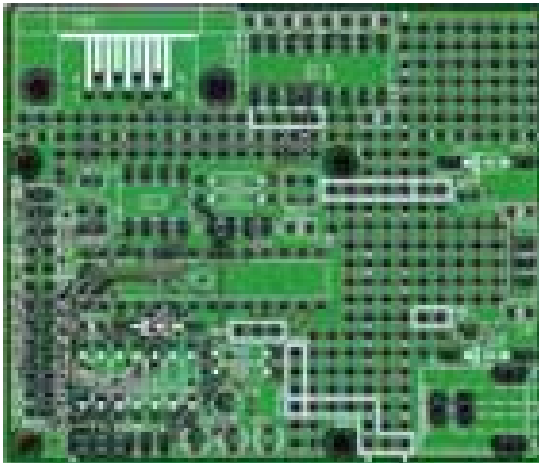# The SX28 Multi Board

by Günther Daubach

The SX Multi Board is a general-purpose PCB for the SX 28 microcontroller, well suited for various applications for home and commercial use, or for prototyping. My company uses the board for production of a new version of the well-known RS-232/I²C Adapter/Monitor, as shown in the picture, below, and for some other customer-specific applications.
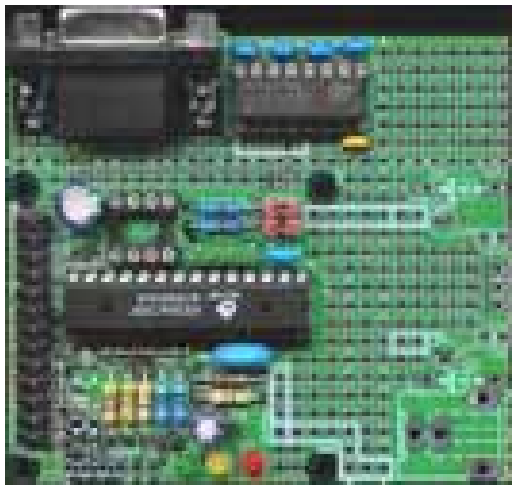
The board's main features are:

- Size: 2.95*2.5 Inches (75*63.5 mm).
- Four-layer PCB with two inner supply layers for enhanced protection against electromagnetic interference.
- No SMT components are used, i.e. components can be installed without special tools.
- Socket pads for an SX 28 ACT together with a ceramic resonator, and an optional reset circuit.
- All SX 28 port pins are externally available via a pin-header (depending on certain components installed on the board, some port pins are used for special purposes).
- The board is divided into three sections, the "Main" section, the "RS-232 Adapter" section, and the "Voltage Regulator" section. The "RS-232 Adapter", and the "Voltage Regulator" section may be cut off when not needed, leaving a "Main" section with a minimum size of 2*1.8 Inches (50*50 mm). Both, the "RS-232 Adapter", and "Voltage Regulator" sections, when cut off can be used as stand-alone modules.
- Optional on-board serial I²C EEPROM.
- Optional components for one bitstream continuous calibration ADC or for a PWM-controlled DAC channel.
- Separate pin-headers for an external I²C bus, and for TTL-level serial communication, e.g. for Parallax BASIC stamp modules.
- Up to three on-board indicator LEDs.
- Breadboarding area with solder pads for additional components.
- Two 2*2 jumper blocks for I²C bus pull-up resistors, and to configure handshake lines for the TTL serial communications port.

Bill Of Material

The table, below, lists the components required for various stages of extension.

Required Components				
Parallax #	Qty.	Device	Value/Description	Name
	1	SX Multi Board		
SX28AC/DP	1	microcontroller	SX28AC/DP	IC2
452-02807	1	DIL socket	28 pins	IC2
250-05060	1	ceramic resonator	50 MHz	RES
450-03201	1	3-pin socket for resonator	optional	RES
201-01050	1	ceramic capacitor	100 nF	C5
201-01062	1	electrolytic capacitor	10 µF/16V	C10 or C11
150-01030	3	resistor	10 kOhm	R3, 7, 9
150-04710	1	resistor	470 Ohm	R8
450-00402	1	4-pin header for SX-Key/Blitz	optional	SX-Key

Optional Components				
SX 28 Reset Circuit				
501-00005	1	diode	1N4148	D1
201-01050	1	electrolytic capacitor	1 µF/16V	C6
LEDs				
150-04710	3	resistor	470 Ohm	R4, 5, 6
350-00006	1	LED, red	3 mm	ST
350-00007	1	LED, yellow	3 mm	I2C
360-00001	1	LED, green	3 mm	RS

Extension Connector				
451-03201	1	26-pin header	optional, for I/O extension	SV1
ADC/DAC				
150-01030	2	resistor	10 kOhm	R6, R10
201-01050	1	capacitor	100 nF	C13
I²C Bus				
451-00402	1	4-pin header	optional, for external I²C bus	I2C
150-02020	2	resistors	2 kOhm I²C pull-up	R1, R2
	1	2*2 pin header	to enable/disable I²C pull-up	JP1
	2	jumpers 1/10"	for JP1	JP1
RS-232 Interface				
452-00005	1	SUB-D 9 print connector	female	RS1
604-00004	1	level-shifter	MAX2323 or MAX232A	IC1
	1	DIL socket	16 pins	IC1
201-01050	5	ceramic capacitor	1 µF/16V	C1, 2, 3, 4, 12
TTL Serial Interface				
451-01201	1	6-pin header	optional, for TTL serial	TTLCOMM
	1	2*2 pin header	to enable RTS/CTS	JP2
	2	jumpers 1/10"	for JP2	JP2
Voltage Regulator				
601-00506	1	voltage regulator	7805 (TO220)	IC4
700-00004	1	heat sink	for 7805 (optional)	IC4
200-01040	2	ceramic capacitor	100 nF	C8, C9
201-04760	1	electrolytic capacitor	100 µF/25V	C7
201-01062	1	electrolytic capacitor	10 µF/16V	C10 or C11
	2	diode	1N4001, or equivalent	D2, D3
	1	DC jack, DIN 5mm	X1	
EEPROM				
604-00020	1	IC	24LCxx	IC3
450-00801	1	DIL socket	8 pins	IC3

"Populating" the SX 28 Multi Board

The picture, below, shows the locations of the various components that may be attached to the SX28 Multi Board.
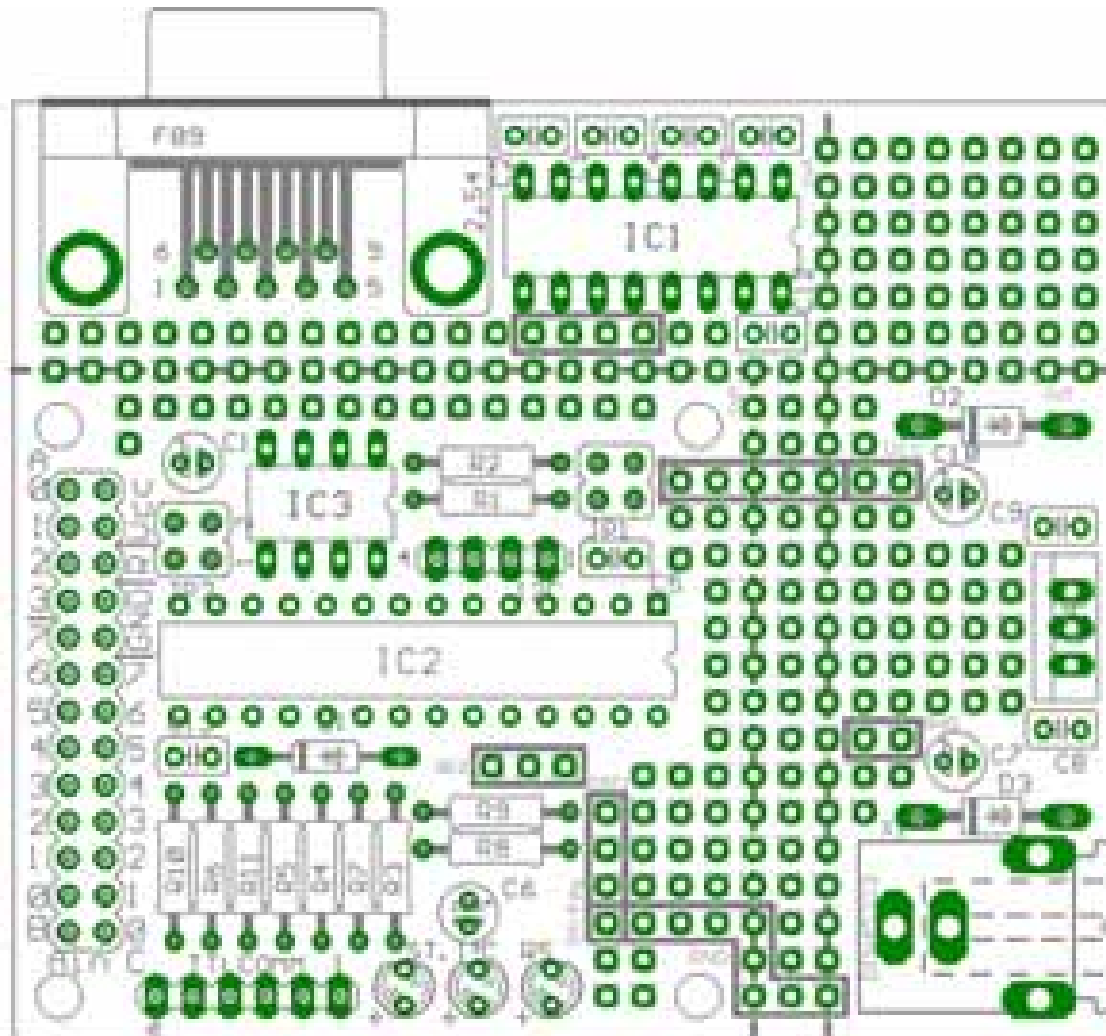
As you learned from the bill of material, there are some components that are always required, where others are optional, depending on your specific applications.

Although IC sockets generally are optional, we strongly recommend that you install them for each IC on board because they make it much easier to replace an IC in case "something goes wrong". Using IC sockets also allows you to easily re-configure the board when necessary, e.g. inserting or removing the serial EEPROM.

The next sections describe optional components that you may install depending on your application.

Reset Circuit

The SX has a built-in power-on reset feature. When the voltage rises too slow at power-on, the internal power-on reset may fail. In such cases, you should install the components listed in the "SX 28 Reset Circuit" section of the BOM, i.e. D1 and C6.

ADC/DAC Support

With three external components (one capacitor, and two resistors), the SX 28 is capable to perform analog to digital conversion when the popular "Bitstream Continuous Calibration" virtual peripheral is executed in the interrupt service routine.

Install R6, R10 (10 kOhm each), and C13 (100nF) when you want to make use of the ADC. The analog input is available at pin 25 of the Expansion Port pin header, and the SX 28 port pins RC.0 and RC.1 are used for the ADC.

As an alternative, you may also use these component positions for a PWM-controlled digital to analog converter (DAC). In this case, port pin RC.0 acts as the PWM output, and R10 and C13 build a low-pass filter for the PWM signal. You may either leave R6 installed, or replace it with a wire jumper when output impedance is a matter. Here, pin 25 of the Expansion Port header acts as analog output.

I²C Support

When you want to connect the SX28 Multi Board to an external I²C bus, you have two options. You may either connect the Extension Connector's pins 1 (SDA) and 3 (SCL), or the I²C Connector's pins 4 (SDA) and 3 (SCL) to the bus lines.

I²C Connector		
Pin	Signal	Comment
1	Vcc	May be used to power the board from an external regulated supply, or to power external modules when the voltage regulator section is installed.
2	GND	May be used to power the board from an external regulated supply, or to power external modules when the voltage regulator section is installed.
3	SCL	The serial clock line (connected to port pin RA0)
4	SDA	The serial data line (connected to port pin RA1)

You may also use pins 2 or 4 of the Extension Connector, or pin 1 of the I²C connector (Vcc), and pins 8 or 10 of the Extension Connector, or pin 2 of the I²C connector (Ground) to either power the SX28 Multi Board externally, or to supply power to the external I²C components from the SX28 Multi Board.

The I²C bus specifications require that the two signal lines SDA and SCL are open-collector, each with a pull-up resistor to the positive supply voltage. In order to use the SX Multi Board together with different I²C setups, two pull-up resistors are provided at positions R1 and R2, together with the jumper block JP1. When jumpers are installed between JP1-1 and JP 1-2 and JP1-3 and JP1-4, the pull-up resistors are active.

When the SX28 Multi Board is connected to an external I²C bus, e.g. to act as an I²C monitor, it is most likely that external pull-up resistors are already installed. In this case, it might be necessary to disconnect the on-board resistors R1 and R2 by removing the jumpers, or not installing the resistors and the jumper block at all.

On the other hand, when the I²C bus shall only be used internally to communicate with the EEPROM at location IC3, or when there are no external pull-up resistors on the bus, the two pull-up resistors R1 and R2 *must* be installed. As an option, you might not install the jumper block, and place the right leads of the two resistors into the two rightmost board pads for the jumper block instead.
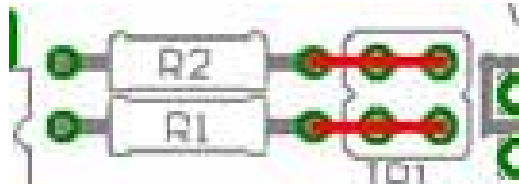
"Hard-wired" I²C pull-up resistors

The EEPROM Section

The SX Multi Board allows to install a I²C serial EEPROM in a DIL-8 package at position IC3. You can install any 24LCxx (or equivalent) type here. Note that the three EEPROM address lines A0…A1 are "hard-wired" to Vcc, i.e. to address bits "111" that are most likely not occupied by a similar device on an external I²C bus.

In order to communicate with such an I²C serial EEPROM, the application program of the installed SX 28 must contain code to act as an I²C master. Samples for such code can be found at various Internet sites related to the SX controllers.

The TTLCOMM Port

This port is connected to a 6-pin header, providing the following signals:

TTLCOMM Port		
Pin	Signal	Comment
1	Vcc	Positive supply input or output
2	GND	Negative supply input or output
3	TxD	Transmit data output, connected to SX 28 port pin RA3
4	RxD	Receive data input, connected to SX 28 port pin RA2
5	RTS	Request to send input, optionally connected to SX 28 port pin RA0
6	CTS	Clear to send output, optionally connected to SX 28 port pin RA1

Devices allowing for serial communications on TTL level, like the Parallax BASIC Stamps may be connected to this port. Please note that the two SX 28 port pins RA0 and RA1 used for handshake are also used to drive the I²C bus. This means, you can only use them for handshaking in applications without I²C support. In order to use them for handshaking, place two jumpers on jumper block JP2 between pins 1-3, and 2-4. Also make sure that the I²C pull-up resistors are de-activated (no jumpers on JP1, or JP1 or resistors not installed), and that there is no EEPROM installed at position IC3.

The RS-232 Interface

In order to connect the SX Multi Board to a standard COM port of a PC, or any other RS-232 compliant device, you should install the components listed in the RS-232 Interface section of the bill of material. This includes a female SUB-D 9 connector, a level shifter IC and some capacitors. We recommend a MAX3232 level shifter because this requires smaller pump charge capacitors, and allows for operating voltages down to 3.0 Volts. When you power the board with 5 Volts, you may use a MAX232A type instead, together with 100 nF capacitors (C1…4).

As an alternative, you may also use a MAX232 but in this case, you need to install 1µF/16V electrolytic capacitors for C1, C2, C3, and C4. Note that electrolytic capacitors are polarized. Therefore, make sure that the positive poles (usually the longer wires, not marked with a white line on the capacitor's body) are oriented like shown in the picture, below:
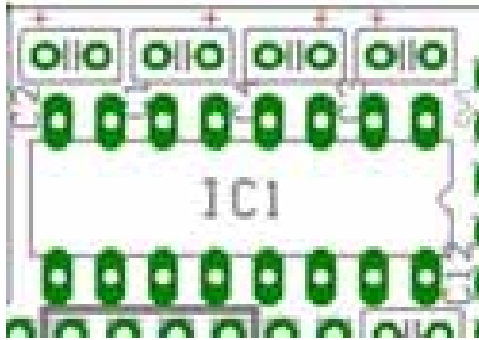
In case you want to use the RS-232 Interface and the TTLCOMM port alternatively, you should re-move the RS-232 level shifter from its socket when using the TTLCOMM port. This avoids that the level shifter's output at pin 12 overrides the RxD signal from the TTLCOMM port going to port pin RA2 of the SX 28.

The Status LEDs

The SX Multi Board allows to install three status LEDs together with the current-limiting resistors, connected to port pins RC5…7 of the SX 28. For example, when used as an RS-232/I²C adapter, these LEDs indicate various states of the adapter. You may use the LEDs for other purposes in your own SX 28 application. When you don't need LEDs at all, do not install them, and don't install R4, R5, and R11. This leaves the SX 28 port pins RC5…7 free for other purposes, e.g. to connect to components installed in the breadboarding area of the SX Multi Board, or via the Expansion Port.

The Extension Port

This is a 2*13 pin header connected to most of the SX 28 port pins, and to some other important signals:

Extension Port		
Pin	Signal	**Comment**
1	RA0	SX 28 port pin, optionally used as I²C SDA or for RTS
2	Vcc	positive power supply input/output
3	RA1	SX 28 port pin, optionally used as I²C SCL or for CTS
4	Vcc	positive power supply input/output
5	RA2	SX 28 port pin, optionally used for RxD
6	RESET*	resets the SX 28 when pulled low (i.e. to GND level)
7	RA3	SX 28 port pin, optionally used for TxD
8	GND	negative power supply input/output
9	RB7	SX 28 port pin
10	GND	negative power supply input/output
11	RB6	SX 28 port pin
12	RC7	SX 28 port pin
13	RB5	SX 28 port pin
14	RC6	SX 28 port pin
15	RB4	SX 28 port pin
16	RC5	SX 28 port pin
17	RB3	SX 28 port pin
18	RC4	SX 28 port pin
19	RB2	SX 28 port pin
20	RC3	SX 28 port pin
21	RB1	SX 28 port pin
22	RC2	SX 28 port pin
23	RB0	SX 28 port pin
24	RC1	SX 28 port pin, optionally used for ADC
25	ADCIN	ADC input/DAC output
26	RC0	SX 28 port pin, optionally used for ADC/DAC

In most cases, you will install the pin header for the Extension Port, as it allows access to all externally available signals. You may either install the pin header on the component side of the SX Multi Board, and then connect external devices via a flat cable, or piggy-back another board on top of the SX Multi Board. You may also install the pin header on the solder side of the SX Multi Board. In this case, you can piggy-back the SX Multi Board on top of another PCB.

The Voltage Regulator Section

The rightmost area of the SX Multi Board allows you to install the components for a voltage regulator and the additionally required components.

Use an 7805, or compatible regulator (TO 220 package). There are two ways how to install the regulator:

- Vertically (attach a matching heat-sink if necessary), as shown in the drawings.
- Horizontally, i.e. flat, on the breadboarding area. In this case, bend the three leads of the 7805 by 90°, and attach it to the board with a screw, a nut and some washers through a mounting hole you would have to drill. Note that the solder pads under the 7805 act as little heat-sinks. If necessary (depending on the total power consumption of the SX Multi Board and other connected components), you may attach an additional heat-sink.

Diode D3 protects the regulator against wrong polarity of the supply voltage fed into the power jack. If you are sure that this will not happen, you may replace D3 by a wire jumper.

Diode D2 protects the 7805 against reverse currents when powered off. This may happen when additional capacitors are connected to the output of the regulator. If this is not the case, you may leave away this diode.

There are two locations for the output filter capacitor on the SX Multi Board, at C11 (close to the SX 28), and at C10 (close to the 7805). In case you install the 7805 regulator, we recommend that you install the 10µF/16V capacitor at location C10, else, install it at position C11.

Adding ISP Support

As an option, you may install a 4-pin header for the SX-Key or SX-Blitz devices for in-system programming/debugging as shown in the picture, below:
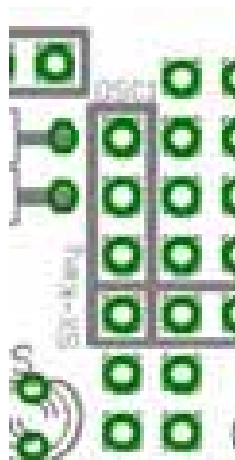
In this case, you should also install a 3-pin socket for the resonator so that it can be removed during programming and debugging sessions as there is no jumper available on-board to open the OSC1 connection to the resonator. When connecting the SK-Key/Blitz, check the correct orientation, i.e. OSC1 pin closer to the resonator, and Vss closer to the LED.

Selecting the Size of the SX 28 Multi Board

The SX Multi-Board consists of three different sections, the "Main Section", the "RS-232 Section", and the "Regulator Section", as shown in the picture, below.
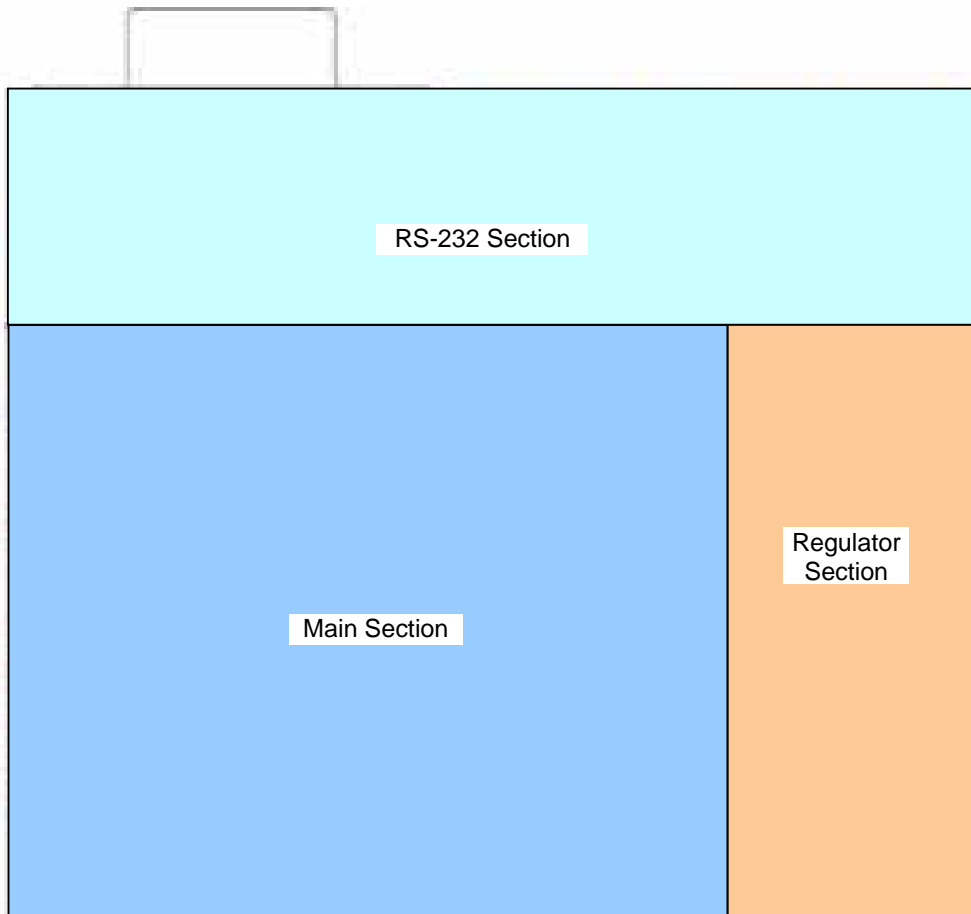

Before installing components on the SX 28 Multi Board, you should decide about the size of the target board. When board size is not critical, you might leave the board "as is". This allows you to add more components later, when necessary.

When required, you can cut off parts of the board along the lines marked with "cut".

IMPORTANT NOTE: The SX 28 Multi Board has four layers with one inner layer connected to Vcc, and one layer connected to GND or Vss. After cutting off parts of the board, and before installing any components, verify that there is no short between the two inner layers. An ohmmeter should indicate an infinite value when one test lead is connected to any Vcc pad, and the other to any GND pad, e.g. pins 2 and 8 of the Extension Port.

Should there be a short, use a fine file, or sandpaper to smoothen the cut off sides of the board until there is no longer a short.

The picture, below, shows how the SX 28 Multi Board can be separated into various sections:

RS-232 Adapter

Breadboard

Main Section

Voltage Regulator
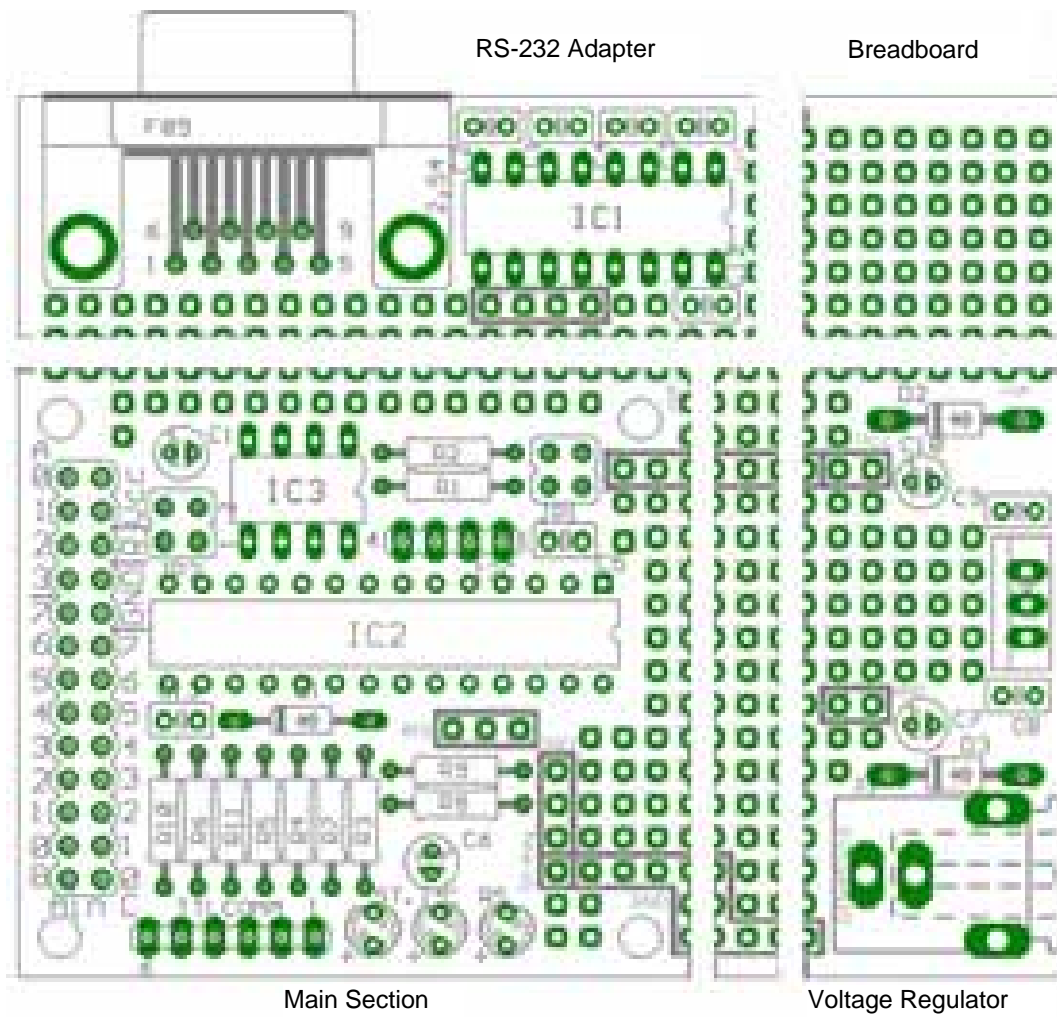
The "Mini Board"

To achieve the smallest possible board, cut off the upper RS-232 interface part first, and then cut off the right part along the leftmost vertical "cut" mark, i.e. remove most of the breadboarding area. When you want to mount components in the breadboarding area, you may only remove the voltage regulator section by cutting the board along the rightmost vertical "cut" mark.
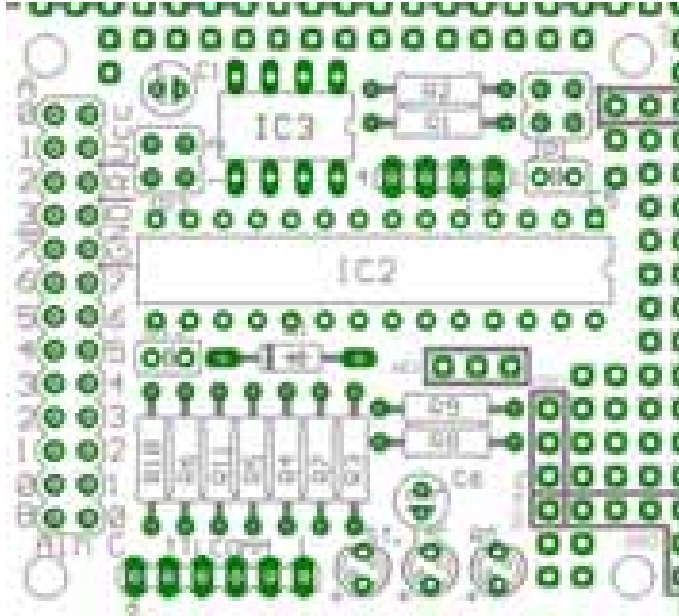
This leaves you with an SX 28 module that requires an external 3.3 to 5 Volt stabilized power supply. Power can be supplied via the following connectors:

Vcc (+):   EXTENSION pins 2 and 4
GND: EXTENSION pins 8 and 10
    or
Vcc (+):   TTLCOM pin 1
GND: TTLCOM pin 2
   or
Vcc (+):   I2C pin 1
GND: I2C pin 2

In this case, it is recommended that you install an electrolytic capacitor (33μF/16V) at position C11 to filter the external power supply.

Before applying power, to any of the pins, double-check the right polarity of the supply voltage in order to avoid that board components might be permanently damaged!

You should at least install all the components contained in the "Required Components" section of the "Bill of Material" list (BOM), plus any other components required for your specific application.

The "RS-232, Externally Powered Board"

When you need the RS-232 interface but have an external stabilized power supply available for the SX Multi Board, you may remove the Voltage Regulator Section by cutting it off along the rightmost "cut" line.
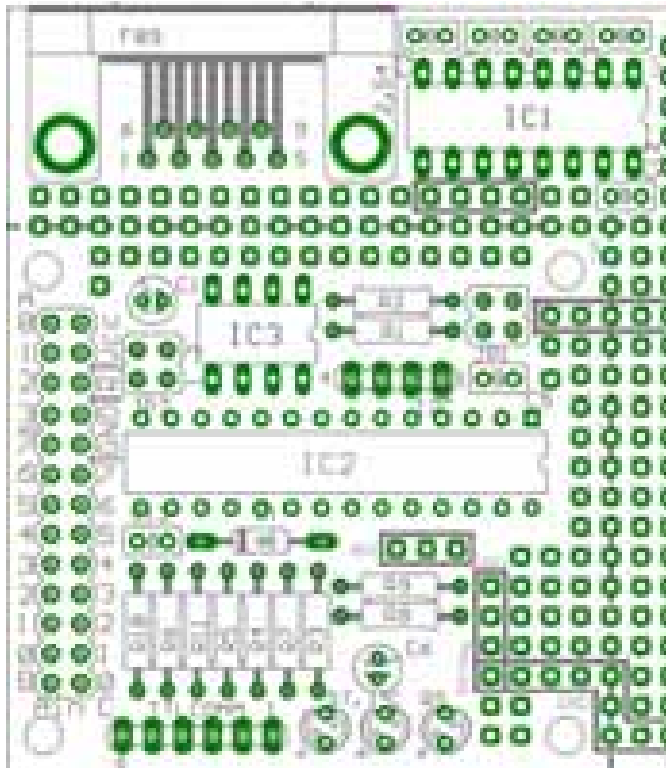

Again, this leaves you with an SX module that requires an external 3.3 to 5 Volt stabilized power supply, and the board may be powered via the same connectors as described before for the "Mini Board". In addition, you may also connect the power supply to the upper and lower rows in the breadboarding area marked with "Vcc" (positive supply voltage), and "GND" (negative supply voltage).

Before applying power, to any of the pins, double-check the right polarity of the supply voltage in order to avoid that board components might be permanently damaged!

The "Non-RS-232 Board with Voltage Regulator"

For this variant, cut off the upper RS-232 Adapter section with the breadboard area at the top right. This leaves you with an SX 28 board with the integrated voltage regulator.
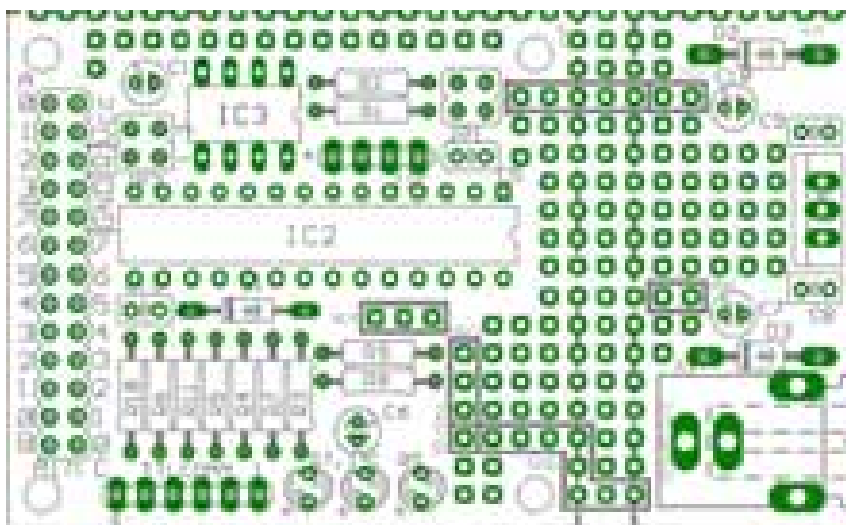
The "Full-Sized" Board

When you don't cut off any sections of the SX Multi Board, and install all the components listed in the Bill of Material, you have a board with all the available features. You may still leave away any components, you currently don't need.

With the components in the "Voltage Regulator" section installed, you can power the board and any attached devices from an unregulated DC power supply (9…12V) connected to the power jack (positive side to the center pin).

Please make sure that the total current drawn does not exceed the limits of the 7805 regulator, and add a heat-sink when necessary.

When you connect the SX Multi Board to devices that are externally powered, it is advisable that you do not power the SX Multi Board from the Voltage Regulator section. Instead, feed the supply voltage through any pair of connector pins mentioned in the previous section. This makes sure that the external devices and the SX Multi Board are powered at the same level.

Please make sure that the external power supply can handle the additional load, and double-check the polarity.

It is no problem to externally power the SX Multi Board with the components in the Voltage Regulator section installed, as long as you don't connect power to the DC jack, and when the diode at position D2 is installed.

What to do With "Cut-off" Parts ?

Both, the RS-232 Interface, and the Voltage Regulator sections can be used as stand-alone parts when cut/broken off from the SX Multi Board.

The RS-232 Interface Section

GND Vcc T1In R1Out
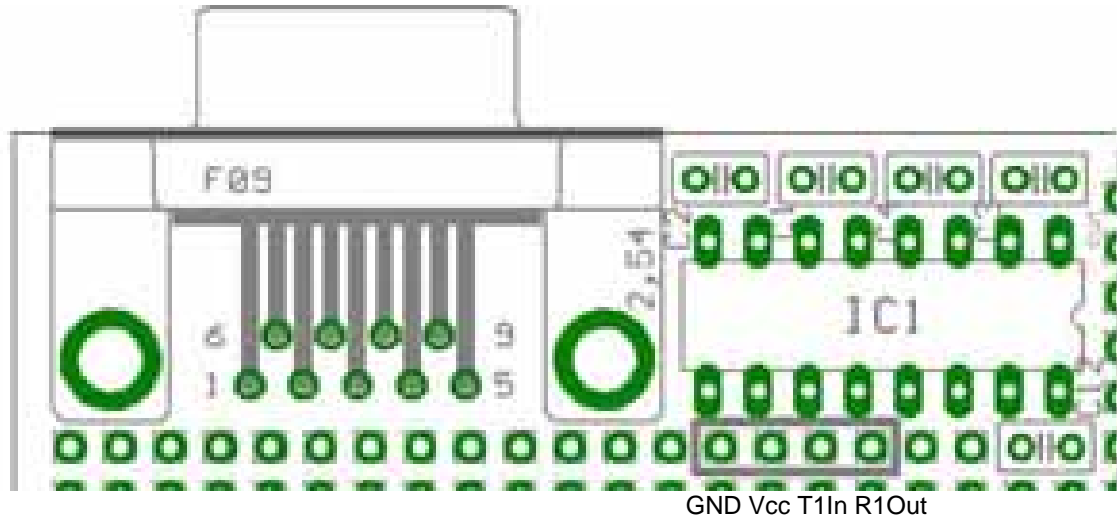
The "RS-232 Interface" Section

On the "RS-232 Interface" section, there are four solder pads marked by a rectangle. These pads allow you to connect the module to the "outside world". As an option, you might consider to install a 4-pin header here. As shown in the picture, above, the pads marked "GND" and "Vcc" are used to for feeding the supply voltage (3.3 to 5V, stabilized), and the next two solder pads, are connected to pin 11 of the MAX3232 (T1In), and to pin 12 (R1Out).

This means that you can use the section as a separate TTL to RS-232 level converter, e.g. to connect the TTL serial port of a Parallax BASIC Stamp to a PC.

When not needed, you may also cut off the small breadboarding section to the right along the "cut" mark (not shown in the picture, above).

The Voltage Regulator section
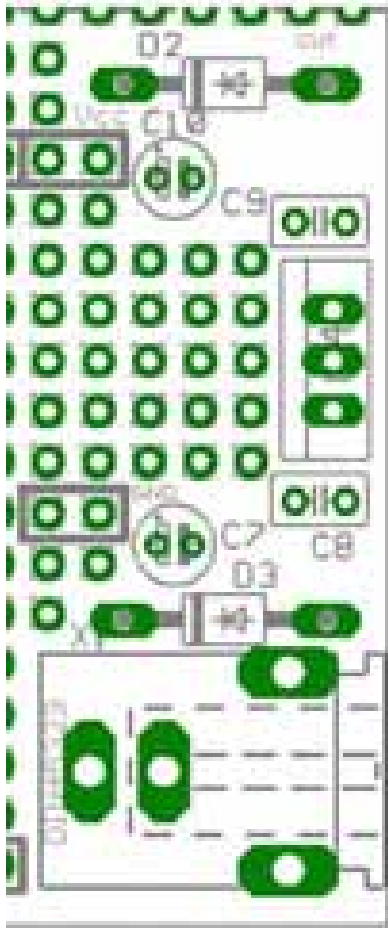
The Voltage Regulator" section has two solder pads marked "Vcc", and two more solder pads marked "GND" where a stabilized 5 Volt supply is available when you connect an un-stabilized supply (9… 12 Volt) to the power jack.

The SX Multi Board Schematic

TITLE: SX Multi 1_4

Document Number: REV:

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