

Scratch Board Technical Information

About This Document

This document provides information regarding the technical aspects of how a Scratch Sensor Board can communicate with a Scratch computer program. (For background information about the Scratch Sensor Board, see http://scratch.wik.is/Support/Scratch_Board.) You may find information in this document useful for building your own, modified versions of Scratch Sensor Boards.

We are publicly releasing this technical information for educational purposes and to support innovation. If you create new designs and/or hardware using the information in this document, we require that you abide by the Scratch Sensor Board license – available at: <http://scratch.mit.edu/files/scratchboard/ScratchBoardLicense.txt>.

The ideas that the license describes in detail are essentially:

- the phrase "Scratch Sensor Board" shall not be used to refer to Derivative Works (New Board – compatible with Scratch is acceptable),
- any Derivative Work based on this documentation shall be made readily available to the public, ideally on a public web site, free of charge and include the Scratch Board License.

Anything specified in the license applies to all unless you receive written permission from the Scratch Board Team at the MIT Media Lab (email: [scratchboard \[at\] media.mit.edu](mailto:scratchboard@media.mit.edu)) stating otherwise. (Direct any inquiries about fee-based distribution of Boards compatible with Scratch to the aforementioned email address.)

Scratch Board Serial Communication Protocol

The Scratch Sensor Board allows inputs from real-world sensors such as switches, sliders, light, or sound to control Scratch programs. It does this by converting sensor inputs into numbers and communicating them to a computer running Scratch over a serial data connection.

Communication is via RS-232 protocol at 38.4k baud. Each Scratch Board ships with a USB-to-serial cable. The Board is a serial device that can communicate with standard serial ports or other USB-to-serial cables. In most cases, the Scratch software automatically detects which COM port that the Scratch Board is plugged into when a Scratch project using sensor value blocks is run (recognition can take from 1.5 seconds to a few seconds in rare cases). One of the serial port pins provides enough current to power a Scratch Board (but not an additional load).

Polling: Scratch sends a "1" data byte (i.e. 0x01 not the ASCII character "1") out communications port, the Scratch Board responds by sending the sensor data encoded in an 18 byte packet, with ~ 400 uSec delay between bytes in the packet. The packet consists of 9 high byte / low byte pairs. Scratch checks to make sure that it receives a complete 18 byte packet in response to each poll request and will ignore data that is not part of a well formed packet.

Encoding: Raw sensor values measured by the Scratch Board are 10-bit numbers. Each sensor value is encoded along with a 4-bit channel number as two-byte pair transmitted by the Scratch Board according to the scheme illustrated Figure 1. The first byte in the pair, (the “high byte”) has its most significant bit set to “1”, followed by 4 bits (labeled ch3-ch0) that contain the channel number, followed by the three most significant bits (labeled d9-d7) of the 10-bit sensor value. The second byte in the pair (the “low byte”) has its most significant bit cleared to “0”, followed by the 7 least significant bits (labeled d6-d0) of the 10-bit sensor value.

High Byte

1	ch3	ch2	ch1	ch0	d9	d8	d7
bit7	bit6	bit5	bit4	bit3	Bit2	Bit1	bit0

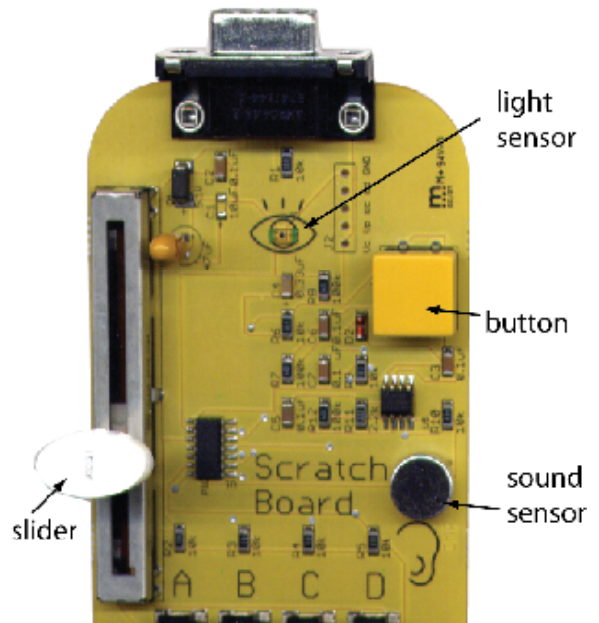
Low Byte

0	d6	d5	D4	d3	d2	d1	d0
bit7	bit6	bit5	bit4	bit3	Bit2	Bit1	bit0

Figure 1

For the Scratch Board Release 1 firmware and Scratch release 1.1 and later, the mapping between channel number and sensor type is given in the following table (figure 2):

Channel Number	Sensor
0	resistance-D
1	resistance -C
2	resistance -B
3	button
4	resistance -A
5	light
6	sound
7	slider



15	firmware-id (currently 0x04)	
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Figure 2

In response to a poll request, the Scratch Board first sends the firmware-id (channel 15), followed by channels 0 through 7 of sensor values.

Scratch maps the 10-bit sensor data onto a 0 – 100 scale using a mapping that is different for each sensor type. Users can access the “raw” 10-bit values by shift-clicking on the Scratch Board Watcher and selecting “report raw data”. Doing so will show sensor values in the range 0 - 1023.

Most of the sensors use a generic linear conversion to report scaled values between 0 - 100. Light and sound sensors use piecewise linear functions that take into account the idiosyncrasies of those sensors. (Note that readings for light are reversed so that more light gives larger values.) Code for scaling functions is shown below in Figure 3.

```

generic(n)
    return round ((100 * n) / 1023)
light(n)
    if n < 25 return 100 - n
    else return round((1023 - n) * (75 / 998))
sound(n)
    //empirically tested noise sensor floor
    n = max(0, n - 18)
    if (n < 50) return n / 2
    //noise ceiling
    return 25 + min(75, round((n - 50) * (75 / 580)))
//noise floor and ceiling values might vary for different
parts

```

Figure 3

Recommendations for Testing Scratch and Sensor Board Communication

When using sensor boards to communicate with Scratch programs, it is important to use a reliable serial port or USB-to-serial converter. We have found converter cables in the Keyspan family to be reliable for sustaining serial communication. When using Windows to run a Scratch program that accesses sensor values, we recommend that you disable any setting that would cause your computer to hibernate while Scratch is running.

Additional Technical Information Documents Online

You can find additional documents containing technical information about the Scratch Sensor Board at http://info.scratch.mit.edu/Sensor_Board.

There, you will find:

Bill of Materials

ScratchBoardBOM.pdf

Firmware (Intel-format hex file)
Gerber files for the PCB
Scratch Board License
Schematic
This document

ScratchBoardFirmwareR1.hex
ScratchBoardGerberR1.zip
ScratchBoardLicense.txt
ScratchBoardSchematicR1.pdf
ScratchBoard_Tech_InfoR2.pdf