click the ***Step*** button (or type the Enter button) to single step. The ***Debug Window*** will change as follows:

- the debug trace shows the **LOADWORD,2575** instruction and the `BREAK` message
- the **A** beside register 10 shows that it's now selected as register A
- register 0 is displayed in red since it has a new value
- the value in register 0 is 2575.0

Click the ***Step*** button (or type the Enter button) to single step. The ***Debug Window*** will change as follows:

- the debug trace shows the **FSET0** instruction and the `BREAK` message
- register 0 is displayed in black since it hasn't changed since the last breakpoint
- register 10 is displayed in red since it has a new value
- the value in register 10 is 2575.0

To continue normal execution, click the ***Go*** button.

You can experiment further by moving the **BREAK** instruction to another point in your program, or by adding multiple breakpoints. More advanced single step capabilities are available using the ***Auto Step*** button. See the section entitled *Reference Guide: Debugging uM-FPU64 Code* for more information.

This completes the tutorial on debugging uM-FPU64 code. With the information gained from this tutorial, and more detailed information from the reference section, you should now be able to use the IDE to debug your own programs.

Tutorial 3: Programming FPU Flash Memory

User-defined functions and parameter bytes can be programmed in Flash memory on the uM-FPU64 chip. This tutorial takes you through an example of creating some user-defined functions.

Making the Connection

For programming Flash memory, the uM-FPU64 IDE must have a serial connection to the uM-FPU64 chip. Refer to the section at the start of this document called *Connecting to the uM-FPU64 chip*.

Defining functions

In the previous tutorials we developed and tested code to calculate the diameter, circumference, and area of a circle. For this demonstration, we'll define each of these calculations as a separate function.

The **`#function`** directive is used to define a function. It specifies the number of the function (0 to 63) and an optional name.

```
#FUNCTION 1 GetDiameter
```

All code that appears after a **`#function`** directive will be stored in that function, until the next **`#function`** directive, an **`#end`** directive, or the end of the source file. There's an implicit **`RET`** instruction at the end of all functions.

Functions can call other functions. To ensure that the function being called is already defined, function prototypes can be included at the start of the program. Function prototypes are defined using the **`FUNC`** operator, which assigns a symbol name to a function number. We'll use function prototypes in this tutorial example. The following function prototype defines `GetDiameter` as function number 1.

```
GetDiameter         func   1
```

You can assign the function number explicitly, or use the `%` character to assign the next unused function number.

```
GetDiameter         func   1
GetCircumference    func   %
GetArea             func   %
```

If a function prototype has been defined, the **`#function`** directive just uses pre-defined name.

```
#FUNCTION GetDiameter
```

Calling Functions

Functions are called by entering the function name in the source code.
e.g.

```
GetDiameter
```

Modifying the Code for Functions

Open the source file called *tutorial1.fpu* that you saved in the first tutorial. Add a function prototype for the three functions called `GetDiameter`, `GetCircumference`, and `GetArea`. Add a **`#function`** directive before the diameter, circumference and area calculations, and add an **`#end`** directive after the area calculation. Move the radius calculation to after the function definitions, and add a call to the three functions. After each function call use the directive `#print_float 63` to generate code to print the floating point value in register A. The source code will now look as follows:

```
distance       VAR  Word       ' Microcontroller variable definitions
areaIn         VAR  Word

Radius         equ  F10          ' FPU register definitions
Diameter       equu  F11
Circumference  equ  F12
Area           equ  F13

GetDiameter         func  1      ' Function prototypes
GetCircumference    func  %
GetArea             func  %

#function GetDiameter            ' Function 1
Diameter = Radius * 2
#end

#function GetCircumference       ' Function 2
Circumference = PI * Diameter
#end

#function GetArea                ' Function 3
Area = PI * Radius * Radius
#end

// main program

Radius = distance / 1000         ' Calculations

GetDiameter

GetCircumference

GetArea

areaIn = ROUND(area)
```

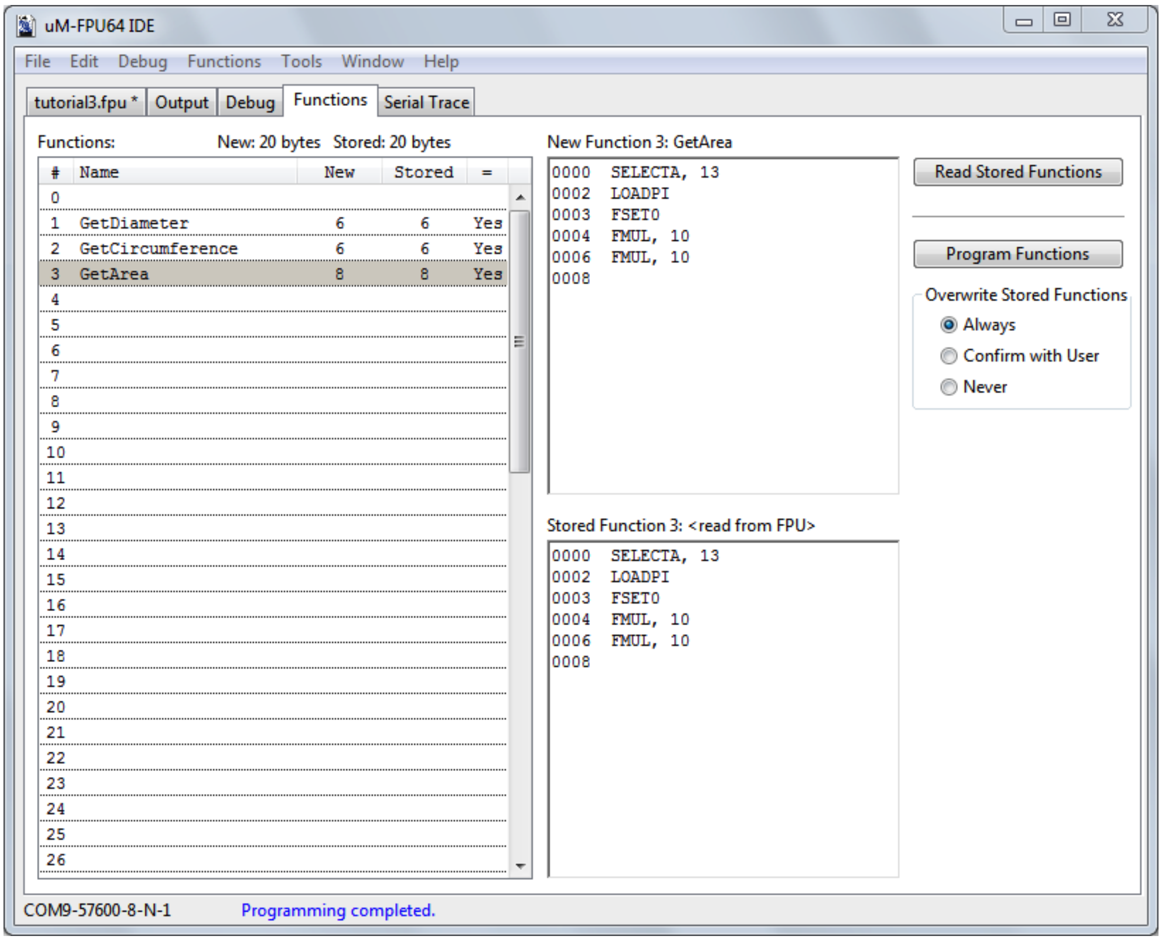
Save the file as *tutorial3.fp4.*

Compile and Review the Functions

Click the ***Compile*** button. In the ***Output Window***, the function code is displayed as comments that show the uM-FPU assembler code that was generated. This is the code that will be programmed to the FPU.

```
 // #function GetDiameter    ' Function 1
// Diameter = Radius * 2
//  SELECTA, 11
//  FSET, 10
//  FMULI, 2
// #end
```

The ***Functions Window*** should look as follows:



The ***Function List*** shows that three functions have been defined. The ***New Function Code*** displays the FPU instructions for the selected function. The ***Stored Function Code*** displays the FPU instructions for the function stored on the FPU. If no function has previously been programmed, the ***Stored Function Code*** will be empty. You can see the code for a different function by selecting it in the ***Function List***.

Storing the Functions

Make sure that the ***Overwrite Stored Functions*** preference is set to ***Always*** (as shown in the figure above). Click the ***Program Functions*** button to program the functions into Flash memory on the FPU. A status dialog will be displayed as the functions are being programmed. If an error occurs, check the connection. You may need to power the uM-FPU64 chip off and then back on to ensure that it has been reset properly before trying again.

Copy Revised Code to the Microcontroller Program

Copy the *uM-FPU Register Definitions* and *Variable Definitions* from the ***Output Window*** and paste them at the start of the *template* program before the `setup()` method (replacing the previous definitions).

Copy the Generated Code from the ***Output Window*** and paste it in the *template* program inside the `loop()` method (replacing the previous code).

Add a `Serial.print` and `FpuSerial.printFloat(63)` statement after each of the following values are calculated on the FPU: `Radius` , `Diameter`, `Circumference` and `Area`. FPU functions restore the register A selection when they return, so a `fpu_write(SELECTA, register)` function call must be to select the register before printing. For example:

```
Fpu.write(SELECTA, radius);
Serial.print("Radius:        ");
FpuSerial.PrintFloat(63);
```

Add `Serial.print` statements for the Arduino variable `areaIn`.

```
Serial.print("\r\nareaIn:        ")
Serial.print(areaIn);
```

Running the Program

Copy the generated code from the ***Output Window*** to the Arduino program, replacing the diameter, circumference and area calculations with function calls. Remember to also copy the *uM-FPU Function* definitions.

The Arduino program should now look as follows:

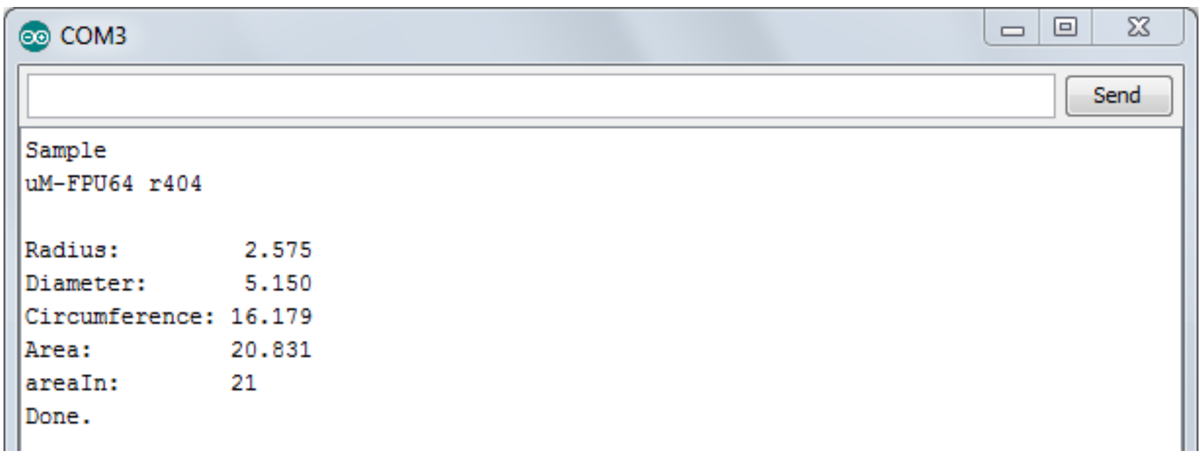
```
#include <SPI.h>
#include <Fpu64.h>
#include <FpuSerial64.h>

//-------------------- uM-FPU Register Definitions -----------------------------
#define Radius  10                      // uM-FPU register
#define Diameter    11                  // uM-FPU register
#define Circumference   12              // uM-FPU register
#define Area    13                      // uM-FPU register

//-------------------- uM-FPU Function Definitions -----------------------------
#define GetDiameter 1                   // uM-FPU user function
#define GetCircumference    2           // uM-FPU user function
#define GetArea 3                       // uM-FPU user function

//-------------------- Variable Definitions ------------------------------------
int distance;                           // signed word variable
int areaIn;                             // signed word variable

//-------------------- setup ---------------------------------------------

void setup()
{
  Serial.begin(9600);
  Serial.println("Sample");
```

```
  SPI.begin();
  Fpu.begin();

  // Check for synchronization and display FPU version
  // (note: this is optional code)
  if (Fpu.sync() == SYNC_CHAR)
    FpuSerial.printVersionln();
  else
  {
    Serial.print("uM-FPU not detected");
    while(1) ; // stop if FPU not detected
  }
}

//-------------------- loop ------------------------------------------------

void loop()
{
    distance = 2575;

//-------------------- Generated Code ------------------------------------------
    // // main program
    //
    // Radius = distance / 1000        ' Calculations
    Fpu.write(SELECTA, Radius, LOADWORD);
    Fpu.writeWord(distance);
    Fpu.write(FSET0, LOADWORD);
    Fpu.writeWord(1000);
    Fpu.write(FDIV0);

    Fpu.write(SELECTA, Radius);
    Serial.print("\r\nRadius:        ");
    FpuSerial.printFloat(63);
    //
    // GetDiameter
    Fpu.write(FCALL, GetDiameter);
    Fpu.write(SELECTA, Diameter);

    Serial.print("\r\nDiameter:      ");
    FpuSerial.printFloat(63);
    //
    // GetCircumference
    Fpu.write(FCALL, GetCircumference);
    Fpu.write(SELECTA, Circumference);

    Serial.print("\r\nCircumference: ");
    FpuSerial.printFloat(63);
    //
    // GetArea
    Fpu.write(FCALL, GetArea);
    Fpu.write(SELECTA, Area);

    Serial.print("\r\nArea:          ");
    FpuSerial.printFloat(63);
    //
    // areaIn = ROUND(area)
    Fpu.write(SELECTA, 0, FSET, Area, ROUND, F_FIX);
```

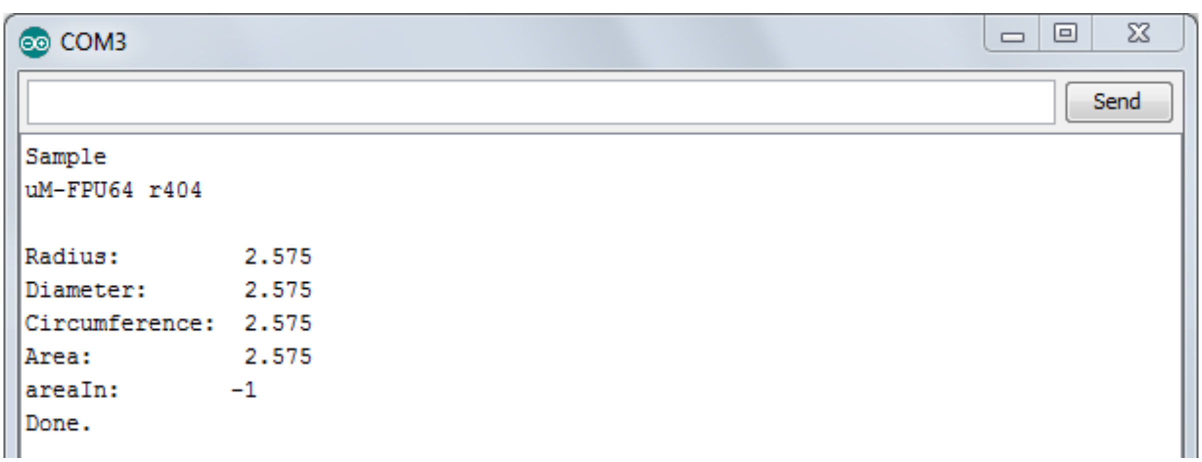
```
    Fpu.wait();
    Fpu.write(LREADWORD);
    areaIn = Fpu.readWord();

    Serial.print("\r\nareaIn:         ");
    Serial.print(areaIn);
    //

  Serial.println("\r\nDone.");
  while(1) ;
}
```

Save the IDE source file as *tutorial3.fpu* and save the Arduino program *tutorial3*, then run the program.

The following output should be displayed in the terminal window:



Note: If the FPU functions have not been programmed to Flash memory, the output will look like the following:

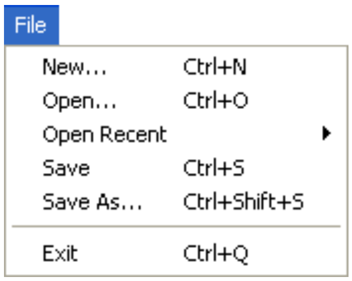


Since calling an undefined functions has no effect, register A remains unchanged after the `Radius` calculation, and the same value prints out for each FpuSerial.`printFormat` call. The `AreaIn` value is displayed as `-1` because the value of `Area` is `NaN`, so `AreaIn` is returned as `-1`.

This completes the tutorial on storing user-defined functions. With the information gained from this tutorial, and more detailed information in the reference section, you should be able to use the IDE to define your own functions and program them to Flash on the uM-FPU64 chip.

Reference Guide: Menus and Dialogs

File Menu



New…

Creates a new source file and sets the name to *untitled*. If a previous source file is open and has been changed since the last time it was saved, you will first be prompted to save the previous source file.

Open…

Opens an existing source file, using the file open dialog. If a previous source file is open and has been changed since the last time it was saved, you will first be prompted to save the previous source file.

Open Recent

Provides a sub-menu that lists up to ten source files that were recently saved. Selecting a source file from the sub-menu will open the file. If a previous source file is open and has been changed since the last time it was saved, you will first be prompted to save the previous source file.

Save

Saves the source file. If the source file has not been previously saved, a file save dialog will be displayed.

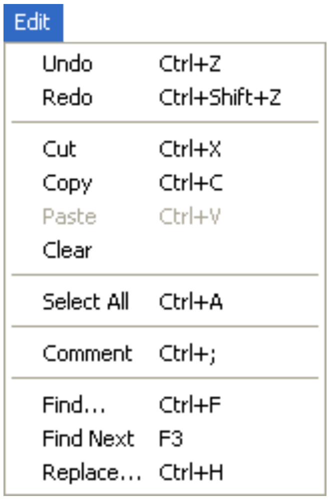
Save As…

Displays a file save dialog and allows a new filename to be specified.

Exit

Causes the IDE to quit. If a source file is open, and has been changed since the last time it was saved, you will first be prompted to save the source file.

Edit Menu



Undo
Cancels the last edit in the **Source Window**.

Redo
Restores the edit cancelled by the last **Undo**.

Cut
Removes the selected text from the ***Source Window***.

Copy
Copies the selected text from the ***Source Window*** to the clipboard.

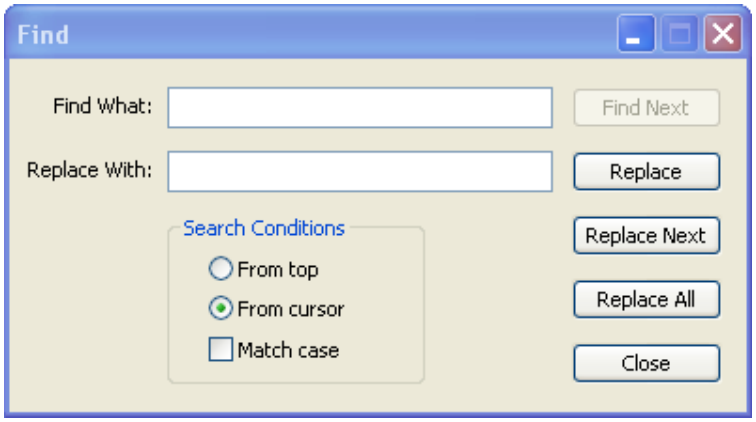
Paste
Pastes the text in the clipboard to the current selection point in the ***Source Window***.

Clear
Deletes the selected text from the ***Source Window***.

Select All
Selects all of the text in the current text field.

Comment
Uncomment
Comment adds a semi-colon as the first character of every currently selected line in the ***Source Window***. This provides a way to quickly comment out a block of code. **Uncomment** removes the semi-colon from the start of all selected lines. If all of the lines currently selected have a semi-colon as the first character, the menu item is **Uncomment**, otherwise it is to **Comment**.

Find…
Brings up the **Find** Dialog.



The ***Find*** dialog is a moveable dialog and can be placed alongside the ***Source Window*** and left open when multiple find and replace operations are done. The ***Find What*** field specified the string to search for, and the ***Replace With*** field specifies the string to replace it with. If the ***From top*** search condition is selected, the search starts from the top of the window. The search condition will automatically change to ***From cursor*** on the first successful match. If the ***From cursor*** search conditions is selected, the search starts from the current cursor position. When the ***Match case*** option is selected, the search is case sensitive. The following special characters can be used in the Find or Replace strings: `\t` for a tab character, `\r` for end of line, and `\\` for backslash.

The **Find Next** button searches the ***Source Window*** for the next match. The ***Replace*** button replaces the matched string. The matching text is highlighted on the first button press and replaced by the ***Replace With*** string on the next button press. The ***Replace All*** button replaces all occurrences of the ***Find What*** string with the ***Replace With*** string. The ***Close*** button closes the ***Find*** dialog.

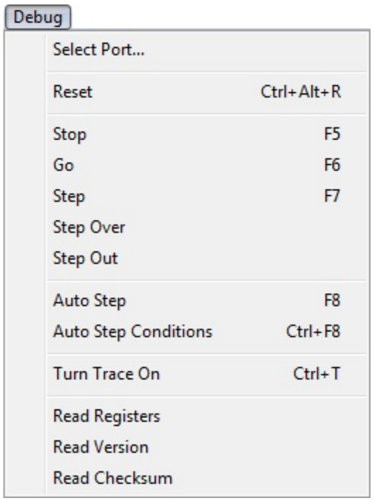
Find Next

Finds the next match based on the current search conditions in the ***Find*** dialog.

Replace

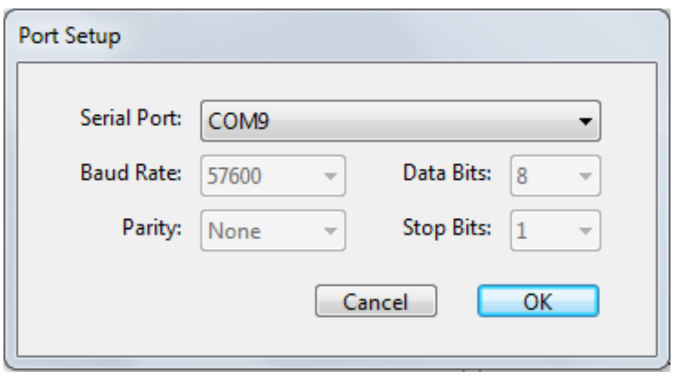
Brings up the ***Find*** Dialog.

Debug Menu



Select Port…

Displays the ***Port Setup*** dialog which is used to select the serial communications port.



Reset

This menu item sends the reset command to the uM-FPU64.

Stop
Go
Step
Step Over
Step Out

These menu items have the same function as the ***Go***, ***Stop***, ***Step***, ***Step Over*** and ***Step Out*** buttons in the ***Debug Window***.

Auto Step

Continues execution in auto step mode. See the section entitled *Reference Guide: Auto Step and Conditional Breakpoints* for more details.

Auto Step Conditions

Brings up the ***Auto Step Conditions*** dialog. See the section entitled *Reference Guide: Auto Step and Conditional Breakpoints* for more details.

Turn Trace On
Turn Trace Off

These menu items have the same function as the ***Trace*** button in the ***Debug Window***.

Read Registers

This menu item has the same function as the ***Read Registers*** button in the ***Debug Window***.

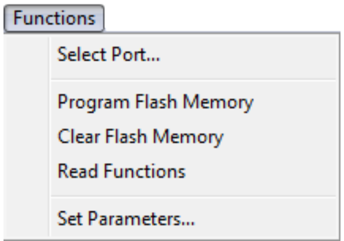
Read Version

Displays the version of the FPU in the ***Debug Trace***.

Read Checksum

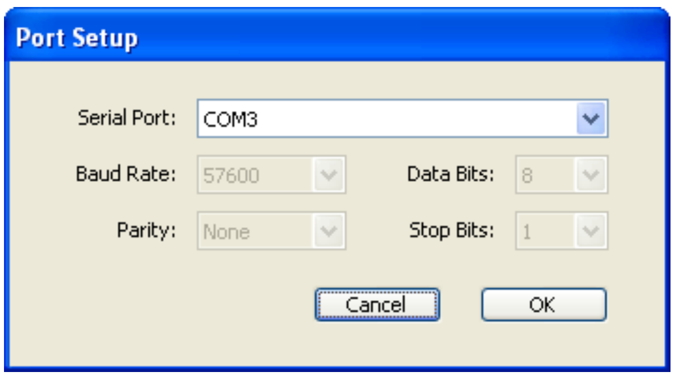
Displays the checksum of the FPU in the ***Debug Trace***.

Functions Menu



Select Port…

Display the ***Port Setup*** dialog which is used to select the serial communications port.



Program Flash Memory

Has the same function as the ***Program Functions*** button. It programs the user-defined functions to the FPU chip.

Clear Flash Memory

Clear all of the user-defined functions from Flash memory on the uM-FPU64 chip. A dialog will be displayed requesting confirmation before the functions are cleared from memory.

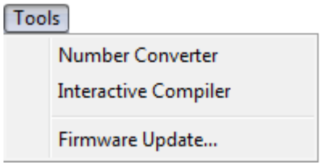
Read Functions

Has the same function as the ***Read Functions*** button. It reads the flash memory and updates the function list in the ***Function Window***.

Set Parameters…

Brings up the ***Set Parameters…*** dialog to set the FPU parameter bytes. See the section entitled *Reference Guide: Setting uM-FPU64 Parameters* for more details.

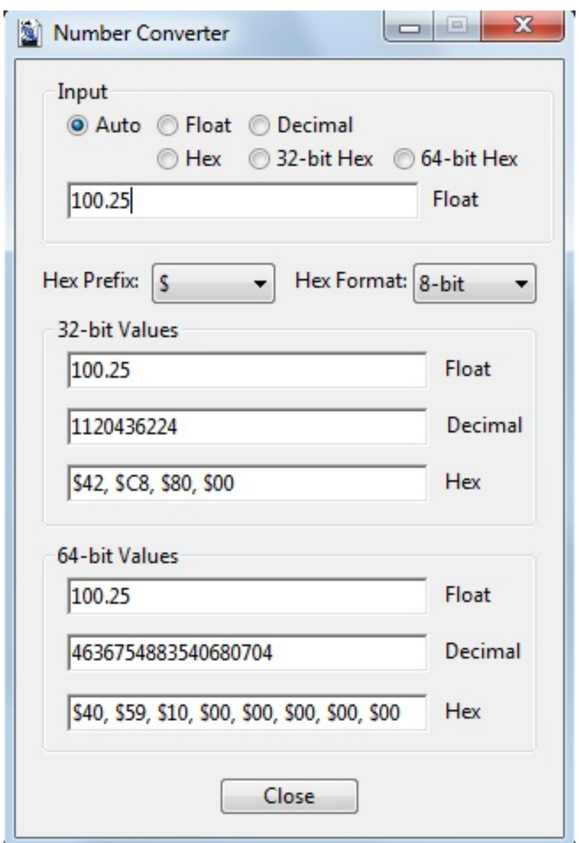
Tools Menu



Number Converter

Brings the **Number Converter** window to the front. The number converter provides a quick way to convert numbers between various 32-bit and 64-bit formats. Floating point, decimal and hexadecimal numbers are supported. The **Auto**, **Float**, **Decimal**, and **Hexadecimal** buttons above the **Input** field determine how the input is interpreted. If **Auto** is selected, the input type is determined automatically based on the characters entered in the **Input** field. The input type is displayed to the right of the **Input** field. The input type can be manually set using the **Float**, **Decimal** and **Hexadecimal** buttons. Invalid characters for the selected type are displayed in red, and will be ignored by the converter. The **Output** fields display the input value in all three formats. The hexadecimal value can be displayed in 8-bit, 16-bit, 32-bit, or 64-bit format, with a choice of prefix characters. The format can be selected to match the format used by microcontroller programs.

One of the handiest ways of using the number converter is with copy and paste. You can copy a number from program code or a trace listing, and paste into the **Input** field. The **Input** field accepts floating point numbers, decimal numbers, and hexadecimal numbers in 8-bit, 16-bit, 32-bit, and 64-bit formats. You can copy from the **Output** fields to program code.



Interactive Compiler

Brings the ***Interactive Compiler*** window to the front. The interactive compiler window takes source code, compiles the code and sends it to the uM-FPU64 instruction buffer. This can be used for a variety of testing applications. User-defined functions can be called, devices can be accessed using FPU instructions, etc. The instruction buffer is cleared before the compiled code is sent. If the FPU is running, the code will be executed immediately. If the FPU is currently at a breakpoint, the instructions will be executed when the next *Go* or *Step* command is issued.

Only equations, procedures and assembly code are supported by the interactive compiler, but all of the symbol definitions from the last source code compile can be used in the interactive compiler window. For example:

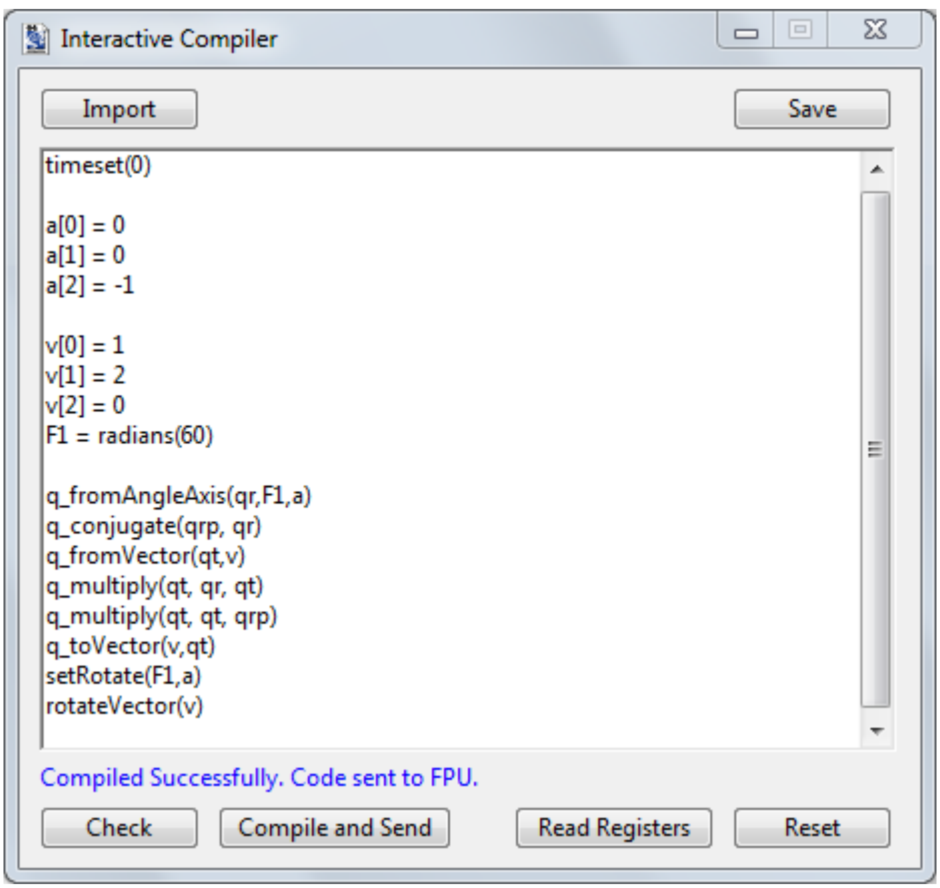
Call procedure main:

```
main
```

Initialize the LCD on pin 0 and write a test string:

```
devio(LCD, ENABLE, 0, ROWS_4+COLS_20)
devio(LCD, WRITE_STR, “test”)
```

Initialize variables and call functions and XOPs:



The ***Import*** button loads previously saved interactive compiler code from a text file.

The ***Save*** button saves the interactive compiler code to a text file.

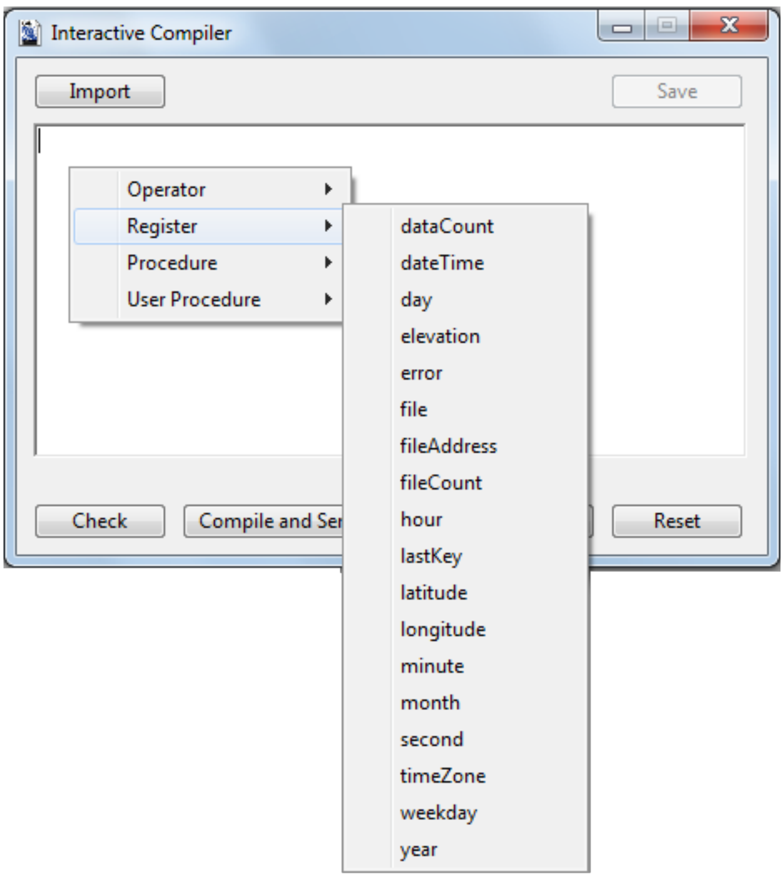
The ***Check*** button compiles the code and checks for errors.

The ***Compile and Send*** button compiles the code and sends it to the FPU instruction buffer.

The ***Read Registers*** button reads the FPU registers and displays them in the Debug Window.

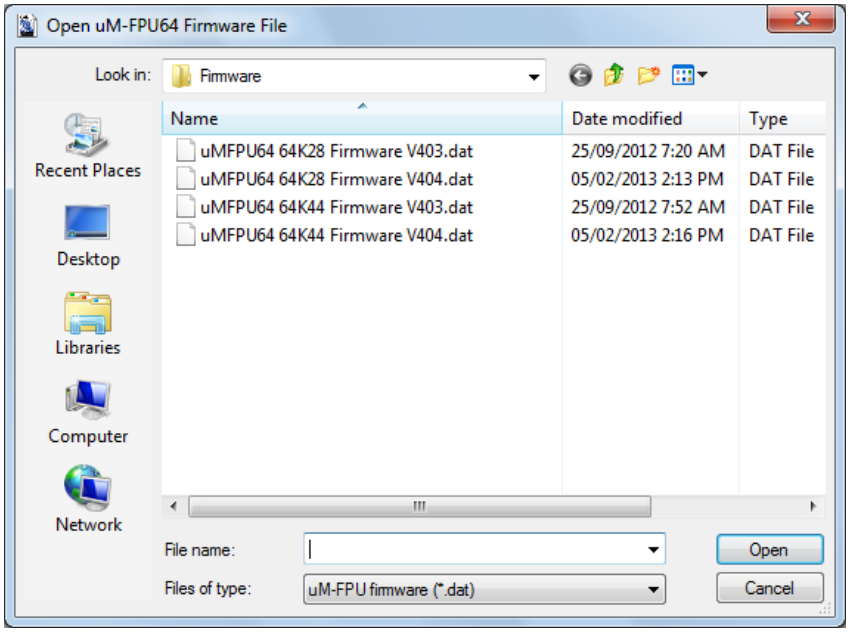
The ***Reset*** button sends a rest command to the FPU.

Compiler code can be entered interactively, with context sensitive menus available to assist. A control-click inside the interactive compiler window displays a context-sensitive pop-up menu of all registers, constants, procedures, functions, and operators that are currently defined. Selecting an item from the pop-up will insert that item into the interactive compiler window. This is a useful way to test user-defined functions. Once the functions are programmed into Flash, the interactive compiler window can be used to call the functions for testing. Equations and procedure calls use the same syntax as the source code compiler.



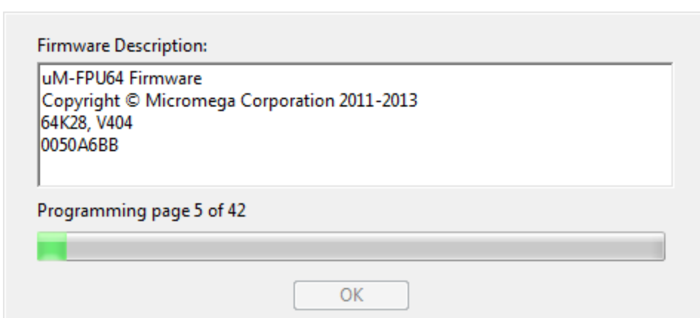
Firmware Update…

This menu item is used to update the uM-FPU64 firmware. Firmware files are provided as part of the uM-FPU64 IDE installation and are installed in the *Firmware* folder. When the ***Firmware Update…*** menu item is selected (or button is pressed), a dialog is displayed to select the firmware file to install.



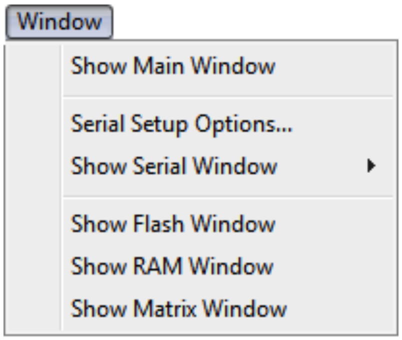
Note: There are two types of uM-FPU64 firmware. The 28-pin chips require firmware files that have *64K28* as part of the filename. The 44-pin chips require firmware files that have *64K44* as part of the filename.

Once the firmware file has been selected a dialog is displayed that shows a description of the firmware file and displays the status and progress of the firmware upgrade. The upgrade process only takes a few seconds. When the upgrade is complete a *Firmware upgrade completed* status message will be displayed.



Note: It's important that a stable 3.3V operating voltage is provided to the uM-FPU64 chip during the firmware upgrade, and that the upgrade process is not interrupted.

Window Menu

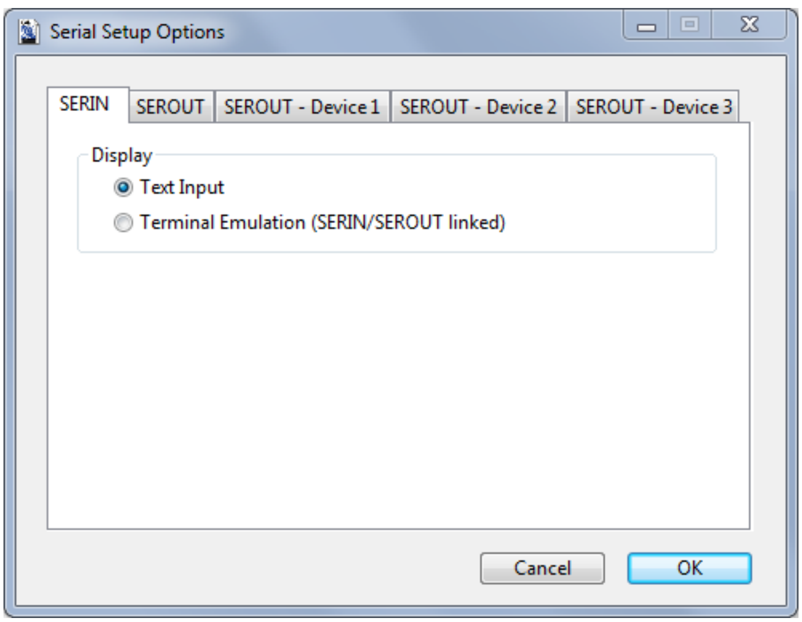


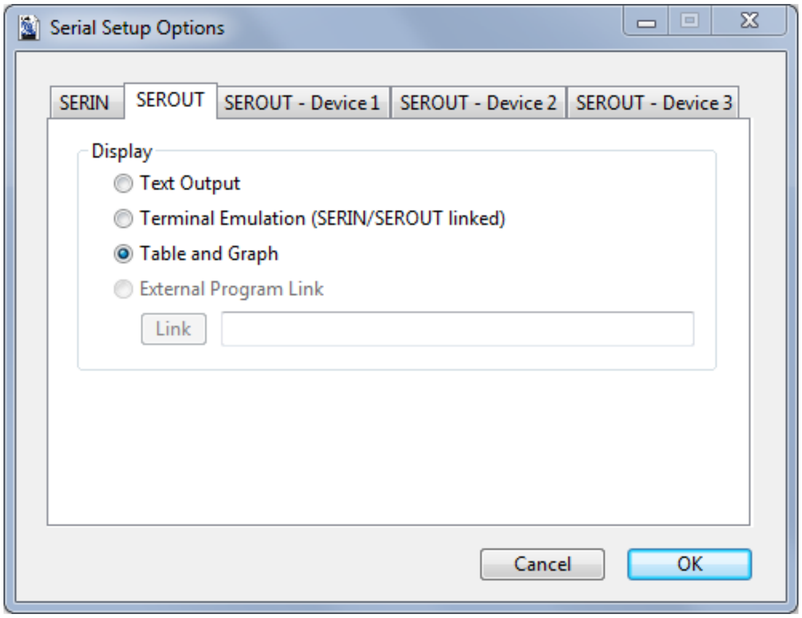
Show Main Window

Brings the main IDE window to the front.

Serial Setup Options…

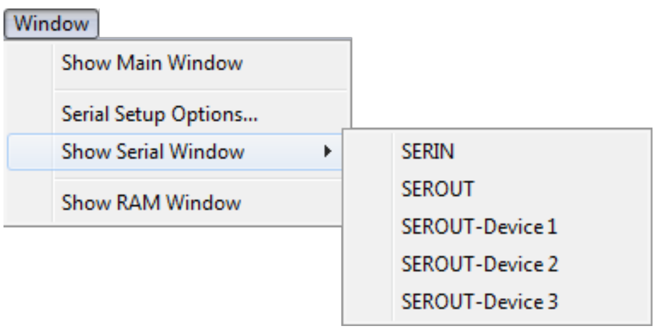
Displays a tabbed dialog that is used to set the display type for each of the serial windows.





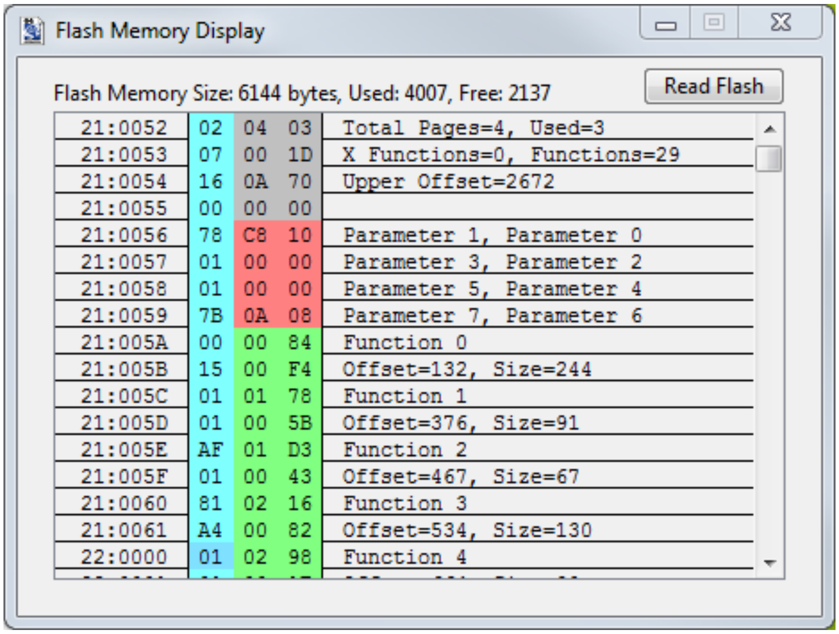
Show Serial Window

Brings the serial window selected from a hierarchical menu to the front.



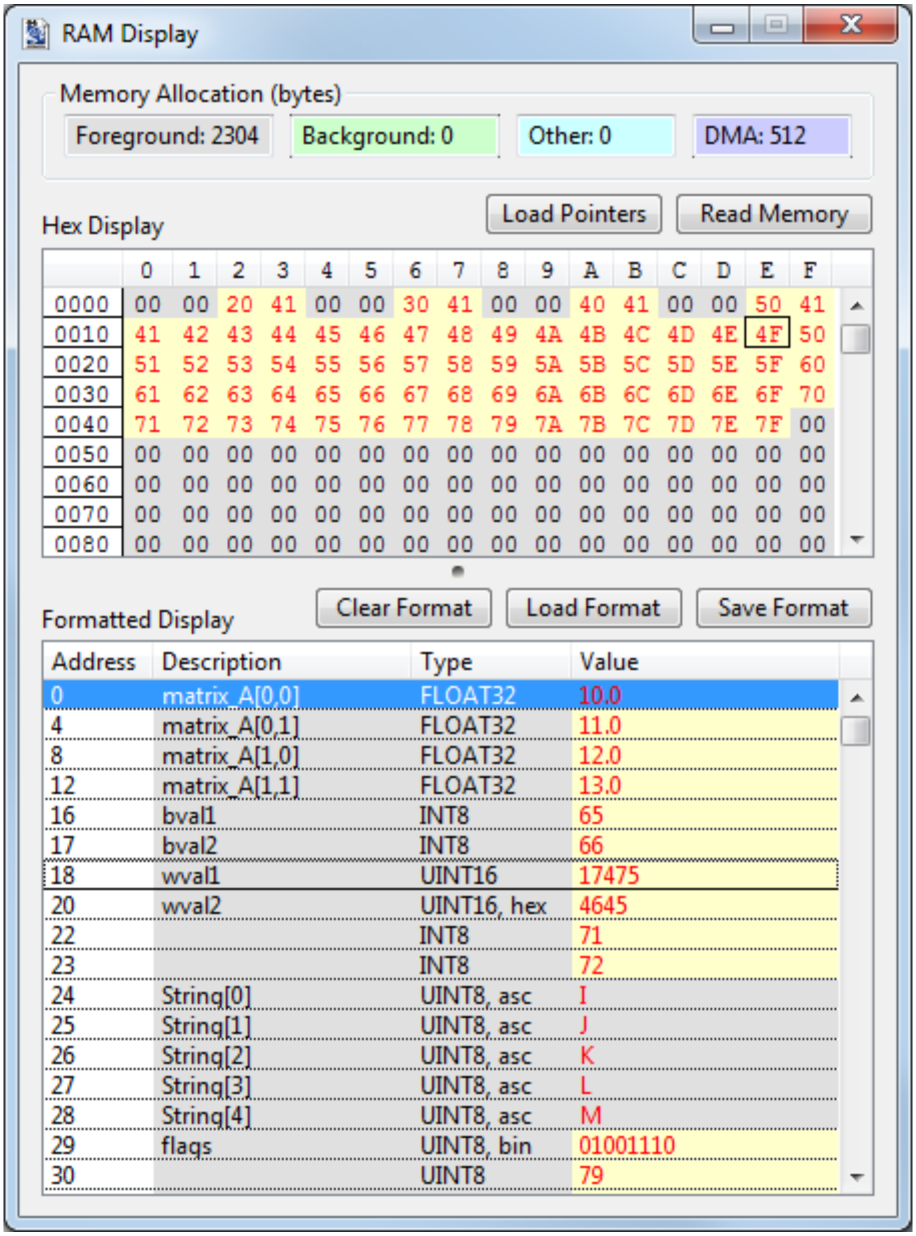
Show Flash Memory…

Displays a memory map showing the usage of the Flash memory reserved for user-defined functions on the uM-FPU64 chip. A status line at the top shows the percent of memory used and the number of bytes available.



Show RAM Window

Brings the ***RAM Display*** window to the front. This window is used to view the contents of RAM.



Memory Allocation shows the allocation of RAM to the various memory areas.

Foreground	Memory allocated to the foreground process.
Background	Memory allocated to the background process.
Other	Memory allocated to FIFO1, FIFO2, FIFO3, FIFO4, and any loadable devices.
DMA	DMA memory. Used by the ADC instructions. Can be accessed with indirect pointers.

The ***Load Pointers*** button set the description, type and value fields for any foreground pointer currently loaded in the Register display of the Debug window. If the pointer is an array pointer, each element of the array is added as a description.

The ***Read Memory*** button reads the current contents of RAM and updates the displays. If the memory allocation has changed, the formatted display is cleared, and the last format file used is reloaded. All RAM values that have changed since the last read are highlighted in red, and all non-zero values are shown with a light yellow background.

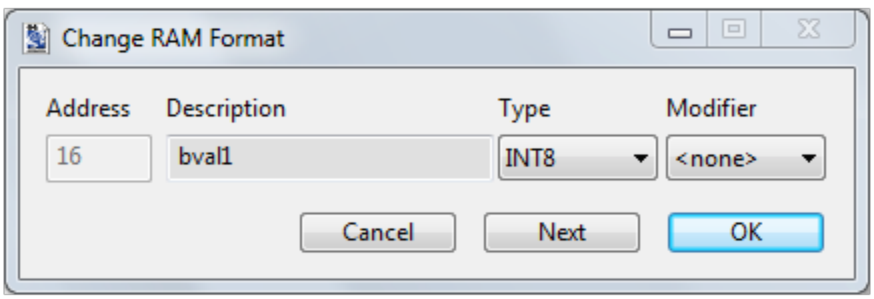
The ***Clear Format*** button clears the formatted display. If the RAM format file *default.txt* exists in the ~/*My Documents/Micromega/RAM Files* folder it will be loaded and the formatted display is updated.

The ***Load Format*** button loads a RAM format file and updates the formatted display.

The ***Save Format*** button saves a RAM format file.

The ***Hex Display*** shows the value of each byte in RAM as a hexadecimal value. The current selection in the formatted display outlined with a box in the hex display. Clicking in the hex display will select the corresponding item in the formatted display. Values that have changed since the last time RAM was read are highlighted in red, and non-zero value are shown with a light yellow background.

The ***Formatted Display*** shows the RAM contents formatted according to the type specified. Each row in the formatted display can have a separate description, type, and modifier. The description, type and modifer can be entered using a RAM format file, or entered interactively using the *Change RAM Format* dialog that is displayed by right-clicking on a row in the formatted display. Multiple rows can be changed by first selecting the multiple rows, then right-clicking within the selection.



The Description field can be used to enter any text string that doesn't include a double quote (") character. There are some special cases:

n — The type and modifier will be repeated *n* times specified (where *n* is a decimal number).

* — The type and modifier will be repeated until the end of the memory area.

name[i]
name[i, j]
name[i, j, k] — Specifies an array *name*, with the dimensions of the array given by *i*, *j* and *k*. For each element of the array, the description will be set the the name of the element and the type and modifier will be repeated.

If you wish to use one of the special cases as a description, without it being handled as a special case, then the *description* should be enclosed in double quotes ("). (e.g. `"name[2,2,2]"` will not be expanded into multiple array elements).

RAM Format Files are text files containing a description of the format to use in the formatted display. They are stored in the ~/*My Documents/Micromega/RAM Files* folder. The *autosave.txt* file is saved automatically to the ~/*My Documents/Micromega/RAM Files* folder when the RAM Display window is closed, and loaded when the RAM Display window is first opened. The RAM format file *default.txt* is used to specify the default format for the formatted display. If *default.txt* exists in the *~/My Documents/ Micromega/RAM Files* folder it will be loaded when the *Clear Format* button is pressed. Other files can be written and edited by the user. The RAM format files can contain the following lines:

Header

`<RAM FORMAT>` or `<RAM FORMAT OVERLAY>`

This must be the first line of the file. The `<RAM FORMAT>` line indicates that the file contains a full format description. The formatted display is cleared before loading the format file. The `<RAM FORMAT OVERLAY>` line indicates that the file is an overlay. The descriptions and types defined in the file will be added the existing formatted display.

Comment

`; comment`

Any line that begins with a semi-colon (;) is a comment line. The *autosave.txt* file adds comments showing the date and time and the memory allocation in effect when the file was saved.

Memory Area

`<FOREGROUND>`
`<BACKGROUND>`
`<DMA>`
`<FIFO1>` to `<FIFO4>`
`<DEVICE1>` to `<DEVICE6>`

Specifies the memory area for the description lines that follow. An optional offset can be added as a second argument (e.g. `<FOREGROUND, 100>`). This specifies a decimal offset into the memory area for the next description line. The offset can also have multiple decimal values that are added together (e.g. `<FOREGROUND, 100+10>`).

Description

`description, type, modifier`

The *description* can be any text string that doesn't include a double quote (") character. There are some special cases:

n	The *type* and *modifier* will be repeated *n* times specified (where *n* is a decimal number).
*	The *type* and *modifier* will be repeated until the end of the memory area.
name[i] *name[i, j]* *name[i, j, k]*	Specifies an array *name*, with the dimensions of the array given by *i*, *j* and *k*. For each element of the array, the description will be set the the name of the element and the type and modifier will be repeated.

If you wish to use one of the special cases as a description, without it being handled as a special case, then the *description* should be enclosed in double quotes ("). (e.g. `"name[2,2,2]"` will not be expanded into multiple array elements).

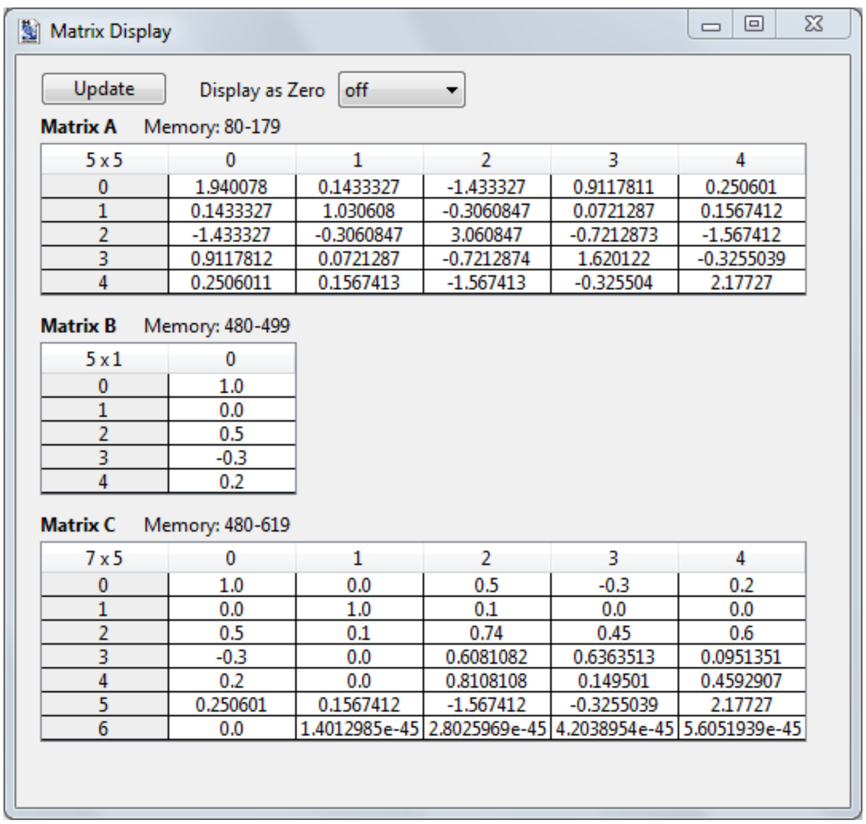
If the *description* string contains a comma, or you wish to use one of the special cases without it being handled as a special case, then the *description* must be enclosed in double quotes ("). (e.g. `"name[2,2,2]"` will not be expanded into multiple array elements).

The *type* can be one of the following: `INT8`, `UINT8`, `INT16`, `UINT16`, `LONG32`, `ULONG32`, `FLOAT32`, `LONG64`, `FLOAT64`.

The *modifier* is optional, and if not specified no modifier is used. The modifier can be one of the following: `HEX`, `BIN`, `ASC`. The `BIN` modifier only displays the lower 16 bits if the *type* is greater than 16 bits. The `ASC` modifier displays the ASCII value of the lower 8 bits.

Show Matrix Window

The ***Matrix Display*** window is brought to the front. This window is used to view the contents of matrix A, matrix B, and matrix C. The matrix values are not updated automatically, they must be updated manually using the *Update* button.



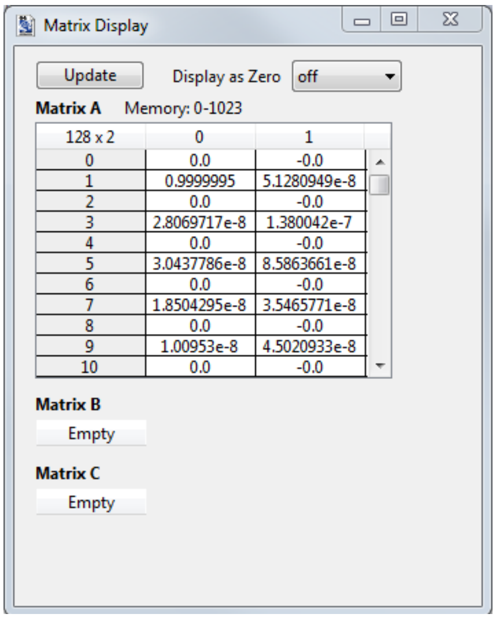
5 x 5	0	1	2	3	4
0	1.940078	0.1433327	-1.433327	0.9117811	0.250601
1	0.1433327	1.030608	-0.3060847	0.0721287	0.1567412
2	-1.433327	-0.3060847	3.060847	-0.7212873	-1.567412
3	0.9117812	0.0721287	-0.7212874	1.620122	-0.3255039
4	0.2506011	0.1567413	-1.567413	-0.325504	2.17727

5 x 1	0
0	1.0
1	0.0
2	0.5
3	-0.3
4	0.2

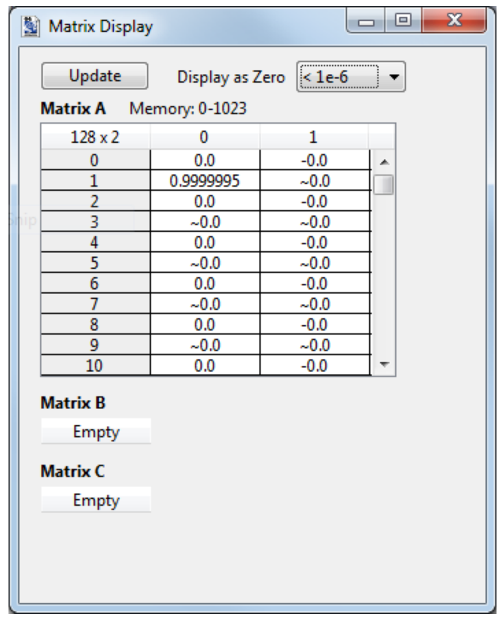
7 x 5	0	1	2	3	4
0	1.0	0.0	0.5	-0.3	0.2
1	0.0	1.0	0.1	0.0	0.0
2	0.5	0.1	0.74	0.45	0.6
3	-0.3	0.0	0.6081082	0.6363513	0.0951351
4	0.2	0.0	0.8108108	0.149501	0.4592907
5	0.250601	0.1567412	-1.567412	-0.3255039	2.17727
6	0.0	1.4012985e-45	2.8025969e-45	4.2038954e-45	5.6051939e-45

The ***Display as Zero*** option can be used to display values that are close to zero as ~0.0.
A zero comparison value from 1e-1 to 1e-15 can be selected from the pop-up menu. If the absolute value of the matrix element is less than the zero comparison value, the value is displayed as ~0.0.

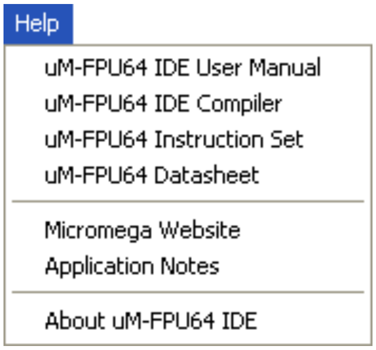
Display as Zero: off



Display as Zero: < 1e-6



Help Menu



uM-FPU64 IDE User Manual
uM-FPU64 IDE Compiler
uM-FPU64 Instruction Set
uM-FPU64 Datasheet

These menu items display documentation files using the default PDF viewer. The IDE will open the files on the Micromega website using the default web browser.

Micromega Website

Opens the Micromega website using the default web browser.

Application Notes

Opens the application notes page on the Micromega website using the default web browser.

About uM-FPU64 IDE

Displays a dialog with product identification, release version and release date of the uM-FPU64 IDE software. A link to the Micromega website is also provided

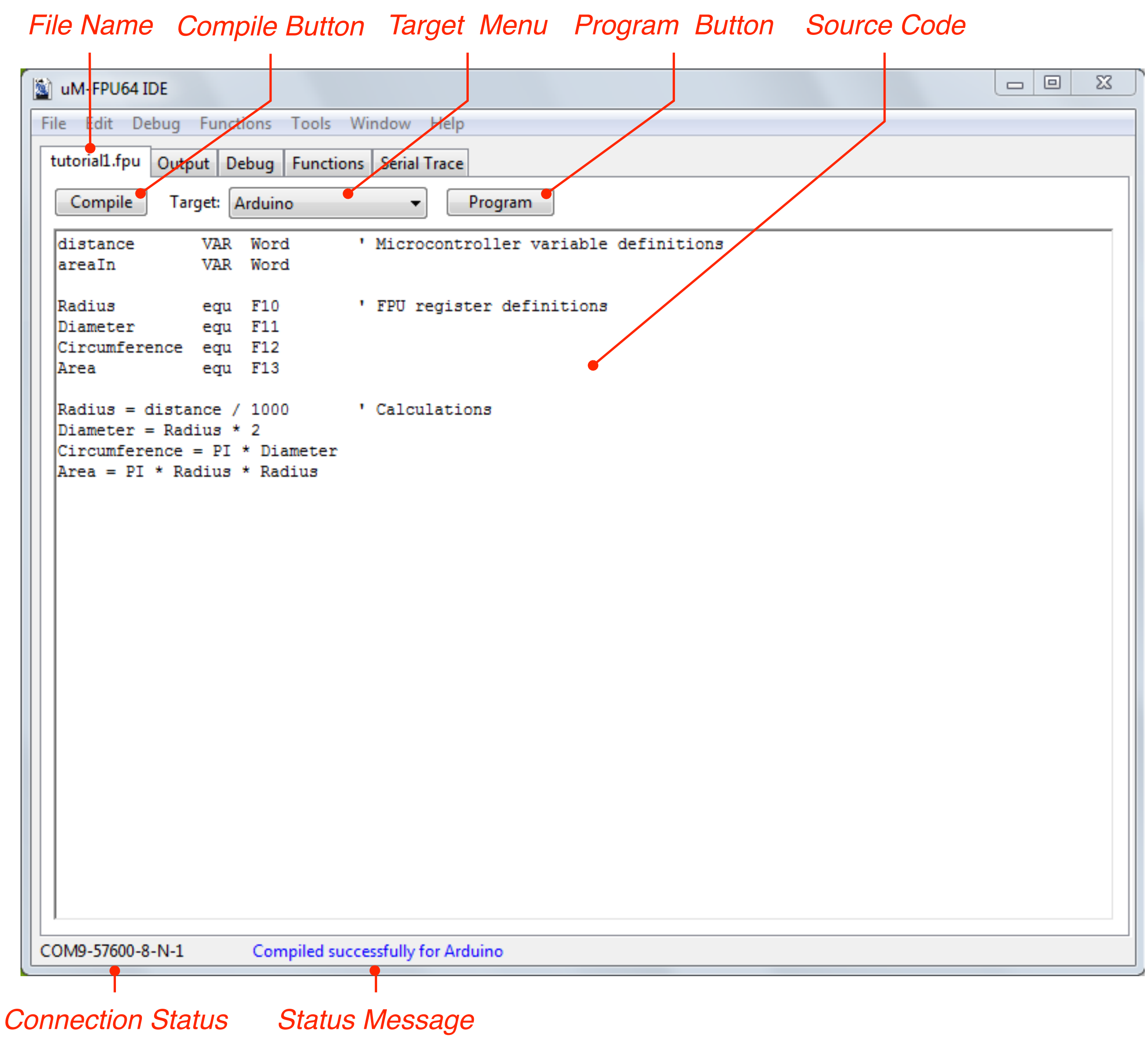
Reference Guide: Compiler and Assembler

The uM-FPU64 IDE provides a compiler and assembler for generating uM-FPU64 code for either a target microcontroller, or for user-defined functions that are stored in Flash memory on the FPU. The ***Source Window*** has a built-in editor for entering the source code. The source code will be converted to FPU instructions by the compiler and assembler. The output format is customized to the correct syntax for the target microcontroller selected by the user. FPU functions can be stored in Flash memory on the uM-FPU64 chip.
Symbol definitions can include constants, FPU registers, pointers, arrays, and microcontroller variables. Math equations can use 32-bit or 64-bit integer and floating point values, and can contain defined symbols, math operators, functions and parentheses. The compiler also supports an in-line assembler for entering FPU instructions directly.

See the *uM-FPU64 IDE Compiler* document for a description of the compiler and assembler.

Source Window

The source code for the program is entered into the Source Window.



The source window provides tab processing and auto-indent to make entering code easier and to improve the layout of source files. All tab characters are replaced by one or more spaces.

Automatic Tab Replacement

When a source file is opened by the IDE, or text is pasted into the source window, all tab characters are replaced by spaces to approximate the old tab settings. Saved files will no longer contain tab characters.

Tab Processing

When a *tab* key is pressed in the source window, the following actions now occur:

Tab with No Selection

If the line immediately above the current line has a space in the same position, spaces will be inserted into the current line until the first non-space character in the line above. This makes it easy to line up the columns text such as definitions or comments. If the line immediately above the current line has a non-space character in the same position, then spaces will be added until the next tab stop. The tab stop for the first 20 characters of a line is two, and the tab stop after 20 characters is four. This makes it easy to indent code, but saves typing later in the line when tabbing to a particular column.

Tab with Text Selection

An indent is inserted by adding two spaces to the start of all lines covered by the text selection. The text selection remains in place.

Shift-Tab

An indent is removed by deleting up to two spaces from the start of the current line, and if text is selected, from all lines covered by the text selection. The text selection remains in place.

Delete

If a delete character is entered immediately after a tab or auto-indent, the last tab stop will be deleted.

Auto-Indent

If a *return* key or *shift-return* key is entered at the end of a source code line, the following actions occur:

Return

If a directive or control statements is detected on the current line, the next line will be indented by two additional spaces, otherwise the next line will have the same indent as the current line. The recognized directives or control statements are as follows:

```
#function
#asm
do
while
for
if...then
else
elseif
select
case
```

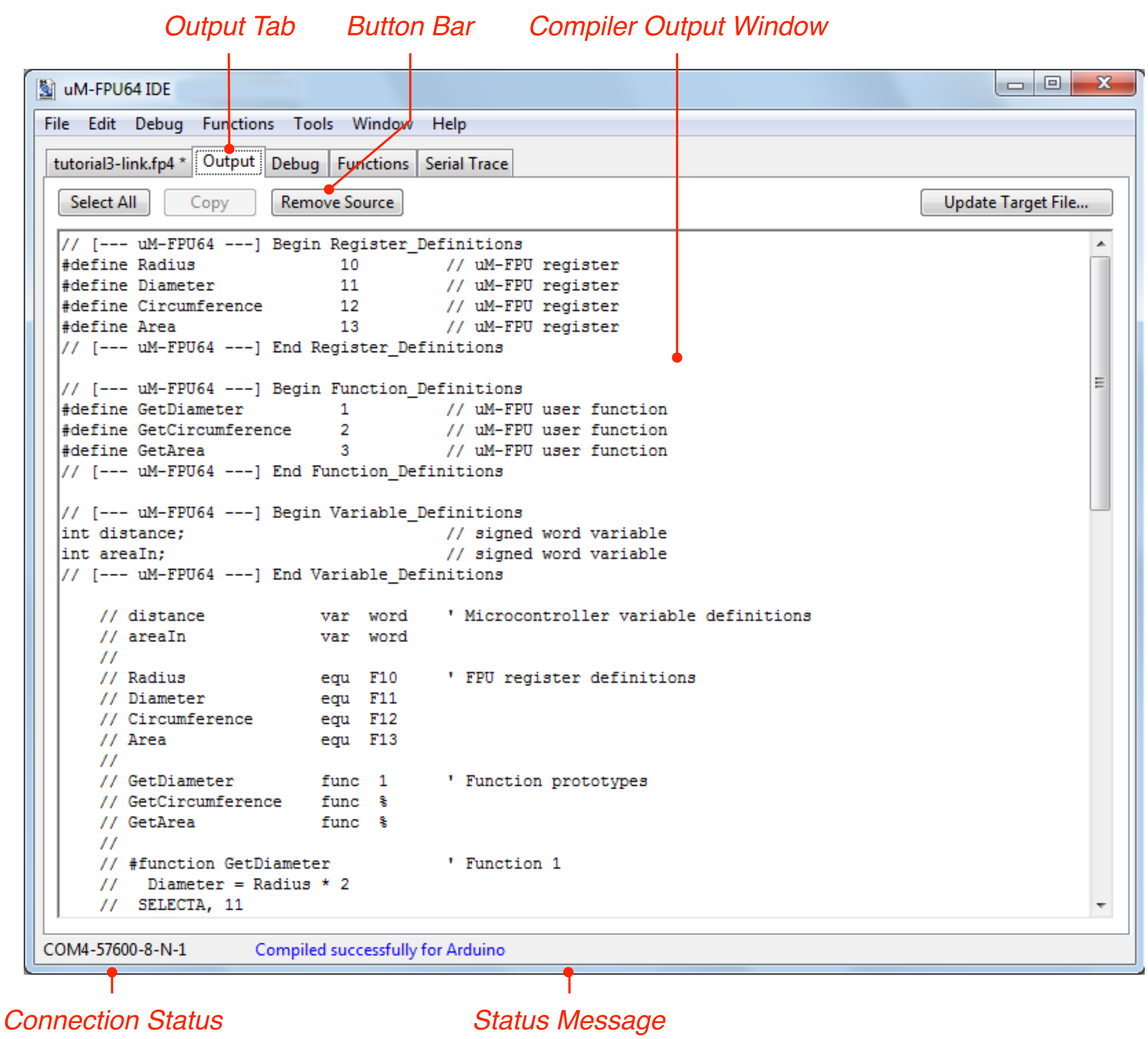
Shift-Return

A *shift-return* key causes the same action as the *return* key, but also appends the matching end statement. The cursor is positioned on the next line. The matching end statement are as follows:

```
#function          do          if...then
#end               loop        endif

#asm               while       select
#endasm            loop        case
                               endselect
                   for
                   next
```

Output Window

The compiled code is displayed in the Output Window.



Updating Target Files with Linked Code

Target code generated by the compiler can by manually copied to target source files using copy-and-paste. An automated update method is available using the ***Update Target File...*** button in the ***Output Window***. To use the automated update method, special comments are inserted into the target source file to define the begin and end points for code insertion. These special comments, or links, are generated by the compiler. Links are automatically generated for register definitions, function definitions, and variable definitions. An example of a register definition link is shown below:

```
// [--- uM-FPU64 ---] Begin Register_Definitions
#define Radius              10         // uM-FPU register
#define Diameter            11         // uM-FPU register
#define Circumference       12         // uM-FPU register
#define Area                13         // uM-FPU register
// [--- uM-FPU64 ---] End Register_Definitions
```

Other user-defined links are generated by using the **`#target_code`** ***`link_id`*** directive in the FPU file. For example, using the following directive in the FPU file:

```
#target_code calculations
```

Will generate the following code in the ***Output Window***.

```
// [--- uM-FPU64 ---] Begin calculations
  //   Radius = distance / 1000   ' Calculations
  Fpu.write(SELECTA, Radius, LOADWORD);
  Fpu.writeWord(distance);
  Fpu.write(FSET0, LOADWORD);
  Fpu.writeWord(1000);
  Fpu.write(FDIV0);
// [--- uM-FPU64 ---] End calculations
```

To initially insert links into the target source file, copy-and-paste the links from the ***Output Window*** to the target source file.

When the ***Update Target File...*** button is pressed, a dialog is displayed so the user can select a target file. Any link in the target file with a matching link in the ***Output Window*** will be updated with the code from the ***Output Window***. A timestamp comment is added to the start of the linked code stored in the target file. Linked code is inserted into the target file using the indentation of the begin link in the target file. This allows the inserted code to be properly aligned with other target code.

Reference Guide: Debugger

Utilizing the built-in debug monitor on the uM-FPU64 chip, the IDE provides a high-level interface for debugging programs that use the uM-FPU64 floating point coprocessor. It supports the ability to trace uM-FPU instructions, set breakpoints, single-step through execution of uM-FPU instructions, and display the value of uM-FPU registers. The IDE includes a disassembler so that instruction traces are displayed in easy-to-read assembler format.

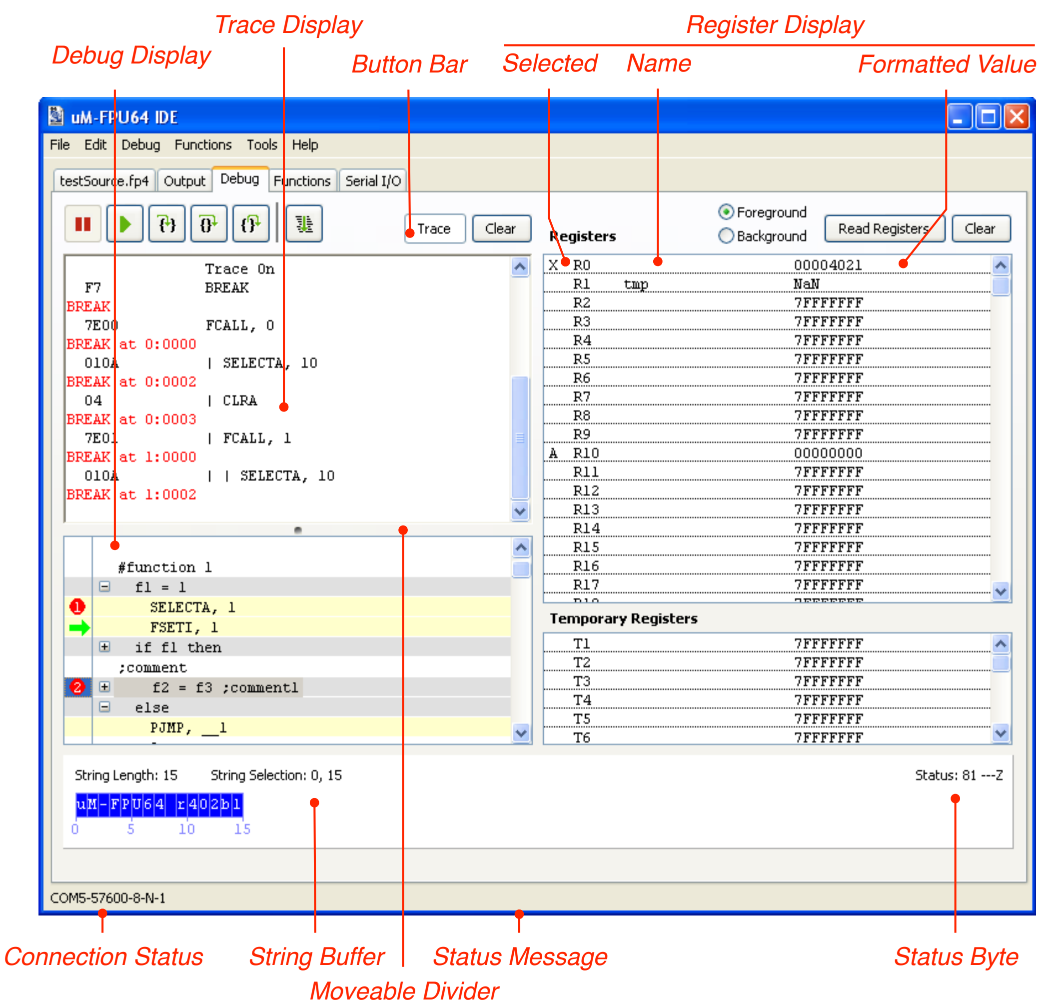
Making the Connection

For debugging, the uM-FPU64 IDE must have a serial connection to the uM-FPU64 chip. Refer to the section at the start of this document called *Connecting to the uM-FPU64 chip*.

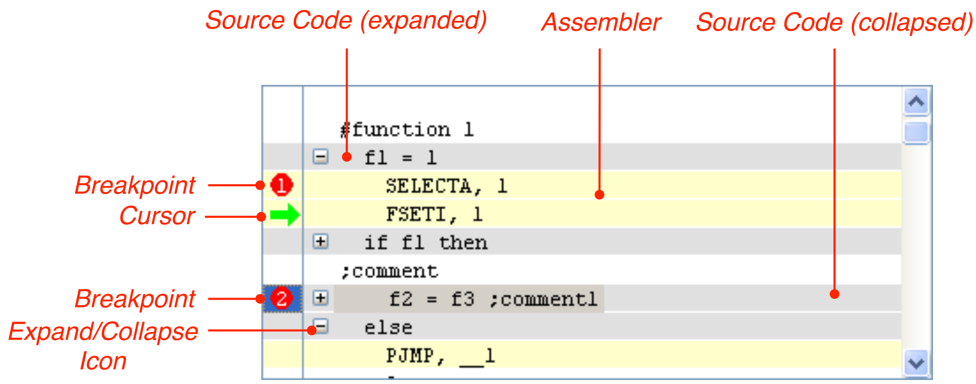
Source Level Debugging

Source level debugging is only available for user-defined functions. The source file is displayed below the trace display. A movable divider is located between the trace display and debug display. Breakpoints can be set on any executable line shown in the debug display (both source level and assembler). All executable lines have an expand/collapse icon. Source lines can be expanded to display the assembler code generated by the source line. When the debugger is active, a cursor shows the next instruction to be executed. If a source line is expanded, the debugger will step by assembler instruction. If the source line is collapsed, the debugger will step by source line.

Debug Window



Source-level Debug Display



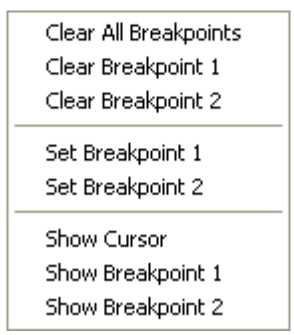
Left column:	Breakpoint and cursor display.
Right column:	Source code and assembler code display.

White background:	Source code (non-executable).
Gray background:	Source code (executable).
Yellow background:	Assembler code (executable).

Double-click on left column (executable line):

Sets or clears breakpoint.
If no previous breakpoint, sets the next breakpoint.
If no more breakpoints, displays a placeholder.
If breakpoint or placeholder present, they are cleared.

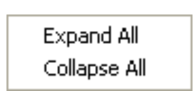
Right-click on left column:



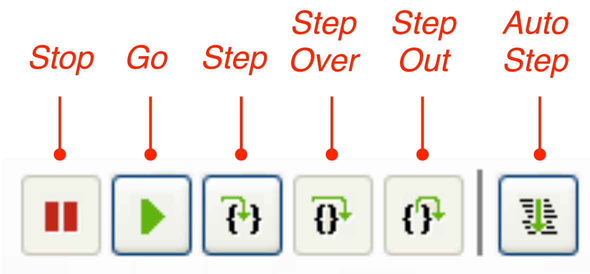
Double-click on right column (executable line):

Expands or collapses the individual line.
Breakpoints are cleared on lines that are collapsed.
Cursor is moved to expanded or collapsed line.

Right-click on right column:



Debug Buttons



Stop
- Stop execution and enter debugger.

Go
- Start or continue execution.

Step
- Step to next executable line.
- If source code is unexpanded, the step is to next executable source line.
- If source line is expanded, the step is to next assembler instruction.

Step Over
- Step to next executable line in the same function (steps over function calls).
- If source code is unexpanded, the step is to next executable source line.
- If source line is expanded, the step is to next assembler instruction.

Step Out
- Steps out of current function.

Auto Step
- Functionality is unchanged from previous version.

The ***Trace Display*** displays messages and instruction traces. The Reset message includes a time stamp, is is displayed whenever a hardware or software reset occurs. Instruction tracing will only occur if tracing is enabled. This can be enabled at Reset by setting the ***Trace on Reset*** option in the ***Functions> Set Parameters...*** dialog, or at any time by sending the **`TRACEON`** instruction.

The ***Register Display*** shows the value of all registers. Register values that have changed since the last update are shown in red. The ***String Buffer*** displays the FPU string buffer and string selection, and the ***Status Byte*** shows the FPU status byte and status bit indicators. The ***Register Display***, ***String Buffer***, and ***Status Byte*** are only updated automatically at breakpoints. They can be updated manually using the ***Read Registers*** button.

The ***Go***, ***Stop***, ***Step*** and ***Trace*** buttons at the top left control the breakpoint and trace features, and the connection status is displayed at the lower left of the window.

Trace Display

The scrolling window on the left of the debug window displays the debug trace output. When a Reset occurs a message is displayed showing the date and time of the Reset.

```
----------------------------------------
RESET: 2011-09-27 13:19:31
----------------------------------------
```

Tracing is turned off at Reset, unless the **Trace on Reset** parameter has been set. Tracing can be controlled by the program using the **TRACEON** and **TRACEOFF** instructions, or manually with the ***Trace*** button. If tracing is enabled, all FPU instructions are displayed as they are executed. The opcode and data bytes are displayed on the left, and the FPU instructions are displayed on the right in assembler format.

```
TRACE: ON
  0104          SELECTA, 4
  5E            LOADPI
  29            FSET0
  2401          FMUL, 1
  2401          FMUL, 1
  1F3F          FTOA, 63
  F232302E3833  READSTR: "20.831"
  3100
```

The ***Trace*** button toggles the trace mode on and off.

Clicking the ***Clear*** button above the ***Debug Trace*** window will clear the contents of the ***Debug Trace*** window.

Breakpoints

Breakpoints can be inserted into a program using the **BREAK** instruction, or initiated manually with the ***Stop*** button. Breakpoints occur after the next FPU instruction finishes executing. When a breakpoint occurs, the last FPU instruction executed before the breakpoint is displayed, followed by the break message, and the register display is updated. Register values are displayed in red if the value has changed since the last time the display was updated, or black if the value is unchanged.

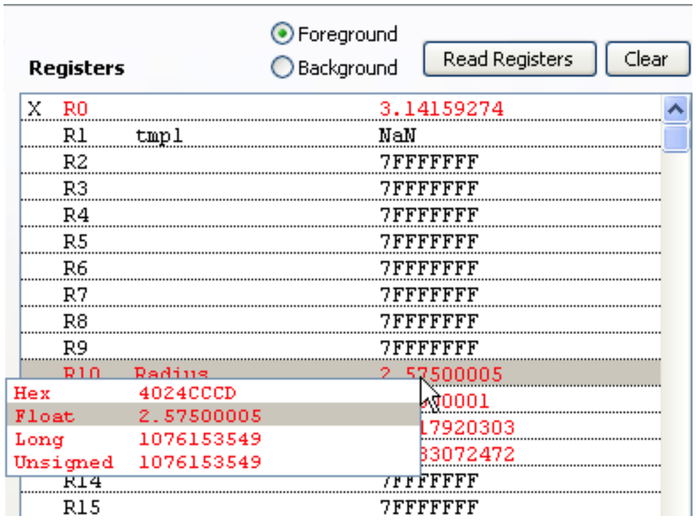
```
 5E            LOADPI
BREAK
```

The ***Go***, ***Stop***, and ***Step*** buttons are enabled or disabled depending on the current state of execution. The ***Go*** button is used to continue execution, and is enabled at Reset or after a breakpoint occurs. The ***Stop*** button is used to stop execution after the next FPU instruction is executed. If the uM-FPU is idle when the ***Stop*** button is pressed, the breakpoint will not occur until the next uM-FPU instruction is executed. If the FPU is already at a breakpoint, then the ***Stop*** button will be disabled. The ***Step*** button is used to single step through instructions, with a new breakpoint occurring after each instruction.

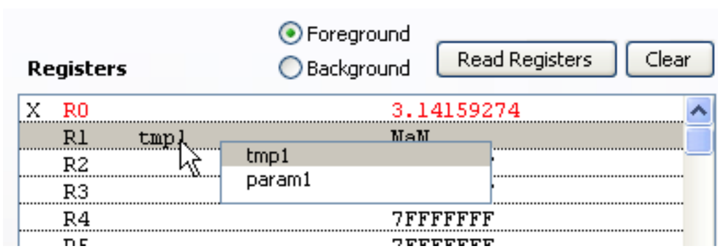
The Register Panel

The register panel displays the value of each register and indicates the register currently selected as register A and register X. Register A and register X are indicated by an `A` and `X` marker in the left margin of the register panel. The temporary registers are displayed at the bottom on the register panel.

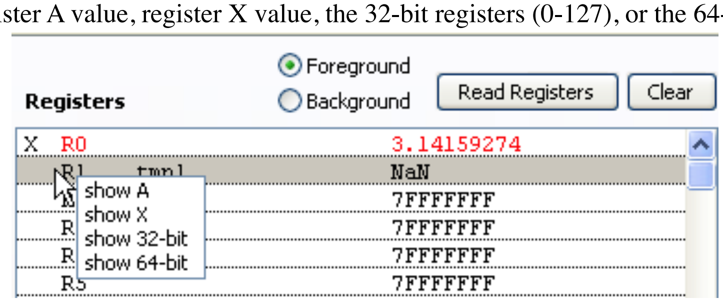
For each register, the register number, optional register name, and formatted value is displayed. If you right-click on the formatted value, a pop-up menu is displayed with the register value displayed in hexadecimal, floating point, long integer, and unsigned long integer format. If you select a different format, the display will be updated to show that format. The format of multiple registers can be changed by selecting a group of registers prior to the right-click for the format pop-up menu.



Register names are automatically set from the register definitions in the source file. Registers can often have several different names assigned. If you right-click on the register name, a pop-up menu is displayed showing all of the names for that register. If you select a different name, the display will be updated to show that name.



If you right-click on the register number, a pop-up menu is displayed that always you to scroll the display to the register A value, register X value, the 32-bit registers (0-127), or the 64-bit registers (128-255).



The current register values are automatically updated after every breakpoint. The ***Read Registers*** button can also be used to manually force an update of the register values. Register values are displayed in red if the value has changed since the last time the display was updated, or black if the value is unchanged.

Error messages

`<data error>`

The IDE communicates with the uM-FPU64 chip using a serial connection. If the IDE detects an error in the data received from the FPU, the data error message is displayed in the ***Debug Trace***. This can sometimes occur immediately before a Reset, if the reset interrupts a trace operation in progress. This situation can be ignored. If it occurs at other times it indicates a problem with the serial communications. The trace in the ***Serial I/O*** window can be reviewed and may help determine the source of the problem.

`<trace suppressed>`

In certain circumstances, the FPU is capable of sending data faster than the PC can handle it. If this occurs, the trace suppressed message is displayed, and the IDE attempts to recover by suppressing data, resynchronizing, and continuing. This situation should not normally occur, but can occur if excessive amounts of trace data are being produced such as tracing a user-defined function that is looping. To avoid this situation, the **`TRACEOFF`** and **`TRACEON`** instructions can be used to selectively disable tracing.

`<trace limit` *`xx`*`>`

The IDE will retain up to 100,000 characters in the ***Debug Trace***. This is normally more than sufficient for tracing and debugging. The ***Debug Trace*** buffer can be cleared with the ***Clear*** button. If the buffer is exceeded, the first portion will be deleted, and the trace limit message displayed in its place. The trace limit messages are numbered sequentially. This message does not necessarily indicate an error, unless it occurs in conjunction with one of the messages described above.

`FPU Error: Address error`

An address error occurred inside an XOP instruction. The likely cause is an invalid parameter being specified in an XOP instruction.

`FPU Error: Buffer overflow`

The 256 byte FPU instruction buffer has been exceeded. This can be avoided by waiting for a ready status at least every 256 bytes, if more than 256 byes are sent to the FPU between read operations. If debug trace is enabled, instructions take longer to execute, particularly if the serial buffer fills, which can sometimes lead to an FPU buffer overflow that doesn't occur an normal execution speed.

`FPU Error: Call level exceeded`

The 16 levels of call nesting available on the uM-FPU64 has been exceeded.

`FPU Error: Device not loaded`

A `DEVIO,`*`device`*`,LOAD_DEVICE,…` instruction failed because the loadable device was not programmed into Flash memory.

`FPU Error: Function not defined`

A user function has been called that has is not currently stored in FPU Flash memory.

`FPU Error: Incomplete Instruction`

An instruction that requires multiple bytes has not received the required number of bytes within the timeout period of one second. This is generally caused by a programming error in the target code.

`FPU Error: Invalid parenthesis`

There are 8 levels of parentheses available using the `LEFT` and `RIGHT` instructions. Either too many `LEFT` instructions have been sent, or there is a mismatch with the number of `LEFT` and `RIGHT` instructions.

`FPU Error: Memory Allocation failed`

A memory allocation failed because the number of bytes requested were not available in the dynamic allocation area.

`FPU Error: XOP not defined`

An extended opcode (`XOP`) was called that is not currently stored in FPU Flash memory.

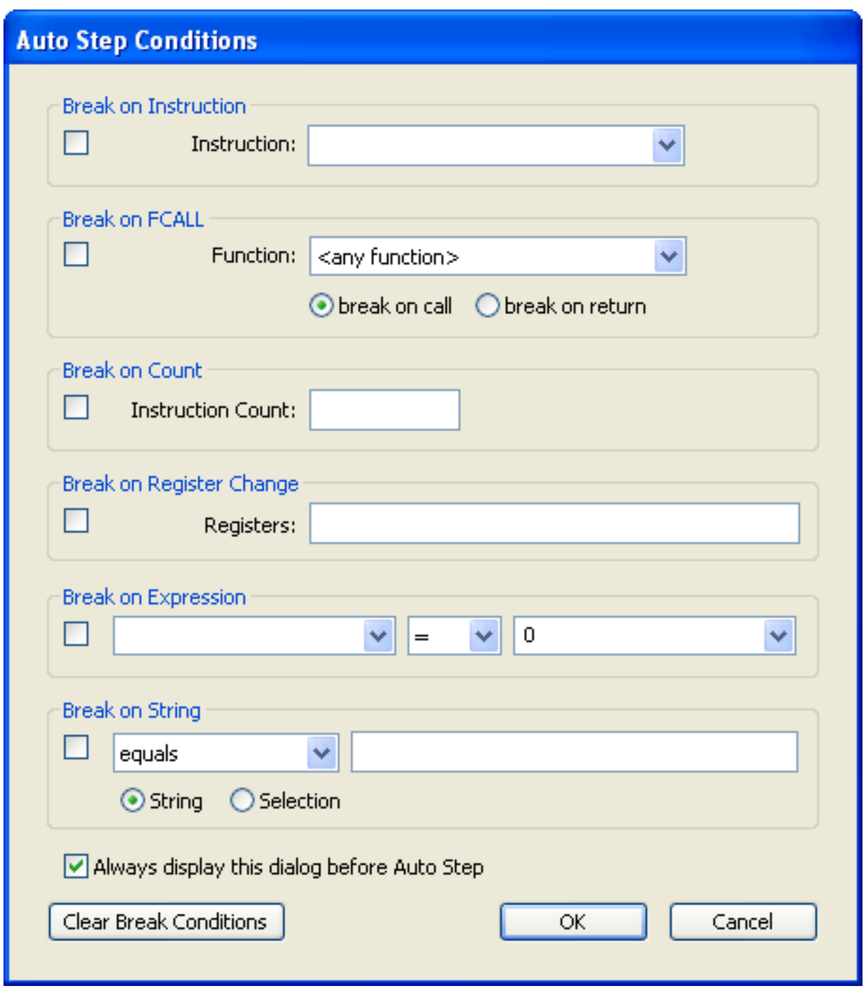
Reference Guide: Auto Step and Conditional Breakpoints

The Auto Step feature provides a means to automatically single step through FPU instructions. This feature, in conjunction with Auto Step Conditions, can be used to implement conditional breakpoints. Conditional breakpoints stop instruction execution when one of the specified conditions occur. Breakpoints can be set for a variety of conditions including: when a particular instruction is executed, when a user-defined functions is called, when a specified number of instructions have been executed, when a register value changes or matches a particular expression, or when a string comparison matches a particular condition. Multiple conditions can be specified, and a breakpoint will occur when any of the conditions is met.

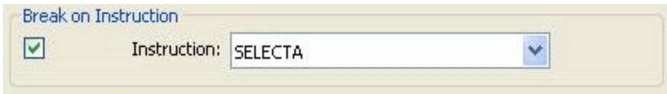
Conditional breakpoints are only active when the ***Auto Step*** operation is used. They are not active when the ***Go*** or ***Step*** operation is used. Instruction execution is much slower using ***Auto Step*** since an internal breakpoint occurs for each instruction, and the debug trace and register data are checked for ***Auto Step Conditions***.

Auto Step is activated by clicking the ***Auto Step*** button, or selecting the ***Debug> Auto Step*** menu item. Auto Step Conditions are set by right-clicking the ***Auto Step*** button, or selecting the ***Debug> Auto Step Conditions*** menu item. The ***Auto Step Conditions*** can also be set to appear each time the ***Auto Step*** button is pressed.

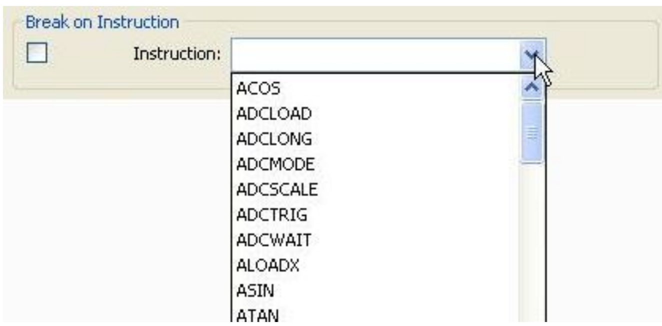
Auto Step Conditions Dialog



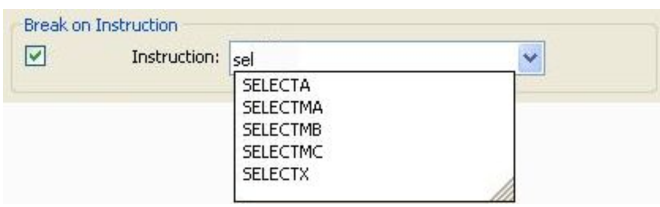
Break on Instruction
This condition causes a breakpoint when a particular instruction is executed. The instruction is specified using assembler format as shown below.



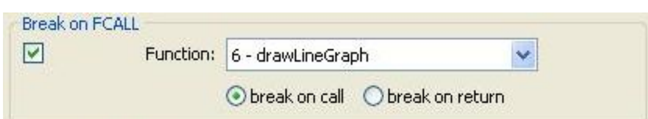
The opcode can be selected from a pop-up menu,



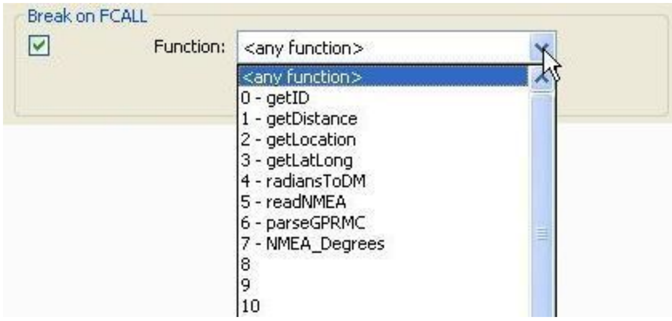
or the opcode can be typed in the field. An auto-complete feature is provided to assist in typing the opcode.



Break on FCALL
This condition causes a breakpoint when a user-defined function is called, or when it returns.

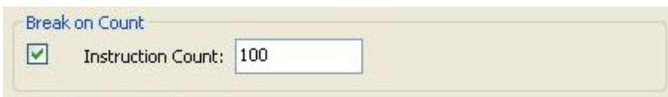


The function is selected from a pop-up menu. The menu has all of the function numbers. If functions have been defined in the current source file, and compiled, the function name is also displayed in the menu. The special item <*any function*> can also be selected to cause a breakpoint on any function call.



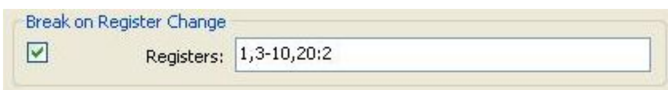
Break on Count

This condition causes a breakpoint after a specified number of instructions has executed.



Break on Register Change

This condition causes a breakpoint when the value changes in one of the specified registers.



Multiple registers can be specified separated by commas. A register can be specified as:

- a single register value (e.g. 1)
- a range of register values (e.g. 3-10 which selects registers 3 through 10)
- an array of register values (e.g. 20:2 which selects two registers starting at registers 20)

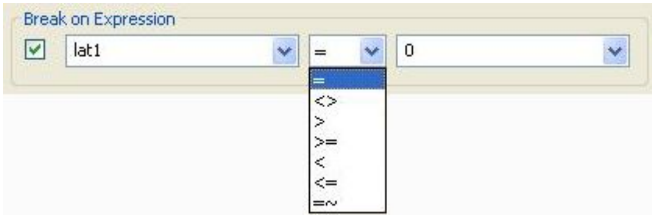
If register names have been defined in the current source file, and compiled, the names can also be used.

Break on Expression

This condition causes a breakpoint whenever the expression is true.

The left side of the expression must be a register. A register number can be typed in, or if registers have been defined in the current source file, and compiled, a pop-up menu can be used.

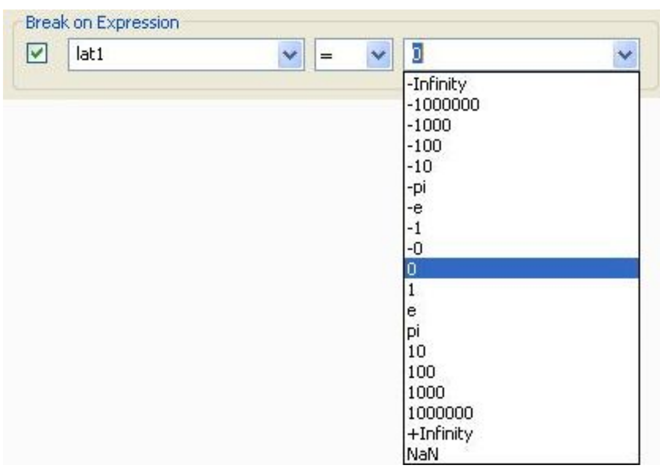
The operator used by the expression is chosen from the middle pop-up menu



The operators are as follows:

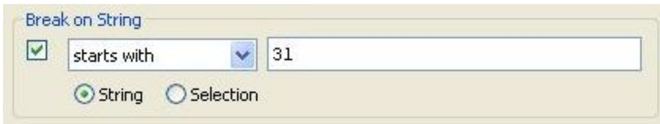
=	equal
<>	not equal
>	greater than
>=	greater than or equal
<	less than
<=	less than or equal
=~	approximately equal

The approximately equal operator is used for floating point values. The condition is true if the register value is greater than (value - 0.000001) and less than (value + 0.000001).
The left side of the expression can be any value. The value can be typed in or the pop-up menu can be used for predefined values.

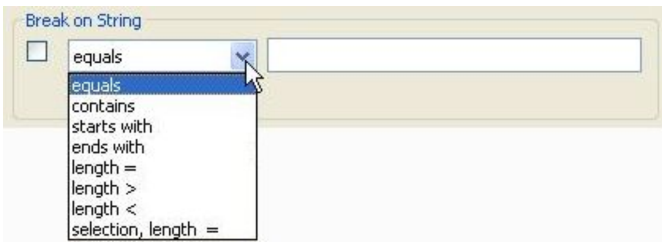


Break on String

This condition causes a breakpoint if the string comparison is true.



The string comparison can either be the entire string buffer, or the current string selection. The comparison operator is selected from the left pop-up menu, and the string to compare is entered in the field on the right.

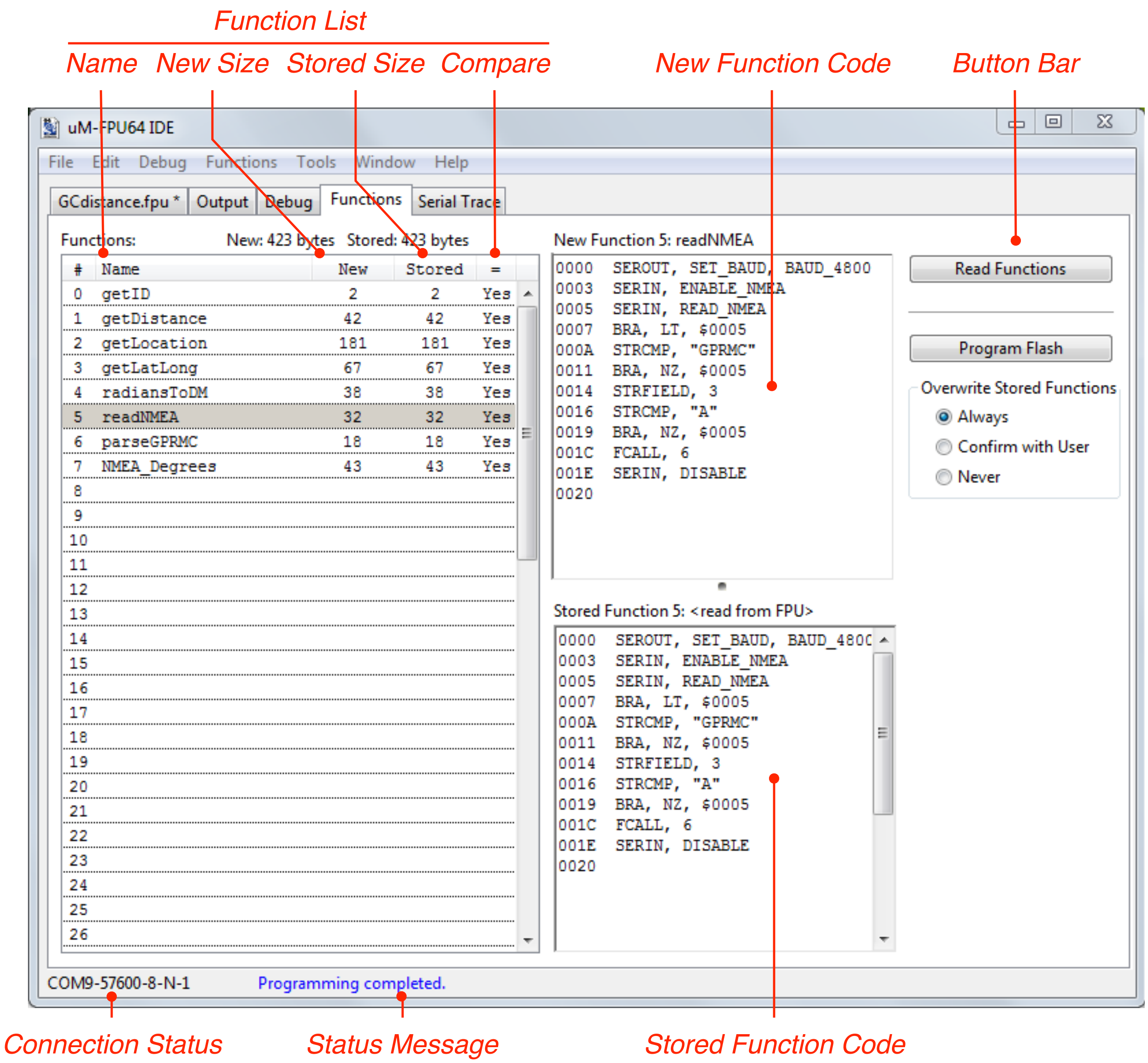


The comparisons for length require a decimal number to be entered in the field on the right. The comparisons for selection, length require two decimal numbers separated by a comma to be entered in the field on the right.

Reference Guide: Programming Flash Memory

The ***Function*** window provides support for storing user-defined functions on the uM-FPU64 chip. Stored functions can reduce memory usage on the microcontroller, simplify the interface and often increase the speed of operation. The uM-FPU64 reserves 2048 bytes of flash memory for user-defined functions and parameters (plus 256 bytes for the header information). Functions are stored as a string of FPU instructions, and up to 64 functions can be defined. Functions are specified in the source file by using the **#FUNCTION** directive. See the section entitled *Reference Guide: Generating uM-FPU64 Code* for more details.

Function Window



The ***Function List*** provides information about each function defined by the compiler and stored on the FPU. The ***Name*** column in the ***Function List*** displays the name of all functions defined in the source file. The ***New*** column shows the size in bytes of the functions defined in the source file, and the ***Stored*** column displays the size in bytes of functions currently stored on the FPU. If nothing is displayed in the ***Stored*** column, the *Read Stored Functions* button can be pressed to read the stored functions from the FPU. The **=** column displays ***Yes*** if the new and stored functions are the same, or ***No*** if they are different. The total bytes used in the ***New*** column and ***Stored*** column is displayed at the top of the function list.

The ***New Function Code*** displays the FPU instructions for compiled functions, and the ***Stored Function Code*** displays the FPU instructions for functions stored on the FPU. The function to be displayed is selected by selecting one of the functions in the ***Function List***.

The ***Read Stored Functions*** button is used to read the functions currently stored on the FPU and update the ***Function List***.

The ***Program Functions*** button is used to program new functions to the uM-FPU64 chip. If a newly defined function is different then the currently stored functions, the action taken is determined by the ***Overwrite Stored Functions*** option.

If the ***Always*** option is selected, a new function will always overwrite any previously stored function.

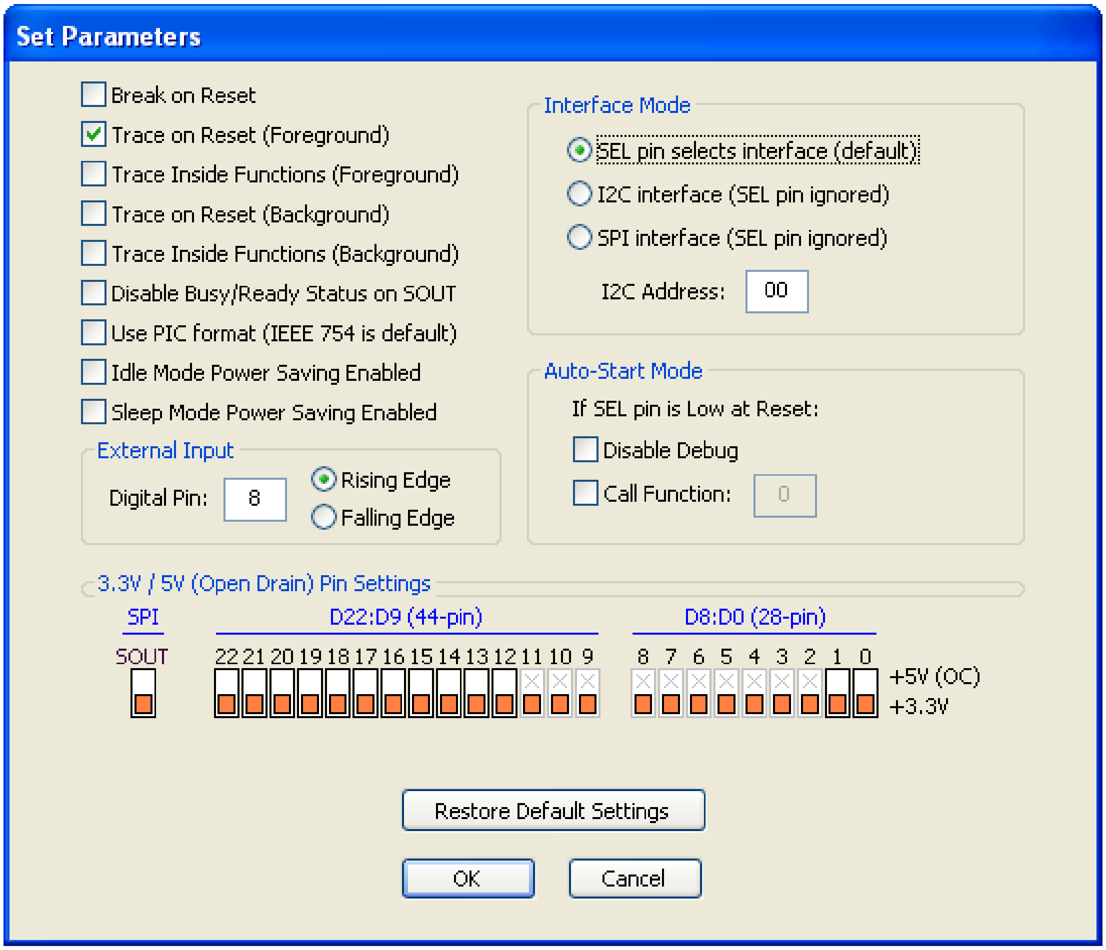
If the ***Confirm with User*** option is selected, you are asked to confirm whether a new function should replace the previously stored function.

If the ***Never*** option is selected, new functions are not allowed to replace previously stored functions.

Reference Guide: Setting uM-FPU64 Parameters

The **Set Parameters…** menu item is used to set the uM-FPU64 mode parameter bytes.

Set Parameters Dialog



Break on Reset
If this option is selected, a breakpoint will occur on the first instruction following a Reset.

Trace on Reset (Foreground)
If this option is selected, debug tracing is turned on at Reset for foreground tasks.

Trace Inside Functions (Foreground)
If this option is selected, debug tracing will be enabled inside functions called by foreground tasks.

Trace on Reset (Background)
If this option is selected, debug tracing is turned on at Reset for background events.

Trace Inside Functions (Background)
If this option is selected, debug tracing will be enabled inside functions called by background events.

Disable Busy/Ready status on SOUT

If this option is selected, the Busy/Ready status will not be output on the **SOUT** pin, and the **/BUSY** pin must be monitored for the Busy/Ready status.

Use PIC Format (IEEE 754 is default)

If this option is selected, the PIC format will be used for reading and writing floating point values. The uM-FPU64 chip uses floating point values that conform to the IEEE 754 32-bit floating point standard. This is also the default format for reading and writing floating point values in FPU instructions. An alternate PIC format is often used by PICmicro compilers. If this option is selected, floating point values are automatically translated between the PIC format and the IEEE 754 format whenever values are read from the FPU or written to the FPU, and the microcontroller program can use the PIC format. The **IEEEMODE** and **PICMODE** instructions can also be used to dynamically change the format. For additional information regarding the **IEEEMODE** and **PICMODE** instructions, see the *uM-FPU64 Instruction Set*.

> Note: The IDE code generator currently only generates code for the default IEEE 754 format. If the PIC format is used you will need to fix the data values in the code generated for **FWRITE**, **FWRITEA**, **FWRITEX** and **FWRITE0** instructions.

Idle Mode Power Saving Enable

If this option is selected, the uM-FPU64 chip will go into a low power mode when idle.

Sleep Mode Power Saving Enabled

If this option is selected, the uM-FPU64 chip will go to sleep when idle and the chip is not selected. This mode is only active if the interface mode is SPI with the **CS** pin used as a chip select.

Interface Mode

This option selects which digital I/O pin will be used for the external input, and specifies the active edge.

Interface Mode

By default, the **SEL** pin on the uM-FPU64 chip is read at Reset to determine if the SPI or I²C interface is to be used. The interface mode parameter can be used to force selection of SPI or I²C at Reset (ignoring the **SEL** pin).

I2C Address

By default, the I²C address used by the uM-FPU64 chip is `C8` (hexadecimal) or `1100100x` (binary). If the default address conflicts with another I²C device, or if multiple uM-FPU64 chips are used on the same I²C bus, the address can be changed to any other valid I²C address. The address is entered as an 8-bit hexadecimal number (with the lower bit ignored). A value of `00` will select the default `C8` address.

Auto-Start Mode

A user-defined function can be called and Debug Mode can be disabled when the FPU is Reset. If the ***Disable Debug*** option is selected, Debug Mode will be disabled at Reset. This is useful if the **SERIN** and **SEROUT** pins are being used for other purposes (e.g. GPS input, LCD output) and prevents the `{RESET}` message from being sent to the **SEROUT** pin at Reset. If the ***Call Function*** option is selected, the specified function will be called at Reset.

These options are only checked if the **CS** pin is Low at Reset. If both the **CS** pin and **SERIN** pin are High at Reset, the auto-start function is not called, and Debug Mode will always be entered. This provides a way to override the auto-start mode once it is set. To use auto-start with an I²C interface, the interface mode bits must be set to I²C (as described above). It's recommended that the interface be set to SPI or I²C using the interface bits whenever auto-start mode is used, so that the **CS** pin can be used to enable or disable the auto-start mode.

3.3V / 5V (Open Drain) Pin Settings

For pins that are 5V tolerant, the output can be defined as open drain to allow a 5V output using a pull-up resistor.

Restore Default Settings

This button restores the parameters to the following default settings:

Break on Reset	*not enabled*
Trace on Reset (Foreground)	*not enabled*
Trace Inside Functions (Foreground)	*not enabled*
Trace on Reset (Background)	*not enabled*
Trace Inside Functions (Background)	*not enabled*
Disable Busy/Ready status on SOUT	*not enabled*
Use PIC format (IEEE 754 is default)	*not enabled*
Idle Mode Power Saving Enabled	*enabled*
Sleep Mode Power Saving Enabled	*not enabled*
External Input	*D8, rising edge*
Interface Mode	*SEL pin selects interface (default)*
I^2C address	*C8*
Auto-Start Mode> Disable Debug	*not enabled*
Auto-Start Mode> Call Function	*not enabled*
3.3V / 5V (Open Drain) Pin Settings	*all set to 3.3V*

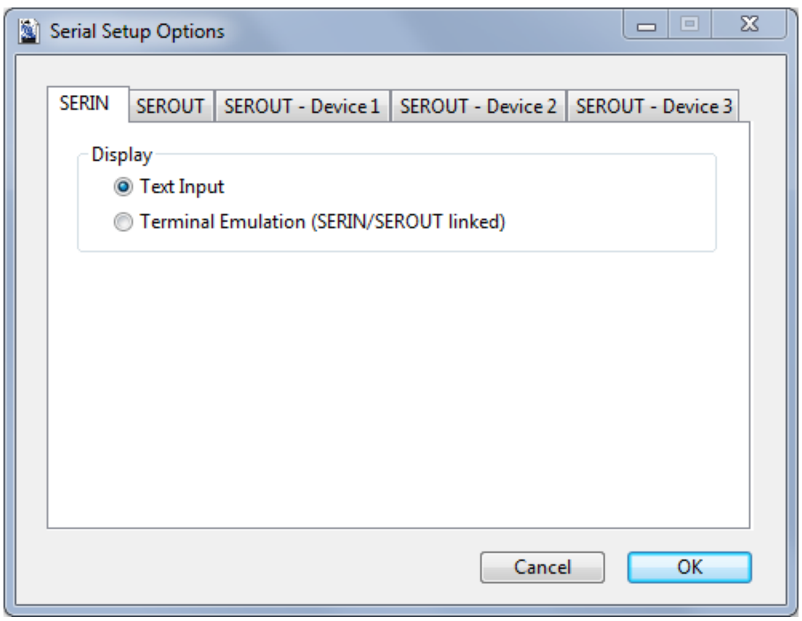
Reference Guide: SERIN and SEROUT Support

The uM-FPU64 IDE uses the `SERIN` and `SEROUT` pins for communication with the debug monitor. It also supports the ability to debug a project that uses the `SERIN` and `SEROUT` pins, and to receive serial data from multiple serial devices. If the debug monitor is enabled, the FPU communicates with the IDE to get data for the SERIN instruction, and sends data to the IDE from the `SEROUT` instruction. The `SEROUT` instruction supports three extra devices that can be used for sending data to the IDE. If the debug monitor is not enabled, output from the additional `SEROUT` devices is suppressed.

Note: To use the IDE support for the `SERIN` and `SEROUT` instructions, the debug monitor on the FPU must be active. All `SEROUT,SET_BAUD` instructions that disable the debug monitor must be commented out while debugging.

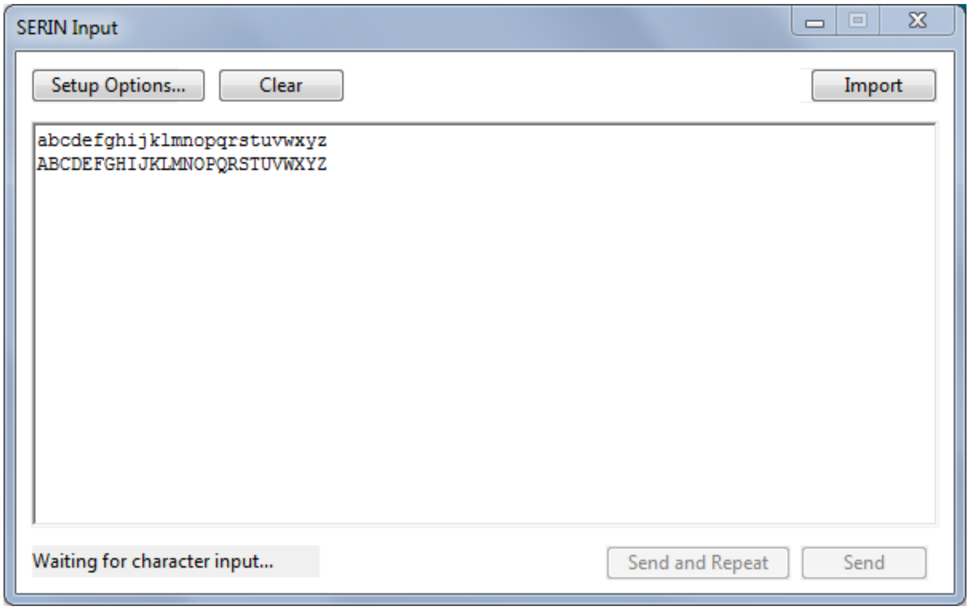
SERIN Window Setup Options

The SERIN window is configured using the ***Window> Show Serial Window> Setup Options*** menu item. It can be configured for *Text Input* or *Terminal Emulation* mode. In *Terminal Emulation* mode, serial input and output are both handled by the SEROUT window.



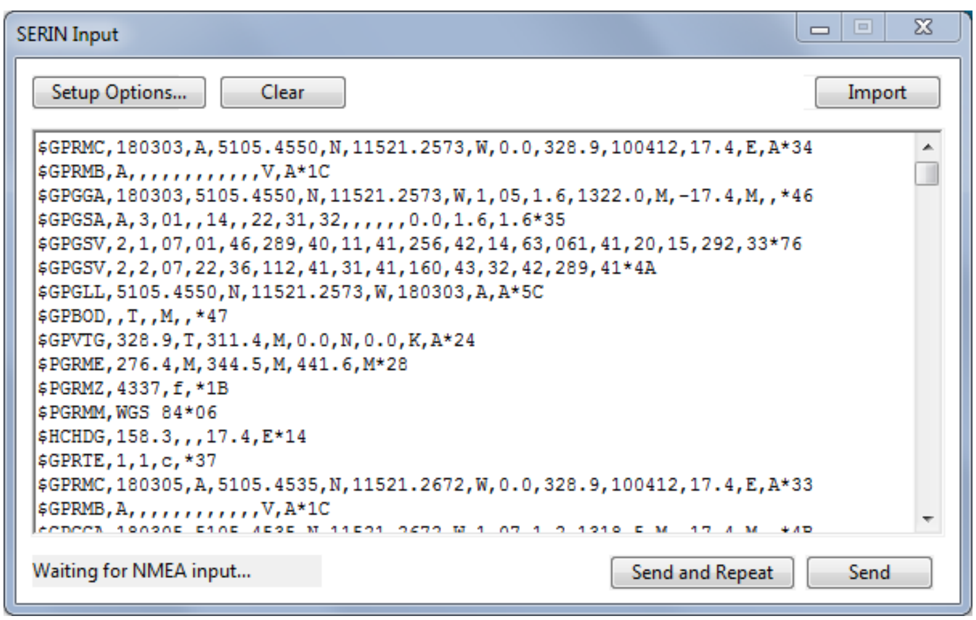
SERIN Window - Text Input, Character Mode

When the `SERIN,ENABLE_CHAR` instruction is executed the IDE enters character mode. When a `SERIN,READ_CHAR` instruction is executed, the IDE waits for the user to send the next character. The characters to send can be entered manually in the SERIN window or imported from a text file. In *Text Input* mode, the text is not actually sent to the FPU until you select a character or group of characters, and press one of the send buttons. The *Send* button sends the single character at the start of a selection. The *Send and Repeat* button sends each of the selected characters, in sequence, one at a time, as each `SERIN,READ_CHAR` instruction is executed. The user is not prompted for additional input until the selection has been completely sent. The repeat action can be stopped by making another selection.



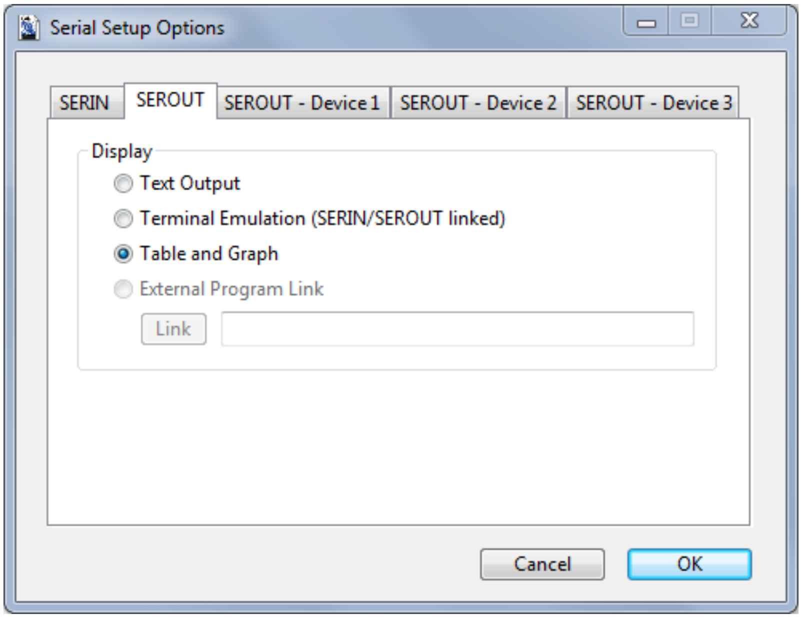
SERIN Window - Text Input, NMEA Mode

When the `SERIN,ENABLE_NMEA` instruction is executed the IDE enters NMEA mode. When a `SERIN,READ_NMEA` instruction is executed, the IDE waits for the user to send the next NMEA sentence. The sentences to send could be entered manually in the SERIN window, but they are normally imported from a text file. The sentences are not actually sent to the FPU until you select a sentence or group of sentences, and press one of the send buttons. The *Send* button sends the single sentence at the start of a selection. The *Send and Repeat* button sends each of the selected sentences, in sequence, one at a time, as each `SERIN,READ_NMEA` instruction is executed. The user is not prompted for additional input until the selection has been completely sent. The repeat action can be stopped by making another selection. Only complete sentences are sent to the FPU. If only part of a sentence is selected, the complete sentence will be sent.



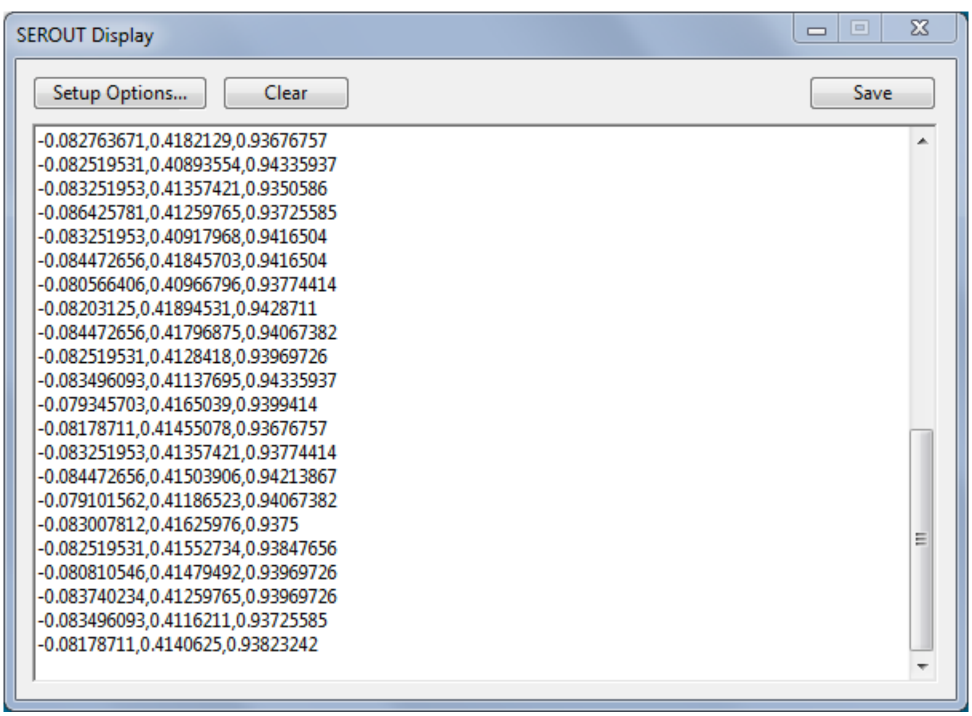
SEROUT Window Setup Options

The SEROUT window is configured using the ***Window> Show Serial Window> Setup Options*** menu item. It can be configured for *Text Output*, *Terminal Emulation*, or *Table and Graph* mode.



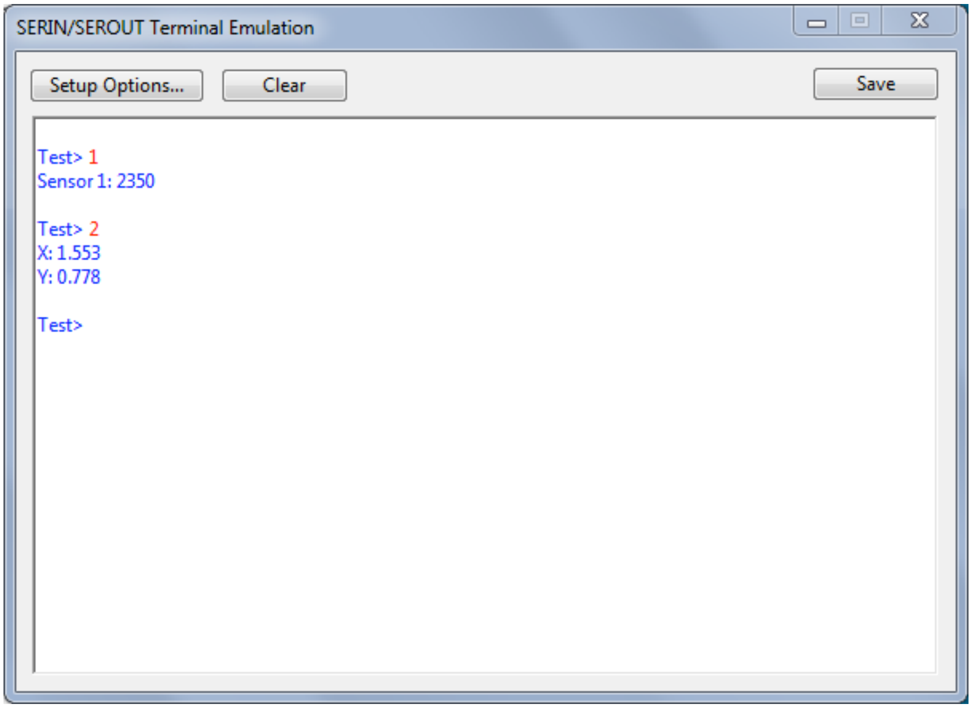
SEROUT Window - Text Output Mode

In *Text Output* mode, data sent by the `SEROUT` instruction is displayed in a text window, in black, with no additional formatting. The text output can be exported to a text file. If a vertical tab character (\v, or \0B) is received from the FPU, the SEROUT display is cleared.



SEROUT Window - Terminal Emulation Mode

In *Terminal Emulation* mode, serial input and serial output are both handled by the SEROUT window. Data sent by the `SEROUT` instruction is shown in blue, with no additional formatting. Characters typed by the user are shown in red. They are not displayed until the `SERIN` instruction requests data. A typeahead buffer is provided. If a vertical tab character (\v, or \0B) is received from the FPU, the SERIN/SEROUT display is cleared.

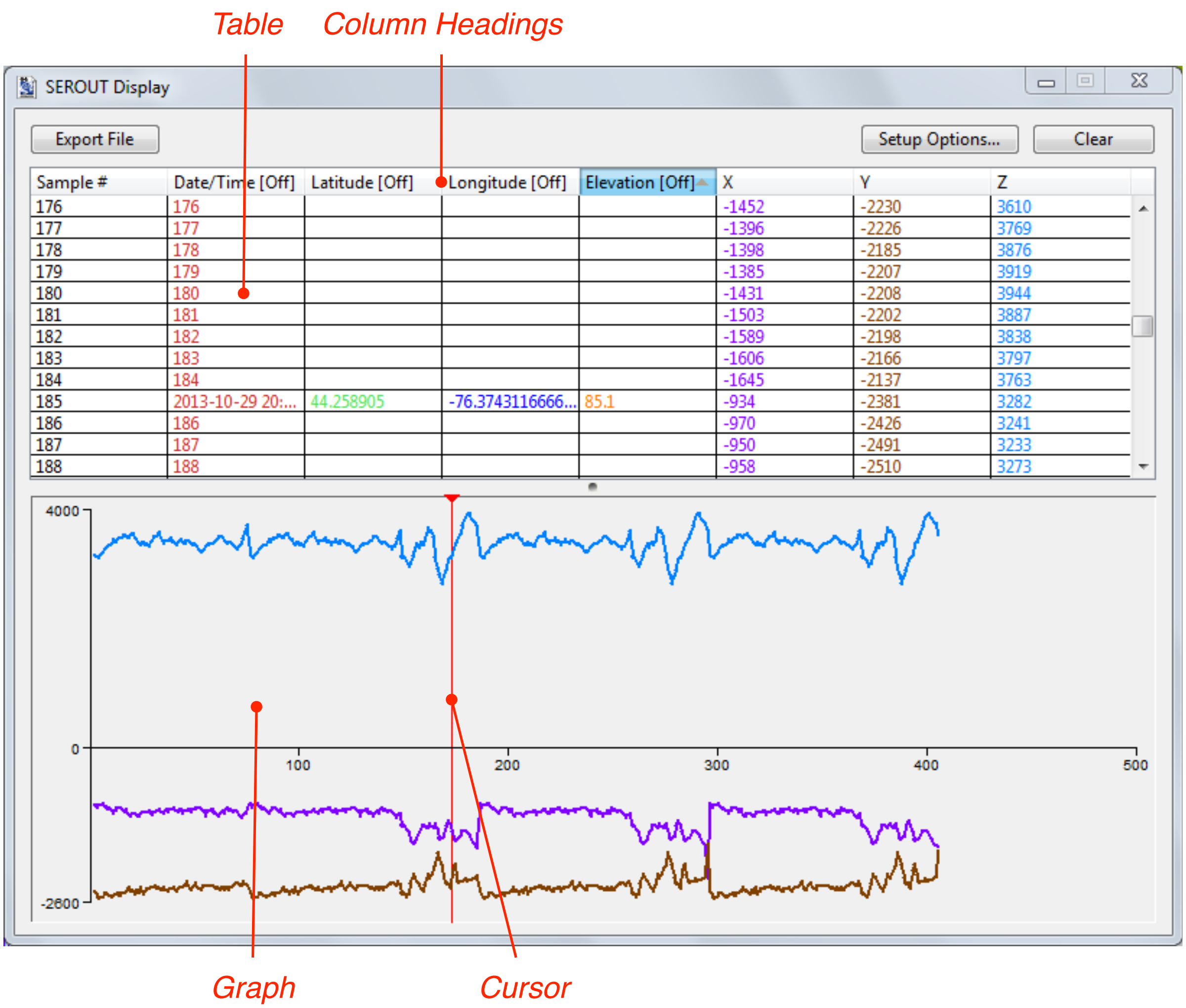


SEROUT Window - Table and Graph Mode

In *Table and Graph* mode, data sent by the `SEROUT` instruction is displayed in a table and graph. The data in each column in displayed in a different color, and each column is graphed using a line of the same color. The X and Y scales for the graph are automatically calculated to display the entire data set.

Data received from the `SEROUT` instruction must be comma separated values terminated with a carriage return. If the values are non-numeric, they are displayed as column headings. If the values are numeric, a new row of data is added to the table.

The new `SEROUT(WRITE_FLOAT…)`, `SEROUT(WRITE_LONG…)`, `SEROUT(WRITE_COMMA)`, and `SEROUT(WRITE_CRLF)` instructions make it easy to create comma separated values. If a vertical tab character (\v, or \0B) is received from the FPU, the SEROUT display is cleared.



Export File

Save the data to a comma separated value (CSV) file.

Clear

Clears the table and graph.

The cursor displayed on the graph corresponds to the currently selected row in the table. The cursor can also be dragged left and right, or stepped left and right using the left and right arrow keys. The selected row in the table and the cursor on the graph are linked, so that changing one will also change the other. This makes it easy to identify the numeric value of any point on the graph.

By default all columns are displayed on the graph, but the graph line for a column can be turned on and off by clicking on the column heading. When the graph line for a column is turned off, **`[OFF]`** will be displayed at the end of the column heading, and the column is not displayed on the graph.

SEROUT Device 1, Device 2, Device 3 Setup Options

The SEROUT - Device1, SEROUT - Device 2, and SEROUT - Device 3 windows are configured using the ***Window> Show Serial Window> Setup Options*** menu item. They can be configured for *Text Output* or *Table and Graph* mode. The capabilities of these modes are the same as described for the SEROUT window, with the exception of *Terminal Emulator* mode, which is only available for the SEROUT window.

The SEROUT Devices have no physical output, and are only supported by the IDE. They can be used for logging background information for testing and debugging. For example run-time statistics could be logged to one of the SEROUT Device windows. If the debugger is disabled, SEROUT instructions for devices 1, 2 and 3 are ignored by the FPU so there is very little overhead for a program that is not being debugged.