s2a_fm

A Scratch 2.0 Hardware Extension for Arduino Micro-Controllers

December 19, 2013
s2a_fm Version 1.1

Version 1.1 Changes:

1. **When enabling a digital pin, the pin is verified to support the requested mode.**

2. **Added debugging feature**

Table of Contents

1. Introduction

Arduino users! Would you like to configure and control your Arduino micro-controller without having to write a single line of Arduino sketch code and at the same time have access to a graphical user interface?

Scratch programmers! Would you like to control and communicate with an Arduino board using Scratch? Imagine, using Scratch to control physical devices such as LEDs, motors, and relays while monitoring devices, such as temperature sensors, potentiometers, and light sensors. What would you create?

Look no further, **s2a_fm** is here!

2. What is s2a_fm?

s2a_fm is a Scratch hardware extension written in Python allowing Scratch and an Arduino micro-controller to communicate seamlessly.

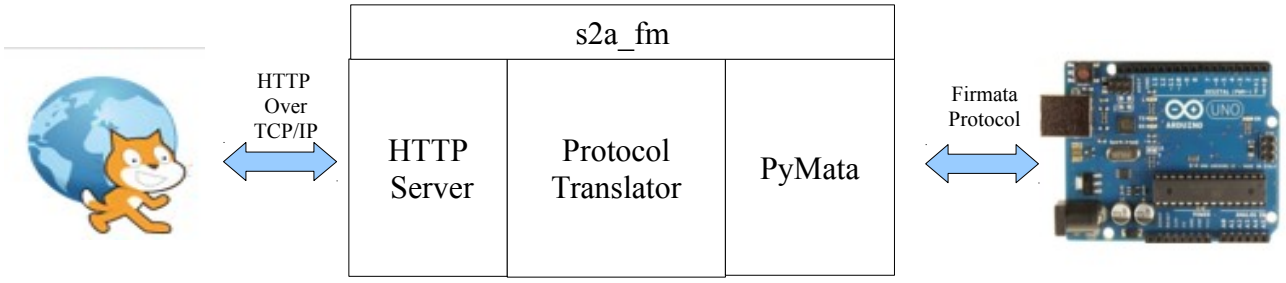


Figure 1 – s2a_fm Architecture

s2a_fm is comprised of three main software components:

1. An HTTP server that communicates with Scratch. The standard Python BaseHTTPServer is used for simplicity and compatibility.
2. The protocol translator translates data between the HTTP and Firmata protocols. This is all done seamlessly and it allows your Scratch/Arduino projects to look and work just like any other Scratch project.
3. PyMata**,** a Python library that communicates with the Arduino using the Arduino Standard Firmata protocol. This makes for fast, efficient and consistent communications. PyMata handles all of the Firmata protocol details.

To start a new project, just upload the *s2a_fm_base.sb2* script file supplied with this release. It contains all of the extension blocks ready to go. After loading this project you will find the extension blocks in the More Blocks tab of the Scratch Project editor ready for use.

3. Installing s2a_fm

3.1. Python and Python Files

Before installing s2a_fm, you must have the following Python components installed on your computer:

Python version 2.7 or greater. You can download Python from: (http://python.org/)

PySerial (http://pyserial.sourceforge.net/)

PyMata (https://github.com/MrYsLab/PyMata)

To install PySerial and PyMata, you may use the "pip' installation program (http://www.pip-installer.org/en/latest/) if you have it installed on your computer. To use it, open a command window and type: pip install *package_name.*

Alternatively, you can download the packages using the links above, and for both the PySerial and PyMata packages type:

python setup.py install.

Note: you may need administrative privileges to perform the install.

3.2. Arduino Sketch

Load Standard Firmata into the Arduino from the examples directory of the Firmata library included with the Arduino IDE.

If you wish to use the Tone functionality provided in S2a_fm, you should load the NotSoStandardFirmata sketch included with this distribution. It adds the Tone functionality, but differs in no other way from Standard Firmata.

See the Project Directory Map (section 8) for its location.

4. Running s2a_fm

Plug your Arduino into a USB port on your computer.

Go to the directory where you installed the **s2a_fm** package and type:

```
python s2a_fm.py COM_PORT_ID
```

where *COM_PORT_ID* is the name of the serial port that is used to communicate with the Arduino. It will have the same name as the one used when you use the Arduino IDE. For example, for Windows, it might be COM3, for linux, it might be /dev/ttyACM0.

After executing the command, you should see something like the following appear in the terminal window:

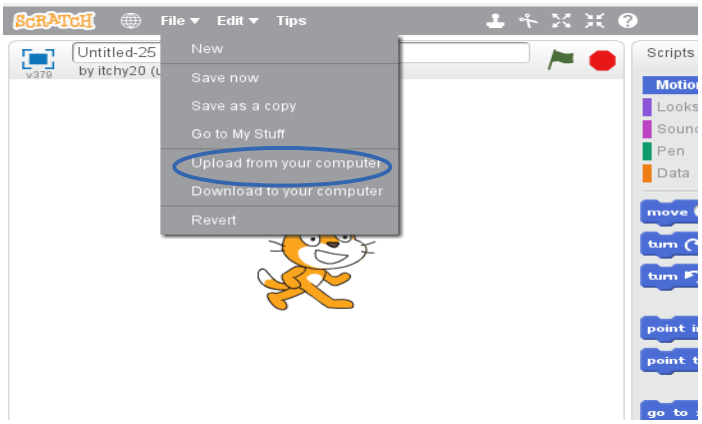
```
s2a_fm version 1.1   Copyright(C) 2013 Alan Yorinks    All Rights Reserved

Opening Arduino Serial port /dev/ttyACM0
Please wait while Arduino is being detected. This can take up to 30 seconds ...
Board initialized in 2 seconds
Total Number of Pins Detected = 70
Total Number of Analog Pins Detected = 16
```

```
Please wait for Total Arduino Pin Discovery to complete. This can take up to 30
additional seconds.
Arduino Total Pin Discovery completed in 6 seconds
Starting Scratch HTTP Server!
Use <Ctrl-C> to exit the extension

Waiting for Scratch handshake ....
Scratch detected! Ready to rock and roll...
```

Now start Scratch 2.0. Create a new project and select File/Upload from your computer and select s2a_fm_base.sb2 from the ScratchFiles/ScratchProjects directory included with this distribution.



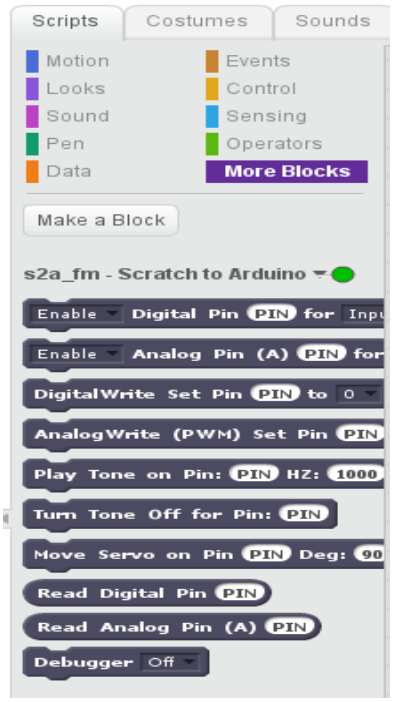
The the command window should now look like this:

```
s2a_fm version 1.1   Copyright(C) 2013 Alan Yorinks    All Rights Reserved

Opening Arduino Serial port /dev/ttyACM0
Please wait while Arduino is being detected. This can
take up to 30 seconds ...
Board initialized in 1 seconds
Total Number of Pins Detected = 70
Total Number of Analog Pins Detected = 16
Please wait for Total Arduino Pin Discovery to
complete. This can take up to 30 additional seconds.
Arduino Total Pin Discovery completed in 1 seconds
Starting Scratch HTTP Server!
Use <Ctrl-C> to exit the extension

Waiting for Scratch handshake ....
Scratch detected! Ready to rock and roll...
```

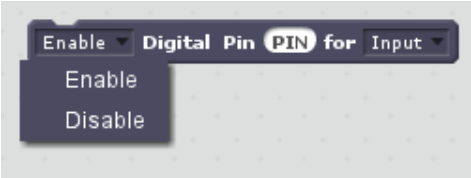
And if you go to the More Blocks tab in Scratch you should see:

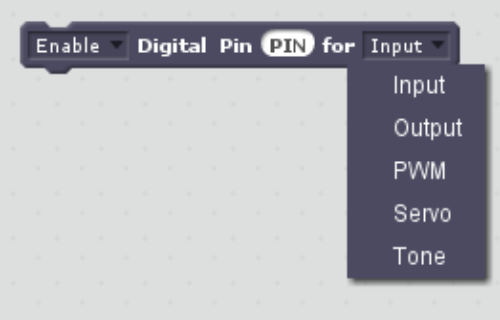


The circular indicator next to " s2a_fm – Scratch to Arduino" should be green, indicating that the connection has been successfully established.

5. The Extension Blocks

5.1. Set Digital Pin Mode





This block enables or disables an Arduino digital pin as an Input, Output, PWM, Servo or Tone.

5.1.1. Enable

Before accessing a pin for input or output it must be enabled. To enable, select Enable from the first drop down menu. If **Input** mode is chosen (see below), enabling the pin will automatically instruct the Arduino board to report value changes for the pin.

5.1.2. Disable

If a pin has been previously been enabled, selecting disable will inactivate the pin from its previously enabled mode and reporting will cease for an I**nput** mode pin. Normally this choice is not used, but is provided to give full flexibility in writing Scratch scripts.

5.1.3. Pin Number

The value entered must be within the range of pin numbers for the board. The number of pins detected for the Arduino is shown in the console window when the program first starts up and this information is also placed in the log file (see section 6). If the pin number is outside of the range for the board, an error message is sent to the console and an error is logged. The command is ignored if an error is detected.

5.1.4. Digital Mode

There are 5 digital modes supported.

- **Input** for connection to an input device such as a switch.
- **Output** for connection to a device such as an LED.

- **PWM** is an output mode used to control a pin with an AnalogWrite. This can be used to fade the light level on an LED.
- **Servo** configures the pin to operate a servo motor.
- **Tone** configures the pin to call on the Tone library through Firmata.

SPECIAL NOTE: Some Arduino boards provide internal pull-up resistors To enable pull-up mode for a pin, refer to the Arduino documentation for instruction.

5.2. Set Analog Pin Input Mode

Analog pins are always input pins and can only be enabled or disabled.

5.2.1. Enable

Before accessing an analog pin for input it must be enabled. To enable, select Enable from the first drop down menu. Enabling the pin will automatically instruct the Arduino board to report changes in values for the pin.

5.2.2. Disable

If a pin has been previously enabled, selecting disable will inactivate the pin from its previously enabled mode. Data will no longer be reported for the pin while it is disabled.

5.2.3. Pin Number

The value entered must be within the range of analog pin numbers for the board. The number of pins detected for the board is shown in the console window when the program first starts up. If the pin number entered is outside of the range of the board, an error message is sent to the console and the error is logged. If an error is detected, the command is ignored. The pin number usse the Arduino analog pin number scheme. For example to enable analog pin A3, set the pin number in the block to 3.

5.3. Digital Write

5.3.1. Pin Number

The pin number must be set to a pin that was previously enabled as Output and is in the range of digital pin values. If the pin is not enabled as an Output pin or if it is out of range, the request is ignored and an error message is written to the console and the log file.

5.3.2. Pin Output Value

If a digital pin has been enabled for output, you can set its output level to either a one or a zero. Select the value from the drop down list in the block.

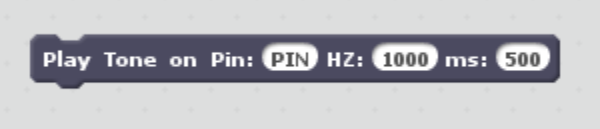
5.4. Analog (PWM) Write

5.4.1. Pin Number

5.4.2. PWM Value

Set the pin output value to be between 0-255. If the value is out of range an error message is written to the console and the log file. The request will be ignored.

5.5. Play Tone



This block instructs the Arduino to play a tone on the designated pin.

5.5.1. Pin Number

The pin number must be for a pin that was previously enabled for Tone and is in the range of digital pin numbers. If the pin is not enabled as a Tone pin or if it is out of range, the request is ignored and an error message is written to the console and the log file.

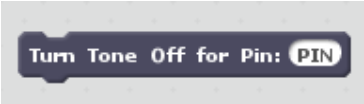
5.5.2. Frequency (HZ)

The tone will be played at the specified frequency. There is no data validation for this entry.

5.5.3. Duration (ms)

The number of milliseconds to sustain the tone. If this value set to zero, the tone will be played indefinitely. It may be turned of my using the Turn Tone Off block.

5.6. Turn Tone Off



This block will turn the tone off. It is used primarily if the duration for Play Tone was set to zero (a continuous tone).

5.6.1. Pin Number

The pin number must be for a pin that was previously enabled for Tone. If the pin is not enabled as a Tone pin or if it is out of range, the request is ignored and an error message is written to the console and the log file.

5.7. Move Servo

This block will set a servo position to the desired value.

5.7.1. Pin Number

The pin number must be for a pin that was previously enabled for Servo and is in the range of digital pin values. If the pin is not enabled as a Servo pin or if it is out of range, the request is ignored and an error message is written to the console and the log file.

5.7.2. Position (Deg)

This sets the motor position expressed in degrees. The range is 0 to 180. A value outside of this will be ignored and an error message is written to the console and the log file.

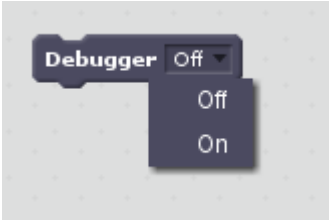
5.8. Read Digital Pin

This block is a “reporter” block for a pin that is enabled as a digital input. It is used to gain access to the current value for the pin number specified. It returns either zero or one to Scratch.

5.9. Read Analog Pin

This block is a “reporter” block for a pin that is enabled as an analog input. It will contain the current value for the pin number specified in the range of 0-1023. Enter the Arduino analog pin number in the PIN field. For example to read analog pin A3, set the pin number in the block to 3.

5.10. Debugger



Turn debugging On or Off (the default is Off) from the drop down list. If debugging is enabled all Scratch commands are logged to both the log and console. Each command is time stamped with the local time. Reporter blocks (sensor information) do not appear as part of the debug report because Scratch polls for data approximately 30 times per second and this would flood the log.

Here is a sample of the debug log:

```
DEBUG: 2013-12-19 14:19:06.733833: debugger On
DEBUG: 2013-12-19 14:19:06.768232: digital_pin_mode Enable 48 Output
DEBUG: 2013-12-19 14:19:06.800449: digital_pin_mode Enable 51 Output
DEBUG: 2013-12-19 14:19:06.849955: digital_write 48 1
DEBUG: 2013-12-19 14:19:06.872217: digital_write 51 1
DEBUG: 2013-12-19 14:19:06.906062: digital_write 48 0
```

5.11. The Red Stop Button

Pressing the red stop button on the Scratch player will send a reset command to the Arduino and will reset all internal data structures to their initial values.

6. Log File

A new log file is created each time s2a_fm is started, and the previous log file is discarded. The name of the log file is“s2a_fm_debugging.log” and is located in a directory called “log” (see the Project Directory Tree in section 8). The log file contains “info” records which are considered part of normal operation and it may contain debug records which will help in debugging a Scratch program accessing an Ardunio board.

Here is part of a typical log:

```
INFO:root:s2a_fm version 1.1    Copyright(C) 2013 Alan Yorinks    All Rights
Reserved
```

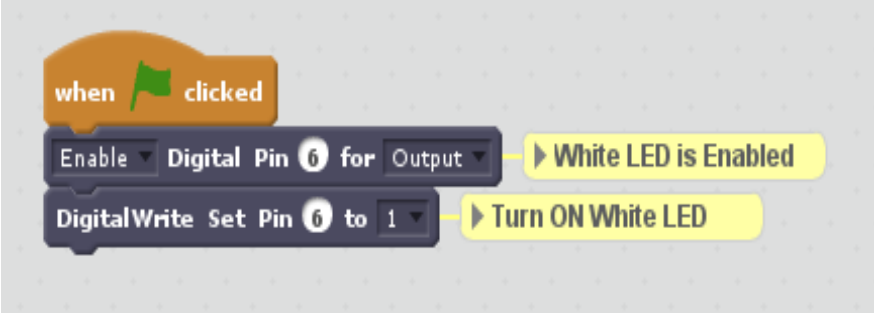
```
INFO:root:com port = /dev/ttyACM0
INFO:root:20 Total Pins and 6 Analog Pins Found
INFO:root:Scratch detected! Ready to rock and roll...
DEBUG:root:digital_pin_mode: The pin number must be set to a numerical value
DEBUG:root:analog_write: The value field must be set to a numerical value
```

In this example, the INFO records indicate normal behavior and provide informational data, and the DEBUG records indicate a problem. In the first DEBUG line, the pin number was not entered properly when setting a digital pin mode, and the second DEBUG indicates that the VAL field needs to be properly entered when executing an analog write block.

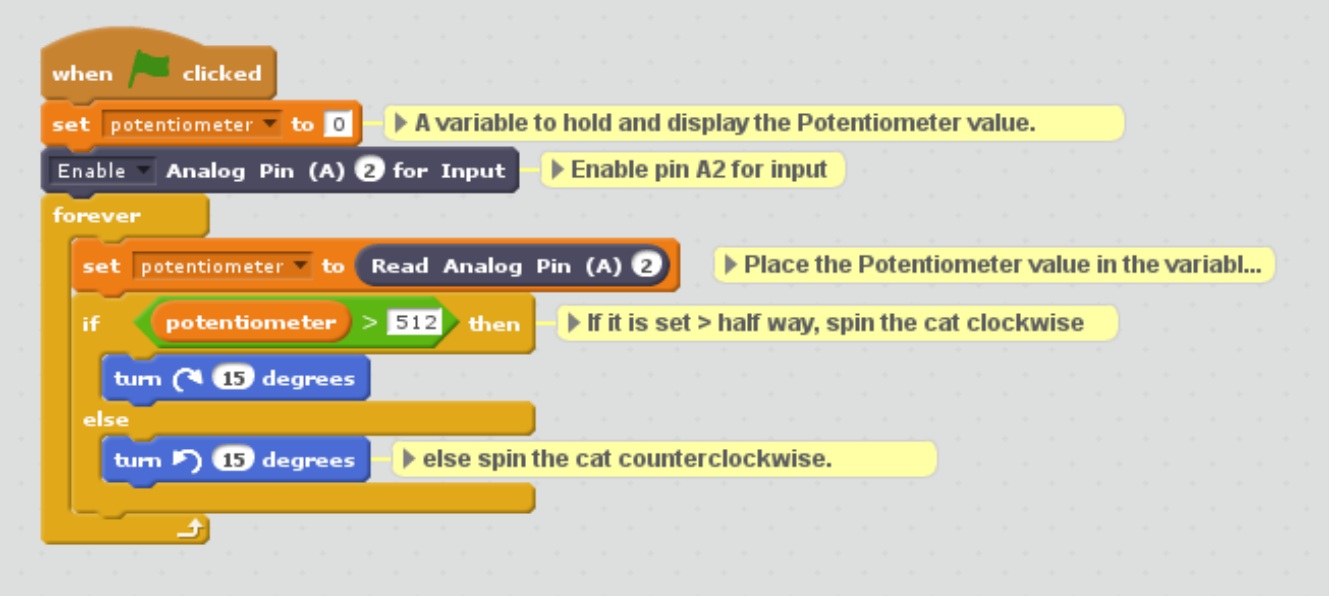
7. Example Programs

These Scratch .sb2 program files for these examples can be found in ScratchFiles/ScratchProjects directory (see the Project Directory Tree in section 8).

7.1. A Scratch Program to Turn On an LED using Digital Pin 6



7.2. Scratch Program to Read A Potentiometer on Pin A2 and Spin the Scratch Cat


when clicked
set potentiometer to 0
A variable to hold and display the Potentiometer value.
Enable Analog Pin (A) 2 for Input
Enable pin A2 for input
forever
set potentiometer to Read Analog Pin (A) 2
Place the Potentiometer value in the variabl...
if potentiometer > 512 then
If it is set > half way, spin the cat clockwise
turn 15 degrees
else
turn 15 degrees
else spin the cat counterclockwise.

8. Project Directory Tree

```
s2a_fm
    ├── ArduinoFiles
    │   └── NotSoStandardFirmata
    │       ├── examples
    │       │   └── NotSoStandardFirmata
    │       │       ├── LICENSE.txt
    │       │       ├── Makefile
    │       │       └── NotSoStandardFirmata.ino
    │       ├── Boards.h
    │       ├── Firmata.cpp
    │       ├── Firmata.h
    │       ├── keywords.txt
    │       ├── LICENSE.txt
    │       └── readme.md
    ├── documentation
    │   └── s2a_fm_reference.pdf
    ├── extra_goodies
    │   ├── linux
    │   │   └── s2a_fm.sh
    │   └── windows
    │       └── s2a_fm.bat
    ├── log
    ├── ScratchFiles
    │   ├── ExtensionDescriptors
    │   │   ├── s2a_fm.s2e
    │   └── ScratchProjects
    │       ├── s2a_fm_base.sb2
    │       ├── spinning_cat.sb2
    │       └── Turn On LED On Pin 6.sb2
    ├── s2a_fm.py
```

```
├── scratch_command_handlers.py
└── scratch_http_server.py
```

9. References

Arduino	http://arduino.cc/
Scratch	http://scratch.mit.edu/
Arduino Standard Firmata	http://playground.arduino.cc/Interfacing/Firmata
PyMata	https://github.com/MrYsLab/PyMata

10. Questions, Comments, Bug Reports

Please contact us at MisterYsLab@gmail.com